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# Residues and Risk Assessment of Abamectin, Chlorpyrifos and Pyriproxyfen in Cucumber Plants under the Greenhouse Conditions

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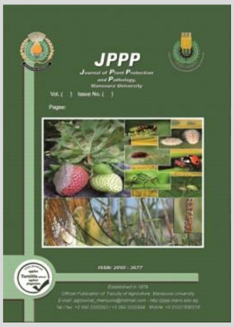


## ABSTRACT

The residual behavior of abamectin (Vertimec 1.8% EC), chlorpyrifos (PestBan 48% EC), and pyriproxyfen (Admiral 10% EC) in cucumber fruits and leaves under greenhouse conditions was investigated. The pesticides were applied as foliar sprays at recommended doses: 0.5, 2 and 0.5 ml/liter for abamectin, chlorpyrifos, and pyriproxyfen, respectively. After treatment, cucumber fruits were sampled in triplicate at intervals of two hours (initial), and 1, 3, 6, 9, 12, and 15 days post-application. Residues were extracted using the QuEChERS method and analyzed by HPLC-UV for abamectin and pyriproxyfen, andGC-FPDfor chlorpyrifos. The study found that all three pesticides dissipated over the 15 days post-application, though chlorpyrifos residues were higher in the fruits compared to pyriproxyfen and abamectin. Initial pesticide levels in cucumber leaves were also higher than in fruits. The calculated half-life($t_{½}$)in cucumber fruits was 1.66, 1.48 and 2.09 days for abamectin, chlorpyrifos, and pyriproxyfen, while in leaves the half-lives were 2.82, 3.08, and 4.06 days, respectively. Dissipation percentages in residue amounts were higher in cucumber fruits than leaves. Residue levels in cucumber fruits exceeded the maximum residue limits (MRLs) up to 3 days for abamectin, and up to 6 days for both chlorpyrifos and pyriproxyfen after spraying, therefore the pre-harvest intervals (PHI) for safe consumption were determined to be 6 days for abamectin, and 9 days for chlorpyrifos and pyriproxyfen. Washing cucumber fruits with tap water, 10% acetic acid, or 1% sodium bicarbonate for 10 minutes significantly reduced pesticide residue levels. Overall, the residues posed a low health risk to consumers.

***Keywords***: abamectin, chlorpyrifos, pyriproxyfen, QuEChERS, residues, cucumber, residues, risk assessment.

## INTRODUCTION

Cucumber (*Cucumis sativus* L.) is highly vulnerable to numerous insect pests, which attack the plant from its vegetative to reproductive stages, causing significant damage, reducing productivity, and increasing farming costs (Hegab, *et al.*, 2016; Adly & Sanad, 2024). Among these pests are various sucking insects, such as *Bemisia tabaci* (Gennadius), *Aphis gossypii* Glover, *Empoasca lybica* (Bergevin), *Thrips tabaci* Linde, and *Tetranychus urticae* Koch. These pests directly impact crop yield by piercing plant tissues and extracting sap from phloem cells or other tissues in the foliage or fruit, disrupting the photosynthesis process by secreting honeydew. Additionally, these pests cause indirect damage by transmitting diseases such as Leaf Cotton Curl Virus and Yellow Vein Mosaic Virus (Tantawy *et al*.,2018; Ismail *et al.*, 2020; Abdallah *et al.*, 2020; Arafa, 2020). Pest control is crucial for ensuring adequate agricultural production, and insecticides have played a significant role in managing many pests affecting cucumber plants.

Pesticides are essential for managing biological threats and increasing crop yields. It is estimated that over 30% of global agricultural output has been preserved due to pesticide use. The global consumption of pesticides has steadily increased, reaching 4.298 million metric tons in 2023 (FAO, 2023). Pesticides are often applied extensively, especially during the fruiting stage, but without observing safe waiting periods. The indiscriminate use of pesticides results in undesirable levels of pesticide residues in marketable vegetables (Kumari *et al.*, 2002). The pesticide residues in food have become a significant concern, posing a serious threat to food security and public health. Public health authorities must prioritize reducing pesticide residues to mitigate environmental and health risks. Pesticides have been linked to harmful effects in humans, including cancer, congenital defects, heart disease, Parkinson's disease, and Alzheimer's disease (Mostafalou & Abdollahi, 2013).

Abamectin, a member of the avermectin family (produced through fermentation of the soil bacteria *Streptomyces avermitilis* as a mixture of avermectin B1a and B1b), has been shown to exhibit variable toxicity against lepidopteran pests. It is recognized as a potent broad-spectrum acaricide and a narrow-spectrum insecticide (Lasota & Dybas, 1991). Abamectin has unparalleled antiparasitic properties, making it effective against a wide range of nematodes, arachnids, and insects (Molinari *et al.*, 2010). It is widely used as an active ingredient in insecticides and nematicides for agricultural purposes (Novelli *et al.*, 2012).

Chlorpyrifos (*O,O*-diethyl *O*-(3,5,6- trichloro-2-pyridinyl) phosphorothioate is one of the most widely used organophosphate insecticides globally. It has played a crucial role in pest management across various regions of the world (Sultatos & Murphy, 1983; Sultatos *et al.*, 1984; Tomlin, 2006).

Pyriproxyfen, chemically known as 2-[1-methyl-2-(4-phenoxyphenoxy) ethoxyl] pyridine, is a new-generation insect growth regulator (IGR) and juvenile hormone analog. As a stable aromatic compound, it disrupts the insect’s hormonal system by overstimulating it, leading to impaired egg production, reduced brood care, and disruption of social

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behaviors, ultimately inhibiting insect growth and development (Glancey, *et al*., 1990; Devillers, 2009).

In light of this information, the objective of the study was to evaluate the residues of abamectin, chlorpyrifos and pyriproxyfen in cucumber fruits and leaves. The effects of washing with tap water, acetic acid 10%, and sodium bicarbonate 1 % to remove their residues from treated cucumber fruits were also examined.

## MATERIALS AND METHODS

**Insecticides**

Chlorpyrifos-Ethyl (PestBan 48% EC) was supplied by Agrochem Co., Egypt; Abamectin (Vertimec 1.8% EC) was supplied by Syngenta Chemical Co., Egypt; and Pyriproxyfen (Admiral 10% EC) was supplied by Sumitomo Chemical Co. Ltd.

**Spraying process:**

The field experiment was conducted using a completely randomized block design with three replicates for each pesticide treatment. The plot size was 10x6 m², and the study took place in the Nobaria district, Beheira Governorate. Pesticides were applied using a 20-liter motor sprayer at the recommended doses: 0.5, 2 and 0.5 ml/liter for abamectin, chlorpyrifos, and pyriproxyfen, respectively, as accredited by the Ministry of Agriculture of Egypt. A buffer zone of approximately two meters separates each plot to prevent cross-contamination. Control plots were left untreated. Samples of fruits and leaves were collected at intervals of 2 h, 1, 3, 6, 9, 12, and 15 days after pesticides application to study the dissipation of the tested insecticides. Additionally, fruit samples collected at 2 hours, 1 day, and 3 days post-treatment were subjected to different washing solutions (tab water, acetic acid 10% and sodium bicarbonate 1 %) for 10 minutes to assess the effectiveness of washing in removing the residues of the three pesticides.

**Extraction, clean up procedures and residues determination**

The extraction and clean-up of cucumber samples according to QuEChERS method, as described by Anastassiades *et al.* (2003) as follows:

**Homogenization:** Half a kg of samples was homogenized using a blender, and 10 g of homogenized cucumber fruits or leaves were transferred into a 50-mL centrifuge tube.

**Extraction:** 15 mL of acetonitrile with 1.0% acetic acid was added to the tube, and the mixture was shaken vigorously for 1 minute. Next, 4 g of anhydrous magnesium sulfate and 1 g of sodium acetate were added, followed by vigorous shaking for an additional 5 minutes. The mixture was then centrifuged at 5000 rpm for 5 minutes.

**Clean-up:** 5 mL of the supernatant was transferred to a 15-mL centrifuge tube, where it was shaken with 50 mg of primary secondary amine (PSA), 10 mg of graphitized carbon black, and 150 mg of magnesium sulfate. The tube was centrifuged for 10 minutes at 6000 rpm.

The resulting supernatant containing abamectin and pyriproxyfen was analyzed using an Agilent 1260 HPLC system. The mobile phase consisted of acetonitrile and water in ratios of 90:10 for abamectin, and 60:40 for pyriproxyfen, at a flow rate of 1 mL/min with detection set at 220 for abamectin and 260 nm for pyriproxyfen (Farouk, *et al*., 2014; Abdelfatah, *et al*., 2024). The resulting supernatant containing chlorpyrifos was analyzed using GC model 6890 equipped with a Ni63 electron capture detector. Nitrogen was the carrier gas, flowing at 4 mL/min. The injector was set at 300°C and the detector at 320°C. The column temperature was programmed to start at 220°C for 2 minutes, then increased by 10°C/min until 280°C. This method followed QUECHERS (2009) and AOAC (2005) guidelines (Extraction, clean-up and determination were conducted in the center laboratory of residues analysis of pesticides and heavy metals in food).

**Recovery samples and statistical analysis**

A recovery assay was conducted using untreated cucumber fruits and leaves, which were homogenized before being spiked with 0.05, 0.1 and 1 mg/kg concentrations of abamectin, chlorpyrifos, and pyriproxyfen, respectively. The spiked samples underwent extraction, cleanup, and quantitative determination using the procedure previously described. All results were corrected based on the recovery values.

The degradation rate and half-life of abamectin, chlorpyrifos, and pyriproxyfen were calculated following the method of Gomaa and Belal (1975). A plot was made of the logarithm of abamectin, chlorpyrifos, and pyriproxyfen residue concentrations versus time intervals, and a straight line was fitted using the Excel trend line tool. The intercept represented the logarithm of the initial concentration, and the slope of the line was calculated. Based on this, the degradation rate constant (K) of abamectin, chlorpyrifos, and pyriproxyfen and their half-life ($t_{½}$) in fruits and leaves were determined using the following formulas:

- Degradation rate constant (K) = 2.303 × slope.
- Half-life ($t_{½}$) = 0.693 / K.

**Risk assessment of abamectin, chlorpyrifos and pyriproxyfen insecticides in cucumber fruits**

Risk assessment of abamectin, chlorpyrifos, and pyriproxyfen in cucumber fruits was conducted by estimating dietary exposure and calculating the risk quotient (R.Q.). The dietary exposure dose (E.E.D.) was determined using the formula:

**Estimated dietary exposure dose (E.D.E.D.) and risk quotient (R.Q.)**

Dietary exposure calculation and risk assessment were calculated using the following equations:

**E.E.D. = residue limit (mg/kg) × daily cucumber intake (Kg/capita/day) (0.03492/60)**

**Risk Quotient R.Q. = E.E.D./acceptable daily intake (ADI) (mg/kg bw)**

For an Egyptian adult with an average body weight of 60 kg, the estimated cucumber consumption is 34.92 g per day (0.03492 kg/person/day) as reported by the Food and Agriculture Organization in 2011. The acceptable daily intake (ADI) values for abamectin, chlorpyrifos, and pyriproxyfen were 0.001, 0.01, and 0.03 mg/kg body weight per day, respectively (Codex Alimentarius Commission, 2016). A risk quotient (R.Q.) greater than one indicates an unacceptable human risk, while an R.Q. below one signifies minimal risk (Zhang *et al*., 2009).

## RESULTS AND DISCUSSION

**Results**

Validation parameters: The data in Table 1 showed that recovery percentages in cucumber fruits ranged from 90.67% to 94.33% for abamectin, 94% to 98.67% for chlorpyrifos, and 88.67% to 93.67% for pyriproxyfen. In cucumber leaves, recovery percentages varied from 96.67% to 101.67% for abamectin, 95.33% to 100.33% for chlorpyrifos, and 94% to 99.33% for pyriproxyfen. According to the European Commission's accepted range for recovery (80–110%) and a relative standard deviation (RSD) below 20% (Sanco, 2021), the results are satisfactory. In fruits, RSD values ranged from 1.32% to 2.27% for abamectin, 2.18% to 3.13% for chlorpyrifos, and 1.41% to 3.93% for pyriproxyfen. In leaves, RSD ranged from 0.49% to 2.02% for abamectin, 0.48% to 3.76% for chlorpyrifos, and 1.26% to 2.61% for pyriproxyfen. These values were within the acceptable range. The lowest detectable residue concentrations were determined by comparing the peak areas of standards with those of spiked or unknown samples under identical conditions.

**Table 1. The recovery percentages and the relative standard deviation (RSD) of abamectin, Chlorpyrifos and pyriproxyfen at spiked levels 1, 0.1, and 0.05 mg/kg.**

| | Spiked level (mg/kg) | Abamectin | | Chlorpyrifos | | Pyriproxyfen | |
|---|---|---|---|---|---|---|---|
| | | % of Recovery± SD | % RSD | % of Recovery± SD | % RSD | % of Recovery± SD | % RSD |
| Fruits | 1 | 90.67±2.05 | 2.27 | 94±2.94 | 3.13 | 93.67±3.68 | 3.93 |
| | 0.1 | 94.33±1.25 | 1.32 | 98.67±2.49 | 2.53 | 92.67±2.05 | 2.22 |
| | 0.05 | 90.67±1.25 | 1.38 | 94.33±2.05 | 2.18 | 88.67±1.25 | 1.41 |
| Leaves | 1 | 101.67±2.05 | 2.02 | 100.33±3.77 | 3.76 | 99.33±1.25 | 1.26 |
| | 0.1 | 97.67±1.25 | 1.28 | 97.67±0.47 | 0.48 | 94±2.45 | 2.61 |
| | 0.05 | 96.67±0.47 | 0.49 | 95.33±2.87 | 3.01 | 97.33±2.36 | 2.42 |

**Residues of abamectin**

Abamectin residue levels on cucumber fruits and leaves after a single application of the insecticide are shown in Table 2 and Fig. 1. Two hours post-treatment, the residue concentrations were 0.916 mg a.i./kg on fruits and 1.331 mg a.i./kg on leaves. Dissipation percentages on fruits were 59.28%, 91.16%, 98.03%, 98.91%, 99.45%, and 99.89% after 1, 3, 6, 9, 12, and 15 days, respectively. On leaves, dissipation percentages were 44.18%, 69.12%, 83.25%, 90.76%, 93.99%, and 98.42% over the same time period. After 15 days, abamectin residues declined to 0.001 mg a.i./kg on fruits and 0.0021 mg a.i./kg on leaves.

The degradation rate constant (k) and half-life ($t_{1/2}$) values were also calculated. On fruits, k was 0.417, with a $t_{1/2}$ of 1.66 days, while on leaves, k was 0.245 with a $t_{1/2}$ of 2.82 days. The higher residue deposits on leaves compared to fruits were likely due to the larger exposed surface area of the leaves, as fruits are often shielded. The faster rate of dissipation rate on fruits suggests greater loss due to growth dilution and enzymatic activity, as Hill *et al.* (1982) noted.

**Table 2. Residues of abamectin detected in cucumber fruits and leaves under the greenhouse conditions at different time intervals from the application**

| Days after treatment | Fruits (mg/Kg)* | Dissipation % | Persistence | Leaves (mg/Kg)* | Dissipation% | Persistence |
|---|---|---|---|---|---|---|
| 0 (2 hr.) | 0.916±0.04 | - | - | 1.331±0.06 | - | - |
| 1 | 0.373±0.04 | 59.28 | 40.72 | 0.743±0.027 | 44.18 | 55.82 |
| 3 | 0.081±0.007 | 91.16 | 8.84 | 0.411±0.01 | 69.12 | 30.88 |
| 6 | 0.018±0.003 | 98.03 | 1.97 | 0.223±0.015 | 83.25 | 16.75 |
| 9 | 0.01±0.004 | 98.91 | 1.09 | 0.123±0.015 | 90.76 | 9.24 |
| 12 | 0.005±0.001 | 99.45 | 0.55 | 0.08±0.02 | 93.99 | 6.01 |
| 15 | 0.001±0 | 99.89 | 0.11 | 0.021±0.004 | 98.42 | 1.58 |
| K | 0.4173 | | | 0.2455 | | |
| $T_{1/2}$ | 1.6606 | | | 2.8225 | | |

**K = Rate of degradation, T 1/2= Half-life values, * average of three replicates**

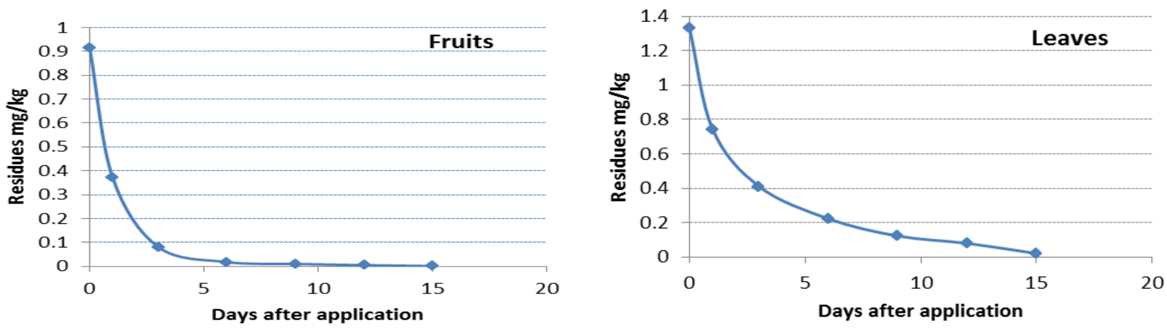



**Figure 1. Decline patterns of abamectin in cucumber fruits and leaves**

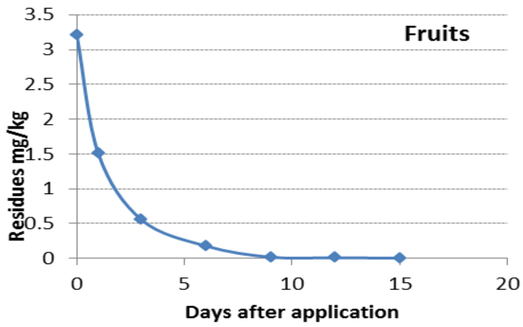
**Residues of chlorpyrifos**

Table 3 shows chlorpyrifos' residues and dissipation percentages on cucumber fruits and leaves. The initial deposits, two hours after treatment, were 3.208 mg/kg on fruits and 6.411 mg/kg on leaves. These levels decreased to 1.506 mg/kg on fruits and 3.112 mg/kg on leaves one day post application, corresponding to dissipation rates of 53.05% and 51.46%, respectively. Chlorpyrifos residues in fruits and leaves gradually declined to 0.556, 0.178, 0.018, 0.01, and 0.003 mg/kg (fruits) and 2.036, 1.116, 0.555, 0.284, and 0.187 mg/kg (leaves) after 3, 6, 9, 12, and 15 days, respectively. These reductions correspond to loss rates of 82.67%, 94.45%, 99.44%, 99.69%, and 99.91% in fruits, and 68.24%, 82.59%, 91.34%, 95.57%, and 97.08% in leaves. The half-life ($t_{0.5}$) of chlorpyrifos was 1.4818 days for fruits and 3.08326 days for leaves, with degradation rate constants (k) of 0.468 for fruits and 0.225 for leaves. These results show that chlorpyrifos degraded faster in cucumber fruits than in leaves (Fig. 2).

**Table 3. Residues of chlorpyrifos detected in cucumber fruits and leaves under the greenhouse conditions at different time intervals from the application**

| Days after treatment | Fruits(mg/Kg)* | Dissipation% | Persistence | Leaves(mg/Kg) | Dissipation% | Persistence |
|---|---|---|---|---|---|---|
| 0 (2 hr.) | 3.208±0.2 | - | - | 6.411±0.26 | - | - |
| 1 | 1.506±0.03 | 53.05 | 46.95 | 3.112±0.02 | 51.46 | 48.54 |
| 3 | 0.556±0.05 | 82.67 | 17.33 | 2.036±0.012 | 68.24 | 31.76 |
| 6 | 0.178±0.016 | 94.45 | 5.55 | 1.116±0.012 | 82.59 | 17.41 |
| 9 | 0.018±0.004 | 99.44 | 0.56 | 0.555±0.005 | 91.34 | 8.66 |
| 12 | 0.01±0.002 | 99.69 | 0.31 | 0.284±0.008 | 95.57 | 4.43 |
| 15 | 0.003±0.001 | 99.91 | 0.09 | 0.187±0.01 | 97.08 | 2.92 |
| K | 0.46767 | | | 0.2247 | | |
| $T_{1/2}$ | 1.4818 | | | 3.08326 | | |

**K = Rate of degradation, T 1/2= Half-life values, * average of three replicates**



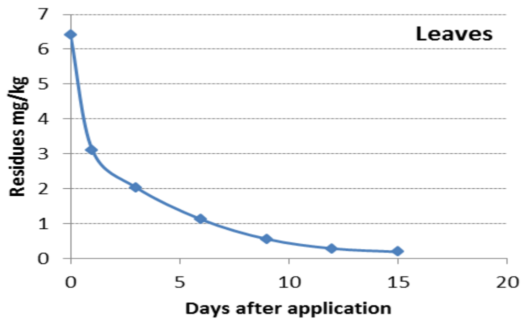




**Figure 2. Decline patterns of chlorpyrifos in cucumber fruits and leaves**

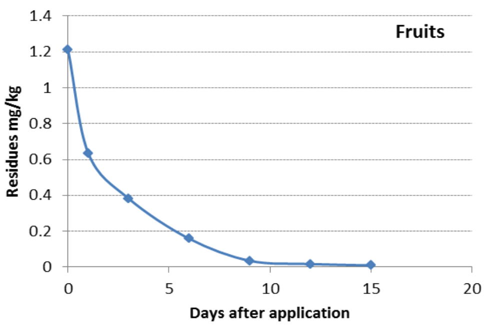
**Residues of pyriproxyfen**

The data in Table 4 show the levels of pyriproxyfen residues on cucumber fruits and leaves at various intervals after the last foliar application. The initial deposit of pyriproxyfen, two hours after application, was 1.213 mg/kg on fruits. Residue levels then decreased to 0.635, 0.382, 0.158, 0.035, 0.017, and 0.009 mg/kg after 1, 3, 6, 9, 12, and 15 days, respectively. The corresponding percentage loss rates were 47.65%, 68.51%, 86.97%, 97.11%, 98.6%, and 99.26% over the same intervals. On cucumber leaves, the initial deposit of pyriproxyfen two hours after application was 2.077 mg/kg. Residue levels subsequently decreased to 1.121, 0.734, 0.538, 0.391, 0.198, and 0.118 mg/kg after 1, 3, 6, 9, 12, and 15 days, respectively. The calculated half-life ($t_{1/2}$) values for pyriproxyfen were 2.09 days for fruits and 4.0592 days for leaves, with corresponding degradation rates (k) of 0.3315 for fruits and 0.1707 for leaves. These results indicate that pyriproxyfen degraded more rapidly in cucumber fruits than in leaves (Fig. 3).

**Table 4. Residues of pyriproxyfen detected in cucumber fruits and leaves under the greenhouse conditions at different time intervals from the application**

| Days after treatment | Fruits (mg/Kg)* | Dissipation % | Persistence | Leaves (mg/Kg) | Dissipation % | Persistence |
|---|---|---|---|---|---|---|
| 0 (2 hr.) | 1.213±0.031 | - | - | 2.077±0.031 | - | - |
| 1 | 0.635±0.019 | 47.65 | 52.35 | 1.121±0.01 | 46.03 | 53.97 |
| 3 | 0.382±0.024 | 68.51 | 31.49 | 0.734±0.034 | 64.66 | 35.34 |
| 6 | 0.158±0.012 | 86.97 | 13.03 | 0.538±0.02 | 74.1 | 25.9 |
| 9 | 0.035±0.008 | 97.11 | 2.89 | 0.391±0.017 | 81.17 | 18.83 |
| 12 | 0.017±0.003 | 98.6 | 1.4 | 0.198±0.022 | 90.47 | 9.53 |
| 15 | 0.009±0.001 | 99.26 | 0.74 | 0.118±0.013 | 94.32 | 5.68 |
| K | 0.3315 | | | 0.1707 | | |
| $T_{1/2}$ | 2.09029 | | | 4.0592 | | |

**K = Rate of degradation, T 1/2= Half-life values, * average of three replicates**



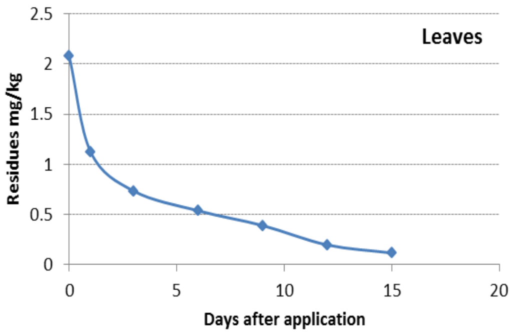




**Figure 3. Decline patterns of pyriproxyfen in cucumber fruits and leaves**

**Pre-harvest intervals (PHI) of abamectin, chlorpyrifos and pyriproxyfen**

The residue of abamectin in cucumber fruits was below MRL (0.02 mg/kg) (according to Codex Alimentarius Commission for Pesticide Residues, 2023) after six days of its application at the recommended rate. On the other hand, the residue of chlorpyrifos was below MRL (0.02 mg/kg) after nine days (according to Codex Alimentarius

Commission for Pesticide Residues, 2008). Also, the residue of pyriproxyfen was below MRL (0.04 mg/ kg, EU, 2024) after nine days (according to the Codex Alimentarius Commission for Pesticide Residues, 2019). The levels of residues were above MRL up to 3, 6, and 6 DAS (days after spray) for abamectin, chlorpyrifos, and pyriproxyfen, respectively, in cucumber fruits.

**Effect of different washing solutions on the removal of abamectin, chlorpyrifos, and pyriproxyfen residues from treated cucumber fruits**

The data in Table 5 provide insights into the residues of abamectin, chlorpyrifos, and pyriproxyfen on cucumber fruits, along with the associated removal percentages after applying different washing solutions and treatments. The results show that, two hours after pesticide application, the residues of abamectin, chlorpyrifos, and pyriproxyfen on raw, unwashed cucumber fruits were 0.916, 3.208, and 1.213 mg/kg, respectively. Washing the fruits with tap water reduced the pesticide levels to 0.782 mg/kg for abamectin, 2.694 mg/kg for chlorpyrifos, and 0.984 mg/kg for pyriproxyfen, with corresponding removal percentages of 14.63%, 16.02%, and 18.88%. The use of sodium bicarbonate solution further reduced the residues to 0.716, 2.458, and 0.899 mg/kg for abamectin (21.83% removal), chlorpyrifos (23.38% removal), and pyriproxyfen (25.89% removal), respectively. The most effective washing solution was 10% acetic acid, which achieved residue reductions of 30.02%, 32.23%, and 34.71% for abamectin, chlorpyrifos, and pyriproxyfen, respectively.

After one day of post-treatment, the removal percentages using tap water were 15.28%, 17.66%, and 20.47% for abamectin, chlorpyrifos, and pyriproxyfen, respectively. Using acetic acid resulted in removal percentages of 33.24%, 33.53%, and 35.28%, while sodium bicarbonate removed 22.79%, 26.1%, and 26.93% of the residues for abamectin, chlorpyrifos, and pyriproxyfen , respectively. After three days, the removal percentages with tap water were 18.52%, 19.24%, and 23.3% for abamectin, chlorpyrifos, and pyriproxyfen, respectively. Acetic acid achieved 33.33%, 35.61%, and 36.65% removal, while sodium bicarbonate removed 25.93%, 28.06%, and 30.89% of the residues, respectively. These results indicate that acetic acid was the most effective washing solution in reducing pesticide residues on cucumber fruits.

**Table 5. Effect of different washing solutions on removal the abamectin, chlorpyrifos and pyriproxyfen residues from treated cucumber fruits:**

| Pesticides | Days after treatment | Initial deposits mg/kg | Tab water | | Acetic acid 10% | | Sodium bicarbonate 1% | |
|---|---|---|---|---|---|---|---|---|
| | | | mg/kg | Removal % | mg/kg | Removal % | mg/kg | Removal % |
| Abamectin | 0 | 0.916 | 0.782 | 14.63 | 0.641 | 30.02 | 0.716 | 21.83 |
| | 1 | 0.373 | 0.316 | 15.28 | 0.249 | 33.24 | 0.288 | 22.79 |
| | 3 | 0.081 | 0.066 | 18.52 | 0.054 | 33.33 | 0.06 | 25.93 |
| Chlorpyrifos | 0 | 3.208 | 2.694 | 16.02 | 2.174 | 32.23 | 2.458 | 23.38 |
| | 1 | 1.506 | 1.24 | 17.66 | 1.001 | 33.53 | 1.113 | 26.1 |
| | 3 | 0.556 | 0.449 | 19.24 | 0.358 | 35.61 | 0.4 | 28.06 |
| Pyriproxyfen | 0 | 1.213 | 0.984 | 18.88 | 0.792 | 34.71 | 0.899 | 25.89 |
| | 1 | 0.635 | 0.505 | 20.47 | 0.411 | 35.28 | 0.464 | 26.93 |
| | 3 | 0.382 | 0.293 | 23.3 | 0.242 | 36.65 | 0.264 | 30.89 |

**Risk assessment**

As presented in Table 6, the health risk quotients (RQ values) for abamectin, chlorpyrifos, and pyriproxyfen residues on cucumber fruits were calculated.

**Table 6. Residues means, estimated exposure dose, and risk quotient (RQ) of abamectin, chlorpyrifos and pyriproxyfen in cucumber fruits under the greenhouse conditions at different time intervals from the application**

| Pesticides | Days after treatment | Residues means mg/kg | EED (mg/kg/bw/ day) | RQ | Health risk |
|---|---|---|---|---|---|
| Abamectin | 0 (2 hrs) | 0.916 | $5.33\times10^{-4}$ | 0.533 | No |
| | 1 | 0.373 | $2.1\times10^{-4}$ | 0.217 | No |
| | 3 | 0.081 | $4.71\times10^{-5}$ | 0.047 | No |
| | 6 | 0.018 | $1.05\times10^{-5}$ | 0.01 | No |
| | 9 | 0.01 | $5.82\times10^{-6}$ | 0.006 | No |
| | 12 | 0.005 | $2.92\times10^{-6}$ | 0.003 | No |
| | 15 | 0.001 | $5.82\times10^{-7}$ | 0.001 | No |
| Chlorpyrifos | 0 (2 hrs) | 3.208 | $1.87\times10^{-3}$ | 0.187 | No |
| | 1 | 1.506 | $8.76\times10^{-4}$ | 0.088 | No |
| | 3 | 0.556 | $3.24\times10^{-4}$ | 0.032 | No |
| | 6 | 0.178 | $1.04\times10^{-4}$ | 0.01 | No |
| | 9 | 0.018 | $1.05\times10^{-5}$ | 0.001 | No |
| | 12 | 0.01 | $5.82\times10^{-6}$ | 0.001 | No |
| | 15 | 0.003 | $1.75\times10^{-6}$ | 0.0002 | No |
| Pyriproxyfen | 0 (2 hrs) | 1.213 | $7.06\times10^{-4}$ | 0.235 | No |
| | 1 | 0.635 | $3.7\times10^{-4}$ | 0.123 | No |
| | 3 | 0.382 | $2.22\times10^{-4}$ | 0.074 | No |
| | 6 | 0.158 | $9.2\times10^{-5}$ | 0.031 | No |
| | 9 | 0.035 | $2.04\times10^{-5}$ | 0.007 | No |
| | 12 | 0.017 | $9.89\times10^{-6}$ | 0.003 | No |
| | 15 | 0.009 | $5.24\times10^{-6}$ | 0.002 | No |

The results showed that the RQ values for these insecticide residues were consistently below 1. This suggests that at the recommended application rates, the potential health risk from these residues in cucumbers is negligible. These findings are consistent with Abbassy et al. (2017), who found no significant risk quotients for chlorpyrifos-methyl and imidacloprid residues, while fipronil posed a potential risk depending on date consumption patterns. Similarly, Attia et al. (2024) reported that imidacloprid, thiamethoxam, and dinotefuran residues in tomatoes pose minimal health risks. Sardar et al. (2023) also found that low levels of cyantraniliprole and indoxacarb residues in wild garlic present minimal risk to human health.

**Discussion**

The persistence and degradation behavior of pesticides are shaped by numerous factors, including the stability of the active ingredient or its metabolites, along with properties like volatility, solubility, formulation, and the method and site of application (Cabras *et al*., 1989). Environmental conditions such as temperature, rainfall, humidity, and wind also play a crucial role. Additionally, plant-related factors including species, crop type, cuticle structure, growth stage and rate, the surface area treated, and the surrounding environment further influence how pesticides degrade or persist (Khay *et al*., 2008; Tewary *et al*., 2005; Fenoll, *et al*., 2009; Malhat *et al*. 2014).

The results of this study indicated that pyriproxyfen demonstrated greater persistence in cucumber fruits and leaves compared to abamectin and chlorpyrifos. After 15 days of application, the lowest residue levels detected were 0.001 and 0.021 mg/kg for abamectin, 0.003 and 0.187 mg/kg for chlorpyrifos, and 0.009 and 0.118 mg/kg for pyriproxyfen in cucumber fruits and leaves, respectively. The calculated half-life (t½) of these pesticides in cucumber fruits was 1.66 days for abamectin, 1.48 days for chlorpyrifos, and 2.09 days for pyriproxyfen, while in leaves the half-lives were 2.82, 3.08, and 4.06 days, respectively. The pre-harvest intervals (PHI) for safe consumption were established as 6 days for abamectin, and 9 days for both chlorpyrifos and pyriproxyfen. These findings are in line with El Masry *et al*. (2024), who reported a half-life of 1.69 days for pyriproxyfen and concluded that cucumbers could be safely harvested five days after application. Similarly, Soliman and Fergani (2021) found that pesticide residues on tomato fruits were below the Codex maximum residue limit (MRL) set at 1 mg/kg for chlorpyrifos-methyl and 0.4 mg/kg for lufenuron (EU, 2022) after pre-harvest intervals of 3 and 8 days, respectively. Regarding abamectin, our results align with Shalaby *et al*. (2020), who reported half-life values of 2.23 days on eggplant fruits and 3.58 days on leaves, with safe consumption recommended 9 days after treatment based on MRL standards. Washing with tap water and 1% acetic acid did not affect this period. In greenhouse-grown sweet pepper fruits, El-Kabbany *et al*. (2013) determined the PHI to be 3 days for abamectin, and 10, 21, and 21 days for diniconazole, methomyl, and phenthoate, respectively. Additionally, Algethami *et al*. (2022) found that the half-life of abamectin ranged from 2.11 to 2.42 days, with a recommended PHI of 7 *days at the* authorized dose and 10 days if the dose is doubled. AbdEl-Fatah et al. (2015) concluded that 10 and 14 days post-application on green beans and squash, respectively, were sufficient to reduce chlorpyrifos residues below the MRL. The half-lives of chlorpyrifos were reported as 2.88 days on green beans and 1.50 days on squash fruits.

## REFERENCES


Abdallah E. S. E. ; Samia, A.G. Metwally and Wafai, Z. A. Mikhail (2020). Survey of pests and their associated natural enemies occurred on cucumber plants (Cucumis sativus). Egypt. J. Plant Prot. Res. Inst. (2020), 3 (2): 771 – 776. http://www.ejppri.eg.net/pdf/v3n2/29.pdf

Abdelfatah, R. M., Soliman, H. M., & Helmy, R. M. (2024). Depreciation, risk assessment study of Pymetrozine, Pyriproxyfen, and Acetamiprid residues using QuEChERS and HPLC (DAD) and their biochemical effects on eggplant under greenhouse conditions. *Journal of Plant Protection and Pathology*, *0*(0), 191-197. https://doi.org/10.21608/jppp.2024.289956.1234

AbdEl-Fatah, R., Saleh, A., Elgohary, L., & Negm, S. (2015). Residues of chlorpyrifos and profenofos on green bean (Phaseolus vulgaris. L) and squash (Cucurbita pepo, L.) fruits and their side effect on some quality properties. *Journal of Plant Protection and Pathology*, *6*(7), 1007-1018. https:// doi.org/1 0.21608/j ppp.2015.74669

Adly, D., & Sanad, A. S. (2024). Comparative evaluation of biological control programs and chemical pesticides for managing insect and mite pests in cucumber greenhouses: A sustainable approach for enhanced pest control and yield. *Egyptian Journal of Biological Pest Control*, *34*(1). https: // doi.org/10.1186/ s41938-024-00806-3

Algethami, J. S., Alhamami, M. A., Ramadan, M. F., & Abdallah, O. I. (2022). Residues of the acaricides Abamectin, Hexythiazox, and Spiromesifen in eggplant (Solanum melongena L.) fruits grown under Field conditions in Najran, Saudi Arabia. *Agriculture*, *13*(1), 116. https://doi.org/10.3390/agriculture13010116

Anastassiades, M.; S. J. Lehotay; D. Stajnbaher and F. Schenck (2003). Fast and easy multiresidue method employing acetonitrile extraction/partitioning and ''dispersive solid-phase extraction'' for the determination of pesticide residues in produce. *J. AOAC. Int*., 86: 412–431.

Arafa E.M.F. (2020). Population dynamic of certain piercing sucking pests and their control with non-traditional means on cucumber plants in Sharkia Governorate. Ph. D. Faculty of Agriculture Benha University. 158pp

Attia M. M. R.; A. A. E. Darwish and A. S. Mansy (2024). Efficacy of Certain Neonicotinoids Against Cotton Whitefly, *Bemisia Tabaci* and Their Residues in Fruits and Leaves of Tomato Plants under Open Field Conditions. Alexandria Science Exchange Journal, VOL. 45, No.1., 1-10

Cabras, P., M. Meloni, F. Cabitza and M. Cubeddu(1989). Pesticide Residues in Lettuce Influence of Formulation. Journal of Agricultural and Food Chemistry, 37: 1405–1407.

Codex Alimentarius Commission for Pesticides residues (2008). List of maximum residue limits for pesticides in food and animal feeds. Joint FAO/WHO food standards program.

Codex Alimentarius Commission for Pesticides residues (2019). List of maximum residue limits for pesticides in food and animal feeds. Joint FAO/WHO food standards program.

Codex Alimentarius Commission for Pesticides residues (2023). List of maximum residue limits for pesticides in food and animal feeds. Joint FAO/WHO food standards program.

Devillers, J. (2009). Endocrine Disruption Modeling; CRC Press: Boca Raton, FL, USA; ISBN 9781138111912.

El Masry, A. T., El-Hefny, D. E., Helmy, R., & El-Ghanam, A. A. (2024). Effect of some insecticides, depletion and risk assessment against whitefly stages, Bemisia tabaci (Gennadius) on cucumber cultivation. Egyptian Journal of Chemistry, Vol. 67, No. 7 pp. 459 - 467. https:// doi.org/ 10.21608/ejchem.2024.231222.8478

EL-Kabbany, S., EL-Marsafy, A., Mohamed, G., & Saadieh, M. (2013). Residues and pre harvest interval of abamectin, diniconazole, methomyl and phenthoate in sweet pepper under greenhouse conditions. Journal of Plant Protection and Pathology, 4 (12) , 1025 - 1033. https:// doi.org/ 10.21608/jppp.2013.87670

EU (2024). Maximum residue levels impact and benefits for Authorizations and Trade.

FAO. 2023. FAOSTAT: Pesticides trade. In: FAO. Rome. Cited July 2023. http://www.fao.org/faostat/en/#data/RT.

Farouk, M., L.A. Hussein and N.F. EL-Azab (2014). New HPLC and fluorometric methods for the determination of pyriproxyfen and pyridalyl insecticide residues in tomatoes. Journal oF AOAC International, 97 (1): 188-196.

Fenoll, J.; Ruiz, E.; Hellın, P.; Lacasa, A. and Flores, P. (2009). Dissipation rates of insecticides and fungicides in peppers grown in greenhouse and under cold storage conditions. Food Chem., 113: 727-732.

Glancey BM, Reimer N, Banks WA. (1990). Effects of IGR Fenoxycarb and Sumitomo S-31183 on the queens of two myrmicine ant species. In: Robert K, Meer V, Jaffe K, Cedeno A, eds. Applied Myrmecology: A world Perspective. Boulder: Westview Press. pp. 604-13.

Gomaa, E.A. and M.H. Belal (1975). Determination of dimethoate residues in some vegetables and cotton plants. Zagazig J. Agric. Res., 2 (2): 215-220.

Hegab, M. F., Ayoub, F. H., Badran, B. A., & Ammar, M. I. (2016). New approaches to control cucumber pest infestation with emphasis on productivity and crop characteristics under greenhouse conditions. *Egyptian Journal of Agricultural Research*, *94*(3), 673-688. https:// doi.org/ 10.21608/ejar.2016.152699

Hill, B.D., W.A. Charnetski, G.B. Schaalje and B.D. Schaber (1982). persistence of fenvalerate in alfalfa: effect of growth dilution and heat units on residue half-life. J. Agric. Food Chem., 30 (4): 653-657.

Ismail, F., El Sharkawy, A., Farghaly, D., Ammar, M., & El Kady, E. (2020). Population fluctuation and influence of different management practices against Bemisia tabaci (Genn.) on cucumber plant under greenhouse condition. Egyptian Academic Journal of Biological Sciences, F. Toxicology & Pest Control, 12(2), 167-174. https://doi.org/10.21608/eajbsf.2020.119103

Khay, S., J.H. Choi, A.M. Abd El-Aty, M.I.R. Mamun, B.J. Park, A. Goudah, H.C. Shin and J.H. Shim (2008). Dissipation behavior of lufenuron, benzoylphenylurea insecticide in/on Chinese cabbage applied by foliar spraying under greenhouse conditions. Bull. Environ. Contamin. Toxicol. 81(4):369-372.

Kumari, B.; V. K. Madan; R. Kumar and T. S. Kathpal (2002). Monitoring of seasonal vegetables for pesticide residues. Environ. Monit Assess; 74: 263-70.

Lasota J.A., Dybas R.A. (1991). Avermectins, a novel class of compounds: Implications for use in arthropod pest control. *Annu. Rev. Entomol.*; 36:91–117. doi: 10.1146/annurev.en.36.010191.000515.

Majed L., Hayar S., Zeitoun R., Maestroni B. M. Dousset, S. (2022). The Effects of Formulation on Imidacloprid Dissipation in Grapes and Vine Leaves and on Required Pre-Harvest Intervals under Lebanese Climatic Conditions. Molecules, 27, 252. https://doi.org/10.3390/molecules27010252

Malhat, F., A. El-Mesallamy, M. Assy, W. Madian, N. M. Loutfy and M. T. Ahmed (2014). Residues, halflife times, dissipation, and safety evaluation of the acaricide fenpyroximate applied on grapes. Toxicological & Environmental Chemistry http://dx.doi.org/10.1080/02772248.2013.877245

Molinari G., Soloneski S., Larramendy M. (2010). New ventures in the genotoxic and cytotoxic effects of macrocyclic lactones, abamectin and ivermectin. *Cytogenet. Genome Res.*; 128:37–45. doi: 10.1159/000293923.

Moriya, K., S. Hirakura, J. Kobayashi, Y. Ozoe, S. Saito and T. Utsumi (2008). Pyridalyl inhibits cellular protein synthesis in insect, but not mammalian, cell lines. Archives of Insect Biochem. and Physiol., 69: 22–31.

Mostafalou S and Abdollahi M. (2013). Pesticides and human chronic diseases: evidences, mechanisms, and perspectives. *Toxicol Appl Pharmacol*, 268(2):157–77. DOI: 10.1016/j.taap.2013.01.025

Novelli A., Vieira B.H., Cordeiro D., Cappelini L.T.D., Vieira E.M., Espíndola E.L.G. (2012). Lethal effects of abamectin on the aquatic organisms Daphnia similis, Chironomus xanthus and Danio rerio. *Chemosphere.*; 86:36–40. doi: 10.1016/j. chemosphere. 2011.08.047. DOI: 10.1016/ j.chemosphere. 2011.08.047

Sakamoto, N. and K. Umeda (2003). Research and development a novel insecticides of pyridalyl. Fine Chemicals, 32 (20): 35-44.

Sakamoto, N., S. Matsuo, M. Suzuki, T. Hirose, K. Tsushima and W.O. Umeda (1995). Patent 9611909; Chem. Abstr., 125, 114466.

Sanco (2021). Method Validation and Quality Control Procedures for Pesticide Residues Analysis in Food and Feed. SANCO/12495/2021.

Shalaby, A., Hendawy, M., Aioub, A., & Saleh, K. (2020). Health risk assessment of Abamectin and Buprofezin residues in eggplant and pepper plants. *Journal of Plant Protection and Pathology*, *11*(12), 693-699. https://doi.org/10.21608/jppp.2020.166218

Sultatos, L. G., Murphy, S. D. (1983). Kinetic analyses of the microsomal biotransformation of the phosphorothioate insecticides chlorpyrifos and parathion. Fundam. Appl. Toxicol., 3, 16– 21.

Sultatos, L. G., Shao, M., Murphy, S. D., (1984). The role of hepatic biotransformation in mediating the acute toxicity of the phosphorothionate insecticide chlorpyrifos. Toxicol. Appl. Pharmacol. 73, 60–68.

Tantawy M.M., S.H. Hammouda, F.K. Aly Marwa, H.H. Mekhemer (2018). Monitoring the fluctuations of certain piercin sucking pests infesting cucumber plants at Sohag governorate, Egypt. Journal of Phytopathology and Pest Management. 5(2): 12-24. https://ppmj.net/index.php/ppmj/article/view/152

Tewary, D.K., K. Vipin, S.D. Ravindranath and S. Adarsh (2005). Dissipation Behavior of Bifenthrin Residues in Tea and its Brew. Food Control 16: 231–237. https://doi.org/10.1016/j.foodcont.2004.02.004

Tomlin, C. D. ., The Pesticide Manual, A World Compendium. 14th Ed. Br. Crop Prot. Counc. Alton, Hampsh. 2006, 186–187.

# دراسة متبقيات وتقييم مخاطر مبيدات الأبامكتين والكلوربيريفوس والبيريبروكسيفين علي نباتات الخيار تحت ظروف الصوبة

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## الملخص

في هذا العمل تم دراسة سلوك متبقيات مبيدات الأبامكتين (Vertimec 1.8% EC)، والكلوربيريفوس (PestBan 48% EC)، والبيريبروكسيفين (Admiral 10% EC) في ثمار وأوراق نبات الخيار تحت ظروف الصوبة. تم رش المبيدات على النباتات بالجرعات الموصى بها: 0.5 مل/لتر للأبامكتين، و2 مل/لتر للكلوربيريفوس، و0.5 مل/لتر للبيريبروكسيفين. بعد المعاملة، تم أخذ عينات من ثمار الخيار (ثلاث مكرات) على فترات ساعتين، و1، و3، و6، و9، و12، و15 يومًا بعد التطبيق. تم استخلاص المتبقيات باستخدام طريقة QuEChERS وتحليلها بواسطة HPLC-UV للأبامكتين والبيريبروكسيفين، وGC-FPD للكلوربيريفوس. وتوصلت الدراسة إلى أن المبيدات الثلاثة تبددت خلال 15 يومًا بعد التطبيق، على الرغم من أن بقايا الكلوربيريفوس كانت أعلى في الثمار مقارنة بالبيريبروكسيفين والأباماكتين. وكانت مستويات المتبقيات الأولية في أوراق الخيار أعلى أيضًا من تلك الموجودة في الثمار. وكانت فترة نصف العمر (t½) للمبيدات في ثمار الخيار 1.66 يومًا للأباماكتين، و1.48 يومًا للكلوربيريفوس، و2.09 يومًا للبيريبروكسيفين، بينما كانت تلك الفترة في الأوراق 2.82 و3.08 و4.06 يومًا على التوالي. وكانت نسب التبدد في كميات المتبقيات أعلى في ثمار الخيار منها في الأوراق. تجاوزت مستويات المخلفات في ثمار الخيار حدود المتبقيات القصوى (MRLs) حتى 3 أيام للأبامكتين، وحتى 6 أيام لكل من الكلوربيريفوس والبيريبروكسيفين بعد الرش، وبالتالي تم تحديد فترات ما قبل الحصاد (PHI) للاستهلاك الآمن لتكون 6 أيام للأبامكتين، و9 أيام للكلوربيريفوس والبيريبروكسيفين. أدى غسل ثمار الخيار بماء الصنبور أو حمض الأسيتيك بنسبة 10% أو 1% بيكربونات الصوديوم لمدة 10 دقائق إلى تقليل مستويات متبقيات المبيدات بشكل كبير. بشكل عام، تشكل المخلفات مخاطر صحية منخفضة للمستهلكين.