*Original Research Article*

# Pesticides and Biopesticides Use in Market Gardening in Ouagadouou (Burkina Faso)


## ABSTRACT

This study aims to identify the pesticides and biopesticides used in market gardening in the outskirts of Ouagadougou in order to raise awareness among producers and populations. A semi-structured survey was conducted among 96 market gardeners on the use of pesticides and biopesticides in market garden production. Descriptive analysis was performed using GraphPad Prism 6 software. GC/MS analysis was performed to search for pesticide residues on the two most widely grown vegetables according to the survey results. The chemical compounds were studied using the WILLEY-CH 1992, NIST∗∗2004 and PEST database libraries. According to this study, men represent 54.17% and women 45.83% of market gardening activity. The main crops encountered in the sites were lettuce (17%), cabbage (15%), eggplant (12%), onion (11%) and tomato (10%). Twenty-eight (28) pesticides were identified; two (2) were very dangerous, of which 18 were moderately dangerous, seven less dangerous and one product not classified according to the WHO classification. Nine (09) families of pesticides have been identified; the most important was pyrethroid (30%). More than half of market gardeners do not respect the dose prescribed (57%) on the labels. A large number of market gardeners (70%) respects the persistence time. The results also indicate eight biopesticide formulations and two complex formulations identified. No hazardous pesticides were detected in the two most widely grown vegetables, lettuce and cabbage.
Market gardening on the outskirts of cities requires constant monitoring and supervision to reduce health and environmental risks.



*Keywords: Survey, market gardening, pesticides, biopesticides, GC-MS analysis, Burkina Faso*


## 1. INTRODUCTION

Market gardening in Burkina Faso is becoming increasingly important[1] and occupies men and women, especially in the outskirts of large cities. The vegetables produced are sources of income and food for producers [2,3] and households in Burkina Faso [4]. The main crops grown are cabbage, eggplant, onion, lettuce, tomato, okra, carrot, cucumber, pepper, etc. These vegetables comprise short and long-cycle speculations and are rich in vitamins, proteins, mineral salts, and other constituents that contribute to nutritional balance and improved health. For example, vegetables like lettuce cure insomnia [5], and cabbage can help to reduce the risk of several diseases, such as cancer and degenerative diseases

[6].These vegetables offer a balanced diet and participate in population's well-being and food security. Market gardening in the outskirts of large cities such as Ouagadougou is practiced on several plots throughout the year and concerns in the most cases vulnerable groups.
Unfortunately, the majority of producers use synthetic pesticides [7] and sometimes complex mixtures of products to overcome pests, weeds, and vegetable diseases [8,9]. Some work on pesticides use in market gardening revealed some unauthorized use of pesticides on vegetable crops [10] and draws attention to the risk of environmental contamination [7]. Also, producers being less aware of the use of these products, sometimes ignore or do not control the persistence time of the products used on vegetables, which could leave pesticide residues on the final product to be consumed. In addition, we are witnessing the repeated treatment of crops pesticides. From then on, we immediately understand the danger represented by repeated pesticide treatments and the use of these chemical substances which could influence the resistance of pests and negatively affect the health of farmers. However, In Burkina Faso, the management of pesticides in agriculture is regulated by a law on quality control, use and compliance with labeling standards [11]. But the control measures on the sites of use (in the fields and the market gardening sites) are not put in place. This therefore leads growers to the use of pesticides according to their understanding. Moreover, today some producers are trying to integrate the use of biopesticides into their production to satisfy a certain number of more rigorous customers [12].
The objective of this study is to identify the pesticides and biopesticides used in market gardening in Ouagadougou outskirts and their presence in post-harvest products. These findings will improve the knowledge on the gardening practices and the pesticides uses in Burkina Faso.

## 2. MATERIAL AND METHODS

### 2.1.Field Investigation

This study was conducted from November 2021 to July 2022 in Ouagadougou outskirts (Kamboinsé and Boulmiougou) (Fig.1). Ninety-six (96) market gardeners were randomly selected across its two sites. The choice of market gardeners was made with the criteria of having a minimum of 500 m2, having at least five years of experience in the field, and consenting to the questionnaires. A total of 96 market gardeners were eligible for the survey. A sowing a semi-directive questionnaire was used.
A descriptive analysis was carried out with the GraphPad Prism 6 software by calculating the means and frequencies and drawing the graphs.

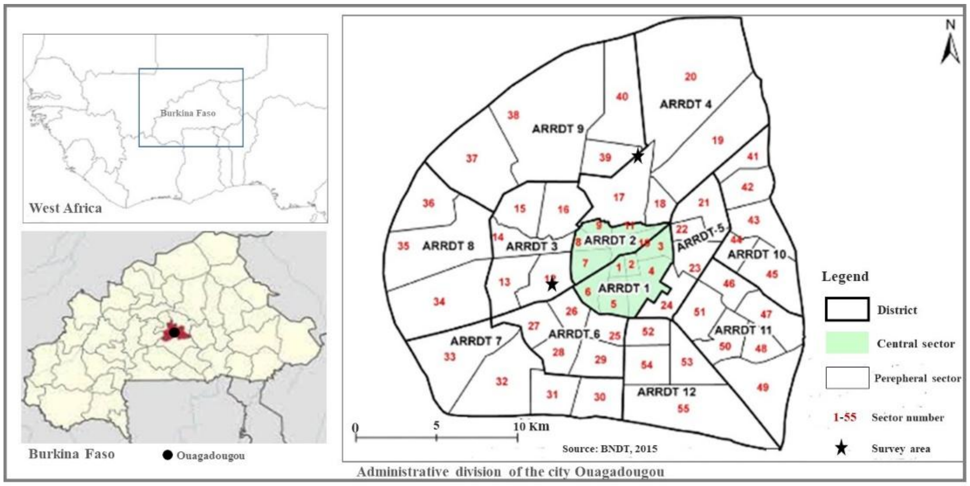


**Fig. 1. Survey area**

## 2.2Sample Preparation and Residues Analysis

The leaf samples of the first two most cited vegetables in market gardening; lettuce and cabbage were collected for GC/MC analysis. In total 20 samples, including 10 cabbage plants and 10 lettuce plants were taken only in the market garden fields of Kamboinsé and Boulmiougou. The samples were prepared by the QuEChers method for residue analysis using 5 g of sample from the mixture of each provenance and acetonitrile (10 mL), all mixed with the kit of chemical reagents composed of sulfate of magnesium anhydride sodium chloride, trisodium citrate dihydrate and sodium citrate dibasic sesquihydrate for extraction. In addition, the purification phase used MgSO4 from PSA (primary and secondary amine). 1 µL of the extract was injected at the level of the mass. Identification of chemical compounds was carried out using WILLEY-CH 1992, NIST∗∗2004) PEST database libraries.

## 3. RESULTS

### 3.1 Market gardener's socio-demographic characteristics

In this study men represented 54.17% and women 45.83% of the respondents (Table 1). The ages of the respondents ranged from 18 to 68 years old. People out of school represented 55.21%, while the rate of people in school was 44.79%. Market gardeners aged more or less than 10 years represented 50% of those questioned.

**Table 1. Distribution of market gardeners by age, gender and educational status (n = 96)**

| Age | Women (%) | Male (%) | Educated (%) | Uneducated (%) | Number of years of experience | |
|---|---|---|---|---|---|---|
| | | | | | <10 years (%) | >10 years (%) |
| 18-28 | 6.2 | 8.33 | 10.42 | 4.17 | 14.58 | 0 |
| 28-38 | 6.25 | 9.38 | 8.33 | 7.29 | 9.37 | 6.25 |
| 38-48 | 8.33 | 10.42 | 8.33 | 10.42 | 5.30 | 13.54 |
| 48-58 | 15.63 | 19.79 | 13.54 | 21.88 | 14.58 | 20.83 |
| 58-68 | 9.37 | 6.25 | 4.17 | 11.45 | 6.25 | 9.37 |
| Total | 45.83 | 54.17 | 44.79 | 55.21 | 50 | 50 |

## 3.2 Main vegetable crops grown

In the urban and peri-urban areas of Ouagadougou several market garden crops were identified and these varied according to the seasons and market demand. However, at the time of our study, the main crops were lettuce (17%), cabbage (15%), eggplant (12%), onion (11%), and tomato (10%), etc. (Fig. 2a).

## 3.3 Pesticides identified

The pesticides recorded during this study in the market garden perimeters are indicated in Table 1. Among the pesticides used in gardens, 4 (four) categories of pesticides have been identified according to the WHO classification[13]: 2 class Ib pesticides (very dangerous), 18 class II pesticides (moderately dangerous), 7 class III pesticides (less dangerous), and 1 unclassified product. Of the 28 products listed, 20 were approved by the Sahelian pesticide council[14,15,16] while CSP did not approve 8.

The most cited pesticides were Emacot 050 WG (57.29%), followed by Lambda super 2.5 EC (52.06%), and Emir Fort 104 EC (41.66%), etc.

There were 10 chemical products (Attackan C 344 SE, Caïman B19, Capt 88 Ec, Emacot 050 WG, Emaron, Emir Fort 104 EC, Hitcel 440 EC, Ibis A 52 Ec; Pichen 440 EC ; Thalis A56 EC ) intended solely for the cotton plant which is used to treat vegetable pests.

Nine families of pesticides have been recorded (Fig 2b), the most important of which are those of Pyrethroid (30%) followed by Neonicotinoid (19%), avermectin (14%), and organophosphate (14%).

## 3.4 Complex formulation

Complex formulations have been recorded, and this concerned 1.04% of the surveyed population who used these complex mixtures to treat fungi and other pests that attacked the leaf and fruit of okra (Table 2).

**Table 2. Other formulations in garden market practice**

| Mixture | Vegetabletreated | Parasites | Frequency of citation (%) |
|---|---|---|---|
| 1. Lambda super 2.5 EC + macerated neem seeds | *Abelmoschus esculentus* (L.) Moench (Okra) | Parasite (fungus) | 1.04 |
| 2. Karaté + Soap | *Abelmoschus esculentus* (L.) Moench (Okra) | Parasite (fungus) | 1.04 |

### 3.5Formulation of natural biopesticides

Biopesticide formulations were developed by market gardeners to sometimes treat certain vegetables attacked by pests (Table 4). This investigation identified 8 formulations composed of a mixture of 5 local plants. These were Azadirachta indica A.Juss., Allium cepa L., Carica papaya L., Allium sativum L. , and Capsicum annuum L. The most cited formulation was the mixture of Azadirachta indica and ash (7%).
Four (4) plant organs including leaves, fruits, seeds and bulbs were used to prepare pesticide mixtures (Table 5). Leaves comprised 31% of recipes and bulbs and fruits shared 25% while seeds comprised 19% (Fig. 2d). The main ingredients consisted of neem organs and Carica papaya L. leaves.
Ingredients such as ash and soap were also involved in formulating biopesticides. Thus, ash was cited 1 time in the listed formulations, while soap was cited 7 times.

### 3.6 Analysis of phytosanitary practices

The analysis of phytosanitary practices showed that more than half of the respondents (57%) did not respect the doses prescribed on the labels (Fig. 2c). Almost all of the market gardeners interviewed (95%) did not wear overalls when using pesticides. Most market gardeners (75%) respected the perseverance time. Pesticides were used on the sites by sprinkling or manual spraying. Most respondents used both types of methods. Watering was done using a bucket of pesticide mixture in which tree branches, brooms and brushes were dipped to spray the plants. For powders, use was done by hand without protective equipment. Manual spraying was carried out using the bottle lids as a measuring tool. The dosage was done approximately without respecting the standards indicated on the bottle label. After using the products, the packaging was left on the cultivation sites.

**Table 3. Pesticides identified in market gardening sites in Ouagadougou and surroundings**

| Commercial specialties | Principle active | Chemical family | Recommended areas of use | Type | Citation frequency (%) | Approval by CSP | WHO class |
|---|---|---|---|---|---|---|---|
| 1. Attackan C 344 SE | Imidacloprid, cypermethrins | Neonicotinoid + Pyrethroid | Cotton | Insecticides | 10.41 | Yes | II |
| 2. Attack 5%WDG | Emamectin Benzoate (5%) | Avermectin | market gardening | Insecticide | 10.41 | No | II |
| 3. Biok 16 | Bacillus thuringiensis 16 000 UI/mg | Bacillus thuringiensis bacteria and their insecticidal proteins | market gardening | Insecticide | 1.04 | Yes | U |
| 4. BOMEC 18 EC | Abamectin 18 g / L | Avermectins | market gardening | Insecticides, Acaricide | 5.21 | Yes | II |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5. Caïman B19 | Emamectin benzoate (19,2 g/l) | Abamectin | Cotton | Insecticide | 31.25 | Yes | II |
| 6. Capt 88 EC | Acetamiprid 16g +cypermethrin72gg/L | Neonicotinoid + Pyrethroid | Cotton | insecticide | 20.83 | Yes | II |
| 7. Cypercal 50 EC | Cypermethrin | Pyrethroid | Vegetable and cerealcrops | Insecticide | 20.83 | Yes | III |
| 8. Dursban 450 ULV | Chlorpyriphos-éthyl, 450 g/L ( | Organophosphates | Arachide | insecticide | 10.41 | Yes | II |
| 9. Decis 25 EC | Deltamethrin, 25g/L | Pyrethroid | Tomato | Insecticide | 15.625 | Yes | II |
| 10. Decis forte 100 EC | Deltamethrin, 100g/L | Pyrethroid | Tomato | Insecticide | 20.83 | Yes | II |
| 11. Emacot 050 WG | Emamectin benzoate 50g/kg | Avermectin | Cotton | Insecticide | 57.29 | Yes | II |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12. Emaron | Emamectin benzoate (20g/L) Lufenuron (80g/L) | Avermectin+Benzoylurea | Cotton | Insecticide | 31.25 | Yes | III |
| 13. Emir Fort 104 EC | Acetamiprid 32g/L + Cypermethrin 72g/L | Neonicotinoid + Pyrethroid | Cotton | Insecticide | 41.66 | Yes | II |
| 14.Furadan | Carbofuran 50 g/Kg | Carbamate | Vegetables, cereals, cotton | Insecticide | 10.41 | No | Ib |
| 15. Hitcel 440 EC | Cypermethrin 40g/L + Profenofos 400g/L | Pyrethroid + Organophosphates | Cotton | Insecticide | 15.625 | Yes | II |
| 16.Ibis A 52 EC | Alpha-cypermethrin 36 g/l + Acetamiprid 16 g/l | Pyrethroid + Neonicotinoid | Cotton | Insecticide | 5.21 | No | II |
| 17. Kapaas 80EC | Emamectin benzoate +abamectin+acetamiprid | Avermectin +Neonicotinoid | Cotton, market gardening | Insecticide | 5.21 | No | _ |
| 18. Karaté | Lambda-Cyhalothrin | Pyrethroid | Any culture | Insecticide | 3.125 | No | III |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 19.Lambda power | Lambda –cythalothrin 0.5% + Dimethoate 20% EC | Pyrethroid + Organophosphate | Vegetable crops, rice, cotton, cowpea, groundnut | Insecticide | 31.25 | No | II |
| 20.Lambda super 2.5 EC | Lambda-cythalothrin (25g/L) | Pyrethroid | Vegetable crops, cotton, cereals, and legumes | Insecticide | 54.16 | No | III |
| 21.Mancozeb | ethylene di-isothiocyanate | Carbamate | Vegetable, fruit, cotton, and cereal crops | Insecticide | 31.25 | Yes | III |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 22.Manga plus | Mancozeb (800 g/kg) | Dithiocarbamate | Vegetable crops, cereals and fruit | Insecticide | 28.125 | Yes | III |
| 23.Pacha 25EC | Acetamiprid 10g/L+Lambda-cythalothrin 15g/L | Neonicotinoid + Pyrethroid | Vegetable and fruit crops | Insecticide | 7.29 | Yes | III |
| 24. Pichen440EC | Profenofos 400g/L+ Cypermethrin40 g/L, EC | Organophosphates + Pyrethroid | Cotton | Insecticide | 22.91 | Yes | II |
| 25.Thalis A 56 EC | Acetamiprid (32g/l) + Emamectin benzoate 24 g/l | Avermectin + Neonicotinoid | Cotton | Insecticide | 5.21 | Yes | II |
| 26.Savahaler | Methomyl 250g/kg WP | Carbamate | cabbage | Insecticide | 31.25 | Yes | II |
| 27.Sniper 1000EC | DDVP80% EC | Organophosphate | Market gardening, fruit, rice, cotton, etc. | Insecticide | 8.33 | No | Ib |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 28.Titan 25 EC | Acetamiprid 25g/l | Neonicotinoid | Vegetable and fruit crops | Insecticide | 6.25 | Yes | II |

*Legend: Ib: Very dangerous; II: Moderately dangerous; III: Not very dangerous; U: Unlikely to present an acute hazard.*

**Table 4. Formulation of natural biopesticides (n=96)**

| **Species** | **Main Organ/ Quantity** | **Secondary ingredient and quantity** | | | | | | **Preparation** | **Active compound** | **Mode of use** | **Frequency of Citation (%)** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | On | Ga | Pe | So | Wt | Ash | | | | |
| *Azadirachta indica*(A.) Juss | Leaf/2kg | - | - | - | 5g | 10L | - | Ma+24h | Azadirachtin | Spreading | 3.125 |
| | Leaf/2kg | | | 2g | 5g | 10L | - | Ma+24h | Azadirachtin | Spreading | 1.04 |
| | Leaf/2kg | | 1clove | 2g | 5g | 10L | - | Ma+24h | Azadirachtin Capsaicin allicin, alliin | Spreading | 1.04 |
| | Leaf/2kg | | 1 clove | 2g | 5g | 10L | - | Ma+24h | Azadirachtin Capsaicin allicin, alliin | Spreading | 1.04 |
| | Seed/200g | - | - | - | - | 10L | 10g | Ma+24h | Azadirachtin | Spreading | 7 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Seed/500g | 2 bulbs | 2 cloves | 2g | 5g | 10L | Ma+2 weeks | Azadirachtin | Spreading | 3.125 |
| | Seed oil/125 mL | - | - | - | 2g | 10L | Mixture | Azadirachtin | Spreading | 1.04 |
| ***Carica papaya*** | Leaf/500g | - | - | - | 5g | 10L | Ma | Papain | Spreading | 4.16 |

**Legend:** As: Ash; Ga : Garlic ; Ma +24 h: Maceration and then left to stand for 24 hours; Ma+ 2 weeks: Maceration and then left to stand for 2 weeks; Mo: Main organ; On : Onion ; Pe : Pepper; Pt : Preparation ; So: Soap; Wt : Water.

**Table 5. Plants species and their organs using as bioinsecticides**

| Species | Vernacular names | Family | organ used |
|---|---|---|---|
| Allium cepa L. | M : Djabá<br>E: Onion | Liliaceae | Bulbls |
| *Azadirachta indica*(A.) Juss | M : Nim<br>E: Neem | Meliaceae | Leaves, seeds |
| *Allium sativum* L. | M: Lyele<br>E: Garlic | Liliaceae | Bulbs |
| *Capsicum annuum* L. | M : Kiparé<br>E : Pepper | Solanaceae | Powder of driedfruits |

| | | | |
|---|---|---|---|
| *Carica papaya* L. | M : Papay tiiga<br>E : Pawpaw | Caricaceae | Leaves |

*Legend:* *M:* *Mooré,* *E:* *English*

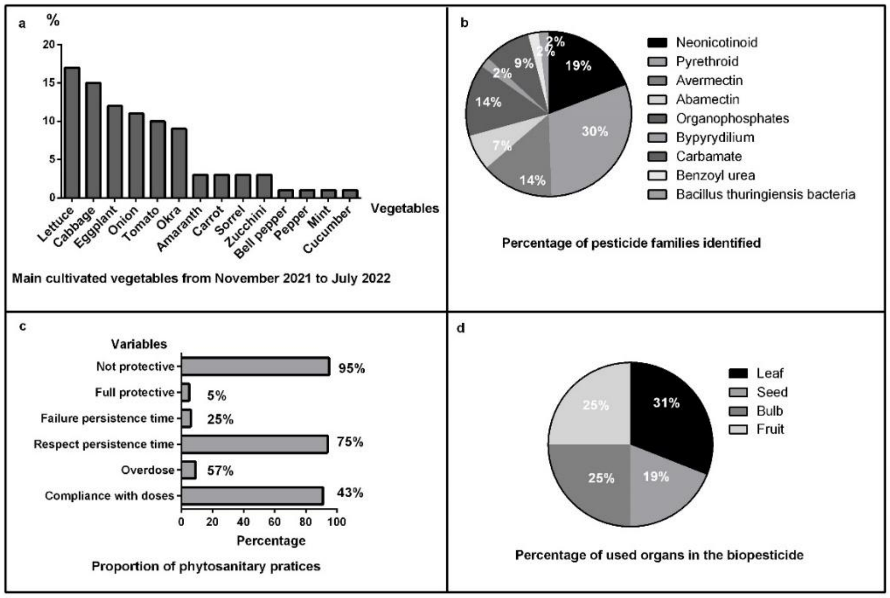


**Fig. 2. Pesticides use by market gardeners and phytosanitary practices**

## 3.7 GC/MS screening

The results of research on pesticides for the most cultivated vegetables are mentioned in chromatograms 1 and 2 (Figures 3 and 4). Indeed, the search for chemical compounds in lettuce indicated 100 compound peaks, among which 21 compounds were identified (Table 6). GC/MS screening of cabbage showed 92 peaks, among which the most abundantly identified were 19 (Table 7).

Regarding the main peaks in lettuce (Lactuca sativa L.) 9 groups were identified including the hydrocarbon group (Heptadecane, 8-methyl-, Tetratetracontane, Pentadecane, Heneicosane, Hexadecane, 10-Methylnonadecane, Heptadecane, Triacontane, Pentacosane, Heptacosane , Octacosane, Hexacosane; phenol (phenol, 2,5-bis (1,1-dimethylethyl)); cyclic ethers (dichloroacetic acid, tridecyl ester); organoiodides (tridecane, 1-iodo-); organooxygen compounds (dichloroacetic acid, sulfurous, butyl dodecyl ester); epoxide (oxirane, hexadecyl-); fatty amide (octadecenamide, (z)-); esters (carbonic acid, isobutyl dodecyl ester); phytosterol (beta. -sisterol) and triterpenoids (A'-Neogammacer-22(29)-en -3-ol, acetate, (3.beta., 21.beta.).

According to the range of compounds the most dominant compounds identified in lettuce were octadecenamide, (z)-(4.60%), A'-Neogammacer-22(29)-en-3-ol, acetate, ( 3.beta.,21 beta)-(2.79%) and heptadecane,8-methyl-(2.72%).

GC/MS research on cabbage (Brassica oleracea L.) allowed us to determine 5 groups: fatty acids (organooxygen compounds); fatty and conjugated acids (nonahexacontanoic acid); hydrocarbons (heneicosane, heptadecane, octadecane, dodecane, nonadecane, Tetratriacontane, Eicosane, Tetratetracontane, Cyclododecane, Octacosane, Pentacosane, Heptacosane, Hexacosane, Pentadecane, 2,6,10-trimethyl-); phenol (Phenol, 2,4-bis (1,1-dimethylethyl)) and fatty amides (Hexadecanamide, Octadecanamide).

The most abundant compounds by distribution area in cabbage were hexadecanamide (7.80%), octadecanamide (6.05%), and dodecane (4.75%).

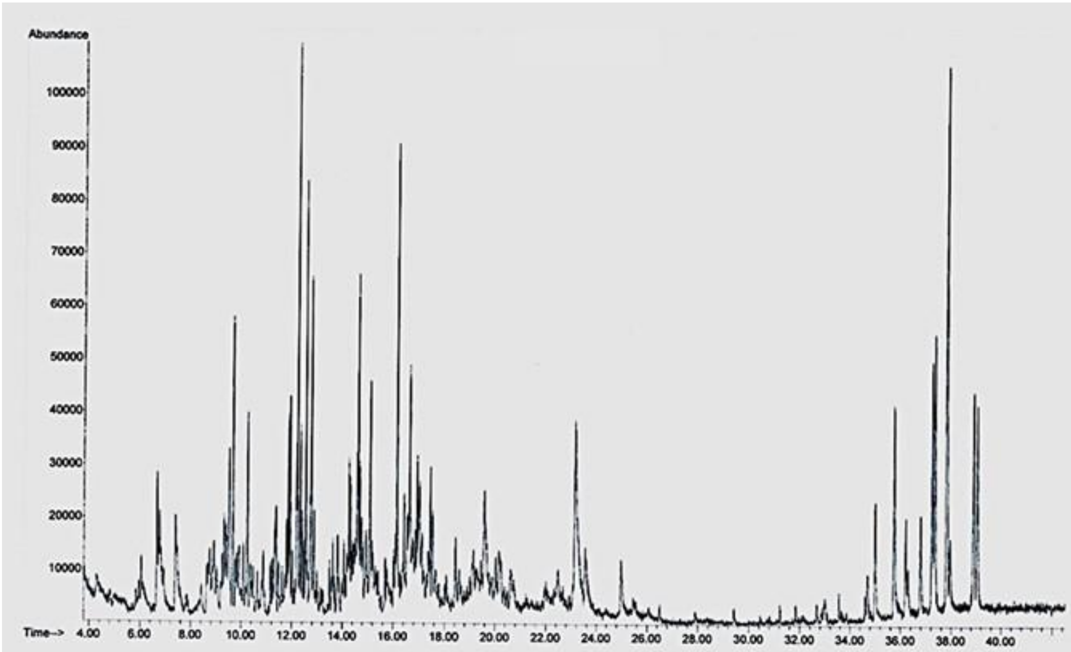


**Fig. 3. TIC chromatogram of total chemical compounds of lettuce samples**

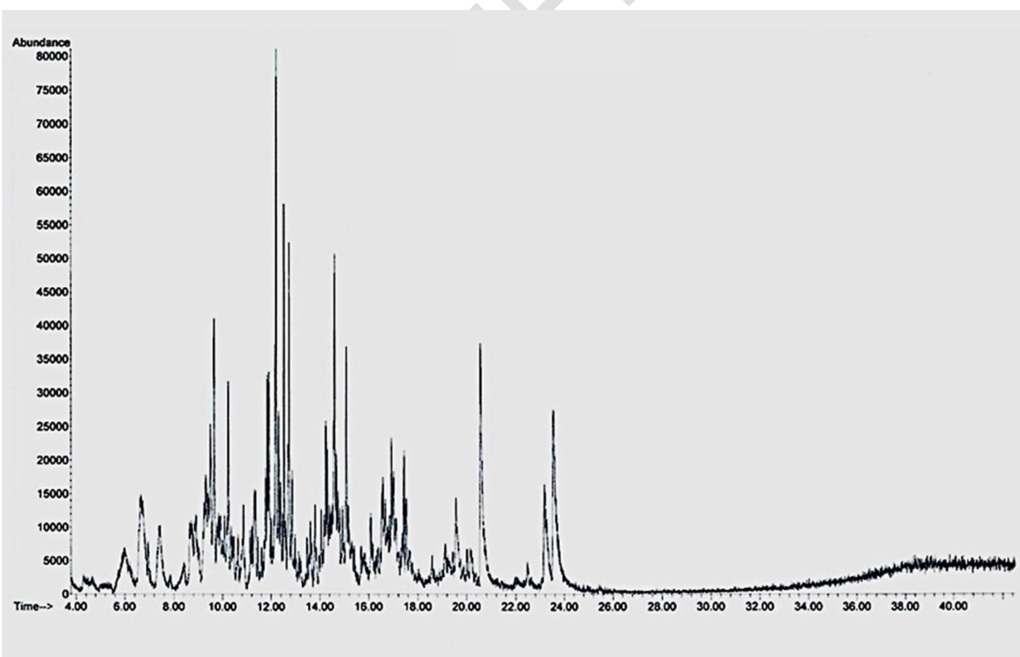


**Fig. 4. TIC chromatogram of total chemical compounds of cabbage samples**

**Table 6. The main peaks of the compound in the Lettuce sample**

| Number | Peak number | Retention time | Area% | Library/ID | Molecular formula | Molecularweight (g/mol) | Nature of compound | CAS | Qual |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 17 | 9.654 | 2.72 | Heptadecane,8-methyl- | $C_{18}H_{38}$ | 254.5 | Branched alkane | 013287-23-5 | 83 |
| 2 | 29 | 11.223 | 0.39 | Tetratetracontane | $C_{44}H_{90}$ | 619.2 | Acyclic alkane | 007098-22-8 | 90 |
| 3 | 30 | 11.315 | 0.87 | Pentadecane | $C_{15}H_{32}$ | 212.41 | Acyclic alkane | 000629-62-9 | 90 |
| 4 | 31 | 11.362 | 0.81 | Heneicosane | $C_{21}H_{44}$ | 296.57 | Acyclic alkane | 000629-94-7 | 86 |
| 5 | 35 | 11.910 | 1.85 | Hexadecane | $C_{16}H_{34}$ | 226.44 | Acyclic alkane | 000544-76-3 | 90 |
| 6 | 36 | 12.002 | 0.35 | 10-Methylnonadecane | $C_{20}H_{42}$ | 282.5 | Branched alkane | 056862-62-5 | 90 |
| 7 | 39 | 12.313 | 1.17 | Heptadecane | $C_{17}H_{36}$ | 240.471 | Acyclic alkane | 000629-78-7 | 90 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 8 | 42 | 12.527 | 2.35 | Phenol, 2,5-bis (1,1-dimethyethyl) | $C_{14}H_{22}O$ | 206.3239 | Diphenylmethanes | 005875-45-6 | 95 |
| 9 | 46 | 13.479 | 0.29 | Dichloroacetic acid, tridecylester | $C_{15}H_{28}Cl_2O_2$ | 311.3 | Alpha-halocarboxylic acids and derivatives | 1000280-48-3 | 87 |
| 10 | 55 | 14.575 | 0.71 | Triacontane | $C_{30}H_{62}$ | 422.8 | Acyclic alkane | 000638-68-6 | 90 |
| 11 | 57 | 14.673 | 0.54 | Pentacosane | $C_{25}H_{52}$ | 352.7 | Acyclic alkane | 000629-99-2 | 90 |
| 12 | 58 | 14.748 | 0.33 | Heptacosane | $C_{27}H_{56}$ | 380.7 | Acyclic alkane | 000593-49-7 | 87 |
| 13 | 59 | 14.921 | 0.52 | Octacosane | $C_{28}H_{58}$ | 394.8 | Acyclic alkane | 000630-02-4 | 87 |
| 14 | 60 | 15.088 | 1.95 | Tridecane, 1-iodo- | $C_{13}H_{27}I$ | 310.26 | Organoiodides | 035599-77-0 | 86 |
| 15 | 69 | 16.571 | 0.46 | Sulfurous acid, butyl | $C_{16}H_{34}O_3S$ | 306.5 | Organooxygen | 1000309- | 91 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | dodecyl ester | | | compounds | 17-9 | |
| 16 | 75 | 17.431 | 0.92 | Hexacosane | $C_{26}H_{54}$ | 366.71 | Acyclic alkane | 000630-01-3 | 83 |
| 17 | 78 | 18.411 | 0.82 | Oxirane, hexadecyl- | $C_{18}H_{36}O$ | 268.5 | Epoxide | 007390-81-0 | 83 |
| 18 | 86 | 23.136 | 4.60 | Octadecenamide, (z)- | $C_{18}H_{35}NO$ | 281.5 | Carboximidic acids | 000301-02-0 | 91 |
| 19 | 88 | 24.970 | 0.89 | Carbonic acid, dodecyl isobutyl ester | $C_{17}H_{34}O_3$ | 286.4 | Ester | 1000314-60-9 | 83 |
| 20 | 90 | 34.991 | 1.66 | Beta.-Sisterol | $C_{29}H_{50}O$ | 414.71 | phytosterol | 000083-46-5 | 93 |
| 21 | 99 | 38.885 | 2.79 | A'-Neogammacer-22(29)-en-3-ol, acetate,(3.beta.,21.beta.) | $C_{32}H_{52}O_2$ | 468.8 | Triterpenoids | 002085-25-8 | 91 |

*Legend: Area %: Percentage of the total measured area in the total ion chromatogram, CAS: CAS Number , Qual: Quality of identification, above 80 % of the compounds is regarded as identified*

**Table 7. The main peaks of the compound in the Cabbage sample**

| Number | Peak number | Retention time | Area% | Library/ID | Molecular formula | Nature of compound | CAS | Qual |
|---|---|---|---|---|---|---|---|---|
| 1 | 23 | 11.315 | 1.74 | Sulfurous acid, 2-propyl tetradecyl ester | $C_{17}H_{36}O_S$ | Organooxygen compounds | 1000309-12-5 | 90 |
| 2 | 24 | 11.362 | 0.87 | Heneicosane | $C_{21}H_{44}$ | Acyclic alkane | 000629-94-7 | 86 |
| 3 | 27 | 11.783 | 1.04 | Heptadecane | $C_{17}H_{36}$ | Acyclic alkane | 000629-78-7 | 83 |
| 4 | 29 | 11.915 | 2.83 | Octadecane | $C_{18}H_{38}$ | Acyclic alkane | 000593-45-3 | 90 |
| 5 | 37 | 12.527 | 3.21 | Phenol, 2,4-bis (1,1-dimethylethyl) | $C_{14}H_{22}O$ | Diphenylmethanes | 000096-76-4 | 96 |
| 6 | 38 | 12.740 | 4.75 | Dodecane | $C_{12}H_{26}$ | Acyclic alkane | 00112-40-3 | 93 |
| 7 | 44 | 13.606 | 0.45 | Nonadecane | $C_{19}H_{40}$ | Acyclic alkane | 000629-92-5 | 90 |
| 8 | 48 | 14.050 | 0.76 | Tetratriacontane | $C_{34}H_{70}$ | Acyclic | 014167-59-0 | 90 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | alkane | | |
| 9 | 58 | 14.742 | 0.31 | Eicosane | $C_{20}H_{42}$ | Acyclic alkane | 00112-95-8 | 86 |
| 10 | 60 | 15.088 | 3.00 | Tetratetracontane | $C_{44}H_{90}$ | Acyclic alkane | 007098-22-8 | 90 |
| 11 | 63 | 15.683 | 0.45 | Cyclododecane | $C_{10}H_{20}$ | Cyclic alkane | 000294-62-2 | 92 |
| 12 | 64 | 16.086 | 0.84 | Octacosane | $C_{28}H_{58}$ | Acyclic alkane | 000630-02-4 | 86 |
| 13 | 70 | 16.571 | 0.48 | Nonahexacontanoic acid | $C_{69}H_{138}O_2$ | Fatty acids and conjugates | 040710-32-5 | 83 |
| 14 | 74 | 16.917 | 1.18 | Pentacosane | $C_{25}H_{52}$ | Acyclic alkane | 000629-99-2 | 86 |
| 15 | 75 | 17.004 | 1.30 | Heptacosane | $C_{27}H_{56}$ | Acyclic alkane | 000593-49-7 | 90 |
| 16 | 77 | 17.367 | 0.5 | Hexacosane | $C_{26}H_{54}$ | Acyclic alkane | 000630-01-3 | 83 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 17 | 79 | 17.523 | 1.29 | Pentadecane, 2,6,10-trimethyl- | $C_{18}H_{38}$ | Sesquiterpenoids | 003892-00-0 | 86 |
| 18 | 89 | 20.563 | 7.80 | Hexadecanamide | $C_{16}H_{33}NO$ | Fatty amides | 000629-54-9 | 86 |
| 19 | 92 | 23.534 | 6.05 | Octadecanamide | $C_{18}H_{37}NO$ | Carboximidic acids | 000124-26-5 | 91 |

*Legend: Area %: Percentage of the total measured area in the total ion chromatogram, Ref: Reference Number , CAS: CAS Number , Qual: Quality of identification, above 80 % of the compounds is regarded as identified*

## 4. DISCUSSION

During this study men were more important and critical than women, which can be explained by women's reluctance to give information. Men and women of every age are increasingly interested in market gardening. This enthusiasm for market gardening could be linked to the fact that this activity is a source of income for households[4].

However, in market gardening activities, several pesticides are used to control pests. The use of insecticides is carried out on the sites surveyed according to the nature of the pest and its resistance. Sometimes growers apply pesticides to crops in excess of the recommended doses. But in our study, more than half of the people surveyed do not respect the recommended dosages. Indeed,Naré et al.[17], reported that growers do not respect pesticide application rates. Producers sometimes use cotton insecticides not approved by CSP for vegetable production. Grunder et al.[18] mentioned this case of using not approved pesticides in their report on culture protection. This constitutes a problem of ignorance and can cause contamination in the short or medium-term on the vegetables produced. In general, the most cited pesticides used in market gardening contain active molecules such as emamectin benzoate, lambda cyhalothrin, acetamiprid, and cypermethrin and belong to the family of Avermectin, Pyrethroid, Neonicotinoid, and Pyrethroid respectively. This family of pesticides was emphasized in the work of Son et al.[19], Grunder et al.[18], and Sawadogo et al.[20]in the market gardening of tomatoes in Burkina Faso and this confirms our results. Thus, non-compliance with regulations could lead to significant risks for the grower, firstly, consumers, and the environment.

In addition, complex formulations have been used in the gardening field, and these formulations can be mixtures of insecticides and biopesticides or insecticides and soap to overcome the parasite. This case has been found in most of the fungal control encountered on the leaves and fruits of okra. These mixtures can increase health and environmental risksWeisneret al.[21]; in fact, products at low doses may not present a health risk, but their mixture may increase risks.

On the other side, biopesticide formulations are used by a small number of market gardeners. These market gardeners producing the biopesticides do so according to them for a particular category of customer. Biopesticides could be very important in controlling vegetable pests and diseases. Indeed, biopesticides based on neem (leaf, seed, and oil) would contain an active ingredient azadirachtin[22]. Biopesticides containing onion and garlic contain active ingredients such as allicin, alliin[23]. Garlic and onion juice contain several compounds that control pests [24,25]. Biopesticides containing pepper would contain capsaicin[26]. Capsaicin can be used as repelling for pests. Hot peppers are sometimes used to treat certain fungal diseases of plants [27]. Biopesticides made from papaya leaves would be full of active ingredients, such as papain, used to fight against insect pests of okra [28].

The use of soap in biopesticide formulation may be due to its action as an adjuvant and contribute to killing the pest. Some authors show that soap disturbs the pest membrane and cuticle and permits to control the pests [29]. Neem seed oil is an insecticide and can be used as an insect repellent.

Phytosanitary practices concerning the means of protection during the application of pesticides are lacking. This could be due to the ignorance and poverty of growers, leading them to neglect protection when using pesticides in the field.

In this study, GC/MS analysis showed that most identified compounds in lettuce are hydrocarbons characterized by their volatility. This richness of lettuce in its compounds could be explained by external factors (environmental, climate change, etc.) and internal factors (physiology, genetics) [30,31].

The majority of compounds found in lettuce agree with the works of some authors who find in lettuce phytoconstituent as hydrocarbon, phytosterol, fatty amide, ester, and triterpenoids [31,5].

The results of GC/MS analysis in cabbage are similar to those of Wei et al[32]who identified hydrocarbons, fatty acids, and conjugates in their work entitled "Development and comprehensive HS-SPME/GC-MS of different cabbage cultivars volatile components. In our analysis of cabbages, we also note that most of the compounds identified are volatiles.
GC/MS screening in lettuce and cabbage does not indicate the presence of any hazardous chemical compound. These results would confirm our investigation, which showed that growers respected the persistence time of chemicals used in the treatment of pests and diseases on speculation or by the low rate of absorption of these pesticides by the two plants, which could explain why we could not identify dangerous chemical compounds during GC/MS analyses. Generally, the most dangerous pesticides are those of class Ia and Ib[33].

## 4. CONCLUSION

In market gardening, several pesticides are used in the field of production. According to the survey periods, lettuce and cabbage are the most cultivated speculations. Several pesticides and their mixtures are used to control pests, which could lead to significant risks for growers and the environment due to non-compliance with regulations and the use of mixtures of pesticides. GC/MS screening in lettuce and cabbage does not indicate the presence of any hazardous chemical compound. Growers in market gardening need training and support on sanitary practices to reduce health and environmental risks.



## REFERENCES

1. Konkobo M. Socio-economic impact of the organization of producers on vegetable production in Burkina Faso: Case of Bobo-Dioulasso, Ouagadougou and Ouahigoua. IDR. 2016; p. 84. Accessed10 October2022. Available from: https://cgspace.cgiar.org/handle/10568/117352
2. Dione M, Diarra S, Ilboudo G, Konkobo-Yameogo C, Lallogo VR, Roesel K, et al. Value chain assessment of animal- source foods and vegetables in Ouagadougou, Burkina Faso – considering food safety, quality and hygiene perceptions and practices. ILRI Res. Rep. 87, Nairobi, Kenya. 2021; p. 60. Accessed11 December 2022. Available from: https://cgspace.cgiar.org/handle/10568/117352
3. Sangwan N, Tasciotti L. Losing the plot : the impact of urban agriculture on household food expenditure and dietary diversity in Sub-Saharan African countries. Agriculture. 2023;13:284–304.
4. Ouédraogo A, Yanogo PI, Ouédraogo I. Contribution of Market Gardening to Household Resilience around the Guido Dam in a Context of Climate Variability in the Réo Commune of Burkina Faso. Am J Environ Prot. 2022;10 (2):73–82.
5. Afsharypuor S, Ranjbar M, Mazaheri M, Shakibaei F. Essential oil constituents of seeds and fresh leaves of garden lettuce ( Lactuca sativa L .) grown in Isfahan , Iran. Res J Pharmacogn. 2018;5 (3):1–5.
6. Liang Y, Li Y, Zhang L, Liu X. Phytochemicals and antioxidant activity in four varieties of head cabbages commonly consumed in China. Food Prod Process Nutr. 2019;1(3):1–9.
7. Sanou A, Konate K, Sama H, Dakuyo R, Diao M, Dibala CI, et al. Cultural practices and pesticides contamination level of tomato in two gardening sites in the region of Boucle du Mouhoun. African J Agric Res. 2020;1(10):1334–41. Doi.org/10.5897/AJAR2020.14977

8. Seiber JN, Coats J, Duke SO, Gross AD. Pest management with biopesticides. Front Agric Sci Eng. 2018;5(3):295–300.
9. Ofuya TI, Okunlola AI, Mbata GN. A Review of Insect Pest Management in Vegetable Crop Production in Nigeria. Insects. 2023;14:111–27.
10. Tarnagda B, Tankoano A, TApsoba F, Sourabié PB, Abdoullahi HO, Djbrine OO, et al. Evaluation of farming practices of leafy vegetables: the case of uses of pesticides and chemical inputs in gardeners sites of Ouagadougou, Burkina Faso. J Appl Biosci. 2017;117:11658–11668.
11. National Assembly-AN. Loi n°026-2017/an. FAO. 2017;p. 29.Accessed 21 July 2023. Available from https://faolex.fao.org/docs/pdf/Bkf171521.pdf
12. Taladi N, Ouédraogo O. Consumers of organic market garden products in Ouagadougou. Antropol food. 2023;17:21p. Available from: http://journals.openedition.org/aof/13957. DOI: https://doi.org/10.4000/aof.13957
13. WHO. The WHO recommended classification of pesticides by hazard and guidelines to classification. Geneva: World Health Organization; 2020.
14. CSP. Global list of pesticides authorized by the Sahelian pesticide commitee. 2020;p. 49. Accessed15 May 2023. Available from: https://dpvsenegal.sn/liste globale pesticides autorise.pdf
15. CSP. Gbobal list of pesticides authorized by the Sahelian pesticide commitee. 2021;p. 53. Accessed 15May2023. Available from: https://reca-niger.org/IMG/pdf/liste_globale_pesticides_csp_decembre_2021.pdf
16. CSP. List of pesticides authorized by the 6th extraordinary session of the Sahelian Pesticides Committee. 2022; p. 20. Accessed 15 May 2023. Available from: https://insah.cilss.int/index.php/2022/10/17/6eme-session-extraordinaire-du-comite-sahelien-des-pesticides-csp-bamako-mali-17-27-oct-2022/
17. Naré WRA, Savadogo PW, Gnankambary Z, Nacro HB, Sedogo MP. Analyzing risks related to the use of pesticides in vegetable gardens in Burkina Faso. Agric For Fish. 2015;4(4):165–72.
18. Grunder J, Clottey V, Dougoud J, Bateman M, Wood A. Étude sur la protection des cultures dans les pays où le programme ‘Centres d’Innovations Vertes pour le Secteur Agro-Alimentaire’ est actif. 2018; p. 143. Accessed 17 August 2023. Available from: https://www.cabi.org/wp-content/uploads/Country-report-Burkina-Faso.pdf
19. Son D, Somda I, Legreve A. Phytosanitary practices of tomato growers in Burkina Faso and risks for health and the environment. Cah d’Agriculture. 2017;26:25005.
20. Sawadogo MW, Somda I, Nacro S, Legrève A. Five years of invasion: Impact of Tuta absoluta (Meyrick) on tomato production in Burkina Faso. Tropicultura. 2020;38:1638–52.
21. Weisner O, Frische T, Liebmann L, Reemtsma T, Vormeier P, Knillmann S, et al. Risk from pesticide mixtures – The gap between risk assessment and reality. Sci Total Environ. 2021;796(6):149017.
22. Kilani-Morakchi S, Morakchi-Goudjil H, Sifi K. Azadirachtin-based insecticide: Overview, risk assessments, and future directions. Front Agron. 2021;3:1–13.

Doi.org/10.3389/fagro.2021.676208
23. Shang A, Cao S, Xu X, Gan R, Tang G, Corke H. Bioactive Compounds and Biological Functions of Garlic ( Allium sativum L .). Foods. 2019;8(7):246.
24. Yildiz HY, Van QP, Parisi G, Sao MD. Anti-parasitic activity of garlic ( Allium sativum ) and onion ( Allium cepa ) juice against crustacean parasite, Lernantropus kroyeri , found on European. Ital J Anim Sci. 2019;18:833–837. Doi.org/10.1080/1828051X.2019.1593058
25. Chakraborty AJ, Uddin TM, Zidan BMRM, Mitra S, Das R, Nainu F, et al. Allium cepa : A Treasure of bioactive phytochemicals with prospective health benefits. Evidence-Based Complement Altern Med. 2022;2022:27 p.
26. Koleva Gudeva L, Mitrev S, Maksimova V, Spasov D. Sadržaj kapsaicina u ljutoj paprici (Capsicum annuum ssp. microcarpum L.) injegova primena kao biopesticida. Hem Ind. 2013;67(4):671–675.
27. Chabaane Y, Marques C, Gaëtan A, Betty G. Altered capsaicin levels in domesticated chili pepper varieties affect the interaction between a generalist herbivore and its ectoparasitoid. J Pest Sci. 2022;95:735–47. Doi.org/10.1007/s10340-021-01399-8
28. Gnago JA, Danho M, Agneroh TA, Kalyl I, Goulivas A. Efficacy of neem (Azadirachta indica) and papaya (Carica papaya) extracts in controlling insect pests of okra (Abelmoschus esculentus) and cabbage (Brassica oleracea) in Côte d'IVoire. Int J Biol Chem Sci. 2010;4(4):953–66.
29. Borden MA, Buss EA, Brown SGP, Dale AG. Natural products for managing landscape and garden pests in Florida: ENY/IN 197 major. 2018;2018:13p.
30. Moghaddam M, Mehdizadeh L. Chemistry of essential oils and factors Influencing their constituents. Soft Chem food Ferment. 2017; p. 379–419.
31. Mughrbi HN, Auzi AA. Lactuca sativa stems as the source of bioctive compounds as well as the leaves. J Pharm Pharmacol. 2020;8:143–150.
32. Wei S, Xiao X, Wei L, Li L, Li G, Liu F, et al. Development and comprehensive HS-SPME/GC-MS analysis optimization, comparison, and evaluation of different cabbage cultivars (Brassica oleracea L. var. capitata L.) volatile components. Food Chem. 2020;340:128–66. Doi.org/10.1016/j.foodchem.2020.128166
33. WHO. Classification WHO recommends pesticides based on the hazards they present and Guidelines for clssification 2019. Geneva: World Health Organization.2019.