Investigation and Season’s Comparison of Pesticides Residues in Vegetables in Khartoum State Markets Using QuEChERS Method and GC/MS Techniques

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Abstract

Pesticides are widely used in food production to increase food security but they can have negative health effects on consumers. Both raw and processed vegetables have been found to be contaminated with pesticide residues. Consumers can be exposure to pesticides via food consumption. In this paper, we present the investigation of 30 pesticides in total of 126 samples of different fresh vegetables from central markets in Khartoum state using the quick easy cheap effective rugged and safe (QuEChERS) multi-residue extraction, followed by gas chromatography-mass spectrometry (GC-MS). Pesticide residues were not detected in 87 samples (69%), while 39 samples (31%) contained detectable amount of pesticide residues. Only seven pesticides chlorpyrifos, chloropyrifos methyl, cypermethrin, deltamethrin, lambda cyhalothrin, dimethoate and profenofos were detected in the analyzed vegetable samples with concentration range between 0.011 - 0.528 mg/kg and mean range between 0.015 - 0.1683 mg/kg. Lettuce and radish don’t show any pesticides residues. In summer and autumn seasons pesticides found in onion, cabbage, carrot and peppergrass but in winter season only onion and peppergrass have been contaminated with pesticides. Multiple residues were present in onion in two samples with chlorpyrifos and dimethoate. It is concluded that the continuous monitoring and strict regulation of pesticide use on food crops, especially vegetables, are necessary.

Keywords: Pesticide Residues; Vegetables; QuEChERS; GC-MS; Seasons; Markets; Khartoum; Sudan

Introduction

In Sudan, vegetables are grown extensively and constitute a large portion of the diet of the average Sudanese. Vegetables are essential for a healthy human body and balanced diet, as well as adding variety, interest and flavor to the most of Sudanese food menu as they form a major component of human diet in every family. Vegetables are Sources of essential biochemical’s and nutrients such as carbohydrates, carotene, proteins, vitamins, calcium, iron ascorbic acid and palpable concentration of trace minerals, most vegetables are low in starch content and are a good source of phytonutrients, vegetables also attract with a wide range of pests and diseases, and require intensive pest management [1,2].

Pesticides are a class of chemical substances used against organisms harmful to humans, animals, and plants, such as insects, fungi, moulds, nematodes, and rodents. These compounds represent an important class of pollutants for food, ground and surface water resources. A pesticide is a substance or a mixture of substances used for killing pests; i.e. organisms dangerous to cultivated plants or to animals. The term applies to various pesticides such as insecticides, fungicides, herbicides and nematocides [3].

The majority of such substances are applied directly to the soil or sprayed over crop fields and hence are release directly to the environment. However, the continued use of pesticides specially insecticides increases the possibility of residues to be found in some vegetables, threatening the alimentary security. Pesticide residue refers to the pesticides that may remain on or in food after they are applied to food crops [4].
General population can be exposed to pesticide residues through the ingestion of contaminated foods (such as cereals, vegetables, and fruits), which are directly treated with different kinds of pesticides or are grown in contaminated fields. The levels of pesticides residues in foods are often stipulated by regulatory bodies in many countries. Therefore, the different kinds of pesticides residue in food have been strictly regulated by government in all countries in order to determine whether the concentrations of the pesticides used exceed their maximum residue limits (MRLs) [5].

The determination of pesticide residues in agricultural products, plant and environmental samples has been a major subject for many years because of their toxic potential risk for human health, persistence and tendency to bioaccumulate. For many years, analysis of fruit and vegetable samples for organophosphorus, organochlorine, and pyrethroids pesticides at low levels were by gas chromatography (GC) using selective detectors: flame photometric, nitrogen phosphorus, and electron capture detectors (FPD, NPD, and ECD). Although these detectors are sufficiently sensitive for compliance with maximum residues limits (MRLs) in European Union regulations, they provide poor specificity for confirmation in these matrixes; therefore, GC coupled with mass spectrometry (MS) was required [6,7].

Many methods and studies have reported the use of GC/MS and LC/MS to control pesticide residues in matrixes such as fruit, vegetables, milk, and soils, with either full scan or selected ion monitoring (SIM) [8,9].

In the last years, the Quick, Easy, Effective, Cheap, Rugged, and Save (QuEChERS) approach, has become very popular for the determination of pesticides on diverse food matrices include fruits and vegetables, this method is characterized by using the polar solvent acetonitrile for extraction of water containing matrices with addition of salts in order to get phase separation. Since its introduction, this method has been readily accepted by many pesticide residue analysts because of its low organic solvent consumption, low cost per sample, fast, the accurate procedures are no time consuming, and high analyte recoveries [10,11].

**Materials and Methods**

**Study area and time**

The vegetable samples were collected from central markets of Khartoum state including Khartoum central market in Khartoum, Khartoum north central market in Khartoum north and Omdurman market (elshaabi) in Omdurman during summer season from September to November 2016, winter season from December 2016 to February 2017 and autumn season from May to July 2017.

**Sample collection and treatment**

A total of 108 vegetables samples were collected for pesticide residue analysis. The vegetable samples included 36 samples of onion, 18 samples of cabbage, 18 samples of carrot, 18 samples of pepperglass, 18 samples of lettuce, and 18 samples of radish. The sampling was performed in accordance with the general principles and methods of the European Commission (EC) directive 2002/63/EC [12]. Each representative vegetable sample was a composite of 6 to 10 subsamples of the same commodity collected through random sampling. All the samples (1-2 kg each) were placed in polythene bags, in box contain ice, to avoid contamination and deterioration, labeled, and transported to the laboratory and stored at -20°C until analysis.

**Chemicals and reagents**

Pesticide reference standards including malathion, diazinon, profenofos, chlorpyrifos, chlorpyrifos-methyl, omethoate, dimethoate, cypermethrin, deltamethrin, fenpropatrin, permethrin, tetramethrin, cyfluthrin, fenvalerate, lambda cyhalothrin, lindane, heptachlor, aldrin, heptachlor epoxide, mixture endosulfan, diaeclin, endrin, o.P-DDT, carbaryl, carbofuran, bendiocarb, atrazine, imidacloprid, thiomethoxam, and pendimethalin were purchased from Sigma Aldrich GmbH (Augsburg, Germany), Supelco and Bayer Crop Science, with certified purity ranging from 95% to 99%. Acetonitrile, acetone, sodium chloride, toluene, acetic acid and anhydrous magnesium sulfate were obtained from Scharlau (Barcelona, Spain). QuEChERS Finisterre micro centrifuge tube containing two or more primary secondary amine (PSA), anhydrous magnesium sulfate (MgSO₄) and graphed carbon black (GCB) with details of TR-Q2035 (150 mg MgSO₄)
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25 mg PSA, 2.5 mg GCB), TR-Q2015 (150 mg MgSO₄, 25 mg PSA) and TR-Q2045 (150 mg MgSO₄, 25 mg PSA, 7.5 mg GCB) were obtained from Teknokroma (Barcelona, Spain). Piperonyl Butoxide (PPB) with certified purity 95% used as internal standard was obtained from Sigma Aldrich GmbH. All the organic solvents used were higher performance liquid chromatography (HPLC) grade.

Preparation of pesticide standard solution

Pesticide standard stock solutions (1000 mg/L) of malathion, diazinon, profenofos, chlorpyrifos, chlorpyrifos-methyl, omethoate, dimethoate, cypermethrin, deltamethrin, fenpropathrin, permethrin, tetramethrin, cyfluthrin, fenvalerate, lambda cyhalothrin, lindane, heptachlor, aldrin, heptachlor epoxide, mixture endosulfan, dieldrin, endrin, o,p-DDT, carbaryl, carbofuran, benzoic carb, atrazine, imidacloprid, thiothixom and pendimethalin were prepared separately with acetone and stored at -20°C until use. A mixed pesticide standard solution of 50 mg/L was prepared by adding the proper volume of each individual stock solution and diluted to volume. Intermediate mixed pesticide standard solution of 10 mg/L was prepared from the mixed pesticide standard solution of 50 mg/L. Matrix-matched calibration standards were prepared by adding mixed pesticide standard working solutions in the blank extract to reach the final concentrations of 0.005, 0.01, 0.05, 0.10, 0.20 and 0.50 mg/kg. Calibration standards in acetone were also prepared at the same concentration levels. All of the standards were kept in a freezer at -20°C until use.

Sample extraction and cleanup procedure

Ten grams of properly homogenized vegetable sample was taken in a 50-mL screw-capped polypropylene centrifuge tube, and 10 ml acetonitrile (MeCN) contain 1% acetic acid was added into the centrifuge tube. The centrifuge tube was closed properly and shaken vigorously for 30s by vortex mixer. Then, 4g anhydrous MgSO₄, 1g sodium chloride, 1g trisodium citrated dehydrate and 0.5g disodium hydrogen citrated sesquihydrate were added into the centrifuge tube, and it was shaken by vortex mixer for 1 minute. afterward, the extract was centrifuged for 5 minutes at 5,000 rpm. An aliquot of 1 mL of the MeCN layer was transferred into a micro centrifuge tube containing 150 mg anhydrous MgSO₄, 25 mg PSA, 2.5 mg GCB for cabbage or containing 150 mg anhydrous MgSO₄, 7.5 mg GCB for peppergrass, carrot and radish or containing 150 mg anhydrous MgSO₄ and 25 mg PSA for onion and lettuce. The content of the centrifuge tube was thoroughly mixed by vortex for 30 s and centrifuged for 5 minutes at 4,000 rpm. A one mL supernatant was taken into a clean test tube, and one drop of toluene was added into the test tube. The test tube containing the extract was stored at -20°C until analysis.

Gas chromatography-Mass spectrometry analyses

A Shimadzu (QP 2010 GC-MS) gas chromatography equipped with mass selective detector and an RTX-5MS column (30m long, 0.25 mm internal diameter; and 0.25 nm film thickness) was used for analysis. Sample injection was performed in the split less mode, with an injector temperature of 250°C. The temperature of the was programmed from an initial value of 60°C for 2 minutes, ramped to 150°C at 10°C/min for 10 minutes, and to 250°C at 10°C/min for 10 minutes and was raised to 270°C at 10°C/min for 15 minutes. Helium (99.999% purity) was used as a carrier gas with a constant flow rate of 1 mL/min. For the mass detector MS the ion source and interface temperatures were maintained at 220 and 270°C, respectively. Electron ionization (EI) was used at 70 eV in selective ion monitoring (SIM) and full-scan modes between 50 m/z and 500 m/z for the detection of different analytes. The solvent cut and total run time were 5 and 53 minutes, respectively

Quality control

The performance of the QuEChERS method was evaluated by performing recovery studies. The recovery rate and precision of the method (expressed as relative standard deviation (RSD), %) were measured by analyzing replicate pesticide-free samples of each type of vegetable, which were fortified at a concentration of 0.01 or 0.05 mg/kg for each pesticide. Sensitivity was evaluated by determining the limit of detection (LOD) and limit of quantification (LOQ), using the signal-to-noise ratio (S/N) of 3:1 and 10:1, respectively [13].

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Results
Pesticide residues in analyzed samples
The level of pesticide residues in 126 vegetable samples was determined. Pesticide residues were not detected in 87 samples (69%), while 39 samples (31%) contained detectable amount of pesticide residues. The percentage of contaminated vegetable samples was not high especially for carrot (22%). Peppergrass (39%), onion (47%) and cabbage (61%) had the highest percentage of contaminated samples. No pesticide residues were detected in any of the lettuce, and radish samples (Figure 1 and 2).

Figure 1: Percentages of samples without pesticides residue and with pesticides residue from the total number of samples analyzed.

Figure 2: Percentages of contamination and non-contamination of different type of vegetable analyzes with pesticides residues.

Detection frequencies of pesticides in analyzed samples

From the 30 pesticides studied, only 7 pesticides were detected in the analyzed vegetable samples. The most common pesticide detected was Chlorpyrifos (11 samples) with concentration range between 0.011 - 0.211 mg/kg and mean of 0.0835 mg/kg. Eight samples were contaminated by each of Cypermethrin, Deltamethrin and Dimethoate with concentration range of (0.0459 - 0.528), (0.016 - 0.324) and (0.021 - 0.235) mg/kg and mean of 0.1683, 0.1186 and 0.0958 mg/kg respectively. Three samples were contaminated by each of Profenofos and lambda cyhalothrin with concentration range of (0.007 - 0.012) and (0.052 - 0.238) mg/kg and mean of 0.0093 and 0.1606 mg/kg respectively. Only two samples found to be contaminated with Chlorpyrifos-methyl with concentration range between 0.014 - 0.016 mg/kg and mean of 0.0150 mg/kg (Table 1).

Table 1: Means and ranges of pesticides found in analyzed vegetable samples.

<table>
<thead>
<tr>
<th>Pesticides</th>
<th>Sample Information</th>
<th>Range</th>
<th>Mean of (+)</th>
<th>Mean of total</th>
<th>Std D</th>
<th>Mean Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total No</td>
<td>No of (+)</td>
<td>% of (+)</td>
<td>mg/kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorpyrifos</td>
<td>126</td>
<td>11</td>
<td>8.7</td>
<td>0.011-0.211</td>
<td>0.0835</td>
<td>0.00860</td>
</tr>
<tr>
<td>Chlorpyrifos methyl</td>
<td>126</td>
<td>2</td>
<td>1.6</td>
<td>0.014-0.016</td>
<td>0.0150</td>
<td>0.00024</td>
</tr>
<tr>
<td>Cypermethrin</td>
<td>126</td>
<td>8</td>
<td>6.3</td>
<td>0.045-0.528</td>
<td>0.1683</td>
<td>0.01068</td>
</tr>
<tr>
<td>Deltamethrin</td>
<td>126</td>
<td>8</td>
<td>6.3</td>
<td>0.016-0.324</td>
<td>0.1186</td>
<td>0.00787</td>
</tr>
<tr>
<td>Dimethoate</td>
<td>126</td>
<td>8</td>
<td>6.3</td>
<td>0.021-0.235</td>
<td>0.0958</td>
<td>0.00608</td>
</tr>
<tr>
<td>lamdacyhalothrin</td>
<td>126</td>
<td>3</td>
<td>2.4</td>
<td>0.052-0.238</td>
<td>0.1606</td>
<td>0.00383</td>
</tr>
<tr>
<td>Profenofos</td>
<td>126</td>
<td>3</td>
<td>2.4</td>
<td>0.007-0.012</td>
<td>0.0093</td>
<td>0.00022</td>
</tr>
</tbody>
</table>

Comparison of pesticides residues in markets and seasons in analyzed samples

The vegetables sample analyzed in summer from Khartoum central market pesticides residues found in four types of samples 2 samples of onion contaminated with chlorpyrifos or dimethoate, 2 samples of cabbage contaminated with deltamethrin or cypermethrin, one carrot sample contaminated with profenofos and one sample of peppergrass contaminated with cypermethrin; but in Khartoum north market only three type of vegetables sample have been contaminated with pesticides residues 3 onion samples contaminated from them 2 with chlorpyrifos and one samples with dimethoate, 2 cabbage samples contaminated with deltamethrin or cypermethrin, one sample of peppergrass contaminated with cypermethrin; but in omdurman pesticides residues found in four types of samples 2 onion samples contaminated with chlorpyrifos, 2 cabbage samples contaminated with deltamethrin or cypermethrin, one carrot sample contaminated with chlorpyrifos methyl and peppergrass one sample contaminated with Cypermethrin. In autumn vegetable samples from Khartoum central market show contamination of onion with chlorpyrifos in two samples, cabbage with deltamethrin and lambda cyhalothrin, carrot with chlorpyrifos methyl and peppergrass with deltamethrin and cypermethrin; but in Khartoum north onion show contamination with chlorpyrifos and dimethoate, cabbage and peppergrass shown contamination with cypermethrin; but in omdurman pesticides residues found in three types of samples 2 onion samples contaminated with dimethoate and one with chlorpyrifos, 2 cabbage samples contaminated with deltamethrin or lambda cyhalothrin, one carrot sample contaminated with profenofos and no contamination with pesticides appear in peppergrass. In winter only onion appear contamination with chlorpyrifos and dimethoate or dimethoate from Khartoum central market and Khartoum north respectively; but in omdurman pesticides residues found in two types of samples 2 onion samples contaminated with dimethoate or chlorpyrifos and deltamethrin in peppergrass (Table 2).

Multiple residues and MRL exceedances in vegetables samples

Onion was only kind of vegetables show the multi residues with 5.5% and 1.6% of onion samples and total analyzed samples; two onion samples contaminated with chlorpyrifos and dimethoate. From the 39 samples contain pesticides residues only 14 samples contain
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pesticides above EC MRL with 11.1% and 35.9% of the total and present samples respectively [13]. In onion only one sample contain chlorpyrifos and 8 samples contain dimethoate above the MRL, in cabbage only 4 samples contain deltamethrin or lambda cyhalothrin above the MRL, in carrot only 2 samples contain chlorpyrifos methyl above the MRL and no peppergrass shown any kind of pesticides above the MRL.

<table>
<thead>
<tr>
<th>Market</th>
<th>Season</th>
<th>Type of Sample</th>
<th>Pesticide found and amount (mg/kg)</th>
<th>No (+)</th>
<th>No above MRL</th>
<th>EC MRL [22]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khartoum central</td>
<td>Summer</td>
<td>Onion</td>
<td>Chlorpyrifos (0.011)</td>
<td>1</td>
<td>0</td>
<td>0.2</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Dimethoate (0.021)</td>
<td>1</td>
<td>1</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cabbage</td>
<td>Deltamethrin (0.096)</td>
<td>1</td>
<td>0</td>
<td>0.1</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Cypermethrin (0.082)</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carrot</td>
<td>Profenofos (0.009)</td>
<td>1</td>
<td>0</td>
<td>0.01</td>
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<tr>
<td></td>
<td></td>
<td>Peppergrass</td>
<td>Cypermethrin (0.045)</td>
<td>1</td>
<td>0</td>
<td>0.7</td>
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<tr>
<td></td>
<td>Autumn</td>
<td>Onion</td>
<td>Chlorpyrifos (0.058, 0.09)</td>
<td>2</td>
<td>0</td>
<td>0.2</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Deltamethrin (0.173)</td>
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<td></td>
<td>Cabbage</td>
<td>Lambda cyhalothrin (0.052)</td>
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<td>Chlorpyrifos methyl (0.016)</td>
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<td></td>
<td>Carrot</td>
<td>Deltamethrin (0.052)</td>
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<td>0</td>
<td>2</td>
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<tr>
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<td></td>
<td>Peppergrass</td>
<td>Cypermethrin (0.284)</td>
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<td>0</td>
<td>0.7</td>
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<td>Winter</td>
<td>Onion</td>
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<td>Dimethoate (0.125)</td>
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<td>0.01</td>
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<td>Khartoum North</td>
<td>Summer</td>
<td>Onion</td>
<td>Chlorpyrifos (0.165, 0.211)</td>
<td>2</td>
<td>1</td>
<td>0.2</td>
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<td>Dimethoate (0.088)</td>
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<td>Cabbage</td>
<td>Deltamethrin (0.324)</td>
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<td>Cypermethrin (0.124)</td>
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<td>Deltamethrin (0.094)</td>
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<td>2</td>
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<td>Chlorpyrifos (0.095)</td>
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<td>0.2</td>
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<td>Dimethoate (0.111)</td>
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<td></td>
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<td>1</td>
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<tr>
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<td></td>
<td>Peppergrass</td>
<td>Cypermethrin (0.079)</td>
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<tr>
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<td>Winter</td>
<td>Onion</td>
<td>Dimethoate (0.022)</td>
<td>1</td>
<td>1</td>
<td>0.01</td>
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</table>

**Table 2:** Comparison between markets and seasons in pesticides residues found in vegetables.

**Discussion**

This study shows the evidence of contamination of vegetables with pesticides residues in Khartoum markets. Slightly more than 30% of the samples analyzed contained pesticides residues and from present samples more than 39% above MRL. Only lettuce and reddish were free from detectable residues in all seasons and markets and these results were similar to the result of Hamad [14], he reported total absence of pesticides in lettuce during summer season. In previous studies some vegetables from Ghana [15], Sudia Arabia [16] and China [17] contain organochlorine pesticides which were banned or restricted in majority of countries but in this study no any kind of vegetables analyzed contained organochlorine pesticides residues. This study were shown contamination of pepper grass with two kind of insecticides cypermethrin and deltamethrin and this result is same in detected of cypermethrin with previous study with Lee and others. In carrot chlorpyrifos methyl and profenofos were detected; all chlorpyrifos methyl were above the MRL in previous study in India by Ananda and others [18] chlorpyrifos were detected in the most carrot samples from Karnataka in other study in Bangladesh by Alamgir and others [19] also chlorpyrifos were detected in carrot in range of 0.03-0.4mg/kg with some level more than MRL. In onion chlorpyrifos and dimethoate were detected and most level of dimethoate was above the MRL and these results were also appeared in Alamgir study. Difference pyrethroids (Deltamethrin, Cypermethrin and Lambda cyhalothrin) were detected in cabbage samples analyzed other kind of pyrethroids (Bifenthrin, Fenpropatrin and Sanmarton) were detected in study by Thanh and others in Korea [20].

In the analysis of pesticides on fresh vegetables using GC, interference and contamination resulting from plant pigments and the matrix are often encountered. Although silica gel and florisil are commonly used to reduce the matrix effects, in this study activated carbon were another material used to remove the pigments from fresh vegetables. Activated carbon is often used because it is cheap and strongly adsorbs many organic compounds in some fresh vegetables [21]. The diversity of classes of pesticide residues such as organophosphorus (Chlorpyrifos, Dimethoate, Profenofos and Chlorpyrifos methyl) and pyrethroids (Deltamethrin, Cypermethrin and Lambda cyhalothrin) detected in this study show that the proposed method, to determine residues of pesticides in various classes of vegetables is rapid, simple, sensitive and uses smaller amount of organic solvents, reducing the risk for workers and the environment [22].

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**Conclusion**

This study investigated the levels of pesticide residues in vegetables and compared this level between seasons and markets in Khartoum state in Sudan. The results indicated that most of the vegetable samples were contaminated with pesticide residues, with some concentrations above the MRL. The observed levels of pesticide residues may pose a potential health risk to consumers. Therefore, to reduce this risk, farmers may sensitized to better pesticide safety practices and the need for continuous pesticide residue monitoring is highly recommended.

**Bibliography**


8. CSN EN 15662. "Foods of plant origin- determination of pesticide residues using GC-MS and/or LC-MS/MS following acetonitrile extraction/partitioning and clean-up by dispersive SPE QuEChERS method" (2008).


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