SJIF Impact Factor (2026): 8.863| ISI I.F. Value: 1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 11 | Issue: 7 | July 2026 - Peer Reviewed Journal

ADULTERATION OF HERBAL MEDICINE AND ITS DETECTION METHOD- A REVIEW ARTICLE

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ABSTRACT
Due to their natural origin and therapeutic value, herbal medicines are used extensively throughout the world. However, widespread adulteration of herbal products has resulted from growing demand and commercialization. Adulteration lowers the effectiveness, safety, and quality of herbal remedies and can pose major health risks. Substitution with subpar materials, contamination, synthetic drug addition, and misidentification of medicinal plants are some examples of adulteration practices. Therefore, to guarantee the authenticity of herbal medicines, appropriate detection and quality control procedures are crucial. While sophisticated analytical techniques like chromatography, spectroscopy, DNA barcoding, and chemometric methods accurately identify adulterants, traditional methods like organoleptic and microscopic evaluation are frequently employed. This review outlines the various forms of adulteration, their causes, health risks, and the different traditional and contemporary detection techniques used in the authentication of herbal medicines.
KEYWORDS: *Quality control, Authentication, Chromatographic Technique .*

INTRODUCTION

Ayurveda, Siddha, Unani, and Traditional Chinese Medicine are examples of traditional healthcare systems that have included herbal medicine as a significant component. The perception that natural products are safer and have fewer side effects than synthetic medicines has led to a notable increase in the demand for herbal products worldwide in recent years [1]. However, the adulteration of herbal medicines has been caused by growing market demand and the scarcity of authentic raw materials [2]. The term "adulteration" describes the intentional or inadvertent substitution, contamination, or addition of inferior, hazardous, or synthetic substances in herbal products [3]. These methods lessen the effectiveness of treatment and could have harmful effects on patients.

Adulteration Causes

Herbal medicines can be adulterated due to a number of reasons:

- High demand and limited availability of therapeutic plants
- Profitability and low production costs
- Absence of appropriate quality control procedures
- Medicinal plant misidentification
- Comparable morphological characteristics of plant materials
- Unsuitable conditions for handling and storage
- Lack of procedures for standardization and authentication [4]

Categories of Adulteration

1. deliberate adultery

In order to profit financially, inferior, less expensive, or synthetic substances are purposefully mixed with authentic herbal medications. Papaya seeds and black pepper are frequently combined, and turmeric powder is colored artificially [5].

2. Adulteration inadvertently

Unintentional adulteration happens unintentionally as a result of ignorance, misidentification of plants, incorrect collection, or inadequate storage.

3. Changing

Genuine medicinal plants can be substituted with related or unrelated species that have morphological similarities to the original medication.

4. Adulteration by Synthetic

Adding chemicals or pharmaceuticals to improve therapeutic effects is known as synthetic adulteration. Common examples include steroids in herbal painkillers and sildenafil in herbal sex enhancement products [6].

5. Contamination by Chemicals and Biology

Additionally, during cultivation, storage, or transportation, herbal medicines may become contaminated with microorganisms, pesticides, heavy metals, insects, fungi, or toxic chemicals [7].

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Health Risks of Adulterated Herbal Medicines

Adulterated herbal products can cause toxicity, allergic reactions, organ damage, drug interactions, and decreased therapeutic efficacy. Undeclared synthetic compounds can cause serious side effects [8].

Detection Methods for Herbal Adulteration

1. Organoleptic Evaluation.

Organoleptic evaluation is the most basic method for determining the color, odor, taste, size, shape, and texture of crude drugs. It is a fundamental pharmacognostic technique for preliminary identification [9].

2. Microscopic Evaluation

Microscopy aids in the identification of adulterants by revealing diagnostic characteristics such as trichomes, fibers, starch grains, and calcium oxalate crystals. It is particularly useful for powdered herbal medications [10].

3. Physical evaluation

Moisture content, ash value, extractive value, and foreign matter determination are all important physicochemical parameters for evaluating herbal drugs' quality [11].

4. Chemical Evaluation

Chemical evaluation entails screening phytochemicals for active constituents in order to authenticate and standardize herbal materials [12].

5. Chromatography Methods

TLC, HPTLC, HPLC, GC, and LC-MS are common chromatographic techniques used to separate, identify, and detect adulterants in herbal medicines [13].

6. Spectroscopic methods

UV-visible spectroscopy, infrared spectroscopy, Raman spectroscopy, and NMR are among the spectroscopic techniques that can be used to quickly and accurately identify herbal products [14].

7. DNA-Based Methods

DNA barcoding and DNA metabarcoding are sophisticated molecular techniques for identifying medicinal plant species and detecting substitution or adulteration [15].

8. Chemometric and AI-based techniques.

The combination of spectroscopy, chemometric analysis, and artificial intelligence improves the detection and classification of adulterated herbal products [16].

Avoidance and Management of Adulteration

The adulteration of herbal medicines can be avoided by taking the following steps:

i. Authenticating raw materials correctly
ii. GACP, or Good Agricultural and Collection Practices
iii. Standardization of herbal products
iv. Tight regulatory standards
v. Advanced analytical methods
vi. Quality control and assurance systems
vii. Education of the public about safe herbal products [17]

Detection Techniques

Chromatographic Fingerprinting

Chromatographic fingerprinting is considered one of the most reliable methods for authentication of herbal medicines. Fingerprint profiles generated using HPLC, HPTLC, GC, and LC-MS help compare genuine and adulterated samples. These methods identify active phytoconstituents and detect substitution or contamination effectively [18].

Fluorescence Examination

Under ultraviolet light, some herbal medications exhibit distinctive fluorescence. Adulteration in powdered crude medications and formulations can be found using fluorescence analysis. Fluorescence behavior under visible and ultraviolet light is observed using various reagents [19].

Techniques for Electrophoresis

Another sophisticated analytical technique for identifying and separating phytochemicals in herbal preparations is capillary electrophoresis. It offers quick analysis with low sample requirements and high sensitivity [20].

Immunological Techniques

Toxic contaminants, pesticide residues, and microbial toxins in herbal medicines are increasingly being identified using immunoassays like ELISA [21].

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Herbal Medicine Quality Control Parameters

To guarantee the safety, effectiveness, and purity of herbal medications, quality control is essential. The following criteria are frequently assessed:

a) Determination of foreign matter
b) Content of moisture
c) Total value of ash
d) Ash that is insoluble in acid
e) Water-soluble extractive value
f) Alcohol-soluble extractive value
g) Determination of volatile oil
h) Analysis of pesticide residues
i) Heavy metal
j) Determination of microbial load [22]

Pharmacognosy's Function in Adulteration Identification

Pharmacognosy is crucial to the standardization and verification of herbal remedies. Basic pharmacognostic techniques for identifying authentic crude drugs and detecting adulterants include macroscopic and microscopic evaluation, histological investigations, powder analysis, and phytochemical studies [23].

Standardization is crucial for herbal medicines.

Standardization guarantees the therapeutic efficacy, safety, quality, and uniformity of herbal remedies. It involves microbiological testing, phytochemical analysis, physicochemical parameter evaluation, and raw material authentication Patient safety is enhanced and herbal product variability is reduced through proper standardization. [24].

CONCLUSION

The quality, safety, and effectiveness of herbal products around the world are significantly impacted by adulteration of herbal medicines. Adulteration practices, whether deliberate or inadvertent, can result in significant health risks and diminished therapeutic value. While modern techniques like chromatography, spectroscopy, DNA barcoding, and AI-based analysis provide precise authentication of herbal medicines, traditional methods like organoleptic and microscopic evaluation are helpful for initial screening. To guarantee the safety and authenticity of herbal medicines, appropriate quality control procedures, regulatory oversight, and cutting-edge analytical technologies must be put into place.

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