AYUSHDHARA
ISSN: 2393-9583 (P)/ 2393-9591 (O)
An International Journal of Research in AYUSH and Allied Systems

Review Article

REVOLUTIONIZING AYURVEDIC HERBOLOGY, DRUG DISCOVERY AND DRUG DEVELOPMENT SUPPORTED BY ARTIFICIAL INTELLIGENCE

Lidia Daniel[1]*, A. Vijaya Lakshmi[2]
*[1]PG Scholar, [3]Professor & HOD, Post Graduate Dept. of Dravyaguna, Dr. BRKR Govt. Ayurvedic Medical College, Hyderabad, Telangana, India.

Article info
Article History:
Received: 30-11-2024
Accepted: 26-12-2024
Published: 15-01-2025
KEYWORDS:
Ayurvedic Herbology, Pharmacognosy, Phytochemical analysis, Spectral analysis.

ABSTRACT

Aim/Objective: In this review an attempt is made to evaluate the advantages and limitations of Artificial Intelligence in Ayurvedic Herbology and Drug Discovery and Development. **Material and Methods**: A comprehensive literature search was conducted to identify relevant studies and articles on the integration of AI and Ayurveda. The search included databases such as PubMed, Google Scholar, and relevant journals. The collected data was analyzed to present a comprehensive overview of the topic. **Discussion:** AI integration into Ayurvedic pharmacology can advance predictive modelling of drug effects and support personalized treatment plans. In pharmaceuticals, AI can optimize formulations and improve quality control. In pharmacognosy, AI aids in accurate plant identification and phytochemical analysis. AI-driven drug discovery can identify new compounds and synergistic effects in polyherbal formulations. Additionally, AI can ensure drug authenticity through block chain and spectral analysis, enhancing the purity and safety of Ayurvedic products. **Conclusion:** AI has the potential to revolutionize the *Dravya* sector in Ayurveda by improving accuracy, efficiency, and personalization. This integration marks a significant advancement towards a technologically sophisticated approach to traditional medicine, promising better patient outcomes and broader acceptance of Ayurveda globally.

INTRODUCTION

Ayurveda is an ancient science of life with a holistic approach to health, comprising of a vast variety of medical perceptions, and personalized medicines.[1,2] *Chatushpada* is an important concept which refers to *Dravya*/drug as the second important quadrant of Ayurvedic treatment. *Bruhat trayees* mentioned the *Dravya,* along with its detailed narration, properties, and applications in the *Suthrasthana* of the *Samhithas*,[2,3] indicates its importance. *Bhishak* can organize treatment only if he has proper knowledge in the field of *Dravyagunavijnana*/Ayurveda Herbology as >90% of Ayurvedic medicines are Plant-based. *Prakruthi, Dosha, Bala* etc. of the patient, *Rasapanchaka*, and *Prabhava* of the drugs are the keyfactors which adopts the elective drugs in a specific pathology. Over 5000 years, Ayurveda has maintained itself with little change in the form as it is being practiced. It is critical to be contemporary with the recent technical inclinations, for the benefit of society and nurturing Ayurveda even though the principles of Ayurveda are immortal. By adopting and adapting to the current expanding technologies like Artificial Intelligence, Machine Learning, Robotics etc.,[4] we can create a revolutionary change in the field of Ayurveda. This incorporation, mindful of not changing the elementary principles, is a challenging mission but inevitable for an improved acceptance of Ayurveda across the globe.

Access this article online	
Quick Response Code	
	https://doi.org/10.47070/ayushdhara.v11i6.1859
	Published by Mahadev Publications (Regd.) publication licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0)

AIM/OBJECTIVE

In this review an attempt is made to evaluate the advantages and limitations of artificial intelligence in Ayurvedic herbology, drug discovery and development.

MATERIALS AND METHODS

A comprehensive literature search was conducted to identify relevant studies and articles on the integration of AI and Ayurveda, especially in the

field of drug identification, drug discovery and development, and cultivation of medicinal plants. The search included databases such as PubMed, Google Scholar, and relevant journals. The collected data was analyzed to demonstrate a comprehensive overview of the topic.

Artificial Intelligence (AI)

AI is defined as the field of computer science that is allied with the thought of machines "thinking like humans" to achieve tasks such as learning, planning, reasoning, problem solving, and identifying patterns. Artificial intelligence is a widespread tool that empowers people to reconsider the way of integrating information, analyzing the data, and use the subsequent understandings to improve decision making. By now, it is transforming every walk of our life, despite its widespread lack of acquaintance.[5]

Subfields/subsets of AI:

1. Machine Learning
2. Deep Learning

Machine Learning: It is the technique of analyzing data, learn from that data and apply what they have learned to make an informed decision. Eg: Amazon product recommendation. If the MLmodel returns an inaccurate prediction, the programmer needs to fix the problem.

Deep Learning: It is the subset of machine Learning that uses multilayered neural networks called deep neural networks to simulate the complex decision-making power of the human brain. Here the Machine will resolve the complex problems and fix the problems by itself, for example, an autonomic car driving system.[6]

Artificial Intelligence: Ability of computer programme to function like a human brain. Machine Learning & Deep Learning are the ways to achieve AI.

Herbal Reserves on Planet Earth

A report by the Royal Botanic Gardens, U.K, declares that there are about 3,91,000 species of vascular plants (those plants which have specialized vascular tissues for the transportof water, minerals and food) currently known to science. These embrace a diverse range from tiny mosses to flowering trees, spread across different ecosystems worldwide, and many of them are now on the edge of extinction. Only about 31,000 of these have at least one documented use, which is for medicine, food, recreation, animal feed et. al.[7,8]

In Ayurvedic healing methodology, plant-based preparations have a significant role (>90%), either as a single drug or poly-herbal formulations. Out of nearly 10000 plants used for medicinal purposes in the Indian Sub-continent, only 1200-1500 have been incorporated into the official Ayurvedic Pharmacopeias in more than 3000 years. Among these, only around 300 are being used for our day-to-day practices.

"---------- jagatyevamanaushadham | na kinchidvidyate dravyam vashannanarthayogayoh ||" {A H:SOO.9/10}

Ashtanga Hrudaya Suthrasthana, *Dravyadivijnayeeyadyaya* mentioned above reference which indicates that all the herbs found on the surface of earth can be used as medicines. [9] In the context of *Mahakashaya vivarana*, in *Shadvirechanashatasritheeyadyaya*, *Acharya Charaka* gave a famous quote as follows:

"*...Panchashanmahakashaya mahatam ca kashayanam l akshanodaharanartham vyakhyata bhavanti* ||" {Ch: Soo 4/19}

In the *Tika*, we are getting more clarity as -

"*Mandabudhinanam lakshanartham* and *Budhimatam tu udaharanartham drushtanthartham"*

Which means still many drugs are there to be explored, identified, and evaluated[10] for the properties and actions, and to be used based on the need of the time and society. Analyzing the period from *Charaka Samhita* to Ayurvedic Formulary of India (in which 636 compound formulation are described) & Ayurvedic Pharmacopoeia of India (which details 326 plants) we find that many drugs are unavailable, endangered or controversial. Many are yet to be discovered, recognized and used in treatment.

The above data shows the importance of identification of the exact botanical sources of theherbs, finding an alternative to those extinct or endangered, finding effective formulations with available drugs, and finding the best available drug in the case of controversy. Both in-vitro and in-vivo study of compound formulations are important as these are the weapons for treatment endowed with multifold medicinal properties.

AI in Drug Identification

From the period of *Samhithas* to *Nighantus,* many changes happened in drug identification and classification criteria. Drug identification with the help of wild dwellers (*Ajapa, Avipa, Vanavasinah*) is advised in *Charaka Samhitha* and some synonyms based on morphology can be found in *Samhitas.* Coming to the period of *Nighantus,* more detailed morphological descriptions are made by authors. The development in botany has been exponential for many decades and we are incorporating that knowledge in *Dravyaguna* for framing a better drug identification strategy. Identification of medicinal plants broadly has two aspects.

1. Identification of the correct botanical source in fresh /dry form.
2. Identification of the herbs effective in particular diseases

The identification of the correct plant is the foremost step for the preparation of Ayurvedic medicine, which has been done manually for many years.[11] Due to demand for mass production, it becomes a cumbersome task and the need to develop automated, or even autonomous tools becomes a necessity.[12] One of the most authoritative works for this is done by Wu et al. and they achieved 90.3% accuracy with Flavia Dataset. Fully automated methods for the recognition of medicinal plants using Convolutional Neural Network (CNN) are investigated.[13]

AI algorithms can analyze vast repositories of ancient texts, research papers, and clinical data to identify patterns and correlations between specific herbs effective in various health conditions. E.g.: A study by Fathifar et al. (2021) demonstrated how AI-driven natural language processing techniques extracted valuable information from historical Ayurvedic texts, leading to the identification of novel herbs with potential anti-inflammatory properties. Some available plant data bases like The World Flora Online (WFO), International Plant Names Index(IPNI), Indian Medicinal Plants, Phytochemistry and Therapeutics (IMPPAT) can be used for training the AI. IMPAAT 2 is the largest digital data base on phytochemicals of Indian Medicinal Plants. For 17967 phytochemicals in this database, 2D & 3D chemical structures have been provided and chemo-informatics tools have been employed to compute their physio-chemical properties, drug likeness based on multiple scoring schemes. Absorption, Distribution, Metabolism, Excretion and Toxicity (ADMET) properties have also been predicted. The website now enables viewing the phytochemicals based on molecular scaffolds.

Dry Drug Identification: Crude drugs are the drugs of natural origin which have undergone no other process except collection and drying. They are divided into two main categories as organized drugs/cellular drugs and unorganized drugs/ acellular drugs. Organized drugs are organs of plants or animals and are made up of cells or definite structures. These are solid in nature. Microscopic characters are important criteria for identification. E.g.: digitalis, clove, saffron. Unorganized drugs are derived from part of plants or animals by some process of extraction and followed by purification. These may be solid, semi-solid or liquid in nature. Chemical tests and physical standards are confirmation tests. E.g.: oils, gums, bee wax, honey. If we are making use of AI algorithms in scrutinizing and understanding the drug specimens based on either physio-chemical constituents or DNA structure**,** we can do the quality assessment and prevent adulteration.

AI Integrated Ayurvedic pharmacognosy

Pharmacognosy is the study of natural products, including plants, animals, and microbes, for their potential medicinal or health benefits. It is a key discipline in pharmaceutical sciences and plays a critical role in drug discovery.[14] Pharmacognosy involves searching for new drugs from natural sources, studying the chemical, physical, and biological properties of natural product, the history, cultivation, collection, extraction, isolation, bio- assaying and quality control of natural products, and consideration of mineral sources. Pharmacognosy has evolved over the years to include modern analytical techniques, such as phytochemistry, phytochemical analysis, molecular biology, botanical techniques, computational techniques, and biological techniques.[15]

In Ayurveda *Samhitas*, drug identification is done with the help of wild dwellers. *Acharyas* narrate the details of the qualities of medicinal herbs to be collected, collection sites (*Dravya sangrahana bhumi pariksha*), seasons (*Dravya sangrahana kala*) of drug collection, storage techniques (*Dravya sangrahana vidhi*), different dosage forms (*Kalpanas*) with effectiveness*, Paka lakshanas* and shelf life (*Saveeryatha avadhi*). *Rasapanchaka* is used for describing the action of drugs instead of physio-chemical analysis.

AI algorithms can be used in Ayurveda pharmacognosy for:

- Drug identification
- Quality assessment of drugs
- Prediction of changes in physio-chemical constituents based on geographical and climatic changes.
- Assessment of *Rasapanchaka* and its relation to chemical constitution
- Structural and functional differences in various dosage forms
- Monitoring of cultivation techniques

Taxonomy is defined as a science that finds, identifies, describes, classifies, and names plants. The earliest known classification was in B.C. 2650 by Emperor Shen Nung ofChina. Most early classification began as lists of medicinal plants. Aristotle (384 B.C-322 BC) classified plants based on simple morphological characters into herbs, shrubs, and trees. Theophrastus (372 B C -287 BC) classified over 500 plants into annuals, biennials and perennials. He is considered as "Father of Botany." Due to Aristotle's profound influence,

There was little innovation made within the taxonomy until the 16th century. Binomial System of Classification by Carolus Linnaeus in "Species Plantarum" (1753), gave a brief description of around 7,300 plant species. Bentham and Hooker System of

Classification describe 97,205 species of seed plants were classified into 7569 genera and 202 families. The Angiosperm Phylogeny Group (APG) Classification classifies flowering plants, or angiosperms, based on DNA sequencing data and the latest APG IV system, came in 2016.

In Ayurveda, drugs are divided into *Ganas* (of similar *Guna karmas*), *Skandhas* (of similar *Rasa*), *Mahakashayas* (of similar actions), *Vargas* etc by analyzing these datasets, AI can do assessment of new drugs and incorporate into comparable groups, reformulate the groups from available species, and frame analogous groups with different drugs available in dissimilar geographical zones.

AI in Medicinal Plant Cultivation

Cultivation of medicinal plants is important for many reasons, such as economic benefits, conservation, health benefits, and uniform production. AI can be utilized in this for predicting weather and pests, optimizing resource use, generating farm specific recommendations, improving irrigation management, identifying disease patterns, monitoringcrop health, and Drone- Assisted Aerial Surveillance.[16,17] E.g.: Kisan e-Mitra: an AI powered chatbot designed to support farmers for making queries related to government programs in the agricultural field by Aqua Terra Solutions uses A I to analyze soil data.

AI in Ayurvedic Drug Discovery[18]

Integration of AI with Ayurvedic drug discovery is transforming the traditional medicine field by the utilization of modern technological progresses. AI in Ayurvedic herbology presents an exciting opportunity to accelerate drug discovery, find novel herbal combinations[19], and predict herb-drug interactions without altering the core principles of Ayurveda. It is important to measure AI accelerated discovery of medicinal herbs, prediction of herb-drug interactions, and developing personalized herbal combinations.[20] One of the most significant contributions is the expedited discovery of potential medicinal herbs and their therapeutic properties. AI algorithms can analyze vast repositories of ancient texts, research papers, and clinical data for identifying patterns and correlations between specific herbs and their effects on various pathologies.[21,22] A study by Fathifar et al. (2021) demonstrated that AI-driven natural language processing techniques extracted information from historical Ayurvedic texts, leading to the identification of new herbs with potential anti-inflammatory properties.[23] AI-assisted such discoveries can significantly enhance the Ayurvedic pharmacopeia and extend the range of treatment options for practitioners.

Drug Safety and Efficacy

AI plays a crucial role in predicting herb-drug interactions, a critical aspect of Ayurvedic medicine related to patient safety and treatment efficacy.[24] AI algorithms can process and analyze complex data sets, like molecular structures and pharmacological profiles, to forecast potential interactions between herbal remedies and conventional medications. Ayurvedic consultants can make informed decisions about combining traditional remedies with modern pharmaceuticals, minimizing the risk of adverse reactions and optimizing therapeutic outcomes by integrating AI-driven tools. Formulating novel herbal combinations personalized to individuals is another important realm. Ayurveda emphasizes the importance of personalized treatments and the unique constitution of the individual (*Prakruti*) while analyzing the health imbalances.[25]

DISCUSSION

The integration of AI with Ayurvedic herbology and drug discovery is a revolutionary advance that offers transformative possibilities for traditional medicine. AI-driven drug discovery can accelerate the identification of potential medicinal herbs and their therapeutic properties, while AI-powered predictions of herb-drug interactions can enhance patient safety. Additionally, AI's ability to formulate personalized herbal remedies aligns flawlessly with the holistic principles of Ayurveda. Even though there are numerous advantages, the integration of AI inAyurvedic herbology and drug discovery comes with a lot of challenges. One primary concern is the validation of AI-generated conclusions through traditional experimental methods.[26] AI algorithms can analyze extensive datasets and propose potential herbal properties, but it is crucial to validate the results of in-vitro and in-vivo studies to confirm safety and effectiveness.[27] Ethical considerations surrounding intellectual property rights and traditional knowledge protection also be addressed when utilizing AI in Ayurvedic drug discovery.[28]

CONCLUSION

In Ayurvedic texts and traditional practices, the knowledge of medicinal herbs and formulations has been passed down through generations. As algorithms uncover potential therapeutic properties of these herbs, it becomes decisive to acknowledge and respect the contributions made by traditional pioneers and protect their traditional wisdom. It is essential to ensure that AI complements and elevates traditional Ayurvedic practices while addressing challenges related to validation and ethical considerations. Collaborative efforts between Ayurvedic practitioners, AI experts, and policymakers are crucial in harnessing

the full potential of AI to strengthen Ayurvedic herbology and promote holistic health care.

REFERENCES

1. Yati GN. Ayurveda - A Holistic Science. Anc Sci Life 1992; 12:286-8.
2. Acharya Charaka, Charak Samhita with Charak Chandrika Hindi Commentary, by Dr. Brahmanand Tripathi, Dr. Ganga Sahay Pandey, Suthra Sthana Chapter 30, verses 26, Chaukamba Surbharti Prakashan, Varanasi. 2007. P.565
3. Acharya Charaka, Charak Samhita, with Charak Chandrika Hindi Commentary, by Dr. Brahmanand Tripathi, Dr. Ganga Sahay Pandey, Suthra Sthana Chapter 09, verse 3, Chaukamba Surbharti Prakashan, Varanasi. 2007. p 207
4. Rajpurkar P, Chen E, Banerjee O, Topol EJ, AI in health and medicine. Nat Med 2022; 28: 31-8
5. Hussain A, Malik A, Halim MU, Ali AM. The use of robotics in surgery: a review. IntJ Clin Pract 2014; 68: 1376–82.
6. Right Care Shared Decision Making Programme, Capita. Measuring shared decision making: A review of research evidence. NHS, 2012. www.england.nhs.uk /wp- content/ uploads/2013/08/7sdm-report.pdf.
7. Bruner AG, Gullison RE, Rice RE, de Fonseca GAB (2001) Effectiveness of parks in protecting tropical biodiversity. Science 291: 125–128
8. Johnson, N. Nature Displaced, Nature Displayed: Order and Beauty in BotanicalGardens; I.B. Tauris: London, UK, 2011. [Google Scholar]
9. Acharya Vagbhata, edited by Pt. Hari Sadashiva Shastri, Ashtanga Hridaya, Chaukhamba Surbharati Prakashan, Varanasi, 2007; chapter 9. ver.10
10. Sastri K, Chaturvedi G, editors. Charak Samhita of Agnivesha, Vidyotini, Sutrasthan, Ch. 4, Ver. 19. Varanasi: Chowkhamba vidya bhawan. 1962. pp.96.
11. S. Kaur and P. Kaur, "Plant species identification based on plant leaf using computer vision and machine learning techniques," Journal of Multimedia Information System, vol. 6, pp. 49-60, 06 2019.
12. H. Zhu, Q. Liu, Y. Qi, X. Huang, F. Jiang, and S. Zhang, "Plant identification based on very deep convolutional neural networks," Multimedia Tools and Applications, vol. 77, 2018
13. K Prashar, R Talwar, C. Kant, CNN based on overlapping pooling method and multi- layered learning with SVM & KNN for American cotton leaf disease recognition [C], 2019 International Conference on Automation, Computational and Technology Management (ICACTM), IEEE (2019), pp. 330-333
14. Joshi K. Leveraging Artificial Intelligence as a Tool to improve health services and Modernize Ayurveda Treatment– A perspective. J Res Ayurvedic Sci 2023; 7: S10-2
15. Liu J., Pei M., Zheng C., Li Y., Wang Y., Lu A., et al. (2013). A Systems- Pharmacology Analysis of Herbal Medicines Used in Health Improvement Treatment: Predicting Potential New Drugs and Targets. Evid. Based. Complement. Alternat. Med. 2013: 938764.
16. Popa, Cosmin. Adoption of Artificial Intelligence in Agriculture [J]. Bulletin of the University of Agricultural Sciences & Veterinary, 2011
17. Mckinion J M, Lemmon H. E. Expert systems for agriculture [J]. Computers & Electronics in Agriculture, 1985, 1(1): 31-40.
18. Ranade M. Artificial intelligence in Ayurveda: Current concepts and prospects. J IndianSys Medicine 2024;12:53-9
19. Brody BA. Traditional knowledge and intellectual property. Kennedy Inst Ethics J 2010; 20: 231-49.
20. Kurande V, Waagepetersen R, Toft E, Prasad R, Raturi L. Repeatability of pulse diagnosis and body constitution diagnosis in traditional Indian Ayurveda Medicine. Glob Adv Health Med 2012; 1: 36-42
21. Fathifar Z, Kalankesh LR, Ostadrahimi A, Ferdousi R. New approaches in developing medicinal herbs databases. Database (Oxford) 2023; 2023: baac 110
22. Pal A, Sengupta S, Kundu R. Tiliacora racemosa leaves include oxidative stress mediated DNA damage leading to G2/M phae arrest and apoptosis in cervical cancer cells SiHa. J Ethnopharmacol 2021; 269: 113686
23. Johnson D, Goodman R, Patrinely J, Stone C, Zimmerman E, Donald R, et al. Assessing the accuracy and reliability of AI-Generated medical responses: An evaluation of the Chat-GPT Model. Res Sq [Preprint] 2023; 28:rs.3.rs-2566942.
24. Chen L, Liu X, Zhang S, Yi H, Lu Y, Yao P. Efficacy-specific herbal group detection from traditional Chinese medicine prescriptions via hierarchical attentive neural network model. BMC Med Inform Decis Mak. 2021 Feb 18;21(1): 66. doi: 10.1186/s12911-021-01411-2. PMID: 33602205; PMCID: PMC7893975.
25. Rastogi S. Development and validation of a prototype Prakriti analysis tool (PPAT): Inference from a pilot study. Ayu 2012; 33: 209-18
26. Wallace RK, Ayurgenomics and modern medicine. Medicina (Kaunas) 2020; 56: 661
27. Ateena F. Too much medicine? Scientific and ethical issues from a comparison between two conflicting paradigms. BMC Public Health 2019; 19: 97
28. Rush B, Celi LA, stone DJ, applying machine learning to continuously monitored physiological data. J Clin monit Comput 2019; 33: 887-93.

Cite this article as:
Lidia Daniel, A. Vijaya Lakshmi. Revolutionizing Ayurvedic Herbology, Drug Discovery and Drug Development Supported by Artificial Intelligence. AYUSHDHARA, 2024;11(6):346-350.
https://doi.org/10.47070/ayushdhara.v11i6.1859
Source of support: Nil, Conflict of interest: None Declared

***Address for correspondence**
Dr. Lidia Daniel
PG Scholar,
Department of Dravyaguna,
Dr. BRKR Govt. Ayurvedic college,
Hyderabad, Telangana
Email: drlidianigi@gmail.com