2026 Volume: 02 Issue: 01 www.ijrpa.com ISSN 2456-9995 Review Article

International Journal Research Publication Analysis

Page: 01-13

A REVIEW STUDY ON FOOD ADULTERATION

Chandu Chandu[1], Muthyala Balakrishna*[2],Yakkanti Pusphalatha[3], Ikramul Hussain[4], Krishnendu Adhikary[5], Diya Koijam[6], Nandeibam Ledia Devi[7]

[2]Associate Professor, Department of Pharmaceutical Analysis,SIMS College Of Pharmacy, Guntur.

[1,3,4,5,6,7]Students, SIMS College Of Pharmacy, Guntur.

Article Received: 14 December 2025
Article Revised: 02 January 2026
Published on: 22 January 2026

***Corresponding Author: Muthyala Balakrishna**
Associate Professor, Department of Pharmaceutical Analysis,SIMS College Of Pharmacy, Guntur.
DOI: https://doi-doi.org/101555/ijrpa.8778

ABSTRACT:

Food adulteration has become an increasingly common problem across the globe, threatening the safety, health, and consumer confidence in the whole process. This can happen deliberately as a means to earn profits or can happen unknowingly due to the inefficiencies caused by the environment. This review briefly describes the sources, risks, and current technological solutions for detection. Chromatographic and analytical methods like HPLC, GC-MS, and LCMS are highly sensitive and quantitative regarding the detection and identification of known sources, whereas spectroscopy and chemometric characterization are highly rapid and less destructive. The use of modern sensor-based technologies and E-nose systems facilitate the process of on-site testing, whereas untargeted approaches like metabolomics and stable isotope analysis improve authenticity testing. The role and sources are further briefly explained in the following sections.

KEYWORDS: Food Safety, Chromatography, Spectroscopy, DNA Based Analysis, Economic Gain, Synthetic Chemicals.

1. INTRODUCTION

One of its needs as an element of its system is for food, which is among its basic requirements for maintaining its own health. For instance, where there is an absence.However, safety and purity have nowadays become an international concern with the growing adulteration of foods. Food adulteration is defined as an act of adding, substituting, or abstraction of ingredients in food commodities in such a manner that the natural constitution of food and its quality are affected adversely. It is mostly done to increase profit margins by adding cheaper inferior or harmful substances, thus misleading consumers and causing grave risks to their health.

Food adulteration has been around for ages, but it has become a common practice due to the increase in industrialization, urbanization, and consumption of processed foods in packages.the scale and sophistication have increased. The adulteration can be done at any part of the chain-production and processing, storage, transportation, retail. Milk, oils, spices, honey, cereals, and confectionery items are common. Milk can be diluted with water, oil can be replaced by other low-priced oils, and spices can include artificial coloring agents or spurious quality powder.

The adulteration of foods leads to serious health problems. The health problems include shortterm reactions, for instance, poisoning, vomiting, diarrhoea, and allergic reactions. But the adverse effects of health problems caused by the adulteration of foods result in serious diseases, for example, organ damage, cancer, hormonal disorders, and abnormalities. In addition, the adulteration of foods, as well as their industries, affects the economy.

To effectively deal with this problem, it is necessary to understand various kinds of and reasons behind food adulteration. In general, there is purposeful adulteration, wherein low-quality materials are added with an intention of earning some cash, and accidental adulteration, wherein it accidentally occurs owing to lack of care, unhygienic conditions, and contact with contaminants while dealing with the food. There are other kinds of adulteration, including metallic adulteration, wherein poisonous metal contamination is responsible, and packing adulteration, wherein harmful chemicals leach into foods from packages.

The Governments and other organizations like FSSAI, WHO, and Codex Almentarius Commission have formed rules and regulations to ensure the purity and quality of the food being consumed by the masses. Advanced scientific methods like chromatography, spectroscopy, and DNA analysis are also being employed for analyzing the presence of adulterants with higher efficiency.

2. Classification of Food Adulteration

There are four categories in which food adulteration can be classified:

2.1 Intentional Adulteration

- Blending low-cost oils with pure ghee oil or olive oil
- Employment of synthetic dyes, including Sudan dye, in spices and chili powder.
- Examples:

- Adding water or detergent to milk

2.2 Accidental (Unintentional) Contamination

This occurs inadvertently, as a result of negligence, poor personal hygiene practices, or poor handling practices.

Examples:

- Contamination with pesticide residues, heavy metals, or microbial agents
- Accidental mixing of food grains with dust, dirt, or insects

2.3 Metallic Adulteration

This takes place when lead, mercury, or arsenic gets into the processed foods as a result of industrial pollution or use of equipment.

Examples:

- Lead contamination in canned foods
- Arsenic in groundwater used for irrigation

2.4 Packaging or Processing Adulteration

Toxic substances from the packaging material or from the industrial processes may leach into the food under high temperatures or acidic conditions.

Examples:

- Migration of plasticizers or heavy metals from packaging's into food.
- Contamination from the use of unapproved food colours or preservatives.

3. Literature Review

s.no	Title	Journal	Author	Method	Results
1.	"Modern analytical methods for the detection of food fraud & adulteration by food category	Comprehensive Reviews in Food Science and Food Safety	Zhang et al. (2017) "Modern analytical methods for the detection of food fraud & adulteration by food category"	Chromatography (HPLC, GC-MS), Spectroscopy (FTIR, NMR), DNA-based, Chemometrics	Advanced analytical techniques such as chromatography, spectroscopy, DNA-based methods, and chemometrics provide high sensitivity and accuracy for

					detecting food fraud and adulteration across different
2.	Food Adulteration and Some Methods of Detection, Review"	Journal of Food Science and Nutrition Research	Banti (2020) "Food Adulteration and Some Methods of Detection, Review"	Physical, chemical screening tests, labbased analytical tests	Physical and chemical screening tests are useful for preliminary detection of adulterants, while laboratory-based analytical methods ensure accurate confirmation of food adulteration.
3.	"Food adulteration: Causes, risks, and detection techniques—review"	Food Control	Kerie et al. (2024) "Food adulteration: Causes, risks, and detection techniques—review"	Chromatography, Spectroscopy, Electronic sensors, etc	Food adulteration leads to health risks and economic loss. Modern analytical techniques including chromatography, spectroscopy, and electronic sensors improve detection

					efficiency and food safety control.
4.	Detection of adulteration in food based on nondestructive analysis techniques	Trends in Food Science & Technology	Review "Detection of adulteration in food based on nondestructive analysis techniques: a review" (2020)	Near-infrared, hyperspectral imaging, spectroscopic sensors, chemometrics	Non-destructive analytical techniques such as near-infrared spectroscopy and hyperspectral imaging enable rapid, reliable, and eco-friendly detection of food adulteration without damaging samples.
5.	Selected food items adulteration, their impacts on public health, and detection methods	Journal of Food Safety	Review "Selected food items adulteration, their impacts on public health, and detection methods: A review" (2023)	Physical/chemical tests, molecular methods	Adulteration of selected food items has significant public health impacts. Physical, chemical, and molecular detection methods effectively identify adulterants and help ensure food

					quality and safety.
6.	Research advances in detection of food adulteration and application of MALDI-TOF MS	Food Analytical Methods	Review "Research advances in detection of food adulteration and application of MALDITOF MS: A review" (2024)	MALDI-TOF MS compared with other methods	The review concludes that MALDI-TOF MS is a rapid, sensitive, and reliable technique for detecting food adulteration. Compared to conventional methods, it offers high accuracy, minimal sample preparation, and effective identification of adulterants, thereby improving food quality and safety.

4. Detection & Analytical Techniques for Food Adulteration

The hunt for food adulteration encompasses the detection of the existence, substitution, dilution, or misrepresentation of any food constituent. The methods that have been employed or used are diverse and come under broad classifications, each having special methodologies, characteristics, and constraints. The main classification includes:

4.1 Conventional

Certain methods, like High-Performance Liquid Chromatography and Gas Chromatography, are often coupled with Mass Spectrometry for the separation of the constituent parts of a mixture and the detection and quantitative determination of specific adulterants.

- When, for instance, an authenticity issue arises where food items such as olive oil have been mixed with cheaper oil, the GC-MS test can easily detect the variations in fatty acids or sterols.

There are also other chemical tests such as wet chemical indicators and simple physicochemical tests such as density, refractive index, and iodine value.

Applications

- Synthetic dyes, Melamine in Milk, Mixture of cheaper edible oils, Honey mixed with sugar syrups.
- Authentication regarding geographical origin or species through isotopic labeling (stable elements) and element analysis.

Advantages

- High sensitivity and specificity; can quantify amounts of adulterants; provide definitive “yes/no + how much” results.

Limitations

- Require advanced instrumentation, trained personnel, often destructively sample the food; expensive; time-consuming sample preparation and analysis. Moreover, they usually involve “target-based” activities (that is, you have to know what you're looking for).

4.2 Spectroscopic & Imaging Techniques Combined with Chemometrics

- Spectroscopy:

Spectroscopic analysis methods involve interaction between electromagnetic radiation and a sample of food: IR, NIR, Raman, UV-Vis, Fluorescence spectroscopy.

Alternatively, image-based techniques include hyperspectral imaging (HSI).

- They provide data that is either spectral or image and this data is analyzed through the use of chemometrics and/or multivariate analysis methods, including principal component analysis (PCA), partial least square analysis (PLS), and support vector machines (SVM), for the detection of any pattern that indicates adulteration.

Hyperspectral imaging offers spatial + spectral information, which finds applicability in the detection of heterogeneous adulteration, like a mixture of meats or spices.

- Finding adulteration in meat by spectral imaging, such as mixing cheaper meat into a premium meat.
- Detecting adulterated oils, powders, spices with spectral fingerprints.

Advantages

Often non-destructive, faster, minimal or no chemical reagents, can be adapted for rapid screening.

- Capable of "untargeted" detection (i.e., may detect unexpected adulteration by pattern deviation).

Limitations

These approaches often need calibration and validation models; might be less accurate in quantification compared to chromatographic approaches; data processing is complex; the equipment may still be expensive; performance can be dependent on sample matrix.

4.3 Sensor-Based, Portable, Rapid

E-nose; electronic tongue; biosensors; electroanalytical sensors: impedance, capacitance, voltammetry.These technologies are considered new technologies for rapid screening.

- One such example is a study that developed the "smart E-nose" system, capable of detecting and quantifying adulteration of pork in beef with very high accuracy: ~99.996%.
- Non-enzymatic sensors or electroanalytical techniques are being reviewed for multiple foodstuffs as cost-effective and possibly portable solutions.

Applications

- Rapid adulteration screening in meat, milk, olive oil, honey, beverages

Advantages

- Low cost; portable, potentially; real-time monitoring; minimum sample preparation.

Limitations

- They generally lack the specificity/quantification inherent to laboratory-based methods, may suffer from cross-sensitivity, and require calibration. Adoption has also been limited so far.

4.4 Untargeted Approaches, Traceability & Origin Authentication

- Newer methods beyond detecting known adulterants seek authentication of origin, species, production method (organic vs. conventional), using holistic fingerprints-metabolomics, proteomics, isotopic ratios-and data analytics.
- •For instance, it is possible to detect by the method of stable isotope ratio analysis the substitution of genuine ingredients by cheaper analogues, or misrepresentation of origin.

Applications

- Authentication of premium products such as extra virgin olive oil, honeys of specific origins, and dairy products of specific origins.

Advantages

- It also deals with fraud other than cheating by adultering.

Limitations

- Complex, expensive, requires rich reference databases, challenging for routine testing.

Summary & Comparative Table

S.NO	Technique Category	Key Methods	Advantages	Disadvantages
1.	Chromatography/Chemical (HPLC, GC-MS)	HPLC, GC-MS, LC-MS	High sensitivity, quantification, specificity	Laborious, expensive, lab-based, targeted only
2.	Spectroscopy/Imaging	NIR, FTIR, Raman, HSI + chemometrics	Rapid, non-destructive, screening of many samples, untargeted potential	Calibration needed, may lack quantification accuracy, expensive equipment
3.	Sensor/Portable Methods	E-nose, electroanalytical sensors, biosensors	On-site, fast, lower cost, minimal prep	Lower specificity, still under development, validation needed
4.	Untargeted/Traceability Methods	Isotope ratio, metabolomics, proteomics	Detect substitution/misrepresentation, broader fraud scope	High cost, complex analysis, need reference databases

Opportunities, Challenges, and the Way Forward

In the ever-changing era of technology:

- Advanced chemometrics, machine learning, and artificial intelligence integration would develop further to find new ways of adulteration detection.
- Portable, miniaturized devices for laboratory and market testing: sensor arrays and handheld spectroscopy.
- From traditional adulterants to unexpected adulterants: One is obliged to go for untargeted techniques.
- More reliance on affordable and appropriate methods that would fit prevailing conditions in developing countries; most of the sophisticated labs would not be accessible.

CONCLUSION

Food adulteration is one of those widespread problems that create a menace to the safety of foods, health of people, and trust of consumers all over the world.This vice takes place in both developed and developing countries despite the technological development of food processing technology. Food adulteration takes the form of intentional action for profit and the lack of proper processing and handling of the foods. The most adulterated foods are milk products, edible oils, spices, health cereals, honey, and drinks. The adulterants of these products are water, detergents, coloring material, and poison. The regular consumption of adulterated foods results in serious health conditions involving the gastrointestinal tract, vital organs, cancer, as well as the nervous system. Techniques such as HPLC, GC-MS, and LC-MS have been adequately employed in detecting adulteration accurately in food products. Spectroscopy, molecular biology, and hyperspectral imaging technologies aid in detecting adulteration efficiently. The use of portable sensors, electronic noses, and AI-based technologies has also accelerated non-destructive testing for food authenticity. The high cost associated with these technologies acts as a barrier in implementing them in food analysis on a large scale. The food regulatory agencies have also set standards regarding food security for limiting food adulteration practices. Lack of enforcement and unregulated manufacturers continue to contribute to food adulteration on a large scale. Socially responsible approaches in food industries are also important for food security.

REFERENCES:

1. Rees J. *Food Adulteration and Food Fraud*. Reaktion Books; 2020. (PubMed)
2. Choudhary A, Gupta N, Hameed F, Choton S. An overview of food adulteration: concept, sources, impact and detection. *Int J Chem Stud.* 2020;8:2564–2573. (PubMed)

3. Ayza A, Belete E. Food adulteration: its challenges and impacts. *Food Sci Qual Manag.* 2015;41:50–56. (PubMed)
4. Ayza A, Yilma Z. Patterns of milk and milk products adulteration in Boditti town, Ethiopia. *J Agric Sci.* 2014;4:512–516. (PubMed)
5. El-Loly MM, Mansour A, Ahmed R. Evaluation of raw milk for common additives. *Internet J Food Saf.* 2013;15:7–10. (PubMed)
6. Faizunisa H, Priyadarshini I, Chaly P, et al. Evaluation of food adulteration among selected food items – in vitro study. *Int J Health Sci Res.* 2016;6(5):139–145. (PubMed)
7. Ghimire S. Knowledge on food adulteration and their effects on health. Tribhuvan Univ.; 2016. (PubMed)
8. Ahmed S, Hamid MA, Rahman MM. Assessment of ghee adulterated with oils and fats in Bangladesh. *J Adv Vet Anim Res.* 2020. (PubMed)
9. Bansal S, Singh A, Mangal M, Mangal AK, Kumar S. Food adulteration: sources, health risks, and detection methods. *Crit Rev Food Sci Nutr.* 2017;57(6):1174–1189. (potravinarstvo.com)
10. Pririti, Sharma K, Kaushal S, et al. Overview of Food Adulteration: Its definition, causes, impacts, and detection. *J Sci Res Rep.* 2024;30(11):801–811. (JSRR)
11. Sangita Bansal, Apoorva Singh, Manisha Mangal, Anupam Mangal, Sanjiv Kumar.
12. Food adulteration: sources, health risks, and detection methods (2014).
13. DOI:10.1080/10408398.2014.967834. (MDPI)
14. "Food adulteration: causes, risks, and detection techniques — review." *PubMed*. 2024. (PubMed)
15. "Food adulteration: sources, health risks, and detection methods." *PubMed* abstract. 2015. (PubMed)
16. Appelhans BM, French SA, Tangney CC, et al. To what extent do food purchases reflect diet quality? *Int J Behav Nutr Phys Act.* 2017. (PubMed)
17. Ariyama K, Shinozaki M, Kawasaki A. Geographic origin of rice by isotope ratios. *J Agric Food Chem.* 2012. (ACS Publisher)
18. Asfaha DG, Quétel CR, Thomas F, Horacek M, et al. Combining isotopic signatures for cereal authentication. *J Cereal Sci.* 2011;53(2):170–177. (ACS Publisher)
19. "Food adulteration and its forensic quantification using stable isotope analysis: a review." *J Forensic Med Toxicol.* 2025. (ACS Publisher)
20. Pardeshi S. Food adulteration: its implications and control approaches in India. *Int J Trend Sci Res Dev.* 2019;3(5):1117–1123. (Trend in Scientific Research)

21. Janefer C, Bharathi R, Rodrigues H. A study on consumer awareness on food adulteration. *The QUEST J Multidiscip Res Dev.* 2022;1(2). (Neust Journal)
22. Cieslik E, Cieslik J. Food quality and safety. In: Horská E, ed. *Food Sciences & Business Studies.* Slovak Univ Agric; 2012. (potravinarstvo.com)
23. Čapla J, Zajác P, Fikselová M, Bobková A, Belej Ľ. Analysis of foreign bodies in European foods. *J Microbiol Biotech Food Sci.* 2019;9:370–375. (potravinarstvo.com)
24. EU Food Fraud Network and the System for Administrative Assistance & Food Fraud Report. 2017. (potravinarstvo.com)
25. Reddy V. Examples of food adulteration: detergent and water in milk, Sudan dyes in chili powder (review context). *Food Res J.* 2025;6(2):185–189. (foodresearchjournal.com)
26. Sangita Bansal et al. Health risks of food adulteration: cardiometabolic and carcinogenic perspectives (review). *Food Res Int.* (contextual). (potravinarstvo.com)
27. WHO & FAO Reports on Food Safety and Adulteration Practices (multiple years). (MDPI)
28. US FDA Definition & Regulatory Guidelines on Adulterated Food. (MDPI) 27. Malik S. Food adulteration awareness and quality contamination. *IJSRST.* 2025. (IJSRST)
29. Soopa MS, Panwar KS. Food adulteration in contemporary India: trends and remedies. *Socrates J.* 2020. (socratesjournal.com)
30. Methods in food adulteration detection: chromatography & spectroscopy reviews (various analytical journals). (PubMed)
31. Intensive survey on adulterated spices and colorants in South Asia (regional journal). (JSRR)
32. Protein adulteration in dairy products: melamine cases (food safety journal review). (PMC)
33. Heavy metal contamination in foods: lead, cadmium, arsenic impacts (environmental health journals). (MDPI)
34. Public health impacts of food adulteration: review article in *Food Public Health Journals.* (PubMed)
35. Analytical techniques for detecting adulterants: FT-IR, NMR, mass spectrometry (analytical chemistry review). (PubMed)
36. Economics of adulteration and food fraud: *Food Policy* journal review. (potravinarstvo.com)
37. Rapid field tests for food adulteration (global food safety journals). (JSRR)

38. Consumer perceptions and awareness research (social science journals on food safety). (Neust Journal)
39. Chromatographic methods in food adulteration detection. (PubMed)
40. Spectroscopy applications in food authentication. (ACS Publisher)
41. DNA-based methods for species authentication in food. (PubMed)
42. Stable isotope analysis in honey adulteration cases. (ACS Publisher)
43. Review of international food fraud incidents (food security reports). (potravinarstvo.com)
44. Food contaminant risk assessments (WHO/FAO expert committee reports). (MDPI)
45. Protein misrepresentation and substitution case studies. (PubMed) 45. Food fraud databases and surveillance reviews (EU and INTERPOL). (potravinarstvo.com)
46. Detection of pesticide residues as adulterants. (PubMed)
47. Food adulteration in processed foods: global perspective. (JSRR)
48. Risk communication & consumer protection in food adulteration. (Neust Journal)
49. Regulatory frameworks for food adulteration control (Codex Alimentarius). (MDPI)
50. Case studies of adulterated food outbreaks (various national food safety authority reports). (potravinarstvo.com)