Short Communication Article

Artificial Intelligence for Better Ayurvedic Medicine Quality and Sourcing

Manjiri Ranade[1]
[1]*Department of Rasa shastra and Bhaishajya Kalpana,Dr.Vijay Ayurvedic Medical College and research centre,Varanasi, Uttar Pradesh*

Corresponding Author
Manjiri Ranade
Email ID: dr.maanjiri@yahoo.co.in

Submission : 20.03.2025 Acceptance : 30.04.2025 Publication: 30.06.2025

Abstract

This systematic review examines the role of Artificial Intelligence (AI) in identifying and selecting raw materials for Ayurvedic drug preparation. AI-driven technologies facilitate botanical identification through image recognition and phytochemical analysis, ensuring quality control and authentication. Similarly, AI enhances mineral identification, dosha analysis for personalized formulations, and sustainable sourcing practices. AI-integrated supply chain management and waste reduction strategies further support environmental sustainability in Ayurvedic manufacturing. Case studies highlight AI's impact on product authenticity, efficacy, and consumer trust in Ayurvedic pharmaceuticals. Looking ahead, AI's continued integration promises personalized healthcare solutions and optimized therapeutic outcomes in Ayurvedic medicine, fostering innovation and accessibility in holistic healthcare delivery.

Keywords : (MeSH terms) : Artificial Intelligence,Ayurvedic Medicine ,Phytochemical Analysis, Rasa Shastra,Quality Control

Introduction

Ayurveda, an ancient system of medicine, relies on precise raw material selection to ensure the efficacy and safety of its formulations. With increasing demand for Ayurvedic drugs, traditional identification methods face challenges such as adulteration, resource depletion, and quality inconsistencies. AI presents a transformative solution by enabling accurate and efficient raw material identification and selection. This review explores AI's applications in Ayurvedic medicine, including botanical and mineral identification, sustainable sourcing, and supply chain optimization, ultimately improving quality control, regulatory compliance, and patient outcomes.

Methods

This systematic review follows the PRISMA guidelines for collecting, analyzing, and synthesizing literature on AI applications in Ayurvedic drug preparation. A comprehensive search was conducted across multiple scientific databases, including PubMed, Scopus, and Google Scholar, using keywords such as "Artificial Intelligence in Ayurveda," "AI for herbal identification," and "AI in mineral analysis." The inclusion criteria consisted of peer-reviewed articles, conference papers, and case studies published in the past 15 years that discuss AI's role in raw material selection for Ayurveda. Studies focusing solely on traditional methods without AI integration were excluded. Data extraction involved reviewing AI methodologies, applications, and their impact on Ayurvedic formulations.

AI-Driven Botanical Identification[(1)]

AI-driven technologies have revolutionized the identification of botanicals in Ayurvedic medicine. Machine learning models, particularly convolutional neural networks (CNNs), analyze high-resolution images of plant specimens, extracting morphological features such as leaf shape, flower patterns, and stem characteristics for accurate species classification. Additionally, AI-based phytochemical analysis tools expedite the identification of active compounds present in botanical extracts. Natural language processing (NLP) algorithms analyze scientific literature and pharmacopoeial references to extract phytochemical information, aiding in the selection of medicinally potent plants. These technologies enhance quality control by ensuring the authenticity and purity of raw materials. Spectroscopic techniques such as near-infrared spectroscopy (NIRS) and Raman spectroscopy, coupled with AI algorithms, enable rapid authentication and characterization of herbal ingredients. Blockchain technology further strengthens supply chain transparency, preventing adulteration and counterfeiting in Ayurvedic medicine.

Mineral Identification and Selection[(2)]

AI significantly improves the identification and selection of minerals used in Ayurvedic drug preparation. Machine learning algorithms process data from mineralogical analysis techniques such as X-ray diffraction (XRD), X-ray fluorescence (XRF), and scanning electron microscopy (SEM) to assess mineral purity, detect impurities, and classify mineral phases. These advancements ensure that

only high-quality minerals are used in Ayurvedic formulations, maintaining therapeutic efficacy and safety. AI-driven dosha analysis tools integrate mineral properties with Ayurvedic principles, personalizing drug formulations based on individual Prakriti (constitutional types of Vata, Pitta, and Kapha). By leveraging patient health records and lifestyle data, AI optimizes mineral selection, improving precision in treatment protocols and enhancing patient outcomes.

Sustainable Sourcing and Environmental Impact[3]

AI plays a crucial role in promoting sustainability in Ayurvedic raw material procurement. Predictive analytics and machine learning algorithms optimize sourcing strategies by considering biodiversity conservation, ethical harvesting, and ecosystem preservation. AI-based supply chain models analyze market trends, demand fluctuations, and seasonal variations to minimize resource depletion and inventory wastage. Furthermore, AI-powered environmental impact assessments evaluate the carbon footprint of raw material extraction and processing, encouraging sustainable practices in Ayurvedic manufacturing. Waste reduction strategies, including robotics and automation, enhance resource efficiency by minimizing material losses during production. AI-driven recycling initiatives contribute to a circular economy, ensuring responsible disposal and reuse of byproducts generated in Ayurvedic pharmaceutical processes.

Results

The integration of AI in Ayurvedic raw material identification has demonstrated substantial improvements in accuracy, efficiency, and sustainability. Studies reviewed indicate that AI-driven botanical and mineral identification methods significantly reduce errors in classification and authentication. AI-based quality control systems improve standardization, leading to consistent product formulations. Sustainable sourcing practices supported by AI-driven analytics contribute to reduced environmental impact and enhanced resource management. Furthermore, AI-assisted dosha profiling allows for personalized medicine, tailoring treatments to individual needs and improving therapeutic outcomes.

Discussion

The application of AI in Ayurvedic medicine represents a paradigm shift in how raw materials are identified, authenticated, and utilized for drug formulations. AI enhances the reliability of botanical and mineral selection, reducing human error and increasing precision. The ability of AI to analyze massive datasets enables the identification of medicinal plants and minerals with high therapeutic value, ensuring consistency in drug formulation and efficacy. Furthermore, AI's integration into supply chain management ensures real-time tracking and authentication of raw materials, mitigating issues of adulteration and contamination.[4]

Despite these advancements, challenges persist in the widespread adoption of AI in Ayurvedic medicine. Limited access to advanced AI technologies, particularly in rural areas where Ayurvedic raw materials are sourced, poses a barrier to implementation. Additionally, resistance to technological change among traditional practitioners and regulatory constraints may slow AI adoption. To fully harness AI's potential, collaborative efforts between technology developers, Ayurvedic researchers, and policymakers are essential.[5]

Future developments in AI, such as the application of blockchain for supply chain transparency and quantum computing for complex phytochemical analysis, could further revolutionize Ayurveda. AI's role in predictive analytics could aid in the discovery of new medicinal plants, broadening the scope of Ayurvedic treatments. Ethical considerations surrounding AI, including data privacy and equitable access to AI-driven healthcare solutions, must also be addressed to ensure sustainable and inclusive growth in this field.[6]

Conclusion

AI is revolutionizing raw material identification and selection in Ayurvedic drug preparation. Through botanical species classification, phytochemical analysis, mineral identification, and sustainable sourcing, AI enhances quality, efficacy, and environmental responsibility. As AI technologies evolve, their integration into Ayurvedic practice will drive innovation, improve patient-centered care, and establish a global standard for high-quality Ayurvedic medicine.

Source of Support: Nil

Conflict of Interest: Nil

References :

1. Nesari, Tanuja Manoj. Artificial intelligence in the sector of Ayurveda: Scope and opportunities. International Journal of Ayurveda Research 4(2):p 57-60, Apr–Jun 2023. | DOI: 10.4103/ijar.ijar_40_23.
2. Kartik Sharma, Aashish Patel, Aswini Ramachandran. Uses and Relevance of Artificial Intelligence (A.I) In

Ayurveda. J Ayurveda Integr Med Sci [Internet]. 2025Jan.8 [cited 2025Mar.2];9(10):197 -200.

3. Chetna Rathor, Vijendra Singh Mandloi, Ishwari Sachan, Vikash Sahu. Artificial Intelligence in Ayurveda: A Simple Overview. J Ayurveda Integr Med Sci [Internet]. 2025Feb.3 [cited 2025Mar.2];9(11): 271 -275.
4. Buvana V. Mundargi, VaishnaviMutalikdesai, Sajitha K, Deepthi R, Ahana Balakrishnan.A Bird's Eye View on the Integration of ArtificialIntelligence (AI) In Ayurveda. J Ayurveda Integr Med Sci2024;8:167-172.
5. Bale Anura, Desai Gaurav, Khedekar Sumod, Nayak Meghna. Artificial intelligence and challenges in ayurveda pharmaceutics: a review. Ayushdhara. 2022; 9(1): 95-101.
6. Vijayan V, Ajitha KA. Review article on exploring the scope of AI in Ayurveda. Kerala Journal of Ayurveda. 2024; 3(2): 37-43.