

ASSESSING PESTICIDE RISK IN CERTAIN FRUITS AND VEGETABLES: A COMPREHENSIVE EVALUATION*

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Original scientific paper

Abstract

Climate changes, freshwater scarcity, diminishing arable land, and particularly the prevalence of harmful agents pose significant challenges to food production, necessitating robust plant protection measures. Contemporary science faces several key issues, including increasing concerns regarding food safety, the rising trend of organic farming, the emergence of resistant populations of pests, and the loss of biodiversity due to chemical pesticide use. It is therefore crucial to protect consumers from exposure to unacceptable levels of pesticides through ongoing monitoring programs. Over the past decade, the presence of food containing pesticide residues has risen significantly, raising major safety concerns for consumers globally. Consequently, the detection and quantification of these residues in food have become paramount. Therefore, evaluation the adverse health effects of pesticides through risk assessment are still required. This is particularly important for food mainly consumed fresh, such as fruits and vegetables. This study assessed the health risks associated with pesticide residues from the classes of diamides, spinosyns, strobilurins, and methoxycarbamates in various fruits and vegetables. The evaluation involved calculating the Estimated Daily Intake (EDI), Hazard Quotient (HQ), and Hazard Index (HI). The research was conducted based on findings from a dissipation experiment. Results indicated that the detected residue levels fell within safe limits, suggesting that their consumption does not present a significant health risk to humans.

Keywords: *pesticide residues, risk assessment, fruits, vegetables*

* Paper presented at the 34th International Scientific-Expert Conference of Agriculture and Food Industry, October 9-11, 2024, Sarajevo, Bosnia and Herzegovina

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INTRODUCTION

During the historical development of plant protection, the number of introduced pesticides effective in controlling numerous harmful organisms grew. Therefore, they have helped enhance the quality and quantity of yields globally (Damalas and Eleftherohorinos, 2011). However, during the long-term intensive application of pesticides, negative effects were manifested in many fields. Due to their ability to retain and accumulate in the environment, and food, growing concerns are focused toward these negative effects (Akoto *et al.*, 2013). Although the development of new pesticide substances and their further application are legally regulated, there are ongoing problems related to their residues, causing further harmful effects (Damalas, 2009). To address these challenges, modern agricultural practices involve the application of pesticides, i.e. plant protection products (PPP), with more favorable ecotoxicological characteristics and a reduced pre-harvest interval (PHI) (Lazić *et al.*, 2012).

Food is essential for human health and represents the primary pathway of human intake of pesticides (Juraske *et al.*, 2009). Therefore, evaluating pesticides' potential health risks remains indispensable, particularly for freshly consumed food, such as fruit and vegetables.

The dietary intake of pesticide residues can be assessed with varying levels of precision, ranging from estimates based on the theoretical maximum daily intake (TMDI) to more accurate assessments using the estimated daily intake (EDI) (UNEP/FAO/WHO, 1989). The detection and quantification of pesticide residues in food is crucial for assessing the extent of human exposure to these substances. Pesticide residues in food are typically monitored regarding Maximum Residue Level (MRL) (Akoto *et al.*, 2013). Health risks associated with those residues, especially in fruits and vegetables, can be evaluated through methods such as calculating the Estimated Daily Intake (EDI), Hazard Quotient (HQ), and Hazard Index (HI). Risk assessment involves comparing potential long- and short-term dietary pesticide intake with two key hazard characterization parameters: Acceptable Daily Intake (ADI) and Acute Reference Dose (ARfD). Short-term dietary exposure is evaluated by comparing the International Estimated Short-Term Intake (IESTI) with the ARfD. This calculation is derived from data gathered in field trials offering a reliable evaluation of acute health risks (Struciński *et al.*, 2006). Long-term dietary exposure is assessed by comparing the Theoretical Maximum Daily Intake (TMDI) with the ADI. The TMDI assumes that food consumed over a lifetime contains pesticide residues at the MRL level, and is calculated using MRL values and the average daily consumption of food for which MRLs are established (Osman, 2011). In contrast, evaluating the Hazard Risk (HR) through EDI incorporates median residue values from trials, considering additional factors for more precise estimation.

This study assessed the health risks associated with residues of pesticides belonging to the chemical groups of diamides, spinosyns, strobilurins, and methoxy-carbamates in various fruits and vegetables. Strobilurins are fungicides widely used in agriculture due to their effectiveness in controlling fungal diseases, acting preventively and systemically. Methoxycarbamates, characterized by a methoxy group in their structure,

are usually applied as insecticides, fungicides, and herbicides, demonstrating efficacy. Diamides, which contain two amide linkages in a single molecule, are utilized for crop protection against insects, fungi, and certain weeds. Spinosyns, natural insecticides derived from the fermentation of *Saccharopolyspora spinosa*, are effective in controlling a broad spectrum of insect pests, with low toxicity to non-target organisms, making them commonly used in ecological farming systems.

All these pesticide groups play a significant role in plant protection within conventional agriculture, however, their application requires careful management to reduce the risk of resistance and negative environmental and health effects.

MATERIALS AND METHODS

In order to obtain data for the calculation of dietary risk assessment, field experiments were conducted at three localities (Kula, Mala Remeta, Gospođinci) in the Republic of Serbia. In this study, diamides insecticides chlorantraniliprol, cyantraniliprol, spinosyns insecticide spinetoram, strobilurine fungicide boscalid and methoxycarbamates fungicide pyraclostrobin were used. They are applied according to EPPO methods, during ripening stage, at the recommended rate for the control of economically important pests (Table 1).

Insecticides chlorantraniliprol and cyantraniliprol were applied in peach, for the control of *Cydia molesta* and *Trialeurodes vaporariorum* in tomato, spinetoram was used for the control of *Psylla piri* in pear, while fungicides boscalid and pyraclostrobin were applied in strawberry and raspberry against *Botrytis cinerea*.

Table 1. Pesticides used in the study

Active substance	The amount of a.s. in PPP	Recommended application rate	Fruit/ vegetable	BBCH stage	PHI (days)	MRL (mg/kg)
chlorantraniliprol	100 g/l	1.2 l/ha	peach	74	14	1
cyantraniliprol	100 g/l	0.6 l/ha	peach	74	7	1.5
			tomato	74	1	0.6
spinetoram	200 g/kg	0.3 l/ha	pear	75	7	0.15
boscalid pyraclostrobin	267 g/kg	1.5 l/ha	strawberry	65-87	7	6
	67 g/kg					1.5
boscalid pyraclostrobin	267 g/kg	1.5 l/ha	raspberry	65-87	7	10
	67 g/kg					1.5

Sampling was performed 1 hour after application (after drying deposit), and afterward daily during pre-harvest interval. Pesticide residues were determined by previously validated the QuEChERS-based method followed with HPLC.

HQ value was calculated by dividing EDI (mg/kg bw/day) with the relevant ADI (mg/kg bw/day) value (Łozowicka *et al.*, 2013), while average consumption and acceptable daily are taken from the EFSA. EDI was calculated using data for the concentration of pesticide obtained in the field experiment, food consumption, and body weight.

RESULTS AND DISCUSSION

Risk assessment was performed based on the results of the field experiments (Žunić *et al.*, 2020; Lazić *et al.*, 2020; Šunjka *et al.*, 2021). For the analysis, only the highest residue level of the insecticides and fungicides in samples, obtained in the dissipation studies, were taken. Samples were collected 1 hour after the application, representing the samples with the highest risk for the consumers.

For long-term risk assessment, HQ was evaluated by comparing the exposure with the toxicological reference value (ADI) (Sharma *et al.*, 2022). The EDI values were calculated for analyzed fruits and vegetable samples and the results obtained are summarized in Table 2.

None of the fruit and vegetable samples reported HQ values >1 thereby indicating that an unacceptable risk of daily intake was not observed in these experiments. Values of HQ between 0.1 and 1.0 were obtained for cyantraniliprole in peaches (0.14931) and tomatoes (0.60407), indicating a moderate risk of cyantraniliprole in this fruit and vegetable. A hazard quotient below 0.1 was in the analysis of spinetoram in pear, as well as boscalid and pyraclostrobin in strawberry and raspberry, with a low risk of their use.

Mainly, there is a lack of data on pesticide risk assessment in fruits and vegetables. Studies of risk assessment of chlorantraniliprole and cyantraniliprole in tomato and paddy ecosystems showed a moderate risk for these insecticides (Paramasivam *et al.*, 2021; Mahato *et al.*, 2023).

Table 2. Results of the evaluation of risk assessment

		ACA/day (kg/day)	Average adults body weight (kg)	Residue level (mg/kg)	EDI (mg/kg/ bw/ day)	ADI (mg/kg/ bw/day)	Hazard quotient (HQ)
pear	spinetoram	0.0074	70.8	0.51	0.00005	0.024	0.00222
peach	cyantraniliprole	0.0167	70.8	6.33	0.00149	0.01	0.14931
peach	chlorantraniliprole	0.0167	70.8	10.14	0.00239	1.56	0.00153
strawberry	boscalid	0.0044	70.8	12.10	0.00075	0.04	0.01880
	pyraclostrobin	0.0044	70.8	10.93	0.00068	0.04	0.01698
raspberry	boscalid	0.0027	70.8	17.6	0.00067	0.04	0.01678
	pyraclostrobin	0.0027	70.8	9.25	0.00035	0.04	0.00882
tomato	cyantraniliprole	0.0990	70.8	4.32	0.00604	0.01	0.60407

ACA – average consumption of adults

CONCLUSIONS

In this study, the maximum residue levels of pesticides obtained one hour after the application were used to evaluate risk assessment as the worst-case scenario. The results indicate that their consumption does not present a significant health risk to humans, however, prescribed PHI values have to be considered.

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PROCENA RIZIKA OD PESTICIDA U ODREĐENIM VRSTAMA VOĆA I POVRĆA: SVEOBUHVAATNA EVALUACIJA

Sažetak

Klimatske promene, nedostatak vode, smanjenje obradivog zemljišta, a posebno rasprostranjenost štetnih agenasa, predstavljaju značajne izazove u proizvodnji hrane, što zahteva adekvatne mere zaštite bilja. Istovremeno, savremena nauka se suočava sa nekoliko ključnih pitanja kao što je rastuća zabrinutost za bezbednost hrane, trend organske poljoprivrede, pojava rezistentnih populacija štetnih organizama i narušavanje biodiverziteta, usled upotrebe hemijskih pesticida. Stoga je jedna od ključnih mera zaštita potrošača od izloženosti neprihvatljivim nivoima pesticida. Tokom protekle decenije, prisustvo hrane koja sadrži ostatke pesticida značajno je poraslo. Shodno tome, neophodna je kontinuirana provera prisustva ostataka pesticida u poljoprivrednim proizvodima, a posebno u hrani koja se uglavnom konzumira u svežem stanju, kao što su voće i povrće. Ovim istraživanjem je, na osnovu procenjenog dnevnog unosa (EDI) i količnika opasnosti (HQ), izvršena procena rizika od ostataka pesticida iz klase diamida, spinozina, strobilurina i metoksikarbamata u različitom voću i povrću. Procena je uključivala izračunavanje bazirano na eksperimentima dinamike degradacije, a rezultati su pokazali da ostaci analiziranih pesticida u uzorcima voća i povrća ne predstavljaju značajan rizik po zdravlje ljudi.

Ključne reči: *ostaci pesticida, procena rizika, voće, povrće*