Food and Chemical Toxicology
Volume 2, Number 2, 2023

Health Risk Assessment of Pesticide Residues in Food: A Literature Review

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Article history:
Received: July 12, 2023
Revised: October 23, 2023
Accepted: November 25, 2023
Published: December 30, 2023

Keywords:
Pesticide Residues,
Health Risk Assessment,
Food Safety,
Chronic Exposure,
Toxicology.

Identifier:
Zera Open
Page: 80-89
https://zeraopen.com/journal/fct

Abstract

This study aims to analyze the health risks of exposure to pesticide residues in food through a literature review approach. Data were obtained from Google Scholar, ScienceDirect, and PubMed with the inclusion criteria of articles published between 2018 and 2022, focusing on pesticides and health, and originating from reputable international journals. The analysis was conducted using content analysis and synthesis of research findings. The results of the study indicate that pesticide residues are still widely found in food, often in the form of a combination of several compounds (multiple residues). Although most residue levels are below the established maximum limit, chronic exposure and cumulative effects still have the potential to pose health risks. Risk assessment using Estimated Daily Intake (EDI), Acceptable Daily Intake (ADI), and Hazard Quotient (HQ) indicators shows that the risk is generally still within the safe category, but vulnerable groups such as children have a higher potential for exposure. Furthermore, existing risk assessment approaches still have limitations in accommodating long-term effects and interactions between pesticides.

1. Introduction

The use of pesticides in modern agriculture has become an integral part of efforts to increase productivity and maintain crop quality. In practice, pesticides are used to control pests, plant diseases, and weeds that can reduce yields. However, intensive and uncontrolled use may leave residues in food products such as vegetables, fruits, and other agricultural commodities. These residues can enter the human body through daily consumption. Over the long term, even low-level exposure can accumulate and lead to serious health effects. Various studies indicate associations with neurological disorders, endocrine disruption, immune suppression, and increased risks of chronic diseases such as cancer (Yura et al., 2021; Gossel, 2018; Rand et al., 2020). Thus, pesticide residues in food are a significant concern not only for food safety but also for public health (El-Sheikh et al., 2022).

Another limitation found in previous studies is the lack of attention to chronic exposure resulting from long-term consumption of contaminated food. Most studies tend to assess risk based on short-term exposure or by comparing residue levels with safety limits without considering cumulative effects in the body. People consume various foods daily that may contain small but continuous amounts of pesticide residues. In addition, there is the phenomenon of exposure to combinations of different pesticides, known as multiple residues. A single food item may contain more than one type of pesticide, and interactions among these compounds may increase toxic effects that cannot be explained by analyzing a single pesticide alone (Jankowska et al., 2024; Zeber-Dzikowska et al., 2025). Therefore, risk assessment approaches that consider cumulative exposure and combined effects are essential.

The development of health risk assessment methods has provided a more comprehensive approach to evaluating the impact of pesticide residues on human health. This approach considers not only residue concentrations but also food consumption rates, body weight, and toxicological parameters such as Acceptable Daily Intake (ADI) and Hazard Quotient (HQ). Through this approach, risk assessment can offer a more realistic picture of potential health hazards (Abtahi et al., 2025; Laor et al., 2019). In addition, international organizations have established standards and guidelines for maximum residue limits to protect public health. However, differences in geographic conditions, dietary patterns, and types of pesticides used across countries may lead to variations in risk assessment outcomes, highlighting the need for more contextual and integrated studies (Riediker et al., 2019; Kihara et al., 2021).

The urgency of evaluating health risks associated with pesticide residues is increasing alongside the rising consumption of agricultural products and the growing use of pesticides in modern farming practices. Without a comprehensive risk assessment, potential long-term health hazards may be overlooked and could affect public health in the future. Furthermore, comprehensive findings are needed to support the development of policies and regulations related to food safety at both national and international levels. With accurate and evidence-based information, efforts to control pesticide use and protect consumers can be carried out more effectively. This study aims to comprehensively analyze the health risks associated with pesticide residues in food through a literature review approach, with a focus on chronic exposure and the combined effects of multiple pesticides on human health.

2. Literature Review

2.1. Pesticide Residues

Pesticide residues are chemical substances that remain on or within food products because of pesticide use in agricultural processes. These residues may consist of active compounds, degradation products, or metabolites formed after application. Their presence is a concern because they have the potential to cause toxic effects, especially when exposure occurs continuously over a long period through daily food consumption (Gossel, 2018; Yura et al., 2021).

The main source of pesticide residues comes from agricultural activities, particularly the use of pesticides to control pests and plant diseases. Improper use, such as excessive dosage or failure to observe pre-harvest intervals, can increase residue levels in crops. In addition, residues may also originate from environmental contamination, such as polluted soil and water, which then enter the food chain and undergo bioaccumulation (Rand et al., 2020; El-Sheikh et al., 2022).

Pesticides include organophosphates, carbamates, organochlorines, and pyrethroids. Organophosphates and carbamates affect the nervous system, while organochlorines are persistent and tend to accumulate in the environment. Human exposure to pesticide residues generally occurs through food consumption, but can also happen through drinking water, inhalation, and skin contact (Laor et al., 2019; Riediker et al., 2019).

2.2. Health Risk Assessment

Health risk assessment is a scientific approach used to evaluate the potential impacts of exposure to hazardous substances on humans, including pesticide

residues in food. This approach integrates data on residue concentrations, food consumption levels, and toxicological parameters to determine the level of risk that may arise. In this context, the concept of risk assessment does not only focus on the presence of harmful substances but also considers the extent of exposure experienced by individuals in daily life (Abtahi et al., 2025; Rand et al., 2020).

One of the main indicators used is the Estimated Daily Intake (EDI), which represents the estimated amount of pesticide entering the body each day through food consumption. This value is then compared with the Acceptable Daily Intake (ADI), which is the maximum amount of a substance that can be consumed daily over a lifetime without causing significant health risks. The comparison between EDI and ADI produces the Hazard Quotient (HQ), which is used to assess the level of risk. If the HQ value is less than one, the exposure is within a safe limit. Conversely, if the HQ value exceeds one, there is a potential health risk that needs attention. Therefore, risk interpretation is based on the relationship between the level of exposure and the scientifically established safety threshold (Jankowska et al., 2024; Zeber-Dzikowska et al., 2025).

3. Methods

This study uses a qualitative approach with a literature review method to comprehensively examine pesticide residues in food and their health risks. Data were obtained from reputable scientific databases such as Google Scholar, ScienceDirect, and PubMed. The inclusion criteria include articles published between 2018 and 2022, focusing on pesticides and health, and originating from reputable international

journals. Data collection was conducted by searching keywords such as "pesticide residues", "health risk assessment", and "food safety", followed by selection based on the relevance of titles, abstracts, and content. Articles that met the criteria were further analyzed. The analysis technique used content analysis to identify patterns, themes, and key findings from each study. Furthermore, the results were synthesized to produce an integrated understanding of the health risks associated with exposure to pesticide residues in food.

4. Results

4.1. Occurrence of Pesticide Residues in Food

Various studies indicate that pesticide residues are still widely found in food products, particularly vegetables and fruits derived from intensive agricultural practices. A study by El-Sheikh et al. (2022) found that several samples from farmer markets contained pesticide residues with varying types and concentrations, although most were still below the maximum residue limits. However, the presence of multiple residues in a single sample is a concern, as it reflects the use of various pesticides within one commodity.

Similar findings were reported by Jankowska et al. (2024), who noted that fruits and vegetables may contain more than one type of pesticide, thereby increasing the complexity of exposure. In addition, a literature review by Yura et al. (2021) emphasized that pesticide residues in food are a global phenomenon influenced by the intensity of pesticide use, types of commodities, and compliance with regulations. These findings suggest that the presence of pesticide residues in food

remains a relevant issue that requires attention, particularly in the context of food safety and public health protection.

4.2. Health Risk Assessment of Pesticide Exposure

Health risk assessment of pesticide exposure is important to understand the extent to which residues present in food may harm humans. This approach generally uses indicators such as Estimated Daily Intake (EDI), Acceptable Daily Intake (ADI), and Hazard Quotient (HQ) to evaluate the level of risk. A study by Abtahi et al. (2025) shows that most pesticide exposure through food consumption remains within safe limits; however, certain groups, such as children, are at higher risk. In addition, research by Laor et al. (2019) reveals that pesticide exposure does not only come from food consumption but also from occupational environments, which can further increase health risks. Furthermore, a study by Zeber-Dzikowska et al. (2025) emphasizes that long-term exposure, even at low doses, still has the potential to cause toxic effects. Therefore, although most residues remain within regulatory limits, health risks still need attention, especially regarding chronic exposure and the combined effects of multiple pesticides in food.

5. Discussion

The discussion of pesticide residues in food indicates that their presence remains a significant issue in the context of food safety and public health. Findings from various studies suggest that pesticide residues are not only found in a single type of food, but also frequently occur as combinations of several compounds within one product. This strengthens concern that human exposure is not singular, but

rather cumulative and complex. Studies show that although most residues remain below the established maximum limits, the presence of multiple residues may increase health risks that are not fully addressed in current regulatory standards (El-Sheikh et al., 2022; Jankowska et al., 2024).

From a health risk assessment perspective, the use of indicators such as Estimated Daily Intake (EDI), Acceptable Daily Intake (ADI), and Hazard Quotient (HQ) provides a quantitative picture of exposure levels and potential risks. In general, an HQ value below one indicates that the risk is within a safe category. However, research findings indicate that there are variations in risk among population groups, where children tend to have higher exposure levels compared to adults. This suggests that demographic factors and consumption patterns play an important role in determining risk levels (Abtahi et al., 2025).

Furthermore, this discussion highlights that current risk assessment approaches still have limitations, particularly in addressing long-term exposure effects and interactions among various types of pesticides. Studies emphasize that chronic exposure, even at low doses, still has the potential to cause serious health impacts. Therefore, the development of more comprehensive risk assessment methods, along with improved monitoring of pesticide use, is necessary to ensure optimal protection of public health (Yura et al., 2021; Zeber-Dzikowska et al., 2025).

6. Conclusion

Food safety remains an important issue in both food security and public health. Pesticide residues are found in various types of food products, especially

vegetables and fruits, with most levels still below the established maximum limits. However, the presence of multiple residues in a single product indicates that human exposure is complex and may increase health risks, particularly over the long term.

Health risk assessment approaches such as Estimated Daily Intake (EDI), Acceptable Daily Intake (ADI), and Hazard Quotient (HQ) generally show that exposure remains within safe limits. Nevertheless, vulnerable groups such as children have a higher potential risk due to differences in consumption patterns and physiological characteristics. In addition, chronic exposure and the combined effects of multiple pesticides are not yet fully addressed in current risk assessment methods.

References

Abtahi, M., Paeezi, M., Dobaradaran, S., Mohagheghian, A., Bagheri, A., & Saeedi, R. (2025). Assessment of health risk and burden of disease associated with dietary exposure to pesticide residues through foodstuffs in Iran. *Food and Chemical Toxicology*, *199*, 115344.

El-Sheikh, E. S. A., Ramadan, M. M., El-Sobki, A. E., Shalaby, A. A., McCoy, M. R., Hamed, I. A., ... & Hammock, B. D. (2022). Pesticide residues in vegetables and fruits from farmer markets and associated dietary risks. *Molecules*, *27*(22), 8072.

Gossel, T. A. (2018). *Principles of clinical toxicology*. Boca Raton: CRC Press.

Jankowska, M., Kaczyński, P., Hrynko, I., Rutkowska, E., Iwaniuk, P., Ilyasova, G., & Łozowicka, B. (2024). Dietary risk assessment of children and adults

consuming fruit and vegetables with multiple pesticide residues. *Chemosphere*, *369*, 143858.

Kihara, S., Köper, I., Mata, J. P., & McGillivray, D. J. (2021). Reviewing nanoplastic toxicology: It's an interface problem. *Advances in Colloid and Interface Science*, *288*, 102337.

Laor, P., Keawdounglek, V., Hongtong, A., Suma, Y., Pasukphun, N., Songla, T., & Ayudhaya, W. S. N. (2019). Health risk and health status of farmers exposed to chemical pesticides used in agriculture. *Journal of Current Science and Technology*, *9*(2), 89-98.

Rand, G. M., Wells, P. G., & McCarty, L. S. (2020). Introduction to aquatic toxicology. In *Fundamentals of aquatic toxicology* (pp. 3-67). CRC Press.

Riediker, M., Zink, D., Kreyling, W., Oberdörster, G., Elder, A., Graham, U., ... & Cassee, F. (2019). Particle toxicology and health-where are we?. *Particle and fibre toxicology*, *16*(1), 19-31.

Yura, W. F., Muhammad, F. R., Mirza, F. F., Maurend, Y. L., Widyantoro, W., Farida, S. S., ... & Fikri, E. (2021, November). Pesticide residues in food and potential risk of health problems: a systematic literature review. In *IOP Conference Series: Earth and Environmental Science*. Washington DC: IOP Publishing.

Zeber-Dzikowska, I., Gworek, B., & Gozdziewska, M. (2025). Health risk resulting from pesticide residues in food of plant origin-a still valid challenge for health and ecological education. *Annals of Agricultural and Environmental Medicine*, *32*(2), 33455.