


Chapter 7


Chromatography in Food Contaminant Analysis: Principles, Advances, and Applications for Food Safety

Maurya Manjunath

 <https://orcid.org/0000-0001-9563-9269>


JSS Academy of Higher Education and Research, India

Chitra Rengarajan

 <https://orcid.org/0009-0005-2425-910X>


Tamilnadu Agricultural University, India

Matthew Chidozie Ogwu

 <https://orcid.org/0000-0001-6054-1667>

Appalachian State University, USA

P. Selvakumar


 <https://orcid.org/0000-0002-3650-4548>

Department of Science and Humanities, Nehru Institute of Technology, Coimbatore, India

Subramanian Udayakumar


Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology, India

T. C. Manjunath

 <https://orcid.org/0000-0003-2545-9160>

Rajarajeswari College of Engineering, India

Jyothsna Devi Kuchipudi

 <https://orcid.org/0009-0002-6500-6721>

Jain University, India

ABSTRACT

Chromatography plays a pivotal role in food contaminant analysis, enabling the detection, separation, and quantification of harmful substances to ensure food safety and regulatory compliance. Recent advancements in chromatographic techniques—such as gas chromatography (GC), liquid chromatography (LC), and mass spectrometry (MS)—have enhanced the identification of low-abundance contaminants, including chiral compounds, organophosphorus pesticides, and mycotoxins. High-

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performance liquid chromatography and ultra-high-performance liquid chromatography, coupled with MS, have improved sensitivity and accuracy, particularly in complex food matrices. Additionally, innovations such as microfluidic technologies, immunochromatographic assays, and magnetic covalent organic frameworks are revolutionizing rapid, on-site contaminant detection. The integration of artificial intelligence and green chromatography further optimizes analytical efficiency while reducing environmental impact. Regulatory frameworks and multi-residue methods support global harmonization of food safety standards, ensuring traceability and consumer protection. This chapter highlights the interdisciplinary applications of chromatography in detecting pesticide residues, mycotoxins, veterinary drugs, and food adulterants, emphasizing its critical role in risk assessment and public health. Emerging trends, including portable platforms and non-targeted screening, are also explored, demonstrating how chromatography continues to evolve in response to new food safety challenges.

INTRODUCTION

The role of chromatography in food contaminant analysis is pivotal, particularly in the detection of various pollutants and harmful substances in food products. This analytical technique enables the separation, identification, and quantification of contaminants, ensuring food safety and compliance with regulatory standards. Recent advancements have leveraged chromatography's capabilities, facilitating the detection of low-abundance chiral compounds, organophosphorus pesticides, and mycotoxins, which are critical for ensuring the integrity of the food supply chain. High-performance liquid chromatography (HPLC) has been notably influential in the analysis of food contaminants. Utilizing reversed-phase HPLC, researchers have been able to separate compounds with varying polarities, effectively analyzing alkenylbenzenes present in food products like flavoring agents (Dang & Quirino, 2021). Traditional methods using HPLC face challenges, particularly in the analysis of complex food matrices, where interference from co-eluting substances can occur, especially in the context of emerging mycotoxins (Sun et al., 2019). Comparatively, ultra-high-performance liquid chromatography (UPLC) coupled with mass spectrometry (MS) has shown improvements in sensitivity and accuracy, proving essential in the analysis of highly polar pesticides in processed fruits and vegetables (Savini et al., 2019; Ashraf et al., 2021).

Furthermore, the applications of gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS) have provided significant insights into volatile compounds associated with food freshness and quality. For example, GC-MS has been instrumental in the rapid monitoring of seafood quality, offering non-

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