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Pesticide Residues in Market Garden Crops in Peri-Urban Areas of Daloa (Cote d´Ivoire)

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Abstract

The purpose of this study was to assess the health aspect of human food through the consumption of vegetable crops in peri-urban areas of Daloa (Côte d'Ivoire). Indeed, the use of phytosanitary products, in particular pesticides is frequent for the cultivation of foodstuffs. Thus, 225 samples, including 90 samples of green onion leaves, 90 fresh okra and 45 lettuces were taken and analyzed by a chromatographic method. Results show that more than half of the samples analyzed (54.22%) contain pesticide residues. These residues belong to several chemical families of pesticides (organochlorines, organophosphates, carbamates, dithiocarbamates and pyrethrenoids).

However, different average concentrations of residues detected were much lower than regulatory standards in force. However, the presence of certain banned residues such as endosulfan on vegetable crops represents a real danger for consumers. We also note the silence of the standards regarding the cocktail effect of pesticide residues in food.

Keywords: Pesticide Residues; Market Garden Crops; Peri-Urban Areas; Daloa (Côte D'ivoire)

List of abreviations: MRL: Maximum Residue Limit; Oc: Organochlorine; Op: Organophosphorus; Pyr: Pyrethroids; Carb: Carbamate

Introduction

Meeting the food needs of a growing world population is becoming an increasingly acute problem [1,2]. Thus, in order to overcome the shortage of agricultural products, the use of chemical plant protection products has proven to be the solution. Phytosanitary chemicals play a very important role in qualitative and quantitative improvement of agricultural products [3,4]. Indeed, the use of chemical phytosanitary products has considerably reduced the arduousness of work in the field while allowing sufficient production and at lower cost to satisfy both market and consumer. In 2013, Popp and his collaborators indicated that production losses, before harvest, of major world crops due to pests (insects, micro-organisms) and weeds are estimated at 35%. Without effective crop protection, these losses would be 70% [5]. According to industry proponents, reduction in global food production caused by non-use of phytosanitary products could be the cause of famines in already vulnerable populations [6].

All these arguments taken into account, it is undeniable that chemical plant protection products have many advantages. However, their use can cause environmental and public health problems, especially since risks inherent in some of them are poorly assessed. Thus, despite their importance, pesticides raise real concerns among populations because of their harmfulness to humans and their environment [7]. Indeed, numerous scientific studies show that several diseases can be caused by the presence of pesticides in the human body [8,9]. Even with low exposure, pesticides can have serious consequences on the body by causing male infertility and cancer [10,11]. Pesticides can cause spontaneous abortions or serious fetal malformations [12,13]. The city of Daloa is not on the fringes of this urban agriculture. There are indeed several market gardening sites spread over the entire city, which provide supplies to the various markets. However, despite the usefulness of urban market gardeners, it remains to be ensured that urban pollution does not constitute an obstacle to the quality of market garden production [14].

The present study was undertaken with the aim of assessing the level of contamination by pesticide residues of some high-consumption market garden products in Daloa (West-central Côte d'Ivoire).

The purpose of this study is to ensure the health status of foodstuffs in order to participate in raising awareness among consumers and public authorities on this important public health problem.

Material and Methods

Material

The search of pesticide residues was carried out on a set of vegetables consisting of okra (*Hibiscus esculentus*), lettuce (*Lactuca sativa*) and green onion leaf (*Allium fistilosum*). These vegetables are highly vulnerable to attacks by parasites. Their cultivation therefore requires the use of many phytosanitary products, including pesticides. These pesticides leave a lot of residues in vegetables, which are widely consumed by the population and particularly that of Daloa city (Figure 1).

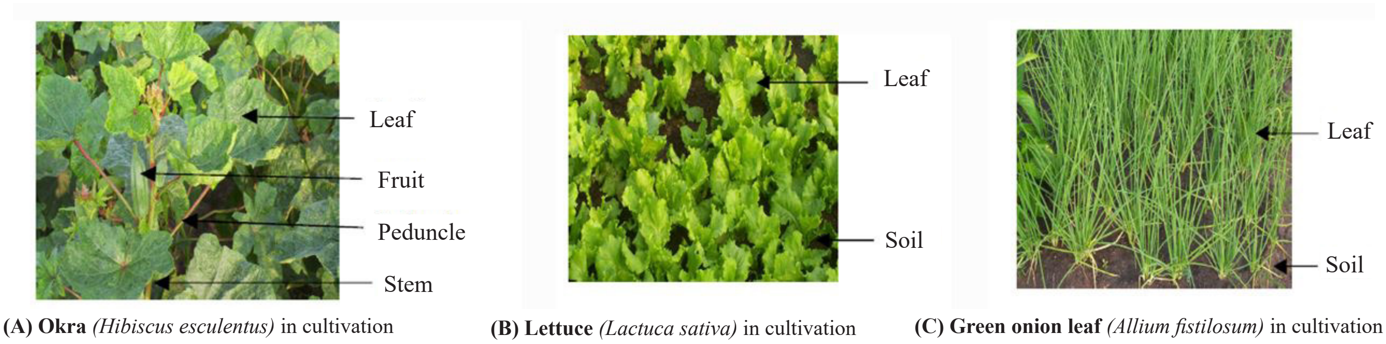


Figure 1: Main peri-urban vegetable crops of Daloa **(A)** Okra *(Hibiscus esculentus)*; **(B)** Lettuce *(Lactuca sativa)*; **(C)** Green onion leaf *(Allium fistilosum)*

Methods

Sampling of the biological material: The sampling method used is that recommended by FAO/WHO committee [15]. This method consists in taking a representative sample from a batch. Thus 225 samples of vegetables including 90 samples of green onion leaves, 90 okra and 45 lettuces were taken in an area (Baoulé quarter) of the city of Daloa where these vegetables are regularly cultivated by the population (Figure 2). Sampling sites are separated by 500 m. The 225 samples allowed several different tests to be performed to obtain reliable results. The number of samples depends on the purchase price of the type of vegetable. Indeed, lettuce is more expensive.

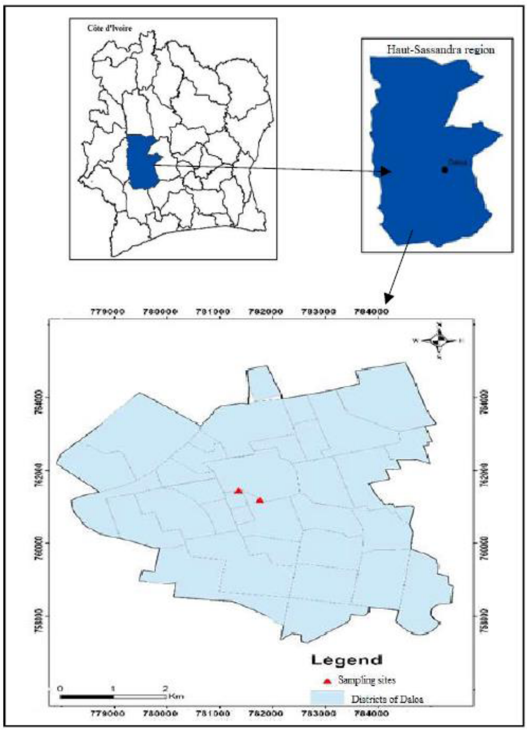


Figure 2: Vegetable sampling sites

The different vegetables were taken during the rainy season from May to June. During this period there is a proliferation of parasites hence the use of phytosanitary products. The treatments by the farmers were carried out in the mornings from 6 to 8 a.m. and in the evenings from 5 p.m. Given the multiplicity of phenomena that can affect the result, these samples were wrapped in aluminum foil and transported to the Laboratory of Environmental Sciences (LSE) Nangui Abrogoua University where analyses were carried out after 48 h of storage at + 4 °C.

Analytical method: Ripening vegetables were sampled and analyzed. Indeed, it is at this stage that these vegetables are generally consumed by the populations.

Gas chromatography coupled with mass spectrometry is the analytical method used for the approach of multi-residue screening.

This technique (multi-residue) makes it possible to analyze several families of residues simultaneously [16].

For data processing, the EXCEL 2016 spreadsheet allowed us to calculate the averages.

Extraction protocol

The extraction of pesticide residues from vegetables was done cold by column elution, liquid-liquid extraction (ELL). Indeed, each vegetable was ground in a porcelain mortar (Avignon). Then 50 g of this slurry are removed and 50 mL of ethanol, 50 mL of hexane and 2 teaspoons of anhydrous sodium sulfate (Na_2SO_4) were added. A homogenate was obtained and filtered under vacuum. Filtrate collected had two phases : an aqueous phase and a solvent phase, which may contain pesticide residues. Two phases were separated in a dropping funnel. Solvent phase was recovered in a flask and the solvent filtrate was evaporated using a vacuum evaporator. Pellet was collected with hexane after several rinses and volume was reduced to 10 mL. This quantity (10 mL of extract) was purified (elimination of co-extracted materials). Ten (10) mL test sample was then introduced into column (respectively filled with glass wool, 20 g of anhydrous Na_2SO_4, 20 g of 5% deactivated Florisil® PR, 60-100 mesh). Then a migration solution (120 mL of hexane and 30 mL of dichloromethane) was used for the percolation. Product leaving the column was collected dropwise in of 500 mL flask. By evaporation on a rotary evaporator under vacuum, 2 mL of concentrate were obtained, the level of which was again adjusted to 10 mL by means of hexane. This new solution was used for injection into the chromatograph.

Instrumental analysis

Identification and quantification of pesticide residues in vegetable samples were carried out by gas chromatograph (SHIMMADZU GC-14A split splitless) equipped with 63Ni electron capture detector and SHIMMADZU C-integrator, R6A CHROMATOPAC. Characteristics of the capillary analysis column are : liquid phase DB-1; 0.25 µm diameter; film thickness = 3 x 0.25 mm; Limit temperature -60 °C to 325/350 °C in program. A compact column with 1.95% QF-1 and 1.5% OV-17 was used for confirmation of the analyzes. Operating conditions were: carrier gas was high purity nitrogen (99.9%) at 2 bars; oven at 255 °C; injector at 250 °C and the detector at 300 °C. The volume of the injected sample was 3µL.

For the detection of pesticide residues in vegetables, the calibration of the gas chromatograph was carried out using pure pesticide standards certified and supplied by Dr Ehrenstorfer GmbH (Germany).

Results and Discussion

Results

Levels of pesticide residues in the vegetables sampled: Chromatographic analysis of the vegetable samples revealed presence of pesticide residues. Indeed, out of a total of 90 samples (green onion leaves), 67 contain 7 different pesticide residues. For fresh okra samples (90), 26 containing 6 distinct residues were detected and out of 45 lettuce samples, the total number of detections was 29 with 4 different pesticide residues. Lettuce was the most contaminated vegetable with a total load of 0.648 µg/kg (Table 1).

In order to ensure that these vegetables can be eaten without risk to the consumer, average concentrations of the different pesticide residues have been compared with current regulatory standards of Codex Alimentarius [17].

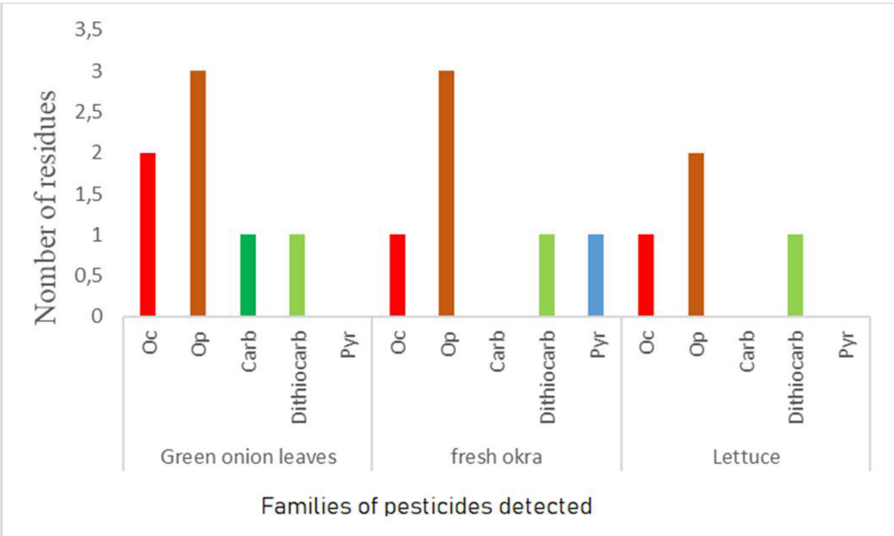
Different values (average concentrations) detected in vegetables in the situations studied are much lower than the standards (MRLs) recommended by Codex Alimentarius (Table 1).

Number of samples analyzed	pesticide residues	Number of detections classified according to various concentrations (µg/kg)				Total number of detections	Average concentrations per residue (µg/kg)	MRLs (µg/kg)
		0,05	0,1	0,5	1			
Green onion leaves (90)	No residue (23)							
	Carbaryl	28				28	0.016	0.1
	Manebe	7				7	0.034	0.05
	Lindane	45	15			60	0.032	0.01
	Endosulfan	8	12			20	0.036	0.05
	Dimethoate	14	9			23	0.065	1
	Profenofos	39				39	0.003	0.05
	Parathionethyl	11	2	12		13	0.033	0.02
	Overall charge						**0.219**	

Number of samples analyzed	pesticide residues	Number of detections classified according to various concentrations (µg/kg)				Total number of detections	Average concentrations per residue (µg/kg)	MRLs (µg/kg)
		0,05	0,1	0,5	1			
Okra (90)	No residue (64)							
	Mancozebe	12	1			13	0.041	1
	Chlorpyrifos	18	3	3		21	0.125	0.5
	Endosulfan	22	2			24	0.024	0.05
	Dimethoate	18	6			24	0.063	0.02
	Profenofos	23				23	0.016	0.05
	Cypermethrine	19				19	0.005	0.5
	Overall charge						**0.274**	
Lettuce (45)	No residue (16)							
	Diazinon		6	8		14	0.341	0.5
	Profenofos	6				6	0.013	0.05
	Mancozebe	10	2	8	4	24	0.253	1
	Endosulfan	13				13	0.041	0,05
	Overall charge						**0.648**	

Table 1: Levels of pesticide residues detected in vegetables

Contamination of vegetables by family of pesticides: Multi-residue analysis carried out detected 11 different pesticide residues into 225 samples analyzed. These pesticide residues belong to 5 major chemical families (organochlorine, organophosphorus, carbamates, dithiocarbamates and pyrethroids) (Figure 3). With the exception of pyrethroid and carbamate, other families were detected. Assessment of this contamination showed that organophosphorus pesticides were the most distinguished with a contamination rate of 47.05%. As for pyrethrenoids and dithiocarbamates, they were the weakest represented (5.88%) (Table 2).



OC: Organochlorine; OP: Organophosphorus; Pyr: Pyrethroids'; Carb: Carbamate; Dithiocarb: Dithiocarbamates

Figure 3: Families of pesticides detected in vegetables

		Samples with residue	Residues detected	Families of pesticides				
				OC	OP	Carb	Dithiocarb	Pyr
Vegetables	Green onion leaves	67 (74.44%)	202					
	Fresh okra	26 (28.88%)	127	23.50%	47.05%	5.88%	17.64%	5.88%
	Lettuce	29 (64.44%)	57					

Table 2: Balance of vegetable contamination by family of pesticides

Discussion

Region of Daloa (Côte d'Ivoire) is a forest area so it is favorable to pests proliferation and vegetable crop diseases. As market gardening is generally practiced in the wetlands. These are subject to parasitic pressure [18,19] To protect crops, farmers use phytosanitary products [20] and products are not without drawbacks for food. They leave residues which represent a risk for consumers [21]. Analysis of the 225 vegetable samples showed that they all contained pesticide residues. Each type of vegetable contains at least four (4) different pesticide residues. In 2019, Kpan *et al.* carried out a similar study on market gardeners in the municipality of Port-Bouët (Abidjan, Côte d'Ivoire) [22]. The results of this study showed contamination of these foodstuffs by pesticides.

The averages of these residues in vegetables are generally less than the current Codex Alimentarius standards (MRLs) [23]. However, residues detected lead to a real health problem for consumers because the analysis revealed the presence of phytosanitary products (lindane and endosulfan) in most developed countries. Endosulfan was detected in all types of vegetables analyzed, a concentration of 0.036 μg/kg in green onion, 0.024 μg/kg in fresh okra and 0.041 μg/kg in lettuce.

In 2007 conducted a study in the city of Cotonou on fertilization practices and phytosanitary treatments on leaf vegetables (*Solanum macrocarpum*) [24].

The chromatographic analyzes carried out revealed the presence of residues of organochlorine pesticides such as lindane, endosulfan, endrin, heptachlor, aldrin and dieldrin. These residues showed concentrations varying from 0.07 to 2.225 μg/g. This study conducted by Assogba-Kom Lan *et al.* showed that quantified levels are higher than the Codex standards applied for the control of food quality.

Use of obsolete products in vegetables cultivation could be explained on the one hand by the fact of fraudulent use and on the other hand by the fact that market gardeners are in the majority illiterate. They do not respect the recommended doses and most often they use inappropriate or even prohibited products on vegetables [25,26]. Market gardeners and consumers are thus exposed to serious health risks linked to pesticides, because even low exposure to these chemical pollutants can have serious consequences for the body. They can cause cancer, male infertility, spontaneous abortions or serious fetal malformations [26]. This contamination of vegetables with organochlorine pesticides (lindane and endosulfan) can also come from a runoff of water following the rains.

The average concentrations of pesticide residues detected are lower than the standards in force; however, the frequent consumption of the vegetables contaminated by pesticides with chronic effects could in the long-term pose risks for consumer.

Conclusion

Used in the peri-urban areas of Daloa to protect crops from pests, pesticides leave residues in food intended for human consumption. These residues are not without consequences for the health of the consumer.

This study is an alert to micropollutants. Indeed, on 225 samples of vegetables taken, more than half (54.22%) contain pesticide residues with concentrations sometimes higher than the maximum residue levels (MRLs).

Chromatography analysis carried out revealed the presence of banned pesticide residues belonging to the organochlorine family (lindane, endosulfan).

Daily consumption of these vegetables exposes consumers to health risks.

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