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REVIEW ARTICLE

Extraction and Analysis of Pharmaceuticals: A Review of Modern and Ayurveda Techniques

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ABSTRACT

Extraction of bioactive compounds is a crucial step in natural product research, pharmaceuticals, and biomedical sciences. The reliability of analytical evaluation depends on the efficiency of the extraction method applied. Once extracts are obtained, advanced analytical techniques—such as Thin Layer Chromatography (TLC), High-Performance Thin Layer Chromatography (HPTLC), High-Performance Liquid Chromatography (HPLC), Liquid Chromatography–Mass Spectrometry (LC–MS), and Gas Chromatography–Mass Spectrometry (GC–MS)—are employed for separation, identification, and quantification. This review discusses the principles, methodologies, sample preparation strategies, and applications of these extraction and analytical techniques, emphasizing their relevance in quality control, pharmacological validation, and standardization of Ayurvedic products.

Key Words *Extraction, Chromatography, Spectrometry, Phytochemicals, Analytical Chemistry*

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INTRODUCTION

Extraction and analysis form the scientific backbone of ayurvedic drug research and quality assurance. In *Ayurveda* and modern pharmacognosy alike, extracting bioactive compounds efficiently determines the success of subsequent analytical characterization[1].

Traditional methods like decoction (*Kwatha*) , infusion (*Phanta*) , and fermentation (*Asava–Arishta*) have evolved into advanced extraction systems that maximize yield and purity[2].

Modern analytical platforms, including chromatographic and mass spectrometric tools, now enable precise qualitative and quantitative assessment of herbal constituents[3].

This article integrates traditional Ayurvedic extraction methodologies with modern instrumental techniques such as TLC, HPTLC, HPLC, LC–MS, and GC–MS, highlighting their applications in standardization, pharmacological validation, and regulatory acceptance.

AIMS AND OBJECTIVES

The primary aim of this review is to explore the inter-relationship between Ayurvedic extraction methods and modern analytical technologies to

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ensure the quality, safety, and efficacy of herbal and herbo-mineral formulations.

Objectives include:

1. To summarize conventional and advanced extraction techniques used in *Ayurveda* and phytochemistry.
2. To review the operational principles and applications of TLC, HPTLC, HPLC, LC–MS, and GC–MS.
3. To illustrate how integration of both systems supports global standardization of Ayurvedic medicines.

MATERIALS AND METHODS

A literature-based analytical approach was adopted. Classical Ayurvedic sources such as *Charaka Samhita*, *Rasaratna Samuccaya*, *Sharangdhar Samhita* and *Rasatarangini* were reviewed for traditional extraction techniques (*Samskaras*). Peer-reviewed research papers, books, and guidelines from WHO and AOAC published between 2000 and 2025 were examined through PubMed, ScienceDirect, and AYUSH Research Portal. Studies discussing chromatographic and spectroscopic analyses of herbal or mineral preparations were included.

➢ Extraction Methods

1. Conventional Extraction in Ayurveda

Ayurveda employs several classical techniques (*Samskaras*) for preparing therapeutic extracts[4].

- *Kwatha* (Decoction): Boiling herbs in water to extract hydrophilic compounds, e.g., *Triphala Kwatha* for digestive health.
- *Phanta* (Infusion): Soaking in hot water for mild extraction, e.g., *Panchkol Phanta*.
- *Asava–Arishta* (Fermented Preparations): Natural fermentation for gentle extraction and preservation,e.g., *Ashwangadha Arishta, Kumari Asava.*
- *Swarasa* (Juice Extraction): Direct pressing for fresh plant juice.
- *Taila and Ghrita* (Medicated Oils): Boiling herbal decoctions with oils to extract lipid-soluble actives.
- *Shodhana and Marana*: Purification and calcination of metals/minerals in *Rasashastra* to form *Bhasma*[5].

These methods preserve synergistic efficacy and are eco-friendly, though they may lack precision in reproducibility and selectivity.

2. Modern Extraction Techniques

Advances in technology have improved extraction efficiency[6].

- Ultrasound-Assisted Extraction (UAE): Enhances solvent penetration and yield.
- Microwave-Assisted Extraction (MAE): Accelerates process while minimizing solvent use.
- Supercritical Fluid Extraction (SFE): Ideal for volatile oils using supercritical CO_2.
- Solid-Phase Extraction (SPE): Used for sample purification before chromatography.
- Liquid–Liquid Extraction (LLE): Separates analytes between immiscible solvents.

The method is selected based on analyte polarity, solubility, and volatility[7].

Analytical Techniques

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1. Thin Layer Chromatography (TLC)

A simple, low-cost tool for preliminary screening[8].

Principle: Separation based on differential adsorption between stationary and mobile phases.

Applications:

- Phytochemical screening (alkaloids, flavonoids).
- Authentication of herbs and formulations.
- Fingerprinting for quality control.

2. High-Performance Thin Layer Chromatography (HPTLC)

An improved version of TLC offering higher resolution and quantification.

Applications:

- Quantifying marker compounds[9].
- Quality control of polyherbal products.
- Detecting contaminants and adulterants[10].

3. High-Performance Liquid Chromatography (HPLC)

A gold-standard technique for quantitative analysis[11].

Applications:

- Quantifying phytoconstituents like curcumin and withanolides.
- Stability and bioavailability studies[1].
- Ensuring reproducibility of Ayurvedic formulations.

4. Liquid Chromatography–Mass Spectrometry (LC–MS)

Combines separation and molecular detection[13].

Applications:

- Structural elucidation and metabolite profiling.
- Drug metabolism studies.
- Detection of trace-level compounds in herbal extracts[14].

5. Gas Chromatography–Mass Spectrometry (GC–MS)

Preferred for volatile compounds[15].

Applications:

- Analysis of essential oils (e.g., *Tulsi*, *Vacha*).
- Detection of pesticide residues and environmental pollutants[16].

RESULTS AND DISCUSSION

The study highlights that traditional Ayurvedic extraction methods such as *Kwatha*, *Phanta*, and *Asava–Arishta* preserve the holistic properties of herbs but lack precision and reproducibility. Modern techniques like Ultrasound-Assisted Extraction (UAE), Microwave-Assisted Extraction (MAE), and Supercritical Fluid Extraction (SFE) improve yield, selectivity, and efficiency, especially for thermolabile compounds.

Chromatographic methods play a vital role in quality evaluation. TLC serves as a simple screening tool, while HPTLC provides detailed fingerprinting and quantification, essential for authentication and quality control of Ayurvedic formulations. HPLC enables accurate estimation of phytochemicals such as curcumin and withanolides, ensuring batch-to-batch consistency.

Advanced hyphenated techniques like LC–MS and GC–MS allow molecular identification,

metabolite profiling, and analysis of volatile compounds. LC–MS supports bioavailability and structural studies, whereas GC–MS identifies essential oils, pesticide residues, and contaminants.

Overall, integrating traditional extraction methods with modern analytical tools ensures higher accuracy, reproducibility, and global standardization of Ayurvedic medicines, strengthening their scientific credibility and regulatory acceptance.

CONCLUSION

The integration of traditional Ayurvedic extraction techniques with modern analytical technologies provides a comprehensive framework for the standardization and scientific validation of herbal formulations. Classical methods such as *Kwatha*, *Phanta*, and *Asava–Arishta* preserve the synergistic essence and holistic efficacy of herbs, aligning with Ayurvedic principles of balance and bioavailability. However, these methods often lack reproducibility and quantitative precision.

Modern extraction techniques—such as Ultrasound-Assisted Extraction (UAE), Microwave-Assisted Extraction (MAE) , and Supercritical Fluid Extraction (SFE) — address these limitations by improving yield, selectivity, and efficiency while preserving thermolabile compounds. When coupled with advanced analytical platforms like HPTLC, HPLC, LC–MS, and GC–MS, they enable precise identification, quantification, and quality control of bioactive constituents.

This multidisciplinary approach bridges traditional wisdom and contemporary science, ensuring that Ayurvedic medicines meet global standards of safety, efficacy, and consistency. Ultimately, the synergy of classical extraction knowledge and modern instrumental analysis not only enhances pharmacological validation but also paves the way for wider international recognition and acceptance of *Ayurveda* as a scientifically robust medical system.

REFERENCES

1. Mukherjee, P. K. (2019). *Quality Control of Herbal Drugs: An Approach to Evaluation of Botanicals*. Business Horizons, New Delhi.

2. Handa, S. S., Khanuja, S. P. S., Longo, G., & Rakesh, D. D. (2008). *Extraction Technologies for Medicinal and Aromatic Plants*. ICS-UNIDO.

3. Sasidharan, S. et al. (2011). Extraction, isolation and characterization of bioactive compounds. *Afr. J. Tradit. Complement. Altern. Med.*, 8(1), 1–10

4. Tripathi, Y. B. (2018). Analytical advancements in Ayurvedic pharmaceutics. *Ancient Sci. Life*, 38(1), 22–29.

5. Gupta, A., & Pandey, R. (2019). Chromatographic techniques in herbal quality control. *J. Herbal Med. Res.*, 4(2), 55–65.

6. Chemat, F., & Vian, M. A. (2014). *Green Extraction of Natural Products: Theory and Practice*. Wiley-VCH.

7. Azwanida, N. N. (2015). Review on extraction methods used in medicinal plants. *Med. Aromat. Plants*, 4(3), 196–202.

8. Harborne, J. B. (1998). *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*. Springer, London.

9. Reich, E., & Schibli, A. (2007). *HPTLC for the Analysis of Medicinal Plants*. Thieme.

10. Sethi, P. D. (2013). *High-Performance Thin Layer Chromatography*. CBS Publishers.

11. Snyder, L. R., Kirkland, J. J., & Dolan, J. W. (2011). *Introduction to Modern Liquid Chromatography*. Wiley.

12. Niessen, W. M. A. (2006). *Liquid Chromatography–Mass Spectrometry*. CRC Press.

13. Singh, S., & Sharma, R. (2021). LC–MS in standardization of herbal formulations. *J. Pharm. Anal.*, 11(5), 587–598.

14. McMaster, M. C. (2008). *GC/MS: A Practical User's Guide*. Wiley.

15. Kratz, P. D. (2018). *Gas Chromatography–Mass Spectrometry: Principles and Applications*. Elsevier.