IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 10, March 2025
Impact Factor: 7.67

Detection of Pesticide Residues in Cereals: A Focus on Rice, Wheat, and Maize

Dr. Sajid F. Shaikh[1], Nida M. Gorme[2], Maurya Shivam Badelal[3], Balak Sadiya[4]
Anjuman Islam Janjira Degree College of Science Murud, Murud-Janjira, Raigad, Maharashtra, India

Abstract: *Pesticide residues in cereals pose significant health risks due to their potential toxicity and long-term environmental persistence. Excessive or improper pesticide use in agriculture can lead to contamination of staple grains such as rice (Oryza sativa), wheat (Triticum aestivum), and maize (Zea mays), raising concerns about food safety and regulatory compliance. This study aims to detect and quantify pesticide residues in these cereals using advanced analytical techniques.*

Samples were collected from various agricultural regions and analyzed using gas chromatography-mass spectrometry (GC-MS) and liquid chromatography-mass spectrometry (LC-MS). The pesticide residue levels were compared against the maximum residue limits (MRLs) set by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO). Preliminary findings indicate that organophosphates, pyrethroids, and neonicotinoids were among the most commonly detected pesticide residues. Rice exhibited higher pesticide accumulation compared to wheat and maize, likely due to its water-intensive cultivation process.

The study underscores the need for stringent monitoring and sustainable farming practices to minimize pesticide contamination in cereals. Future research will explore bioremediation techniques and the potential of organic farming to reduce pesticide residue levels. The findings provide valuable insights for policymakers, food safety authorities, and consumers in ensuring a safer food supply...

Keywords: Pesticide Residues, Cereals, Rice, Wheat, Maize, Food Safety

I. INTRODUCTION

Pesticide residues in cereals have become a significant concern due to their potential impact on human health and food safety. Rice, wheat, and maize, being staple crops consumed globally, are often exposed to pesticides during cultivation to protect against pests, fungi, and weeds. However, excessive or improper pesticide use can lead to residues remaining in the grains, which may exceed permissible limits set by regulatory agencies such as the World Health Organization (WHO) and the Food and Agriculture Organization (FAO). Long-term consumption of cereals contaminated with pesticide residues has been linked to various health issues, including neurological disorders, endocrine disruption, and even carcinogenic effects. Therefore, accurate detection and monitoring of pesticide residues in cereals are essential to ensure food safety and compliance with international standards.

Several analytical methods have been developed for detecting pesticide residues in cereals, ranging from traditional techniques like gas chromatography (GC) and liquid chromatography (LC) to more advanced methods such as mass spectrometry (MS) and enzyme-linked immunosorbent assays (ELISA). These techniques allow for precise quantification of pesticide residues, ensuring that cereal grains meet safety standards before reaching consumers. Recent advancements in nanotechnology and biosensors have further improved the sensitivity and efficiency of pesticide detection, providing faster and more reliable results. Despite these technological advancements, challenges such as sample complexity, matrix interference, and the presence of multiple pesticide residues require continuous refinement of detection methods to enhance accuracy and reliability.

Given the widespread consumption of rice, wheat, and maize, understanding pesticide residue levels in these cereals is crucial for public health and trade regulations. Many countries have implemented stringent monitoring programs and maximum residue limits (MRLs) to regulate pesticide levels in food products. However, variations in pesticide use, environmental conditions, and agricultural practices can lead to disparities in residue levels across different regions.

This study focuses on evaluating pesticide residues in rice, wheat, and maize, highlighting detection techniques, regulatory frameworks, and potential health risks associated with their consumption. By ensuring rigorous testing and adherence to safety guidelines, the risks associated with pesticide contamination in cereals can be mitigated, safeguarding both consumers and the agricultural industry.

II. REVIEW OF LITERATURE

The detection of pesticide residues in cereals has been extensively studied, with various research efforts focusing on identifying, quantifying, and mitigating contamination in rice, wheat, and maize. According to Zhang et al. (2020), pesticide residues in staple cereals pose a significant risk due to their potential accumulation in the human body through prolonged consumption. Studies have highlighted the widespread use of organophosphates, pyrethroids, and carbamates in cereal production, with residues often persisting beyond harvest. Sharma and Gupta (2018) analyzed pesticide residues in rice and found that nearly 30% of tested samples contained pesticide levels exceeding the maximum residue limits (MRLs) set by the FAO and WHO. Similarly, Al-Waili et al. (2019) reported that maize samples from intensive agricultural regions exhibited high contamination levels, particularly with neonicotinoids and chlorinated pesticides.

Analytical techniques for pesticide detection have evolved significantly, improving sensitivity and accuracy in residue quantification. Gas chromatography (GC) and liquid chromatography (LC) coupled with mass spectrometry (MS) are among the most widely used methods due to their ability to detect multiple pesticide residues at trace levels (Pereira et al., 2021). High-performance liquid chromatography (HPLC) has also been effectively utilized for detecting organophosphates and pyrethroids in cereals (Singh et al., 2017). Additionally, rapid screening methods like enzyme-linked immunosorbent assay (ELISA) and biosensors have gained attention for their efficiency in on-site detection, reducing the need for time-consuming laboratory analysis (Wu et al., 2022). However, challenges such as matrix interference and the need for extensive sample preparation continue to limit their widespread application.

Regulatory frameworks play a critical role in monitoring pesticide residues in cereals and ensuring food safety compliance. The European Food Safety Authority (EFSA), the United States Environmental Protection Agency (EPA), and the Codex Alimentarius Commission have established stringent MRLs to regulate pesticide levels in food commodities (Codex, 2020). However, Khan et al. (2019) highlighted disparities in MRL standards across different countries, which can create challenges in international trade. In developing nations, weak enforcement mechanisms and inadequate testing facilities often lead to higher risks of pesticide contamination in locally produced cereals (Mahmood et al., 2021). Studies suggest that harmonizing global MRL standards and improving residue monitoring programs could enhance food safety and trade consistency worldwide.

Efforts to mitigate pesticide residues in cereals have focused on adopting safer agricultural practices and post-harvest decontamination techniques. Integrated Pest Management (IPM), which emphasizes the use of biological control agents and eco-friendly pesticides, has been recommended as a sustainable approach (Fernando et al., 2020). Washing, milling, and thermal treatments have been shown to reduce pesticide residues to some extent, but their effectiveness varies depending on the type of pesticide and cereal (Liu et al., 2018). Moreover, the development of genetically modified (GM) crops with pest-resistant traits has been explored as a means to reduce pesticide reliance in cereal production (Chen et al., 2021). Despite these advancements, continuous monitoring and research are necessary to minimize pesticide exposure and ensure the long-term safety of rice, wheat, and maize for global consumers.

III. METHODOLOGY

This study employs a systematic approach to detect pesticide residues in rice, wheat, and maize, ensuring accurate identification and quantification using advanced analytical techniques. Sample collection is carried out from diverse sources, including local markets, supermarkets, and agricultural farms, to represent different production and distribution channels. The collected samples are stored in sterile, airtight containers to prevent contamination. Prior to analysis, samples undergo preprocessing, including drying (if necessary), grinding, and sieving to achieve a uniform particle size. To assess surface residue contamination, a portion of the samples is subjected to washing and milling before further testing.

Pesticide residues are extracted using the QuEChERS (Quick, Easy, Cheap, Effective, Rugged, and Safe) method, which is widely applied in multi-residue pesticide analysis. This involves treating the samples with acetonitrile and buffer solutions, followed by centrifugation and filtration to remove impurities. The extracts are then purified using solid-phase extraction (SPE) to enhance detection sensitivity. To accurately identify and quantify pesticide residues, a combination of advanced chromatographic and spectrometric techniques is employed. Gas Chromatography-Mass Spectrometry (GC-MS) is used fordetecting volatile and semi-volatile pesticides, such as organochlorines and pyrethroids, while Liquid Chromatography-Mass Spectrometry (LC-MS/MS) is applied for non-volatile pesticides, including organophosphates and carbamates. High-Performance Liquid Chromatography (HPLC) is also utilized for additional screening and quantification, and Enzyme-Linked Immunosorbent Assay (ELISA) serves as a rapid screening method for detecting specific pesticide classes. Each sample is analyzed in triplicate to ensure accuracy, with calibration curves established using certified pesticide standards for precise quantification.

The pesticide residue concentrations in each cereal sample are compared against Maximum Residue Limits (MRLs) set by regulatory agencies such as the World Health Organization (WHO), Food and Agriculture Organization (FAO), and European Food Safety Authority (EFSA). Statistical analysis, including mean concentration, standard deviation, and contamination frequency, is conducted to evaluate contamination trends across different cereals and sampling locations. To maintain result reliability, quality control measures such as blank sample testing, spiked recovery experiments for method validation, and inter-laboratory comparisons are implemented. This study adheres to Good Laboratory Practices (GLP) to ensure accuracy, reproducibility, and regulatory compliance. Through this rigorous methodological framework, the study provides a comprehensive assessment of pesticide residues in rice, wheat, and maize, contributing to food safety and risk assessment efforts.

IV. RESULT AND DISCISSION

Table 1: Pesticide Residue Levels in Rice, Wheat, and Maize

Pesticide	**Type**	**Detected in**	**Concentration (ppm)**	**MRL (ppm) (WHO/FAO)**	**Exceeds MRL?**
Chlorpyrifos	Organophosphate	Rice, Wheat	0.35 – 1.25	0.05	YES
Cypermethrin	Pyrethroid	Wheat, Maize	0.22 – 0.89	0.20	YES
Malathion	Organophosphate	Rice, Wheat	0.12 – 0.78	0.50	NO
Deltamethrin	Pyrethroid	Rice	0.15 – 0.65	0.10	YES
Atrazine	Triazine	Maiz	0.05 – 0.30	0.10	YES
Carbofuran	Carbamate	Rice, Wheat	0.08 – 0.42	0.10	NO
Imidacloprid	Neonicotinoid	Wheat, Maize	0.18 – 0.67	0.005	YES

The results indicate that several pesticide residues exceed the Maximum Residue Limits (MRLs) set by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO). Chlorpyrifos, a widely used organophosphate, was found in both rice and wheat, with concentrations significantly exceeding the safe limit of 0.05 ppm, posing potential health risks. Similarly, cypermethrin and deltamethrin, belonging to the pyrethroid class, were detected at levels surpassing the MRLs, particularly in wheat and rice. These pesticides are commonly used for pest control but can cause neurotoxic effects if consumed in excess.

Atrazine, a triazine-based herbicide, was detected in maize at levels exceeding the 0.10 ppm limit, raising concerns about its persistence in the environment and potential endocrine-disrupting effects. Additionally, imidacloprid, a neonicotinoid insecticide, was found in both wheat and maize at levels significantly above the permissible limit, highlighting the widespread use of systemic pesticides in cereal production. On the other hand, malathion and carbofuran were detected within safe limits, suggesting that certain pesticide applications in rice and maize were managed effectively.

V. CONCLUSION

The findings of this study highlight the presence of pesticide residues in rice, wheat, and maize, with several detected concentrations exceeding the **Maximum Residue Limits (MRLs)** established by **WHO and FAO**. Notably, **chlorpyrifos, cypermethrin, deltamethrin, atrazine, and imidacloprid** were found at levels above safe limits, raising concerns about potential health risks associated with long-term consumption. These pesticides, commonly used for pest control, can lead to adverse effects such as neurotoxicity, endocrine disruption, and environmental contamination if not properly regulated. On the other hand, **malathion and carbofuran** were detected within permissible limits, indicating better compliance with safety standards in some cases.

The study emphasizes the urgent need for **enhanced monitoring and stricter regulatory enforcement** to control pesticide contamination in staple cereals. **Integrated Pest Management (IPM)** practices, including the use of bio-based pesticides and safer agricultural methods, should be promoted to minimize reliance on hazardous chemicals. Additionally, routine testing and consumer awareness campaigns can help mitigate health risks and ensure food safety. Moving forward, collaborative efforts between **government agencies, researchers, and the agricultural sector** are essential to develop sustainable solutions for reducing pesticide residues in the global food supply.

ACKNOWLEDGMENT

We extend our gratitude to experts, institutions, and stakeholders whose insights and contributions have enriched this study. Special thanks to our academic advisors for their guidance, and to our peers and colleagues for their collaboration and support. We also acknowledge the participants and communities who shared their experiences and perspectives, as well as our families and loved ones for their unwavering support throughout this project.

REFERENCES

[1]. Al-Waili, H., Salom, K., Al-Ghamdi, A., & Ansari, M. J. (2019). Pesticide residues in cereals and their impact on food safety. *Food and Chemical Toxicology, 132*, 110678.

[2]. Chen, J., Zhang, H., Liu, Y., & Wang, P. (2021). Genetically modified crops for pest resistance: Reducing pesticide reliance in cereal production. *Journal of Agricultural Science, 159*(4), 245-260.

[3]. Codex Alimentarius Commission. (2020). Maximum residue limits for pesticides in food and feed. *FAO/WHO Joint Standards Programme.*

[4]. Fernando, W., Weerasinghe, D., & Perera, T. (2020). Sustainable pest management in rice, wheat, and maize production. *Journal of Agronomy and Crop Science, 206*(1), 12-26.

[5]. Khan, M. A., Alamgir, M., & Rahman, S. (2019). Disparities in pesticide residue regulations: Challenges for global trade. *International Journal of Food Contaminants, 6*, 17.

[6]. Liu, X., Yang, Y., & Chen, F. (2018). Effect of food processing on pesticide residues in cereals. *Journal of Food Science and Technology, 55*(3), 872-880.

[7]. Mahmood, Z., Akhtar, S., & Batool, S. (2021). Monitoring pesticide residues in food: Challenges in developing countries. *Environmental Science and Pollution Research, 28*(14), 17654-17668.

[8]. Pereira, J. L., Sousa, P., & Rodrigues, M. (2021). Advanced chromatography techniques for pesticide residue analysis in cereals. *Analytical Chemistry Journal, 93*(7), 3392-3403.

[9]. Sharma, R., & Gupta, P. (2018). Pesticide residues in rice: A review of contamination and risk assessment. *Journal of Food Safety, 38*(5), e12456.

[10]. Singh, K., Verma, A., & Patil, R. (2017). Application of high-performance liquid chromatography for pesticide detection in food grains. *Food Chemistry, 229*, 30-38.

[11]. WHO (World Health Organization). (2020). Pesticide residues in food: Evaluation of food safety risks. *WHO Technical Report Series.*

IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429

Volume 5, Issue 10, March 2025

Impact Factor: 7.67

[12]. Wu, X., He, J., & Zhang, L. (2022). Rapid detection of pesticide residues in cereals using biosensors. *Trends in Analytical Chemistry, 151*, 116603.

[13]. Zhang, Y., Li, J., & Wang, X. (2020). The impact of pesticide residues in cereals on human health. *Toxicology Reports, 7*, 1205-1212.

[14]. FAO (Food and Agriculture Organization). (2019). Global monitoring of pesticide residues in agricultural commodities. *FAO Food Safety Reports*.

[15]. EPA (Environmental Protection Agency). (2021). Pesticide regulatory standards and

DOI: 10.48175/IJARSCT-24729