Research paper **P 12**

DETERMINATION AND ASSESSMENT OF PESTICIDE RESIDUES IN FRUITS FROM THE SERBIAN MARKET

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DOI: 10.68725/FDSQ_WORKSHOP.2026.9.23

ABSTRACT

The presence of pesticide residues in fruits represents an important aspect of food quality and consumer safety. This study aimed to evaluate the occurrence and distribution of multiple pesticide residues in conventionally and organically produced fruits available on the Serbian market. Fruit samples from different groups (berries, stone fruits, and citrus fruits) were analyzed using GC-MS. The most frequently detected pesticides were cypermethrin, fludioxonil, boscalid, and tebuconazole. Berries and stone fruits showed the highest diversity of detected residues, while organic fruits generally exhibited lower residue occurrence. The highest individual concentrations were observed for imazalil in sour cherry and pyraclostrobin in raspberry samples. Although most detected concentrations were within regulatory limits, the findings demonstrate that pesticide application during cultivation may result in detectable residues in fruits and highlight the importance of continuous monitoring.

INTRODUCTION

Fruit consumption is strongly associated with beneficial health effects due to the presence of many bioactive compounds. Intensive agricultural production requires the application of plant protection products to prevent losses. Although pesticides play an important role in modern agriculture, their intensive or inappropriate use may result in the accumulation of residues in edible plant parts. The presence of pesticide residues in food represents an important food safety concern due to possible long-term dietary exposure and potential adverse effects on human health. To protect consumers, maximum residue limits (MRLs) have been established by national and international regulatory bodies, while continuous monitoring programs are implemented to verify compliance and assess dietary exposure. Previous studies [1,2] have shown that fruits,

particularly berries and stone fruits, belong to the food groups where multiple pesticide residues are frequently detected. Differences in residue occurrence may be related to agricultural practices, crop susceptibility, environmental conditions, and post-harvest treatments.

The aim of this study was to investigate the occurrence and distribution of pesticide residues in different fruits available on the Serbian market, with emphasis on comparing conventional and organic production systems and evaluating their implications for food safety.

EXPERIMENTAL

Conventionally and organically produced fruit samples (a total of 77 samples), including berries, stone fruits, and citrus fruits, were obtained from the Serbian market over two years. Samples were homogenized and prepared for pesticide residue analysis using a multiresidue extraction procedure based on the QuEChERS method. The determination of pesticide residues was performed by gas chromatography coupled with tandem mass spectrometry (GC-MS).

RESULTS AND DISCUSSION

The summary of detected pesticide residues in different fruit categories from the Serbian market is presented in Table 1. The analysis of 77 fruit samples demonstrated that pesticide residues were detected in most of the samples, while residue occurrence and composition varied among different fruit types. It was shown that various pesticide residues belong mainly to fungicides and insecticides (such as fludioxonil, boscalid, tebuconazole, pyraclostrobin, cypermethrin, pyridaben, imazalil) (Table 1).

Berries, including raspberry, blackberry, strawberry, and blueberry, showed the highest diversity of detected pesticide compounds. Frequently identified residues included cypermethrin, fludioxonil, boscalid, and tebuconazol (Table 1). Several berry samples contained multiple pesticide residues simultaneously, suggesting the intensive use of combined crop protection treatments during production. Among berry samples, the highest concentrations were observed for pyraclostrobin (0.5522 mg kg^{-1}) and boscalid (0.3867 mg kg^{-1}) in raspberry samples (Table 1).

Stone fruits, including plum and sour cherry, also demonstrated considerable variability of pesticide residue. Fludioxonil, cypermethrin, tebuconazole, and other fungicides were commonly detected. The highest individual concentration observed in the dataset was recorded for imazalil (1.2842 mg/kg, Table 1) in sour cherry samples, indicating the importance of continuous monitoring of certain fruit commodities with higher susceptibility to fungal contamination or post-harvest treatments. Pyridaben, which is an insecticide in the acaricide group, was important for plum samples, with the highest value of 0.144 mg/kg (Table 1).

Table 1. Summary of detected pesticide residues in different fruit categories from the Serbian market.

Fruit group	No. of samples	Most frequently detected pesticides	Max detected concentration (mg kg^{-1})	Food safety observation
Berries (raspberry, blackberry, strawberry, blueberry)	39	Cypermethrin, Fludioxonil, Boscalid, Tebuconazole	up to 0.55	Multiple residues frequently detected; levels generally below MRLs
Stone fruits (plum, sour cherry, apricot)	21	Fludioxonil, Cypermethrin, Tebuconazole, Imazalil	up to 1.28	Occasional elevated residues requiring monitoring
Citrus fruits (lemon)	2	Cypermethrin, Imazalil	<0.02	Low residue occurrence
Organic fruits	15	Fludioxonil, Cypermethrin, Boscalid (sporadic)	<0.05	Lower residue frequency compared with conventional fruits

Organic fruits generally exhibited a lower number of detected residues compared with conventional samples. However, occasional detection of pesticide compounds was observed, which may be associated with environmental contamination and spray drift from neighboring agricultural areas.

Overall, the detected concentrations were generally low, and the residue patterns were comparable with those reported by the European Food Safety Authority (EFSA) [3]. The obtained residue profiles indicate that pesticide occurrence is highly dependent on fruit type and production conditions. In addition, the presence of multiple residues in individual samples highlights the necessity of regular surveillance programs. These results contribute to the current knowledge of pesticide residue occurrence in fruit available on the Serbian market and provide useful data for future exposure assessment and food safety evaluation.

CONCLUSION

This study provides an overview of pesticide residue occurrence in different fruit samples available on the Serbian market. The results demonstrated variability in residue profiles among berries, stone fruits, and citrus fruits, with multiple pesticide residues detected in several samples. Fungicides and insecticides represented the predominant groups of detected pesticides, reflecting their

widespread application in fruit production. Among the detected fungicides, pyraclostrobin was identified in several berry samples, with the highest concentration observed in raspberry samples. Organic fruits generally showed a lower frequency of pesticide detection. However, the occasional detection of pesticide residues emphasizes the need for continuous monitoring programs to provide reliable data for dietary exposure assessment, support regulatory actions, and ensure consumer confidence in food safety. The obtained data contribute to a better understanding of pesticide contamination patterns in fruits and provide valuable information for future food safety evaluations and consumer exposure assessments.

Acknowledgement
This work was partially supported by the Ministry of Science, Technological Development and Innovation of Republic of Serbia under the contract on the realization and financing of scientific research work of research organizations: Contract Nos: 451-03-33/2026-03/200051 (M.K., Ž.N., M.Ć., S.B.), 451-03-33/2026-03/200030 (A.T.).

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