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Research Article

Analysis of insecticide residues in cabbage (Brassica oleracea var. Capitata) from three major markets in Kumasi

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Abstract

Cabbage from 3 major markets (Abinchi, Bantama and Sofoline) in Kumasi were screened for organochlorine, organophosphate and pyrethroid insecticide residues. Ninety cabbage heads - 30 from each market – were randomly sampled and analysed at the Pesticide Residues Laboratories of the Ghana Standards Authority, Accra. The analysis was carried out using Multiple Reaction Monitoring by Gas Chromatography-Pulsed Flame Photometric Detector (GC-PFPD), Gas Chromatography-Electron Capture Detector (GC-ECD) and Quick, Easy, Cheap, Effective, Rugged, and Safe (QuEChERS) method to detect residues. The limit of detection (LOD) of organochlorine was set at 0.005 mg/kg and that of organophosphate and pyrethroid was set at 0.01 mg/kg. We observed that no organochlorine was present in any of the samples. Only Diazinon was present in the samples from Abinchi and Bantama but at a level (0.003 ± 0.006 mg/kg) below the maximum residue limit (MRL) of 0.01 mg/kg for cabbage. However, there was a multi-residue contamination in samples from the Sofoline market with Diazinon (0.057 ± 0.098 mg/kg), Cypermethrin (0.007 ± 0.012 mg/kg), Fenvalerate (0.010 ± 0.017 mg/kg) and Lambda-cyhalothrin (0.003 ± 0.006 mg/kg). With these, only the Diazinon was found to exceed its established MRL (0.01 mg/kg) and so is more likely to pose danger to consumers health.

Introduction

Cabbage (*Brassica oleracea var. capitata)* is recognised as a vital component of human diets by virtue of its high nutritive value, and high content of essential vitamins, proteins, carbohydrates and vital minerals [1]. In addition to its contribution to food needs, cabbage serves as a source of income for people who engage in its production thereby serving as a source of livelihood. According to Drechsel and Keraita (2014) [2] cabbage production serves as a source of income for about 316 urban farmers within the Kumasi metropolis.

As a popular vegetable in urban and peri-urban Ghana, cabbage is mostly attacked by insect pests that lead to reduction in market value and total crop failure. The most serious pests of cabbage are caterpillars of diamond back moth (*Plutella xylostella*), cabbage web worm (*Hellula undulasis*) and cabbage aphids (*Brevicoryne brassicae*). Susceptibility of cabbage to pests and diseases leads to intensive pest management in its production by farmers. To reduce insect pests' damage, farmers commonly apply synthetic pesticides at different stages of the crop growth [3,4].

Nevertheless, many farmers misapply chemical pesticides by way of applying non-recommended pesticides or applying excess or harvesting shortly after spraying without waiting for the recommended period thereby leaving harmful chemicals residues on them [5-8].

Insecticides are known to result to health hazards including death as a result of accident during application or operation, movement from fields and or residual contamination of food produce and water [9-12]. They are poisonous to nervous system of mammals. Organochlorine pesticides act as nerve

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poison by interfering with the transmission of nerve impulse along the axon in poisoned mammals. Organophosphates pose toxic effect on the nervous system by inhibiting the enzyme acetylcholinesterase (AchE) responsible for metabolism of the neurotransmitter Acetylcholine. They are known to cause respiratory problems, memory disorder, neurological deficits, miscourage, birth defects and cancer. Also, pyrethroid pesticide poisoning in mammals is known to stimulate nerves discharge repeatedly causing hyper-excite.

With knowledge or perception about this, many consumers are sceptical to consume vegetables produced conventionally. Thus, to enhance consumer confidence it is important to monitor and control the residue levels of chemicals used in crop production. The aim of this study was to screen cabbage sold in Abinchi, Bantama and Sofoline markets in the Kumasi Metropolis for the presence and levels of organochlorine, organophosphate and pyrethroid insecticide.

Analysis of pesticide residue levels in food is a relevant mechanism in food quality and safety management by identifying residues levels that can pose human health problems. Previous studies in Ghana, have revealed awkward findings about pesticide residue levels in different food products, and have therefore cautioned for regular monitoring of dietary intake of pesticides residues and their potential health risk.

A study by [13], revealed that some fruit samples contained insecticides residues that are above the accepted Maximum Residue Limit (MRL) which could result in deadly chronic effects [14]. Also detected that some fruit and vegetable samples collected from major markets across the Greater Accra, Eastern and Central Regions of Ghana contained pesticide residues levels above their Maximum Residue Limits.

As earlier studies have contributed immensely to residue analysis in vegetables particularly cabbage, focus on these three major markets (Abinchi, Bantama and Sofoline) have been limited. Also, as campaign against pesticides misapplication has been on the rise coupled with keen regulation on the production, supply and distribution of pesticides it is important to determine if things have changed with regards to pesticide use on crops and a surest means of detecting this is to screen for pesticides contamination.

Materials and methods

A total of 90 cabbage heads were randomly sampled from the three markets (Figure 1) on three different occasions over a year i.e. 05-11-2016; 06-13-2017 & 06-27-2017. On each occasion, 10 cabbage heads were picked from each market, making a total of 30 in all, put into separate polythene bags, sealed and appropriately labelled, kept in an ice chest and then transported to the Pesticide Residue Laboratories of the Ghana Standards Authority (GSA) in Accra for the laboratory analysis.

Samples from each market were separately washed properly under running tap water to clean them, as commonly done by consumers, and then chopped separately into pieces and homogenized using FOSS homogenizer (2096). 10 g of each homogenized sample was put in a centrifuge tube, and 10 ml of cold distilled water added to make it paste.

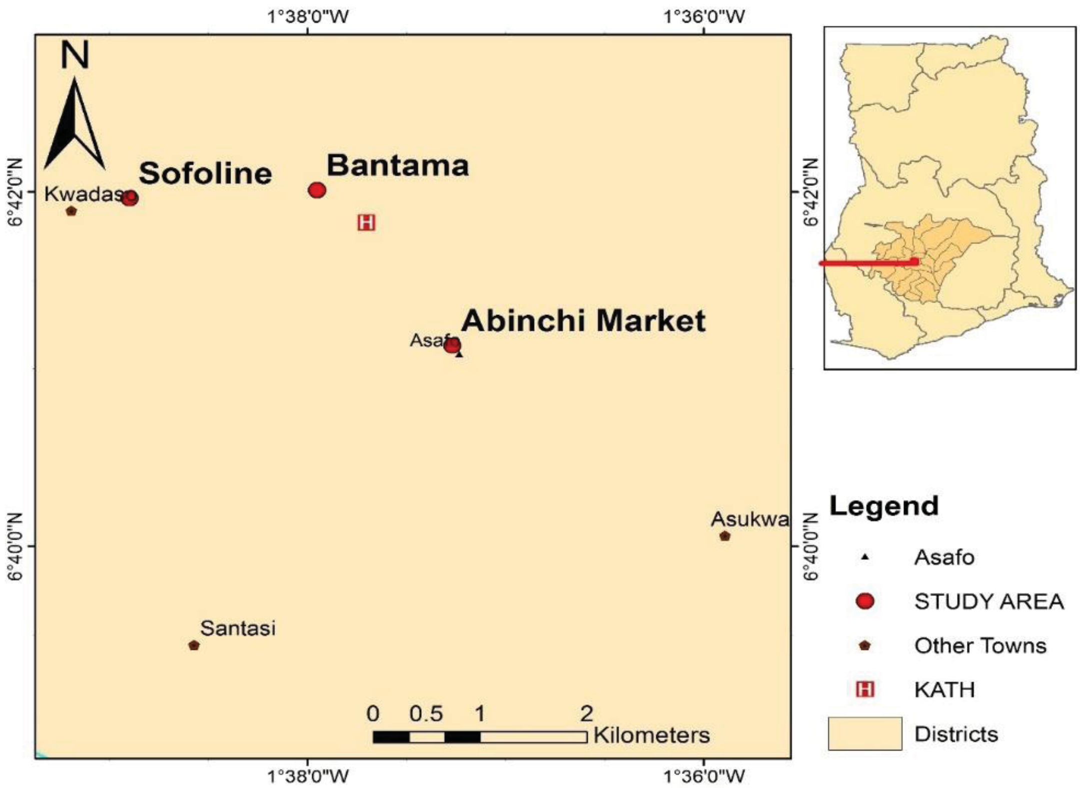

Figure 1: Map showing sampling markets.

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The content was vortexed for 30 s to mix it thoroughly. 10 ml of acetonitrile was then added as an extraction solvent and vortexed for 60 s. After, 0.5 g of sodium hydrogencitrate sesquihydrate; 1 g of tri-sodium citrate dehydrate GR; 1 g of sodium chloride CP, and 4 g of magnesium sulphate anhydrous powder were added to the mixture as extraction salts and vortexed for 60 s to obtain the extract. The sodium hydrogencitrate sesquihydrate and tri-sodium citrate dehydrate GR acted as buffer; the sodium chloride CP helped in partitioning the organic and inorganic layers, and the magnesium sulphate anhydrous powder absorbed moisture from the extract.

The extract was then centrifuged at 3000 rpm for 300 s for the organic and inorganic layers to separate. 6 ml of organic layer of the extract was measured into a centrifuge tube. 900 ml of magnesium sulphate anhydrous powder plus 150 mg of PSA (primary and secondary amine) were added to the 6 ml extract content in the centrifuge tube to get rid of residual water and unwanted contaminants in the extract and vortexed for 30 s. The extract was then centrifuged at 3000 rpm for 300 s to obtain a clean extract.

4 ml of the content was pipetted into a 50 ml pear-shape flask, and 40 µl of 5% formic acid prepared in acetonitrile was added to it and taken to a rotary evaporator to concentrate the insecticides i.e. dry out extract to leave insecticides in the flask. The formic acid was added so that the storage stability of the pesticides could be enhanced. After, 1 ml of ethyl acetate was added to dissolve the dried insecticide in the pear-shape flask.

The content was then poured into 2 ml GC vial, and assayed for multi-residues of organochlorine, organophosphate and pyrethroids. A multiple reaction monitoring by GC-PFPD, GC-ECD and QuEChERS method was employed for detection of residues. GSA-prepared standards for the various pesticides were used. The LOD of organochlorine was set at 0.005 mg/kg, and that of organophosphate and pyrethroids was set at 0.01 mg/kg.

The organochlorine and synthetic pyrethroid residues were analysed by CTC ANALYTICS GC machine (CTC01019) equipped with ^{63}Ni electron capture detector (ECD). The GC conditions used for the analysis were: capillary column coated with VF-5 ms (30 m + 10 EZ Guard, 0.25 mm, 0.25 µm film thickness). Carrier gas and make-up gas was nitrogen at a flow rate of 1 and 29 mL/min, respectively. The temperature of injector operating in splitless mode was held at 270 °C, and that of the electron capture detector was set at 300 °C. The column oven temperature was programmed as follows; 70 °C for 2 min. and increased steadily at a rate of 25 °C/min to 180 °C /min and increased at 5 °C/min up to 300 °C. The injection volume of the GC was 1 µL.

The organophosphorus residues were analysed by same machine make equipped with pulse flame photometric detector (PFPD). The GC conditions used for the analysis were: capillary column coated with VF-1701 ms (30 m, 0.25 mm, 0.25 µm film thicknesses). Carrier gas was nitrogen at a flow rate of 2 mL/min with Air 1, Air 2 and H_2 flow rates of 17, 10 and 14 mL/min respectively. The temperature of injector operating in splitless mode was held at 270 °C and the PFPD was set at 280 °C. The column oven temperature was programmed as follows; 70 °C for 2 min. and increased steadily at a rate of 25 °C/min to 200 °C/min and increased at 20 °C/min up to 250 °C.

Extracts of fortified samples were serially diluted by a factor of 2 to give different concentrations. 1 µl of each concentration was injected and the least concentration that gave response was noted, and LOD was calculated by the formula:

$$LOD = (V_1/V_2) * \text{concentration fortified}$$

V_1 – volume injected

V_2 - final volume of fortified extract

The detection limit for organochlorine pesticides was determining to be 0.005 mg/kg, while that of both organophosphorus and pyrethroid pesticides were 0.01 mg/kg.

Results

Fifteen organochlorine including Aldrin, Alpha-endosulfan, Beta-Endosulfan, Beta-HCH, Delta-HCH, Dieldrin, Endosulfan Sulphate, Endrin, Gamma-chlordane, Heptachlor, Lindane, Methoxychlor, P'P DDE, P'P-DDD and P'P-DDT were screened for. However, none of them was detected in any of the samples.

Of the 13 organophosphates screened for i.e. Chlorfenvinphos, Chlorpyrifos, Diazinon, Dimethoate, Ethoprophos, Fenitrothion, Fonofos, Malathion, Methamidophos, Parathion, Phorate, Pirimiphos-methyl and Profenofos, only Diazinon was detected at different concentrations in the different market samples. In both Abinchi and Bantama markets, the concentration of Diazinon was (0.003 ± 0.006 mg/kg) which is below its EU MRL of 0.01 mg/kg for cabbage. However, in the Sofoline market the concentration of Diazinon was 0.057 ± 0.098 mg/kg, which is higher than its MRL (Table 1).

Nine pyrethroids including Allethrin, Bifenthrin, Cyfluthrin,

Table 1: The results of organophosphate insecticide analysis from cabbage.

Insecticide	Abinchi	Bantama	Sofoline	EU MRL
	Mean ± SD	Mean ± SD	Mean ± SD	
Chlorfenvinphos	Nd	Nd	Nd	0.01 (Max)
Chlorpyrifos	Nd	Nd	Nd	1.00 (Max)
Diazinon	0.003 ± 0.006	0.003 ± 0.006	**0.057 ± 0.098**	0.01 (Max)
Dimethoate	Nd	Nd	Nd	0.02 (Max)
Ethoprophos	Nd	Nd	Nd	0.02 (Max)
Fenitrothion	Nd	Nd	Nd	0.01 (Max)
Fonofos	Nd	Nd	Nd	0.01 (LOD)
Malathion	Nd	Nd	Nd	0.02 (Max)
Methamidophos	Nd	Nd	Nd	0.01 (Max)
Parathion	Nd	Nd	Nd	0.05 (Max)
Phorate	Nd	Nd	Nd	0.01 (Max)
Pirimiphos-methyl	Nd	Nd	Nd	0.05 (Max)
Profenofos	Nd	Nd	Nd	0.01 (Max)

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Cypermethrin, Deltamethrin, Fenpropathrin, Fenvalerate, Lambda-cyhalothrin and Permethrin were screened for. With these, only 3 namely Cypermethrin, Fenvalerate and Lambda-cyhalothrin were detected, only in samples from the Sofoline market, at concentrations of 0.007 ± 0.012 mg/kg; 0.010 ± 0.017 mg/kg and 0.003 ± 0.006 mg/kg respectively (Table 2). These concentrations were below the respective established MRLs for cabbage (i.e. 1.00 mg/kg for Cypermethrin and 0.02 mg/kg for Fenvalerate and Lambda-cyhalothrin) and so are not likely to pose health danger when consumed.

Table 2: The results of pyrethroid insecticide analysis from cabbage.

Insecticide	Abinchi	Bantama	Sofoline	EU MRL
	Mean ± SD	Mean ± SD	Mean ± SD	
Allethrin	Nd	Nd	Nd	0.01 (LOD)
Bifenthrin	Nd	Nd	Nd	1.00 (Max)
Cyfluthrin	Nd	Nd	Nd	0.30 (Max)
Cypermethrin	Nd	Nd	0.007 ± 0.012	1.00 (Max)
Deltamethrin	Nd	Nd	Nd	0.01 (Max)
Fenpropathrin	Nd	Nd	Nd	0.01 (Max)
Fenvalerate	Nd	Nd	0.010 ± 0.017	0.02 (Max)
Lambda-cyhalothrin	Nd	Nd	0.003 ± 0.006	0.02 (Max)
Permethrin	Nd	Nd	Nd	1.05 (Max)

Discussion

The absence of organochlorine pesticides in our analysis might be because the farmers did not apply any organochlorine insecticide as this category of pesticides have been banned since 1994 [15] or organochlorines were present but at levels less than their LOD of 0.005 mg/kg. A study by [16] reported that cabbage samples together with other vegetables and fruits purchased from some markets in the Kumasi metropolis including the Bantama market contained organochlorine pesticides such as Gamma-HCH, Methoxychlor, Dieldrin, Endrin, p,p'-DDE and p,p'-DDT. [17] also found that cabbage samples from the Ejisu-Juaben Municipal, a major source of cabbage to markets in the Kumasi metropolis contained residues of Alpha BHC, Gamma BHC (Lindane), Delta BHC, Heptachlor, Aldrin, DDT, DDE, Endrin, Beta Endosulfan, Dieldrin, Endosulfan sulphate and Beta BHC at concentrations greater than their MRLs. But our finding contrasts these findings.

Our finding suggests that the farmers never used any organochlorine on their farms. Even if they used, it was before the period 1994 when this category of insecticides was banned in Ghana, and so it was possible to detect them some years after their ban due to bioaccumulation or residues that persisted might have been remediated over time and so would not be present for detection in recent times.

The very high concentration of Diazinon in the Sofoline samples might be as a result of producers for the market not complying with the prescribed dosage of the insecticide or the waiting time before harvesting their cabbage for sale or both. According to [5,6] some cabbage farmers apply insecticides in overdose to improve their efficacy in controlling insects or continue to spray produce immediately before they harvest them to the market so that the produce will look appealing to buyers. Disregarding prescribed dosage and waiting period can make residues persist on produce and render them hazardous to consumers.

The presence of multi-residues of pyrethroids in the Sofoline samples might be because producers for the market used a mixture of different pyrethroid insecticides to control insects on their crops but failed to comply with their prescribed waiting periods. According to [17], majority of farmers use a mixture of two or more pesticides by relying on trade names without consideration of compatibility or active ingredients.

Conclusion

The cabbage heads sampled from Abinchi and Bantama were found to contain only Diazinon and at a safe level. However, those from Sofoline contained multi-residues including Diazinon, Cypermethrin, Fenvalerate and Lambda-cyhalothrin. With these, Diazinon exceeded its MRL. The results suggest that some cabbage farmers still misapply some approved insecticides and so we advocate that farmer education on insecticides or pesticides use and safety should be intensified especially for small scale vegetable farmers. We again advocate that policies or programmes that seek to motivate vegetable farmer (or all farmers) to comply with insecticides or pesticides use guidelines should be put in place by the Government or agriculture related institutions. In this regard, we suggest 'residue-free award schemes' to be featured in the national farmers day celebration to encourage compliance.

References

1. Norman JC (1992) Tropical Vegetable Crops. Arthur H. Stockwell Ltd. Ilfracombe, UK, 1-252. Link: https://bit.ly/2yyRJhP

2. Drechsel P, Keraita B (Eds.) (2014) Irrigated urban vegetable production in Ghana: characteristics, benefits and risk mitigation. 2nd ed. Colombo, Sri Lanka: International Water Management Institute (IWMI), 1-247. Link: https://bit.ly/2LVYI7L

3. Osei MK, Osei K, Braimah H, Mochiah MB, Berchie JN, et al. (2013) Practices and constraints to cabbage production in urban and peri-urban Ghana: focus on Brong Ahafo and Ashanti regions. Basic Res J Agric Sci Rev 2: 5-14. Link: https://bit.ly/2B4426P

4. Ghana Ministry of Food and Agriculture (2011). Agriculture in Ghana: facts and figures (2010) Produced by the Statistics, Research and Information Directorate 1-53.

5. Odhiambo JAO, Gbewonyo WSK, Obeng-Ofori D (2014) Insecticide Use Pattern and Residue Levels in Cabbage (Brassica Oleracea Var capitata L.) within Selected Farms in Southern Ghana. Journal of Energy and Natural Resources Management (JENRM) 44-55. Link: https://bit.ly/2TDZKJO

6. Amoako PK, Kumah P, Appiah F (2012) Pesticides usage in cabbage (Brassica oleracea) cultivation in the Ejisu-Juaben Municipality of the Ashanti Region of Ghana. International Journal of Research in Chemistry and Environment 2: 26-31. Link: https://bit.ly/36wb7se

7. Botwe BO, Ntow WJ, Kelderman P, Drechsel P, Derick C, et al. (2011). Pesticide residues contamination of vegetables and their public health implications in Ghana. Journal of Environmental Issues and Agriculture in Developing Countries 3: 10. Link: https://bit.ly/2LVEjj8

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8. Ntow WJ, Gijzen HJ, Kelderman P, Drechsel P (2006) Farmer perceptions and pesticide use practices in vegetable production in Ghana. Pest Manage Sci 62: 356-365. **Link:** https://bit.ly/2X0VFBt

9. Fait A, Iversen B, Tiramani M, Visentin S, Maroni M, et al. (2001) Preventing health risks from the use of pesticides in agriculture. Ed. International Centre for Pesticide Safety. Protecting workers' health series No. 1, WHO 1-35. **Link:** https://bit.ly/36uIX0Z

10. Eyer P (2003) The role of oximes in the management of organophosphorus pesticide poisoning. Toxicological reviews 22: 165-190. **Link:** https://bit.ly/2TH0Rbx

11. PAN Germany (2012) Pesticides and health hazards: Facts and figures. Pestizid Aktions-Netzwerk e.V. IBAN 1-16. **Link:** https://bit.ly/3encxrl

12. Toe AM, Ouedraogo M, Ouedraogo R, Ilboudo S, Guissou PI (2013) Pilot study on agricultural pesticide poisoning in Burkina Faso. Interdiscip Toxicol 6: 185-191. **Link:** https://bit.ly/2LWByhq

13. Bempah CK, Donkor AK (2011) Pesticide residues in fruits at the market level in Accra Metropolis, Ghana, a preliminary study. Environ Monit Assess 175: 551-561. **Link:** https://bit.ly/2zoN5Ue

14. Asiedu E (2013) Pesticide Contamination of Fruits and Vegetables - A Market-Basket Survey from Selected Regions in Ghana. MPhil. Thesis, University of Ghana, Legon 1-133. **Link:** https://bit.ly/2M34Fzu

15. Ghana EPA (1994) Environmental Protection Agency Act. Act 490. Government of Ghana. **Link:** https://bit.ly/3d3ly9t

16. Bempah CK, Buah-Kwofie A, Denutsui D, Asomaning J, Tutu AO (2011). Monitoring of pesticide residues in fruits and vegetables and related health risk assessment in Kumasi Metropolis, Ghana. Research Journal of Environmental and Earth Sciences 3: 761-771. **Link:** https://bit.ly/3gnPhfg

17. Amoako PK (2010) Assessment of pesticides used to control insect pests and their effects on storage of cabbage (Brassica oleracea var capitata) - a case study in Ejisu-Juaben Municipal Area. MSc. Thesis, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana 1-88. **Link:** https://bit.ly/2AdLujO

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