Chapter 6
Analysis of Mycotoxin and Pesticide Residue in Food: Current Practices and Potential Future Trends

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ABSTRACT

This chapter provides a comprehensive overview of mycotoxin and pesticide residue analysis, aiming to elucidate current practices, address challenges, and explore innovative technologies for ensuring food safety. It details analytical methods like LC-MS/MS, GC-MS, HPLC, TLC, and ELISA. Seven key challenges- analytical sensitivity, matrix complexity, cost, regulatory harmonization, environmental impact, emerging contaminants, and scalability are examined, emphasizing barriers to effective detection. Emerging trends, including HRMS, DART-MS, portable biosensors, nanotechnology, AI, and green analytical chemistry techniques like SPME and DLLME, are discussed for their potential to enhance sensitivity, speed, and sustainability. Future directions involve multi-omics, cost-effective platforms, and international collaborations led by Codex Alimentarius, FAO, and WHO to standardize methods and MRLs. By integrating recent studies and regulatory perspectives, this chapter bridges foundational knowledge with forward-looking solutions, fostering interdisciplinary innovation in food safety.

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INTRODUCTION

Mycotoxins and pesticide residues represent significant food contaminants, posing substantial risks to human health, animal welfare, and global food security. Mycotoxins, toxic secondary metabolites produced by fungi such as *Aspergillus*, *Fusarium*, and *Penicillium*, contaminate crops like cereals, nuts, and spices, particularly under warm and humid conditions (Figure 1; Patel et al., 2014). Common mycotoxins, such as aflatoxins, ochratoxin A, and deoxynivalenol, cause severe health effects, from acute poisoning to chronic conditions like liver cancer and immunosuppression (Table 1; Marin et al., 2013; Patel, 2025). Pesticide residues, resulting from the application of chemical agents to control pests, persist in food and the environment, raising concerns about neurotoxicity, endocrine disruption, and ecological damage (Kim et al., 2017). The pervasive nature of these contaminants necessitates robust analytical methods to ensure food safety and compliance with regulatory standards, such as maximum residue limits (MRLs) set by bodies like the Codex Alimentarius and the European Union (EU).

The importance of residue analysis cannot be overstated, as it underpins efforts to safeguard public health, support international trade, and meet stringent regulatory requirements. Analytical techniques, such as liquid chromatography-mass spectrometry (LC-MS) and enzyme-linked immunosorbent assay (ELISA), have become critical tools for detecting and quantifying mycotoxins and pesticide residues in complex food matrices (Maphaisa et al., 2025). These methods enable the identification of contaminants at trace levels, ensuring adherence to safety thresholds. However, challenges like matrix effects, cross-contamination, and the need for rapid, cost-effective solutions persist, particularly in resource-limited settings (Maphaisa et al., 2025).

This chapter offers a comprehensive overview of mycotoxin and pesticide residue analysis, targeting researchers, regulators, and industry professionals. It aims to clarify current analytical methods, address detection challenges, and explore innovative technologies shaping food safety's future. By integrating recent studies and regulatory perspectives, it bridges foundational knowledge with forward-looking solutions. Structured to progress from core concepts to future strategies, the chapter covers practices, challenges, emerging technologies, and long-term approaches, providing a holistic view of food contaminant mitigation and fostering interdisciplinary collaboration and innovation in food safety.