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Dietary risk assessment of diamide insecticides in peach fruits

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Abstract

In this study long-term and short-term dietary risk assessment of peach fruits treated with diamide insecticides, chlorantraniliprole and cyantraniliprole, was conducted. The evaluation was done by calculating the dietary risk quotient (HQ) and International Estimated Short-Term Intake (IESTI). In order to obtain estimated daily intake (EDI), residue data in treated fruits were generated from dissipation experiments. Plant protection products based on these two insecticides were applied at the rate recommended for the control of *Grapholita molesta*, at two localities in the Republic of Serbia, in peach orchards with the Royal gem cultivar. Fruit sampling was performed immediately after application till the end of the pre-harvest interval (PHI), and for the residue analysis, the QuEChERS-based method followed by HPLC was used. The chlorantraniliprole and cyantraniliprole residues in peach fruits dissipated with a half-life of 2.50 and 3.15 days. The amount of chlorantraniliprole in the peach fruits at the EU maximum residue level (1 mg/kg) was achieved seven days after the application (0.95 mg/kg), while cyantraniliprole was at the MRL (1.5 mg/kg), immediately after the drying of the deposit. For the EDI value of chlorantraniliprole and cyantraniliprole, results obtained from the field experiments were multiplied by the average consumption rate (16.7 g/day) and divided by the mean weight of an adult (70.8 kg). Finally, obtained results indicate low risk from chlorantraniliprole and cyantraniliprole residues in the peach, thus fruits can be safely consumed.

Key words: Risk assessment, Chlorantraniliprole, Cyantraniliprole, Peach fruits

Introduction

As a source of minerals, vitamins, and other nutrients, fruit represents an essential part of a healthy diet. However, due to the presence of a wide range of pests, fruit production requires

chemical protection. Intensive and/or inadequate use of pesticides leads to the presence of pesticides in fruits, causing side effects on human health. To overcome these problems, nowadays, good agricultural production implies the use of pesticides with more convenient ecotoxicological properties (Lazić et al., 2012) and a shorter pre-harvest interval (PHI).

When it comes to peach production, one of the most significant and destructive pests is Grapholita molesta (Busck, 1916) and it is regularly found in peach and quince orchards (Stamenković 2005). Damages caused by *G. molesta* have an impact on overall plant conditions, reduce fruit quality and create economic losses. Recently, for the control of this pest, diamides insecticides, chlorantraniliprole and cyantraniliprole showed to be effective substances. However, only a few studies have reported the detection and dissipation of these insecticides in peaches (Žunić et al., 2020).

Despite the necessity for pesticide use, the risks related to their residues in the human body and the environment are being established. Even though very strict regulation processes during pesticide registration, with minimal impact on human health and the environment, are developed, serious concern have been raised about health risks resulting from occupational exposure to pesticides and from residues in food and drinking water (Damalas and Eleftherohorinos, 2011).

Thus, it is still required to evaluate the adverse health effects of pesticides through risk assessment. This is particularly important for food mainly consumed fresh, such as fruit.

Pesticide residue intake through the diet can be predicted with different degrees of accuracy, from "Crude estimation" with theoretical maximum daily intake (TMDI), to "Best estimation" using estimated daily intake (EDI) (UNEP/FAO/WHO, 1989). Risk assessment is based on a comparison of potential long- and short-term dietary intake of pesticides with two established parameters of hazard characterization, Acceptable Daily Intake (ADI) and Acute Reference Dose (ARfD). Long-term hazard implies a comparison of the Theoretical Maximum Daily Intake (TMDI) to the ADI of the pesticide, where the TMDI is based on assumption that food products consumed over the lifetime contain residues at the MRL level. It is calculated using the MRL and the average daily consumption of food for which an MRL has been established (Osman, 2011). For the calculation of hazard risk (HR), EDI values take into account residues in food at the level of median residue values from trials, thus including more factors and providing better estimation.

Short-term dietary exposure to pesticides is based on the comparison of International Estimated Short-Term Intake (IESTI) to ARfD. The calculation of IESTI requires data from field trials (Struciński et al., 2006).

In this study, the supervised field experiments were carried out to study the persistence, dissipation and risk of the consumption of peaches treated with chlorantraniliprole and cyantraniliprole was assessed.

Materials and Methods

Dissipation studies

For the dissipation studies field trials were conducted at two localities in the Republic of Serbia, according to EPPO methods (Žunić et al., 2020), in peach orchards under the Royal gem cultivar. Briefly, plant protection products based on cyantraniliprole (100 g a. i./l, SE) and chlorantraniliprole (200 g a. i./l, SC) were foliar applied at the recommended rate (0.6 and 0.2 l/ha, respectively) for the control of *G. molesta*, when the plants were in the BBCH 74 phenophase. Fruit sampling was performed daily during the PHI, while for the residue analysis, the QuEChERS-based method followed by HPLC was used. Estimated PHI for chlorantraniliprole and cyantraniliprole in the Republic of Serbia is 14 and 7 days, respectively.

Dietary risk assessment

In this study, HQ is obtained by dividing EDI (mg/kg bw/day) by the relevant ADI (mg/kg bw/day) value (Łozowicka et al., 2013). For the estimated daily intake of chlorantraniliprole and cyantraniliprole, residues (mg/kg) obtained from the field experiments were multiplied by the average consumption rate (16.7 g/day) and divided by the mean weight of an adult (70.8 kg). HQ describes the risk characterization of a single chemical, while the hazard index (HI) is used for a mixture of chemicals (EPA, 1986), i.e. the sum of all component chemicals' HQs constitutes the hazard index (HI) for the whole pesticide mixture's effect.

The long-term risk assessment of intakes and HQ is calculated as followed (Ambrus et al., 2023):

$$EDI = \frac{concentration\ of\ pesticide\ from\ field\ trial\ \left(\frac{mg}{kg}\right) * food\ consumption\ (\frac{kg}{day})}{\text{body weight of an adult (kg)}}$$

$$HQ = \frac{\text{EDI}}{\text{ADI}} \qquad \text{HI} = \sum \text{HQ}$$

Short-term dietary exposure to insecticides is evaluated through International Estimated Short Term Intake (IESTI), and it is calculated as followed using single-day consumption data for the 97.5 of food intake and the highest residue (HR) of the edible part of the crop observed in supervised field trials (Struciński et al., 2006).

IESTI = HR × 97.5% food intake

Results and Discussion

A dietary risk assessment was conducted based on the results of the dissipation experiment (Žunić et al., 2020). The dissipation dynamic of chlorantraniliprole and cyantraniliprole dissipation in peach fruits followed first-order kinetics with a half-life of 2.50 and 3.15 days. The long-term risk was evaluated by calculating (HQ) using residue data obtained in treated fruits immediately after application till the end of PHI and ADI. ADI value of chlorantraniliprole is 1.58 mg/kg bw/day (EFSA, 2012), while the toxicological profile of cyantraniliprole was assessed in the framework of the EU pesticides peer review under Regulation (EC) No 1107/2009, and based on these data an acceptable daily intake (ADI) is 0.01 mg/kg body weight (bw) per day. Results are shown in Tables 1 and 2.

HQ values for chlorantraniliprole in peach fruits range between 0.0006 immediately after insecticide application, and 0.00003 at the end of PHI. A similar situation occurred in the experiment with cyantraniliprole, where HQ ranged from 0.00034 to 0.00003. Numerically, HQ of >1, indicates that could be an unacceptable risk from chlorantraniliprole and cyantraniliprole residues present in the peach fruits. If the HQ is <0.1 the risk is low, while the values between 0.1 and 1.0, indicate moderate risk (Sánchez-Bayo et al. 2002). The results obtained in this study indicate that peach fruit treated with chlorantraniliprole and cyantraniliprole are safe for consumption.

Table 1. Dietary risk assessment of chlorantraniliprole in peach fruits

average peach consumption per adults per day (kg/day)	average adults body weight	Days after treatment	Maximum residue (mg/kg)	EDI (mg/kg/bw/day)	ADI (mg/kg/bw/day)	Risk quotient (RQ)	ARfD (mg/kg/bw)
0.0167	70.8	0	2.32	0.00055	1.56	0.00035	n.n.
0.0167	70.8	1	2.04	0.00048	1.56	0.00031	n.n.
0.0167	70.8	3	1.73	0.00041	1.56	0.00026	n.n.
0.0167	70.8	5	1.32	0.00031	1.56	0.00020	n.n.
0.0167	70.8	7	0.95	0.00022	1.56	0.00014	n.n.
0.0167	70.8	9	0.51	0.00012	1.56	0.00008	n.n.
0.0167	70.8	11	0.23	0.00005	1.56	0.00003	n.n.
0.0167	70.8	13	0.10	0.00002	1.56	0.00002	n.n.
0.0167	70.8	15	0.12	0.00003	1.56	0.00002	n.n.

n.n. not necessary

Table 2. Dietary risk assessment of cyantraniliprole in peach fruits

average peach consumption per adults per day (kg/day)	average adults body weight	Days after treatment	Maximum residue (mg/kg)	EDI (mg/kg/bw/day)	ADI (mg/kg/bw/day)	Risk quotient (RQ)	ARfD (mg/kg/bw)
0.0167	70.8	0	1.46	0,00034	0.01	0.03444	Acute risk assessment not required as an ARfD is not necessary (EFSA, 2014).
0.0167	70.8	1	1,32	0,00031	0.01	0.03114	
0.0167	70.8	2	1.2	0,00028	0.01	0.02831	
0.0167	70.8	3	0.65	0,00015	0.01	0.01533	
0.0167	70.8	4	0.46	0,00011	0.01	0.01085	
0.0167	70.8	5	0.39	0,00009	0.01	0.00920	
0.0167	70.8	6	0.24	0,00006	0.01	0.00566	
0.0167	70.8	7	0.19	0,00004	0.01	0.00448	
0.0167	70.8	8	0.13	0,00003	0.01	0.00307	

An acute reference dose (ARfD) is the estimate of the amount of a substance in food or drinking water, expressed on a milligram per kilogram body weight basis. This quantity of a substance can be ingested over a short time, usually in one meal or during one day, without appreciable health risk to the consumer on the basis of all known facts at the time of the evaluation. ARfD was not established for chlorantraniliprole and cyantraniliprole, as they are of low acute toxicity, and did not demonstrate evidence of a genotoxic, neurotoxic, or reproductive/developmental toxicity potential after a single dose. Despite this, short-term dietary risk to diamide insecticides is expressed as IESTI, with obtained values of 0.038 for chlorantraniliprole and 0.024 for cyantraniliprole.

Studies of risk assessment of chlorantraniliprole and cyantraniliprole in other agricultural products show a hazard index of less than 1 (Paramasivam, 2021; Saraswati et al., 2022).

Conclusion

The pattern of chlorantraniliprole and cyantraniliprole dissipation in peach fruits was best fitted to first-order kinetics with a half-life of 2.50 and 3.15 days. Based on these data dietary risk of the applied insecticides was assessed. According to results obtained for long- and short-term dietary risk assessment, peach fruits can be safely consumed after insecticide application in the doses recommended for effective control of *Grapholita molesta*.

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