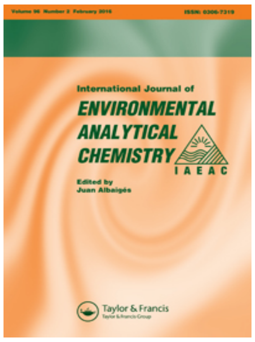

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Residues and risk assessment of bifenthrin and chlorfenapyr in eggplant and soil under open ecosystem conditions

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ABSTRACT

Dissipation and residue levels of bifenthrin and chlorfenapyr in eggplant and soil under field conditions were investigated using gas chromatography coupled with an electron capture detector (GC-ECD). The mean recoveries of bifenthrin and chlorfenapyr were 85.2–104.9%, with relative standard deviations (RSDs) of 0.5–9.1%. The limit of quantification (LOQ) was 0.01 mg kg^{-1}. Bifenthrin exhibited half-lives of 3.3 to 4.1 days in eggplant and 17.8 to 25.7 days in soil; the half-lives of chlorfenapyr were 3.5 to 3.8 days in eggplant and 21.7 to 27.7 days in soil. During harvest, the terminal residues of bifenthrin and chlorfenapyr were below 0.031 and 0.083 mg kg^{-1}, respectively. Risk assessment for different groups of people in China was evaluated. The risk quotients (RQs) of bifenthrin and chlorfenapyr were ranged from 0.0068 to 0.0148 and from 0.0033 to 0.0072, respectively. These results may provide guidance on reasonable use of pesticides and serve as a basis for establishing maximum residue limits (MRLs) in China.

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KEYWORDS
Bifenthrin; chlorfenapyr; eggplant; risk assessment

1. Introduction

Pesticide application is one of the most effective ways to protect crops from weeds, pests and infectious diseases. However, rising concern about food safety and environmental impact has led to increasing number of studies on pesticide residues consumed by humans [1–4]. Moreover, international organisations and governments have established maximum residue limits (MRLs) [5–7] and pre-harvest intervals (PHI) for pesticides in fruits and vegetables. Human exposure to pesticides through food consumption can be estimated using quantitative exposure assessments [8]. Risk assessment outputs are the scientific basis for risk management decisions and option analysis [9].

Bifenthrin, one of the synthetic pyrethroid insecticides, exhibits selective toxicity and is relatively environmentally friendly [10]. Bifenthrin can be applied to corn and cotton to control household pests [11–13]. Chlorfenapyr has been used to control *whitefly, thrips, caterpillars, mites*, etc., which is unlikely to show any cross-resistance to standard neurotoxic insecticides [14–16]. With regular and repeated pesticide application, pests may quickly develop resistance. Mixtures of pesticides, which show broader spectrums

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and higher insecticidal activities, have played an important role in extending pesticide lifetimes [17–19]. Indeed, chlorfenapyr has been effective in controlling *Cx. Quinquefasciatus* [16], *Haematobia irritans* [20] and *Anopheles gambiae* [21], which have proven to be resistant to pyrethroids [22].

The eggplant originated in tropical Asia, which is widely grown and consumed in China [23]. A major bottleneck to increase eggplant production is caused by lepidopteran insect [24], which can be effectively controlled by bifenthrin and chlorfenapyr. In Codex, China and EU, the MRLs for bifenthrin in eggplant are 0.3 mg kg^{-1}, and the MRL in US is 0.05 mg kg^{-1} [5–7,25,26]. The South Korean, US and EU have established MRL for chlorfenapyr of 0.5, 1 and 0.01 mg kg^{-1}, respectively [26,27]; however, until now no MRL has been established by China or Codex for chlorfenapyr in eggplant.

Several studies have recently reported analytical methods for bifenthrin and chlorfenapyr. The bifenthrin residues have been determined in cabbage, cotton, tea and aquatic environment [28–31]; and the studies on chlorfenapyr in cabbage, chieh-qua, soybean, cucumber, apple and amaranth [32–37] also have been reported. The methods for determination of the residues of bifenthrin and chlorfenapyr were developed using GC-ECD, HPLC-UV and HPLC-MS/MS [28–37]. However, to the best of our knowledge, few papers have reported simultaneous determination of bifenthrin and chlorfenapyr in eggplant to date. In addition, the dissipation, terminal residues or risk assessments of bifenthrin and chlorfenapyr from the combination treatment have been rarely evaluated to date. This study aims: (1) to develop a simple, fast and efficient analytical method to simultaneously determine the bifenthrin and chlorfenapyr residues in eggplant; (2) to evaluate the dissipation kinetics of bifenthrin and chlorfenapyr in eggplant and soil and (3) to assess risk for different groups of people in China, provide guidance on proper use of pesticide and serve as a reference for establishing associated MRLs in China.

2. Experimental

2.1. *Materials and chemicals*

Reference standards of bifenthrin (purity of 99.5%) and chlorfenapyr (purity of 99.0%) were purchased from Dr. Ehrenstorfer Gmbh. A mixed formulation of a suspension concentrate (SC) containing 3% bifenthrin and 7% chlorfenapyr was obtained from Hailir Pesticides and Chemicals Group. All solvents, including acetonitrile, sodium chloride, acetone and petroleum ether, were analytical grade and purchased from Beijing Chemical Reagent Co., Ltd. Petroleum ether was distilled before use, and the fraction at 60–70ºC was collected. The Florisil SPE column (1 g 6 mL^{-1}) was purchased from ANPEL Laboratory Technologies, Inc. (Shanghai, China).

2.2. *Field trials*

Field trials were performed in Beijing (116.08E, 40.04N) and Anhui (116.45E, 34.07N) in 2012, according to the 'Guideline on Pesticide Residue Trials' and 'Standard Operating Procedures on Pesticide Registration Residue Field Trials' (NY/T 788-2004, P. R. China; 'Standard Operating Procedures on Pesticide Registration Residue Field Trials', 2007). A plot with no application history of bifenthrin and/or chlorfenapyr was selected, and, during the course of the experiment, applications of similarly structured pesticides were forbidden. Each treatment consisted of three replicate plots and a control plot. The area of each plot was 15 m^2. A buffer area was also employed to separate each plot.

To study the dissipation of these two pesticides in eggplant and soil, the 10% SC was applied to the eggplant at a rate of 480 g a.i. ha^{-1} (four times the highest recommended dose) and to the soil at a rate of 3334.5 g a.i. ha^{-1}. Pesticide applications were started when the eggplant fruit was half size of ripe fruit.

For the terminal residue experiment on eggplant and soil, the 10% SC was sprayed at the highest recommended dose (120 g a.i. ha^{-1}) and 1.5 times the highest recommended dose (180 g a.i. ha^{-1}). Each dosage level was sprayed once and twice with interval of 7 days between each application.

The control area was sprayed with equal amounts of water in lieu of pesticides.

2.3. *Sampling and storage*

For the dissipation experiment, representative samples were collected at 2 h, 8 h, 1, 2, 3, 5, 7, 10 and 14 days after the application of pesticide to eggplant crops and 2 h, 8 h, 1, 2, 3, 5, 7, 10, 14, 21, 30, 45 days for soil. For the terminal-residues study, the eggplant and soil samples were collected 3, 7, 10 and 14 days after the last application.

About 2 kg of eggplant and soil (0–10 cm of depth) were collected randomly from several points in each plot. All the samples were stored at −20ºC for further analysis.

2.4. *Extraction and clean-up*

Eggplant samples were crushed in a blender. Soil samples were prepared by removing large stones and passed through a 40-mesh sieve. Briefly, homogenised samples (10.00 ± 0.01 g) were placed into a 50-mL centrifuge tube, to which 20 mL of acetonitrile was added. The tube was shaken vigorously by hand for 1 min and then treated to ultrasonic extraction for 15 min. Afterwards, 7 g of sodium chloride was subsequently added, and the tube was vortexed for 1 min and centrifuged at 3000 rpm for 5 min. A portion (10 mL) of supernatant was transferred and evaporated to near dryness using a vacuum rotary evaporator at 35ºC.

The Florisil SPE column was conditioned with 5 mL of petroleum ether. The concentrated extract was dissolved in 20 mL (5 mL × 4) of acetone-petroleum ether (v/v, 1:9) and eluted through the column. The eluents were collected and evaporated to near dryness using a vacuum rotary evaporator at 30ºC. The residues were re-dissolved in 2.5 mL of acetone-petroleum ether (v/v, 1:9) for GC-ECD analysis.

2.5. *Preparation of standard solutions*

Standards of bifenthrin and chlorfenapyr were weighed in a 25-mL measuring flask and dissolved in acetone separately, each at a concentration of 1000 mg L^{-1} (stock solution). Aliquots of these two stock solutions were mixed to form a working solution of 10 mg L^{-1}, and a series of working solutions at concentrations of 0.01, 0.05, 0.10, 0.25, 0.5, 1.0 and 1.5 mg L^{-1} were subsequently prepared using distilled petroleum ether.

2.6. *GC analysis*

An Agilent 7890A gas chromatography equipped with an electron capture detector (GC-ECD) and a capillary column DB-1701 (30 m × 320 μm × 0.25 μm) was used to determine bifenthrin and chlorfenapyr. The injector was maintained at 240°C with an injection volume of 2 μL. The injection mode is splitless. The temperature program started at 150°C (held for 1 min), increased to 240°C at 5°C min^{-1} and maintained for 5 min. The carrier gas, nitrogen (purity >99.999%), was at a flow rate of 2 mL min^{-1}. The detector was maintained at 300°C. The retention times were 19.3 (chlorfenapyr) and 20.5 min (bifenthrin).

2.7. *Method validation*

Validation of the analytical method was performed on parameters of linearity, sensitivity, accuracy and precision. Linearity was determined by constructing calibration curves using standard solutions of different concentrations (solvent standard). Sensitivity was given with the limit of detection (LOD) and the limit of quantification (LOQ). LOD was set at a signal-to-noise ratio (S/N) of 3:1, whereas the LOQ was defined as the minimum fortified level of recovery. The accuracy of the method was checked by recovery studies. Blank eggplant and soil samples free from pesticide contamination were collected from control area. Samples were fortified with known amounts of pesticide standard. At different spiked level (0.01, 0.2, 0.5, 2 mg kg^{-1}), the samples were extracted and cleaned-up as mentioned in Section 2.4. At each spiking level, five replicates were analysed. The precision of the modified method was based on the relative standard deviations (RSDs) of a set of five replicates. Matrix-matched standard and solvent standard were prepared to evaluate the matrix effect. Matrix-matched standard solution was prepared by mixing working standard solutions with blank eggplant extracts.

2.8. *Dissipation kinetics*

The concentrations and half-lives of the bifenthrin and chlorfenapyr residues were calculated using the first-order kinetics equations $C = C_0e^{-kt}$ and $t_{1/2} = \ln 2/k$, in which the variables are defined as follows: C (mg kg^{-1}) denotes the concentration of the pesticide residue at time t, C_0 (mg kg^{-1}) denotes the initial concentration, k (day^{-1}) is the rate constant and $t_{1/2}$ (day) is the half-life [38].

2.9. *Health risk estimations*

Dietary exposure and risk assessment calculations employed the following equations:

$$\mathrm{EDI} = \frac{F_i \times \mathrm{RL}_i}{\text{mean body weight}}$$

where EDI is the estimated daily intake (mg kg^{-1}, bw), F_i is the food consumption data (g d^{-1}), and RL_i is the residue level in the commodity (mg kg^{-1}). Results under the LOQ of the analytical methods used for intake calculations were taken as LOQ values [38].

$$RQ = \frac{EDI}{ADI}$$

where RQ is the risk quotient, ADI is the acceptable daily intake (mg kg^{-1}, bw). An RQ value that is higher than RQ = 1 indicates that the risk of pesticide for humans is unacceptable. By contrast, an RQ value that is less than RQ = 1 represents minimal risk to humans [39].

3. Results and discussion

3.1. *Method validation*

3.1.1. *Matrix effect*

The matrix effect of present method was investigated by comparing standards in solvent with matrix-matched standards. The response (response matrix/response solvent) was approximately 1.0. The value showed that the matrix did not significantly suppress or enhance the response of the instrument. As a consequence, standards in solvent were selected as external standards.

3.1.2. *Linearity*

For the preparation of calibration curves, bifenthrin and chlorfenapyr standard was diluted with petroleum ether in series at 0.01, 0.05, 0.10, 0.25, 0.5, 1.0 and 1.5 mg L^{-1}. A standard calibration curve was constructed by plotting analyte concentrations against peak areas. Good linear correlations of bifenthrin and chlorfenapyr were obtained (y = 294454x − 1019.2 for bifenthrin, y = 1033920x − 11724 for chlorfenapyr), with correlation coefficients of 0.9999 and 0.9995, respectively.

3.1.3. *Senstivity*

LOD was defined as the concentration with an S/N of 3. LOQ was defined as the lowest fortified level of recovery. The LOD and LOQ were 0.0025 and 0.01 mg kg^{-1}, respectively, for both bifenthrin and chlorfenapyr in eggplant and soil. The results indicated that the method was capable of determining the target compounds with GC-ECD.

3.1.4. *Accuracy*

Recoveries were carried out in five replicates at four fortification levels (0.01, 0.2, 0.5, 2 mg kg^{-1}) by spiking 10 g of blank sample with standard solution. The average recoveries of bifenthrin in eggplant and soil ranged from 85.2% to 104.9% with RSDs of 0.5–9.1%. The average recoveries of chlorfenapyr from eggplant and soil are ranged from 96% to 104% with RSDs of 0.9–3.5%. The average recoveries and RSDs are shown in Table 1. The results confirmed that the developed method was suitable for the determination of bifenthrin and chlorfenapyr in eggplant and soil.

Figure 1 shows the GC-ECD chromatograms of (a) matrix-matched standard of bifenthrin and chlorfenapyr in eggplant with a concentration of 0.02 mg/L, (b)

Table 1. Average recoveries and relative standard deviations (RSDs) of bifenthrin and chlorfenapyr in eggplant and soil (n = 5).

Pesticide	Eggplant			Soil		
	Spiked level (mg kg^{-1})	Average recovery (%)	RSD %	Spiked level (mg kg^{-1})	Average recovery (%)	RSD %
Bifenthrin	0.01	85.2	4.2	0.01	95.7	9.1
	0.2	99.1	1.1	0.2	100.6	3.0
	0.5	102.4	0.5	0.5	98.0	3.0
	2	104.9	3.4	2	99.9	2.9
Chlorfenapyr	0.01	96.0	3.5	0.01	99.2	1.3
	0.2	100.9	2.4	0.2	101.8	2.5
	0.5	103.0	0.9	0.5	96.8	3.1
	2	103.8	2.1	2	96.7	2.8

matrix-matched standard of bifenthrin and chlorfenapyr in soil with a concentration of 0.02 mg/L, (c) blank of eggplant, (d) blank of soil, (e) eggplant spiked with bifenthrin and chlorfenapyr at 0.01 mg/kg, (f) soil spiked with bifenthrin and chlorfenapyr at 0.01 mg/kg and (g) solvent standard of bifenthrin and chlorfenapyr with a concentration of 0.02 mg/L.

3.2. *The dissipation of bifenthrin in eggplant and soil*

The dissipation equations and half-lives of bifenthrin are listed in Table 2. The initial concentrations in eggplants were 0.15 and 0.13 mg kg^{-1} with half-lives of 3.3 and 4.1 days, from Beijing and Anhui, respectively. The initial concentrations in soil were 1.59 and 1.83 mg kg^{-1} with half-lives of 25.7 and 17.8 days, from Beijing and Anhui, respectively.

The initial concentration is defined as the quantity of pesticide adhering to the surface of vegetables after pesticide application, which may be influenced by several factors, including dosage, application mode and the growth stage of the plant. According to the standard operation procedures on pesticide registration residue field trials [40], pesticide applications were started when the eggplant fruit was half size of ripe fruit. Although two types of eggplants were used in Beijing and Anhui (Beijing, Zaoshouwang No. 2; Anhui, Fengyan No. 1), the initial eggplant concentrations in the two experimental fields were similar.

Dissipation rate may be influenced by many factors, including the physical and chemical properties of the pesticide, the plant species, the weather (light, temperature, humidity) and soil properties (pH, micro-organisms) [41]. Compared with some of the physical and chemical properties of pesticides, the plant's growth dilution factor played an important role in reducing residue levels [28,29]. As a result of strong growth dilution factor that occurs in eggplants, the dissipation rates of bifenthrin in eggplants were much faster than in soil. The half-lives of bifenthrin were 7.7–9.0 and 10.6–12.3 days, in cabbage and soil, respectively [28]. Fang measured bifenthrin half-lives of 4.2–6.7 and 10.6–16.0 days in cotton and soil, respectively [29]. Both Chen and Fang explained the shorter half-lives observed in crops versus soil in terms of the important role played by the growth dilution factor. In this regard, different types of crops may exhibit slightly different growth dilution factors, which can lead to distinctive half-lives.

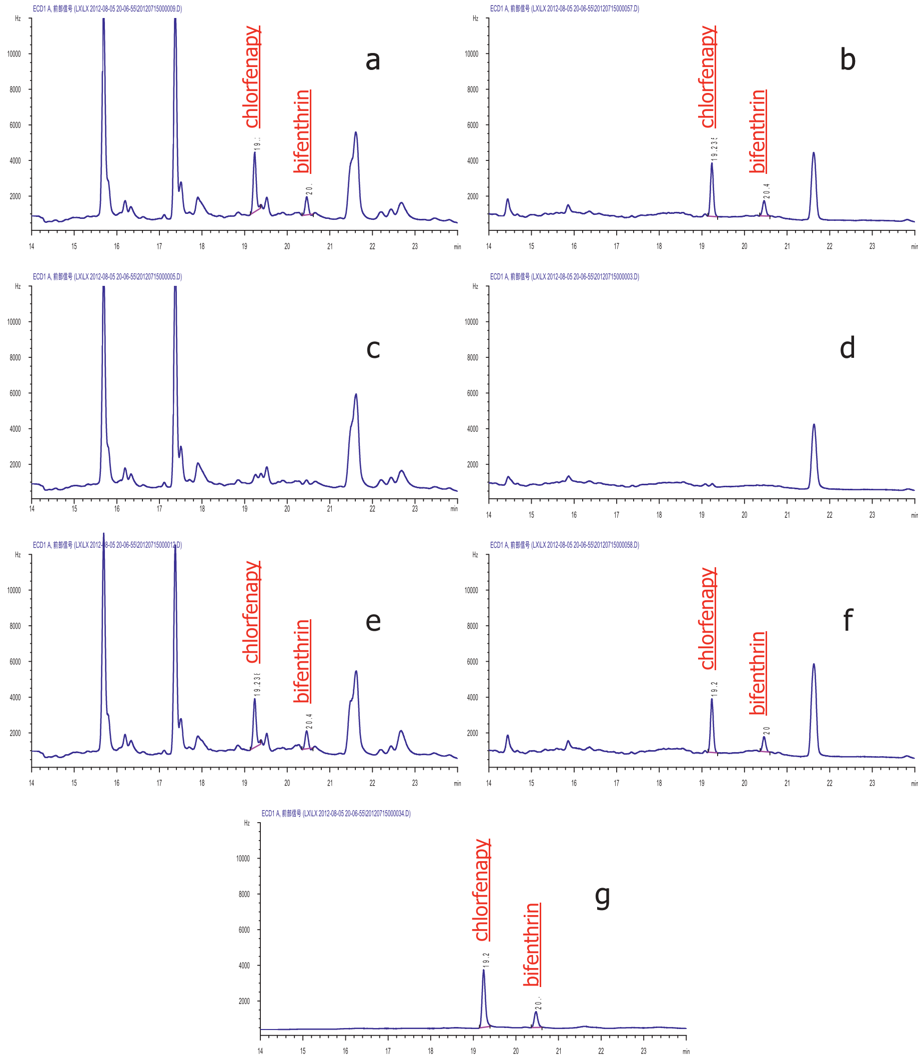

Figure 1. GC-ECD chromatograms of (a) matrix-matched standard of bifenthrin and chlorfenapyr in eggplant with a concentration of 0.02 mg/L, (b) matrix-matched standard of bifenthrin and chlorfenapyr in soil with a concentration of 0.02 mg/L, (c) blank of eggplant, (d) blank of soil, (e) eggplant spiked with bifenthrin and chlorfenaypyr at 0.01 mg/kg, (f) soil spiked with bifenthrin and chlorfenapyr at 0.01 mg/kg and (g) solvent standard of bifenthrin and chlorfenapyr with a concentration of 0.02 mg/L.

3.3. *The dissipation of chlorfenapyr in eggplant and soil*

The dissipation equations and half-lives of chlorfenapyr are listed in Table 2. The initial concentrations in eggplants were 0.36 and 0.37 mg kg^{-1} with half-lives of 3.9 and 3.5 days, from Beijing and Anhui, respectively. The initial concentrations in soil were 4.13 and 4.67 mg kg^{-1} with half-lives of 27.7 and 21.7 days, from Beijing and Anhui, respectively.

Table 2. Dissipation and half-lives of bifenthrin and chlorfenapyr in eggplant (2013) and soil from Beijing and Anhui (2012).

Pesticide	Matrix	Location	Equation	ɣ	Half-life
Bifenthrin	Eggplant	Beijing	$C = 0.15e^{-0.21t}$	−0.8596	3.3
		Anhui	$C = 0.13e^{-0.17t}$	−0.9116	4.1
	Soil	Beijing	$C = 1.59e^{-0.027t}$	−0.8420	25.7
		Anhui	$C = 1.83e^{-0.039t}$	−0.9818	17.8
Chlorfenapyr	Eggplant	Beijing	$C = 0.36e^{-0.18t}$	−0.9140	3.9
		Anhui	$C = 0.37e^{-0.20t}$	−0.8993	3.5
	Soil	Beijing	$C = 4.13e^{-0.025t}$	−0.8637	27.7
		Anhui	$C = 4.67e^{-0.032t}$	−0.9752	21.7

C (mg kg^{-1}) denotes the concentration of the pesticide residue at time t, C_0 (mg kg^{-1}) denotes the initial concentration, k (day^{-1}) is the rate constant and $t_{1/2}$ (day) is the half-life, ɣ denotes correlation coefficient.

The dissipation rate of chlorfenapyr in eggplant is much faster than soil, which could be a result of growth dilution factor. Cao [32] reported that the half-life of chlorfenapyr nanoformulation and suspension concentration in cabbage were 2.2 and 2.6 days. Field tests by Huang [37] indicated that the half-life of chlorfenapyr in chieh-qua ranges from 2.6 to 3.5 days. Wu [36] find that half-lives of chlorfenapyr were 4.2 and 9.4 days at a dose of 216 g a.i./ha, in cucumber and apple, respectively. Chen [34] reports a half-live of 5 days in vegetable soybean. Because of different crop varieties or matrices, data showed that differences in half-lives were significant, compared to these in the literatures.

3.4. *Influencing factors of the dissipation rate in soil*

The dissipation rates of bifenthrin and chlorfenapyr in Beijing were faster than in Anhui. It may be due to differences in the properties of soil obtained from Beijing versus Anhui; this may include differences in pH, micro-organism content, organic content, etc. In the present study, the soil from Beijing and Anhui are both belong to sandy loam, with pH of 7.1 and 7.4, respectively. Further study is needed to reveal the relevance between soil properties and residue levels. Indeed, Kang determined that the dissipation rate of bifenthrin in soil was related to the presence (or absence) of micro-organisms [42].

Figures 2 and 3 show the dissipation curves for bifenthrin and chlorfenapyr in eggplant and soil under field conditions.

3.5. *Terminal residues of bifenthrin and chlorfenapyr in eggplant*

The terminal residues determined in eggplant are summarised in Table 3. Based on this data, the terminal-residue contents of bifenthrin and chlorfenapyr were under 0.031 and 0.083 mg kg^{-1}, respectively. All of the residues were lower than the stricted MRLs (0.05 mg kg^{-1} for bifenthrin and 0.5 mg kg^{-1} for chlorfenapyr). These results suggest that the residual levels depend on application rates, the number of applications and PHI values. For instance, residue levels decreased with increasing PHI values when the same number and rate of applications were employed; on the other hand, residue levels decreased with lower dosages and application frequencies when the PHI maintained the same value. Zhang, Malhat and Liu arrived at a similar conclusion in previous studies [43–45]. Chlorfenapyr residue levels were slightly higher than

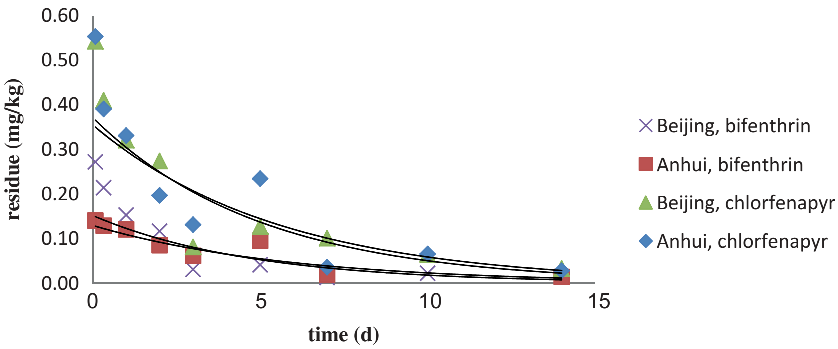

Figure 2. Dissipation of bifenthrin and chlorfenapyr in eggplants.

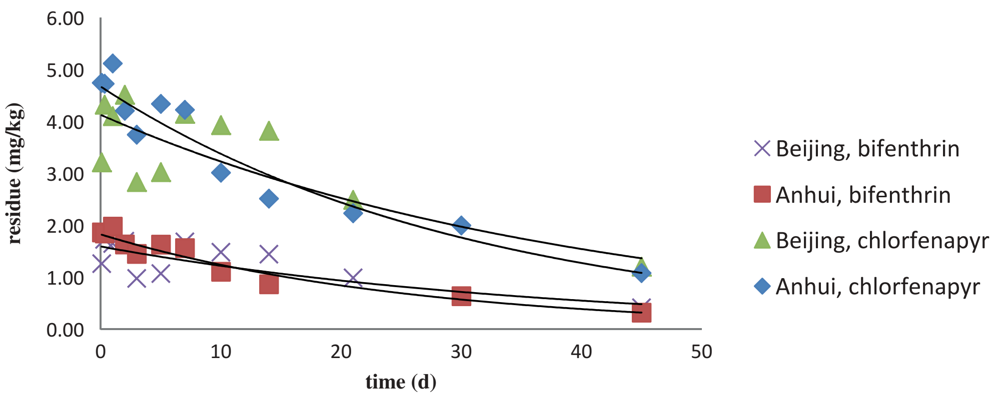

Figure 3. Dissipation of bifenthrin and chlorfenapyr in soil.

Table 3. Terminal residues of bifenthrin and chlorfenapyr in eggplant.

Application rate (g a.i. ha^{-1})	Number of applications	PHI	Residue (mg kg^{-1}) Bifenthrin	Residue (mg kg^{-1}) Chlorfenapyr
120	1	3	0.010–0.016	0.010–0.035
		7	0.010–0.013	0.010–0.026
		10	<0.010	<0.010
		14	<0.010	<0.010
	2	3	0.010–0.018	0.010–0.038
		7	0.010–0.012	0.010–0.022
		10	<0.010	<0.010
		14	<0.010	0.010–0.012
180	1	3	0.010–0.028	0.010–0.074
		7	0.010–0.014	0.010–0.018
		10	<0.010	0.010–0.012
		14	<0.010	<0.010
	2	3	0.010–0.031	0.010–0.083
		7	0.010–0.015	0.010–0.034
		10	0.010–0.013	0.010–0.012
		14	<0.010	0.010–0.083

bifenthrin residue levels, a result that may be due to the different proportions of chlorfenapyr and bifenthrin in the mixed formulation applied (3% bifenthrin and 7% chlorfenapyr).

3.6. *Risk assessment*

Long-term risk assessment requires comparing the estimated daily intake calculated using the residual level consumed and the ADI.

In general, food consumption is not same across different countries due to variety of dietary structures. Moreover, consumptions differ based on the ages of the consumers. Thus, risk assessment for different groups of people, based on typical food consumption in China, are urgently needed. Average vegetable intakes and average body weights pertaining to different Chinese age groups are listed in Table 4 [46]. The ADI values for bifenthrin and chlorfenapyr are 0.01 and 0.03 mg kg^{-1} bw [7].

Based on the terminal residue results, the residue behaviour of bifenthrin and chlorfenapyr followed a trend in which shorter PHI values led to more residues. Consequently, the risk should be low if the assessment results pertaining to the shortest PHI (3 days) are acceptable.

At PHI of 3 days, the highest residues for each of the three replicate plots of bifenthrin were as follows: <0.010, <0.010, <0.010, <0.010, <0.010, 0.011, 0.012, 0.013, 0.016, 0.018, 0.024, 0.024, 0.024, 0.028, 0.038 and 0.041 mg kg^{-1}. For chlorfenapyr, the correlated residues are as follows: <0.010, <0.010, <0.010, <0.010, <0.010, 0.010, 0.017, 0.018, 0.026, 0.039, 0.042, 0.050, 0.052, 0.055, 0.110 and 0.120 mg kg^{-1}. According to the supervised trial median residue (STMR), the residue limits (RLs) for bifenthrin and chlorfenapyr are 0.015 and 0.022 mg kg^{-1}, respectively,

Risk assessment of bifenthrin and chlorfenapyr in eggplant are summarised in Table 4 [46]. As shown, the EDIs of bifenthrin and chlorfenapyr range from 0.07 to 0.15 μg kg^{-1} and from 0.10 to 0.22 μg kg^{-1}, respectively. The RQs of bifenthrin and chlorfenapyr range from 0.0068 to 0.0148 and from 0.0033 to 0.0072, respectively. The total RQ values by adding two parts together ranged from 0.0101 to 0.0220, and are far lower than RQ = 1. These results indicate that for the recommended dose and PHI, the long-term exposure of consumers to bifenthrin and chlorfenapyr residues through eggplant consumption is relatively low.

Table 4. Risk assessment of bifenthrin and chlorfenapyr in eggplant.

			EDI (μg kg^{-1},bw)		RQ	
Age	Body weight (kg)	Consumption of vegetable (g d^{-1})	Bifenthrin	Chlorfenapyr	Bifenthrin	Chlorfenapyr
2 ~ 3	12.7	125.1	0.15	0.22	0.0148	0.0072
4 ~ 6	16.5	162.8	0.15	0.22	0.0148	0.0072
7 ~ 10	22.3	206.5	0.14	0.20	0.0139	0.0068
11 ~ 13	34.05	235.85	0.10	0.15	0.0104	0.0051
14 ~ 17	45.95	255.35	0.08	0.12	0.0083	0.0041
18 ~ 29	55.25	286.05	0.08	0.11	0.0078	0.0038
30 ~ 44	60.3	297.15	0.07	0.11	0.0074	0.0036
45 ~ 59	60.05	304.95	0.08	0.11	0.0076	0.0037
60 ~ 69	57.95	278.75	0.07	0.11	0.0072	0.0035
≥70	54.75	248.9	0.07	0.10	0.0068	0.0033

4. Conclusions

A GC-ECD analytical method for determination of bifenthrin and chlorfenapyr in eggplant and soil was developed. The fortified recoveries of bifenthrin and chlorfenapyr were between 85.2 and 104.9%, with RSDs of 0.5–9.1%. Dissipation and terminal residues obtained in eggplant and soil under field conditions were investigated. The half-lives of bifenthrin were 3.3 to 4.1 days in eggplant and 17.8 to 25.7 days in soil, respectively,, whereas those of chlorfenapyr were 3.5 and 3.8 days in eggplant and 21.7 and 27.7 days in soil, respectively. The terminal-residue content of bifenthrin and chlorfenapyr in eggplant were below 0.031 and 0.083 mg kg^{-1}, respectively. The total RQ value ranged from 0.0101 to 0.0220, indicating that the associated risk in eggplant for different groups of people in China is low. These results may provide guidance on the reasonable use of pesticide in agriculture. In addition, the present work may serve as a reference for the establishment the MRLs in China.

Disclosure statement

No potential conflict of interest was reported by the authors.

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