

A REVIEW ON IDENTIFICATION OF ADULTERANTS IN HERBAL SPICES

Dr. Divya*¹, K. Sindhuja², S. Kavyasri³, Dr. Asha Ranjani⁴, Dr. G. Tulja Rani⁵

Mallareddy Pharmacy College of Maisammaguda, Dhullapally, Secunderabad, Medchal District, Hyderabad-500100, Telangana, India.

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***Corresponding Author: Dr. Divya**

Mallareddy Pharmacy College of Maisammaguda, Dhullapally, Secunderabad, Medchal District, Hyderabad-500100, Telangana, India.

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ABSTRACT

Herbal spices, essential for culinary and medicinal uses, are frequently adulterated with cheaper fillers, synthetic dyes, or toxic substances, posing health risks and eroding authenticity. This review synthesizes conventional and advanced methods for identifying adulterants in spices. Adulteration affects up to 17-48% of spice samples in global markets, with oregano often contaminated by olive or myrtle leaves, pepper by starch fillers, and turmeric by cheaper Curcuma species or dyes. Economic incentives drive these frauds, leading to health risks from allergens, toxins, or reduced potency. Rapid Alert System data highlights recurring issues in Europe and India over decades.

KEYWORDS: Herbal Spices, Adulteration.

INTRODUCTION

Herbal spices have been an integral part of human diet and traditional medicine since ancient times. They are valued not only for their flavour, colour, and aroma but also for their therapeutic properties such as antioxidant, antimicrobial, anti-inflammatory, and digestive effects. In systems like Ayurveda, Siddha, and Unani, herbal spices play a crucial role in maintaining health and preventing diseases. Due to their wide usage and high commercial demand, herbal spices have become vulnerable to adulteration.^[1]

Adulteration of herbal spices refers to the intentional or unintentional addition of inferior, cheaper, or harmful substances that reduce the quality and purity of the original spice. Common adulterants include artificial colors, starch, sawdust, brick powder, exhausted spices, and nonauthentic plant parts. For example, chili powder may be adulterated with brick powder or Sudan dyes, turmeric with metanil yellow or chalk powder, black pepper with papaya seeds, and cumin with colored grass seeds.

Such adulteration not only lowers the nutritional and medicinal value of spices but also poses serious health risks, including gastrointestinal disorders, like allergic reactions, liver toxicity, and even carcinogenic effects in long-term consumption. Lack of proper quality control, insufficient consumer awareness, and weak regulatory enforcement further contribute to the problem.

By the detection and prevention of adulteration in herbal spices is essential to ensure food safety, protect public health, and preserve the authenticity and therapeutic significance of these valuable natural products.^[2]

Types of adulterants

Adulteration of foods is done by many means but broadly There are two types of adulteration's. According to El-loly et Al. (2013) there are intentional/deliberately/knowingly and Unintentional adulterations.

Intentional Adulteration

Intentional adulteration is an adulteration in which food item Is deliberately adulterated. It is inclusion of inferior Substances having properties similar to the foods in which They are added. They are thus difficult to detect. The Adulterant could be physical or biological in nature. It is done In order to promote the level of their essential nutrients after Reduction of a given amount in order to increase their profit Margin by several chemicals like urea, melamine, and Increase its volume by adding substances such as starch, flour, Cane sugar, vegetable oils, water, skim milk, sand, chalk Powder, molasses, stone, brick powder, ergot, chicory, roasted barley powder, grinded papaya seeds, etc. into various food Items It is the most dangerous form Of adulteration because of amounts of nutrients deducted and Extraneous substances added into food items that is done by Business oriented people just forgot the humanity in behind of Money making mentality.^[3]

Incidental Adulteration

Adulteration which is due to lack of proper hygienic Conditions of food products and drinks throughout production Site to consumption table. Accidental adulterants are Pesticides residues, dropping of rodents, larvae in foods, etc. Metallic contamination with arsenic lead, mercury can also Occur accidentally. Accidental adulterants also involve pests Such as rodents and insects that trespasses the food at high Degree and produces impurity in the form of excreta, bodily Secretions and spoilage through micro-organisms. Most Common accidental adulterants are pesticides, D.D.T. and Residues present on the plant product.^[4]

Detection Mechanism of Adulterated food

The mechanisms of identifying the usage of adulterants in foods depends on physical, chemical, biochemical, and other techniques. All these methods, which have replaced the early organoleptic and other empirical tests, are continuously updated because food adulteration is interminable, and new problems are always arising. Different types of analytical procedures are usually employed for most cases of adulteration so that the analyst has the flexibility to choose the appropriate one (number of samples to be analyzed, sensitivity required, etc). For example, red wine adulterated with the juice of bilberries or elderberries produced a deep blue precipitate with lead acetate.^[5]

Chemical and biochemical method

There are different designed chemical and biochemical Methods for detection of adulterants which can be categorized as chromatography based, spectroscopy and immunology Based and electrophoresis based. According to these Authors,

the basic analytical approach involves various steps including extraction with a suitable solvent, clean-up for removal of interfering matrix components, chromatographic separation and selective detection. These and other methods of detection of adulterants can be done by following the respective procedures of each of the methods. HPLC can be used as a quality control tool as it can separate various chemical constituents from mixtures; it is also used for characterizing food products or to detect adulteration. That means, its use in adulterant detection lies in its capacity to separate mixtures of chemicals. For example, among the analytical techniques of adulterant detection, HPLC (High-performance liquid chromatography) is the most widely used technique and the procedures will follow the normal procedure of chemical determination by this instrument.

Gas chromatography (GC) is an extra apparatus for identification of adulterants and is used for separating volatile organic compounds. GC along with mass spectroscopy (MS) and Fourier transform infrared spectroscopy (FTIR) has been widely used for adulterant detection as these are non-destructive techniques with respect to the sample. Gas chromatography is generally used to discriminate among different varieties of the same product, adulteration detection, and organic compound authentication and identification. Among the spectroscopic techniques, near infrared spectroscopy (NIR) helps in rapid detection of adulterants in raw material but is unable to identify the contaminant.^[6]

The authors further stated another detection method; nuclear magnetic resonance (NMR) which will not only detect an adulterant but also provides structural identification of the contaminant.^[7]

Atomic Absorption Spectrometry can be utilized as a validation method for analysis of lead in all foods except oils, fats and extremely fatty products. A combination of chromatographic and spectroscopic techniques have also shown a high potential for detection of adulterants, for example, GC-MS has shown potential to detect honey adulteration with commercial syrups.^[8]

The indirect enzyme-linked immune-sorbent assay (ELISA) was also developed for the detection and quantification of bovine milk adulteration in goat's milk. It has been observed that ELISA can be successfully used to determine adulteration of milk samples and thus ELISA kits will help in routine inspection of milk.^[9]

Physical Methods

There are various physical methods for detection of adulteration including microscopic and macroscopic visual structural analysis as well as analysis of food by analyzing the physical parameters like morphology, texture, solubility, bulk density etc. have been designed but these methods do not guarantee quantitative adulterant detection. For instance, microscopic examination of some spices namely cumin, coriander, chilies, and cloves lead to easy detection of extraneous starch in these powdered spices. In grain, detection of adulteration with different impurities (dust, stones, straw, weed seeds, damaged grain, weevil grain, insects, rodent hair and excreta and etc) could be detected by taking a small quantity of sample in a glass plate and examining the impurities visually because, pure food grains will not have any such impurities.^[10]

Sensory Methods

Traditionally, sensory methods have been employed in detecting some adulteration. Sensory methods however have not been incorporated yet into legislation for the detection of food adulteration, although routine analysis of a sample always includes the examination of its organoleptic characteristics. International organizations such as the International

Standards Organization (ISO), American Society for Testing Materials (ASTM), and others have developed and recommended sensory Methods for foods in general and for particular commodities.^[11]

Such methods are useful in trade (e.g., grading of goods) and the Management of resources. Moreover, the US Food and Drug Administration (FDA) has accepted results of sensory panel tests as prima facie evidence of product efficacy, and in some cases, Legal decisions in the USA have relied exclusively upon sensory Evaluation data. The limitations concerning the application of Sensory methods for the detection of adulteration are subjectivity Of judgment and though it have fewer limitations that Multivariate statistical techniques are employed. With these methods, sensory data are better evaluated, and more Reliable conclusions can be drawn. For example, the results of Free-choice Profiling tests can be analyzed by the Generalized Procrustes method. The latter adjusts for several types of Variation in the way each panelist describes samples and then Manipulates the data to combine terms that appear to measure the Same characteristics. Such an approach has been meaningfully Applied to classify coffee, tea, and alcoholic beverages.^[12]

Table 1: Procedures followed to test the common adulterants in selected spices and condiments.

Food category	Adulterants	Procedure
Turmeric powder	Metanil yellow colour	Take 5 g of sample in a test tube with 5 mL water. Add a few drops of concentrated HCl. Instant pink colour which disappears on dilution indicates adulteration.
Cumin seeds	Grass seeds coloured with charcoal dust	Rub cumin seeds between palms. If palms turn black, adulteration is present.
Coriander powder	Salt	Take 5 mL of sample and add 50 mL of silver nitrate solution. White precipitate indicates adulteration.
Black pepper	Papaya seeds/ immature and light black pepper	Papaya seeds are shrunk, oval, and brownish-black. Float 5 g pepper in 15 mL alcohol: mature pepper sinks, immature floats. Press with fingers: immature breaks easily, mature does not.
Salt	Artificial white colour (chalk)	Stir a spoonful of salt in water. Chalk makes solution white and insoluble impurities settle down.

Adulteration during Production of Genetically Modified Foods

Genetically modified organisms (GMOs) are organisms in which the genetic material (DNA) has been changed in a manner That does not happen in nature. It is often called modern Technology or gene technology. Combining genes from different Organisms is said to be genetic modification. The GM products Include medicines, vaccines, food and food ingredients, feeds and Fibers. Though GM foods are developed and marketed because There is some perceived advantage either to the producer or Consumer of these foods; there are safety issues including Allergens, transfer of antibiotic resistance markers, and unknown Effects can happen. Thus, unless communicated to users, GM Food could be one form of adulterations.^[13]

Health Problems Related to Adulteration

Adulterated foods can leads to different health problem After consumption and considered as one of the major problem Of everyday life. For example, addition of argemone Seeds to mustard can cause loss of vision and heart diseases.^[14]











Table 2: Health problems related to adulteration in spices.

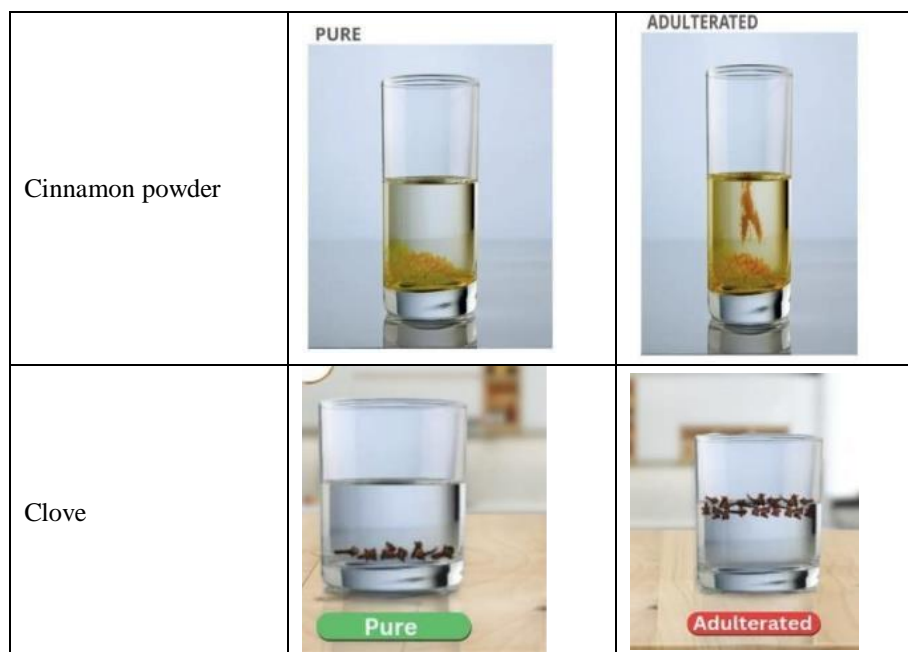
Spice powder	Common Adulterants	Potential Health problems and Disorders
Turmeric	Lead chromate (to enhance yellow colour)	Lead poisoning, neurotoxicity (brain damage), kidney damage, anemia, reduced fertility
Turmeric	Metanil yellow (artificial dye)	Cancer, liver damage, neurotoxicity, stomach disorders, kidney dysfunction

Chilli powder	Brick powder, sand, dirt, talc	Digestive issues, intestinal blockage, stomach pain, respiratory problems
Coriander	Sawdust, dung powder	Stomach problems, digestive disorders, allergic reactions
Cumin	Grass seeds (dyed with charcoal)	Potential toxicity, indigestion
Cinnamon	Cassia bark (inferior, high coumarin)	Liver damage/toxicity (due to high coumarin levels)
Black pepper	Papaya seeds, mineral oil	Liver dysfunction, stomach irritation
Saffron	Colored corn silk, gelatin/plastic	Allergic reactions, kidney damage
Mixed spices	Coal tar dyes, industrial dyes	Cancer, skin rash, respiratory distress, endocrine disruption

Found in families who consume adulterated food. Thus, adulterated Foods may be illegal profit for those who are adulterating while it is Not only expense of money for consumer but also leads to illness as Well. With time, acceptance of foods in the any types of market Could decrease due to destruction in originality of adulterated foods and this in turn is economic loss.

Table3: Common herbal spices.

Herbal spices	Pure Form	Adulterated Form
Turmeric		
Chilli powder		
Coriander powder		
Cumin powder		
Black pepper		



Methods to detect adulterants

Organoleptic Evaluation

Which involves macroscopic evaluation of an colour, odour, taste, size, shape, and texture Helps detect which is seen through naked eyes adulterants like stones, husk, sawdust, or exhausted spices Simple, rapid, but subjective for example black pepper mixed with papaya seeds which is seen through naked eyes.

Physical method

Physical method describes physical properties of herbal spices like weight, size, solubility, and floatation. for example Papaya seeds float in water while black pepper sinks; iron filings are detected Physical methods to ensure quality, safety, and shelf-life, rather than using chemical agents. Key methods include cleaning, drying, size reduction (grinding), and physical decontamination techniques.

Microscopic method

Adulterants Identification based on examination of cellular and anatomical characters under a microscope. For example Starch granules detected in ginger powder; cassia differentiated from true cinnamon by bark structure. It includes fibres, calcium oxalate crystals, vessels trichomes it includes Powder microscopy, staining microscopy, microchemical tests, quantitative microscopy, scanning electron microscopy.

Chemical test

Chemical test based on specific chemical reactions that show colour change or precipitate With in the sample to detect the adulterants for example Metanil yellow in turmeric turns pink with concentrated HCl; chalk powder shows effervescence with dilute HCl.

Chromatographic method

Chromatographic method involves Separation of chemical constituents to detect foreign substances. By using mobile phase and stationary phase for example Thin layer chromatography used to detect synthetic dyes in chilli powder. Chromatographic methods, primarily High- Performance Liquid Chromatography (HPLC), Gas Chromatography-Mass

Spectrometry (GCMS), and Thin-Layer Chromatography (TLC), are used to detect adulterants in herbal spices by identifying, quantifying, and profiling characteristic biomarkers. These techniques, often combined with UV-Vis or MS detectors, separate components based on polarity or volatility to authenticate spices and detect contaminants like dyes, fillers, and synthetic substances.

High-Performance Liquid Chromatography (HPLC)

Frequently used for separating and quantifying non-volatile bioactive compounds to determine purity, such as measuring curcumin in turmeric or safranal in saffron.

Gas Chromatography (GC/GC-MS)

Ideal for volatile components and essential oils in spices for example eugenol in cinnamon, making it effective for detecting plant-based adulterants and chemical residues.

Thin-Layer Chromatography (TLC)

A fast, inexpensive, and simple method used for preliminary screening, such as detecting artificial colors (e.g., Sudan red) in chili powder.

Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS)

Offers high sensitivity for identifying trace amounts of adulterants, including synthetic drugs or pharmaceuticals in adulterated herbal products.

Spectroscopic method

Spectroscopic methods, are particularly Near-Infrared (NIR) and Fourier Transform Infrared (FTIR) spectroscopy, combined with chemometrics, as they advanced techniques to detect adulterants in the sample are fast, non-destructive, and efficient techniques to detect adulterants in herbal spices by identifying unique molecular fingerprints. These methods analyze spectral data to differentiate authentic samples from fillers like starch, flour, or non-authentic plant materials.

Near-Infrared (NIR) Spectroscopy

Analyzes C–H, N–H, and O–H bond vibrations, highly effective for detecting fillers in powdered spices. Fourier Transform Infrared (FTIR) Spectroscopy:

Identifies specific functional groups and molecular structures, often used for quick screening.

Raman Spectroscopy

Complements FTIR, offering molecular structure data often used in rapid screening for adulterants.

Hyperspectral Imaging

Combines imaging and spectroscopy to provide both spatial and spectral data for identifying impurities.

UV-Visible Spectroscopy:

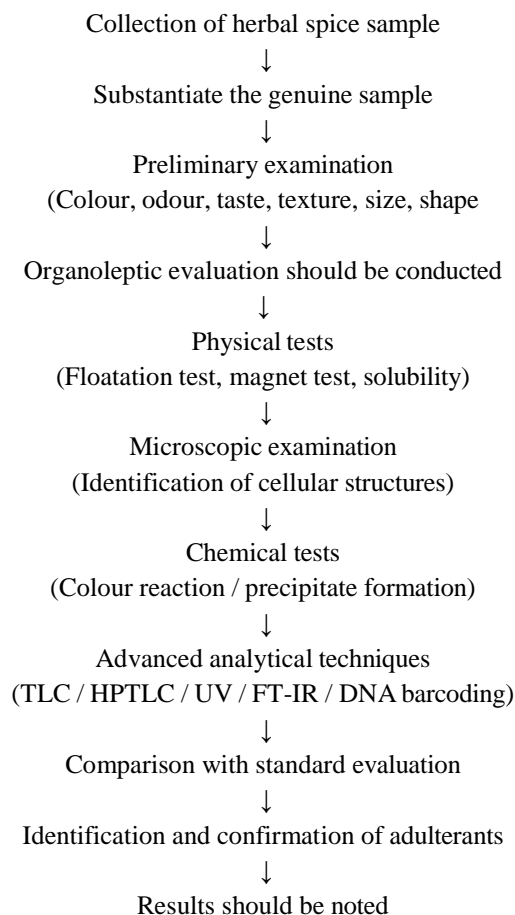
Provides rapid identification of contaminants based on color and chemical properties.

DNA based method

DNA-based methods, are based on DNA barcoding it provide highly sensitive and accurate detection without any errors of herbal spice adulteration by analyzing unique genetic signatures. These technologies including PCR-based methods,

sequencing, and Bar-HRM—overcome limitations of traditional chemical testing by identifying adulterant species even in powdered samples, ensuring food safety and authenticity.^[17]

Plan of work for detection of adulterants (Flow chart)



CONCLUSION

Adulteration of herbal spices remains a critical challenge affecting public health, therapeutic efficacy, and the credibility of traditional medicine systems. The intentional or accidental substitution of genuine spices with inferior, exhausted, synthetic, or harmful materials compromises not only their pharmacological value but also consumer safety. With increasing global demand and commercialization of herbal spices, economically motivated adulteration has become more sophisticated, often evading conventional detection methods. Advances in analytical, microscopic, chromatographic, spectroscopic, and DNA-based techniques have significantly improved the identification and authentication of herbal spices. However, the lack of standardized quality control protocols, inadequate regulatory enforcement, and limited awareness among producers and consumers continue to hinder effective control of adulteration.

Moreover, the presence of toxic adulterants such as synthetic dyes, heavy metals, and nonpermitted fillers poses serious long-term health risks.

REFERENCES

1. Khare B, Mishra MK, Kesharwani L. Screening of adulterants In herbal formulations for forensic considerations. *Journal of Pharmacognosy and Phytochemistry*, 2018; 7(2): 532-6.
2. Jalili R, Miraghaei S, Mohamadi B, Babaei A, Bahrami G. Detection Of corticosteroid compounds by HPLC method Detection of Corticosteroid compounds and phosphodiesterase inhibitors (PDH-5) as counterfeit in herbal products available in Iranian.
3. El-Loly MM, Mansour AIA, Ramadan RO. Evaluation of Raw Milk for Common Commercial Additives and Heat Treatments. *International Journal of Food Safety*, 2013; 15: 7.
4. Pandit GG, Sharma S, Srivastava PK, Sahu SK. Persistent organochlorides pesticide residues in milk and Dairy products in India. *Food Additives and Contaminants*, 2002; 19(2): 153-157.
5. Laura Schumm, 2014 *Food Fraud: A Brief History of the Adulteration of Food*.
6. Bansal, S., Apoorva, S., Manisha, M., Anupam, K M. and Sanjiv, K., *Food Adulteration: Sources, Health Risks and Detection Methods*. *Critical Reviews in Food Sciences*, 2015.
7. Xue, H. Y., Hu, W. W., Son, H., Han, Y. and Yang, Z. Y., Indirect ELISA for detection and quantification of bovine milk In goat milk. *Food Sci*, 2010; 31: pp. 370-373.
8. Ref: Nielsen, S. S., 2010. *Food Analysis*, Food Science Texts Series, DOI 10.1007/978-1-4419- 1478-1_6,. Fourth Edition ed. Purdue University, West Lafayette, IN, USA: Springer.
9. Fiorino, G. M., Garino, C., Arlorio, M., Logrieco, A. F., Losito, And Monaci, L., 2018.
10. Overview on untargeted methods to Combat food frauds: a focus on fishery products. *Journal of Food quality*, 2018.
11. Bansal, S., Apoorva, S., Manisha, M., Anupam, K M. and Sanjiv, K., 2015. *Food*.
12. *Adulteration: Sources, Health Risks and Detection Methods*. *Critical Reviews in Food Sc*.
13. Food safety & standards authority of india (FSSAI), 2010 (ministry of health & family welfare) fda bhavan, kotla road, New delhi – 110 002.
14. Vasireddi, 2013. *Food Adulteration & Control Mechanism; At The Workshop on Food*.
15. *Defense Awareness for Food Business Operators and Exporters February 5, 2013 – Hyderabad*.
16. Fiorino, G. M., Garino, C., Arlorio, M., Logrieco, A. F., Losito, And Monaci, L., 2018. Overview on untargeted methods Combat food frauds: a focus on fishery products. *Journal of Food quality*, 2018.
17. Mansuri, Z., *Study of adulterants in foods*. Delhi, India, 2011.
18. Kohda, Y. and Haque, I., Knowledge and Perception About Food Adulteration Problem among School Children in Bangladesh Iffat Haque. *European Journal of Public Health*, 2017; 27 (suppl_3).
19. Asrat, A. and Ermias, B., E., *Food Adulteration: Its Challenges and Impacts*. *Food Science and Quality Management*, 2015; pp. 50-56.
20. Kohda Y, Haque I. Knowledge and Perception about Food Adulteration Problem among School Children in Bangladesh Iffat Haque. *European Journal of Public Health*, 2019; 27(3).