Analysis, quantification and identification of pesticides from vegetables (lettuce) in Ouagadougou, Burkina Faso

ABSTRACT

In Burkina Faso, chemical inputs are used massively in market gardening to increase yields. The misuse of these chemicals is responsible of contamination of market garden products, leading to the rapid rotting of vegetables. The objective of this study was to determine the pesticides in chemical inputs applied on vegetables produced in Ouagadougou City. To do this, some vegetables have been sampled from producers (Tanghin, Boulmiougou and Kossodo) and analyzedusing Gas Chromatography coupled with mass spectrometry (GC / MS).

Chemical analyses have carried out on three lettuce samples andthe extraction of chemical input residues was done according to QuEChERS (Quick Easy Cheap Effective Rugged and Safe) method. Results revealed the presence of six (06) pesticide molecules (chlordimeform, quintozene, lindane, cypermethrin, α-cypermethrin, δ-deltamethrin) in Boulmiougou sample, four (04) molecules (methomyl, cypermethrin, α-cypermethrin, δ-deltamethrin) in Kossodo sample and three (03) molecules (cypermethrin, α-cypermethrin, δ-deltamethrin) in Tanghin sample. In this regard, analysis of pesticide amount revealed that the quantity of molecules was acceptable for the consumer, but these pesticides could contribute to the rapid rotting of our vegetables which generates economic and social losses for the country.

Keywords: Chemical inputs, fertilizers, pesticides, rapid rot, vegetables.

1. INTRODUCTION

In Burkina Faso, agriculture is the main source of income for the poorest populations and the pillar of the country's food security. It contributes approximately 35% to GDP and the market gardening sector generates more than 125 008 194 Euros annually [1].

However, agriculture in Sub-Saharan African countries is characterized by its low productivity [2]. Indeed, this sector is threatened, in addition to poor soils, by crop pests which can cause a drop in yields of up to 50% in Burkina Faso [3]. Thus, to increase yields and satisfy growing consumer demand, in addition to the use of fertilizers, vegetable producers wage an incessant fight against insects, fungi, plant diseases, and weeds using pesticides. Market gardening is a major component of the agricultural production sector. This component generates more than eighty-two (82) billion FCFA to the Burkinabè economy annually [1].

However, in addition to poor soil conditions, this sector is faced with biotic stress caused by various pests. These pests, without pesticide treatment, were responsible for 72.5% of damage to cabbage in the towns of Ouagadougou [4, 5]. Thus, to increase yields, maintain healthy crops and satisfy increasingconsumer demand, market gardeners wage an incessant fight against insects, weeds, fungi, and plant diseases by applying the pesticides. Unfortunately, the majority of market gardeners have no level of education, hence the widespread use of pesticides without respecting good usage practices [6]. In addition, some unbalanced and excessive supplies of chemical fertilizers are applying in market gardening systems in most African countries.

In Burkina Faso, analysis of 46 samples of vegetables taken in Loumbilavillage (12°31′9″ N, 1° 22′14″W)located at 30 km from Ouagadougou city revealed the presence of pesticide residues in all sampleswith 5 samples containing pesticide doses up to the acceptable maximal values. A previous study [7] assessed the presence of pesticide residues in 240 vegetable samples collected from shopping centers in Accra region (Ghana). The general objective of this work was to contribute to the identification of pesticides resulting from chemical inputs applied in the production of vegetables (lettuce) from Ouagadougou city. Specifically, this involved the determination of the pesticide quantities in lettuce of each site.

2. MATERIALS AND METHODS

2.1. Presentation of the study area

The study took place in the city of Ouagadougou (12°45'N, 1°15'W), the capital of Burkina Faso. The city is located between 2°00 and 1°15 West Longitude and between 12°45 and 12°00 North Latitude. Thus, the sites selected are the market gardening sites of Boulmiougou, Kossodo and Tanghin. The choice of these sites was based on the fact that they are part of the main market gardening sites in the city of Ouagadougou, the intensive practice of market gardening the relatively short distance for transport and the preservation of samples [8].

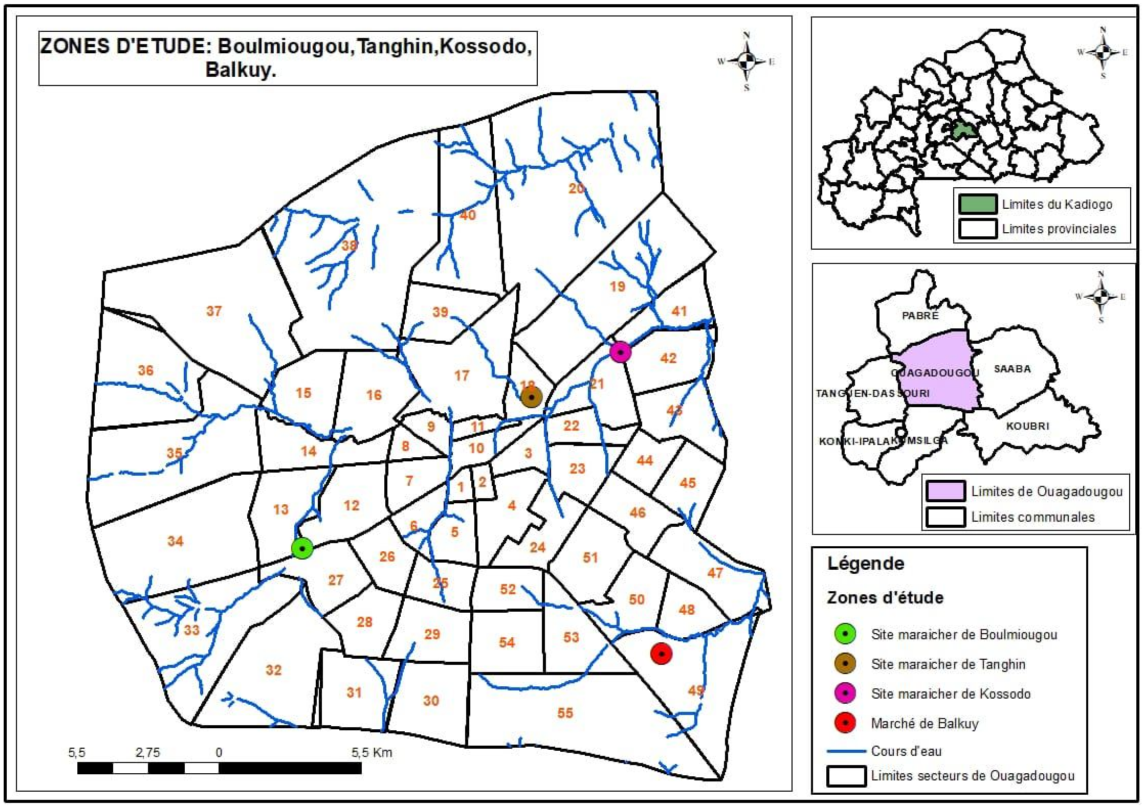


Figure 1 : Map of the study area (*IGB /BNDT 2012)*

2.2. Plant material

Lettuce (Lactuca sativa) was chosen because it is most frequently cultivated in Ouagadougou in both the dry and rainy seasons[8]. Futhermore it is one of the most consumed crops and the most sprayed with chemical pesticides and even in the spreading of fertilizers [8]. As lettuce is a leafy vegetable, chemical inputs are deposited directly on its leaves at a high dose and at a very short delay before harvest. Thus, lettuce is highly contaminated, even though it is mainly consumed in its raw state. Once rotting begins in a lettuce leaf, it is no longer edible.

Figure 2:*LactuCa sativa L. (*Lettuce)more cultivated in Burkina Faso

2. 3. Sampling

Sampling was done on three (03) market gardening sites with the aim of bringing the plant material which is lettuce to the laboratory for chemical analyses. Samples were taken on the morning of March 20th, 2020 from three (03) sites and stored in a cool place at National Public Health Agency. Samples are taken and packaged in blue plastic bags. After coding, samples are taken to the laboratory where they are preserved in the freezer. A sampling sheet containing all the information relating to the collection conditions was attached to the three samples.

2.4.Analysis of pesticide residues

The analysis wascarried out by Gas Chromatography coupled with mass spectrometry (GC/MS). The type of extraction wasthat ofpolyvalent methodNF EN 15662 -QuEChERS[9]which is used especially for fruits and vegetables with a water content greater than 80%. The protocol consists of three essential steps: sample preparation, pesticide extraction and analysis.

2.4.1. Sample preparation

The 16-Acetone decontaminatedof 16 50 mLbottles were distributed as follows: 4 extraction bottles, 4 purification bottles, 4 test sample bottles and 4 bottles for the analytical portion.

Extraction kit: 4 numbered bottles containing 4 g of magnesium sulfate ($MgSO_4$), 1 g of sodium chloride (NaCl), 1 g of trisodium citrate dihydrate, 0.5 g of sodium citrate dibasic sesquihydrate.

Purification Kit: 4 bottles containing: 0.15 g Primary and Secondary Amine (PSA), 0.9 g $MgSO_4$. Acetone decontamination of the lettuce shredder as before.

Crushing lettuce: 500 g of frozen lettuce is cut into small pieces and put in a crushing device. Each time a new sample is crushed, the device is decontaminated. Test portion of 5 g of crushed lettuce was taken in a 50 ml bottle for analysis.

2.4.2. Extraction

The extraction is composed of several steps:

Analytical portion of Boulmiougou: Take 5g of crushed lettuce + 10mLAcetonitrile + 1 extraction kit, all in a bottle. Mix everything together with a vortex mixer for one minute;

Centrifugation: Centrifuge the mixture at 3500 rpmfor one minute. Organic moleculeswill be present at the pellet at the supernatant contains inorganic molecules;

Purification: Take 6ml of the supernatant + a purification kit. Mix with a vortex mixer for one minute;

Centrifugation: Centrifuge the mixture at 3500 rpm for one minute. Take 500 microliters of the supernatant and put it in a vial for analysis.

2.4.3. Sample analysis

The analysis of 500 microliters of the supernatant is done by Gas Phase Chromatography coupled with a Mass Spectrometer (GC/MS) connected to a computer with software. The result came out in the form of a chromatograph and a table.

Figure 3: Equipment of Gas Phase Chromatography

The quantity of pesticide residues (Re) expressed in mg/g was calculated using the following relation.

$$\mathbf{Re} = \mathbf{C}_x \frac{V}{v} \quad (1)$$

V: extraction volume (0.01 L),

v: volume of test portion (5 mL) with volumic mass equal 1 g/mL, it corresponds to 5 g.

C_X = Concentration of the compound given by chromatography (mg/L)

3. RESULTS AND DISCUSSION

3.1. Chemical composition of pesticide residue molecules

To counter the actions of pests, different control methods are implemented, the most common of which is the application of phytosanitary products. Three samples of lettuce in each sampling site were analyzed, including one sample per site. The various results reveal that all the samples are contaminated by more than fifty molecules, the main ones of which are presented in Table 1 according to the different sites.

Pesticides applied to crops mainly belong to 4 large chemical families: Carbamates, organochlorines, chlorophenyls and pyrethroids. The active ingredients of pyrethroids are the most frequently found present in all samples. The concentrations of pesticide residues found are lower than those established by Codex, therefore they are legally acceptable. Results obtained from the chemical analyzes of the lettuce sample are given in Table 1.

Table 1: Characteristics of Lettuce in 3 sampled sites.

Name of pesticide	Chemical formula	Chemical family	Quantity of pesticide (mg/g)		
			Tanghin	Kossodo	Boulmiougou
Methomyl	$C_5H_{10}N_20_2S$	Carbamate	1.02	0.98	-
Chlordimeform	$C_{10}H_{13}ClN_2$	organochlorine	0	0	2.42
Quintozene	$C_6Cl_5NO_2$	Chlorophenyl	0	0	0.56
Lindane	$C_6H_6Cl_6$	Organochlorine	0	0	0.94
Cypermetrine	$C_{22}H_{19}Cl_2NO_3$	Pyrethrinoids	0.82	0.82	0.88
α-Cypermetrine	$C_{22}H_{19}Cl_2NO_3$	Pyrethrinoids	0.84	0.84	0.78
δ-Deltamethrine	$C_{22}H_{19}Br_2NO_3$	Pyrethrinoids	0	0.84	0.84

(-): not found

The highest quantities of residues are those of the Chlordimeform molecule (2.42) from the organochlorine family followed by the methomyl molecule (1.02) from the carbamate family. The use of pesticides from the organochlorine family is prohibited according to international texts. The pyrethroid family is the most numerous (Cypermetrine, alpha Cypermetrine, and Deltamethrin).

The pesticide inventory revealed twenty-seven (27) trade names of pesticides used by market gardeners, including a biopesticide. According to the classification of Sahelian Pesticide Committee, the most used pesticides are insecticides (70.37%) because insects are increasingly resistant to insecticides and cause more destruction. This result corroborates the previous study that reported 27 trade names of pesticides on market gardening sites and the most used are insecticides.

For the fight against pests, results of our surveys revealed that 98.75% of vegetable producers used chemical pesticides. This result is contrary to the conclusion of Diogo*et al.* [10] from Benin where all the producers surveyed use organic pesticides that they prepare themselves. It is a mixture of neem leaves and certain spices including garlic.

Chemical analyzes of lettuce samples revealed three (03) chemical families of insecticides (organochlorines, carbamates and pyrethroids)and one family of fungicides (chlorophyll). This result corroborates to that found by Diop[7] from Senegal who found in lettuce: the quantity of organophosphates is greater than that of pyrethroids, which are also greater than those of organochlorines, which are also greater than carbamates.

3.2. Identification of chemical molecules in pesticides

After the analyses, seven (07) molecules of pesticide residues were found, distributed as follows: six (06) in Boulmiougou, four (04) in Kossodo and three (03) in Tanghin. Figure 4 gives us the summary of the chemical analyses. Higher dose of Chlordimeform was obtained in Boulmiougou lettuce.

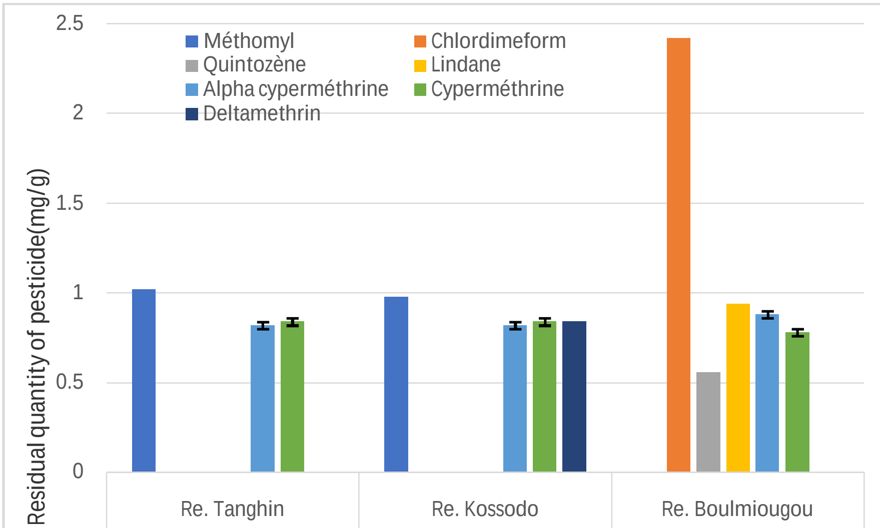


Figure 4: Residual quantity of pesticides molecules in different sites.

From chemical analysis, six insecticides and one fungicide have been observed and classified as well:

One molecule from the carbamate family (Methomyl) which are insecticides derived from carbamic acid. According to Tarnagdaet al. [11], the half-life of carbamates is estimated between 10 to 20 days. Its concentration is highest in Tanghin, followed by that of Kossodo.

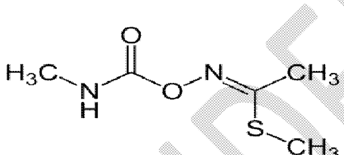
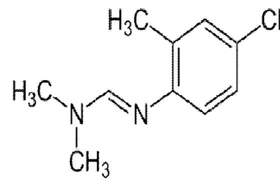
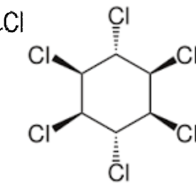


Figure 5: Chemical formula of Méthomyl($C_5H_{10}N_2O_2S$)

Two organochlorine molecules (Chlordimeform and Lindane) which are insecticides composed of carbon, hydrogen and chlorine atoms. They are also called chlorinated hydrocarbons, chlorinated organic products. They are still called Persistent Organic Pollutants where their half-life varies between 28 days to 12.8 years in vegetables [11]. Their concentrations are the highest compared to the others and found only in the Boulmiougou sample.

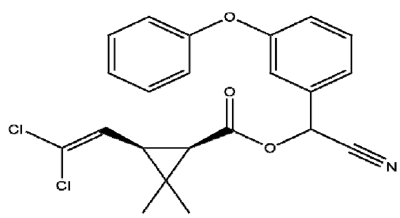


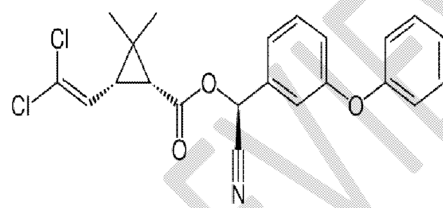


Chlordimeform ($C_{10}H_{13}ClN_2$) Lindane (C_6Cl_6)

Figure 6: Chemical formulas of chlordimeform and lindane

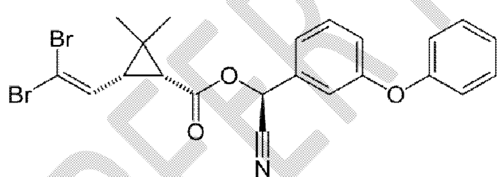
Three molecules of the pyrethroid family (cypermethrin, α-cypermethrin and δ-deltamethrin) are synthetic insecticides and derivatives of pyrethrins. Their half-life is estimated at 5 to 7 days [11]. They are the most numerous and their concentration is approximately the same in the three samples.





Cypermethrine ($C_{22}H_{19}Cl_2NO_3$) α-cypermethrine ($C_{22}H_{19}Cl_2NO_3$)

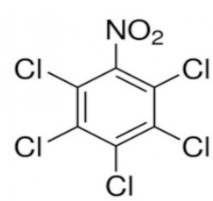
Figure 7: Chemical formulas of cypermethrine and α-cypermethrine



δ-Deltamethrine ($C_{12}H_{19}Br_2NO_3$)

Figure 8: chemical formula of δ-methrine

One molecule from the chlorophenyl family (Quintozene) which is part of fungicides. This is the lowest concentration and is present in the Boulmiougou sample only. The use of all pest control products containing quintozene in vegetable crops is not accepted by Sahelian Pesticide Committee. But this pesticide enters in the country through Ghana and Nigeria using the fraud and nacrotransfers men. These reasons concern exposure in the workplace, and through diet, persistence in the environment, bioaccumulation, etc.



Quintozene ($C_6Cl_5NO_2$)

Figure 9: Chemical formula of quintozene

The classification of pesticide quantity was given as follow: the highest quantity of residues are organochlorines, followed by carbamates, then pyrethroids and finally chlorophenyls.

4. CONCLUSION

Chemical analyzes revealed several active ingredients belonging to the family of organochlorines, pyrethroids, carbamates and chlorophenyls. The use of chemical inputs in market gardening, in addition to fertilizers to increase yields, pesticides to protect crops against pests remains a major issue in West Africa, particularly in Burkina Faso. Indeed, the fraud and porous borders contributes the expansion of prohibited and unapproved pesticides.

Thus, seven (07) pesticide residues were found and divided into four (04) major chemical families. These are three (03) families of insecticides and one (01) family of fungicides. For insecticides, the presence of carbamates (mythomyl), organochlorines (Chlordimeform and Lindane) and Pyretrinoids (Cypermetrine, α-Cypermetrine, and δ-deltametrine) is noted. Regarding fungicides, only the chlorophenyl (quintozene) family was present.

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