



A REVIEW: ARTIFICIAL INTELLIGENCE AND CHALLENGES IN AYURVEDA PHARMACEUTICS

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ABSTRACT

Ayurveda, the science of life is used for maintenance of health from ancient time. The most important aim was to prolong lifespan of human subjects as well as to maintain and promote their positive health and the equivalent is the motto of Ayurveda science. Pharmaceutical department in Ayurveda with more than five thousand permutation and combinations are utilized in day today practice for cure the various diseases. This traditional medical system along with established annals of several centuries is becoming one of the most popular sciences with safety and efficacy. With raise demand of Ayurveda medicine and acceptance of Ayurveda in the whole world, there is need of modernization and use of progress methodology in Ayurveda Pharmaceuticals. Now a day's newly advanced branch called as Artificial Intelligence (AI) can be used to meet increasing demands of Ayurveda medicines and to face the challenges faced during drug manufacturing. AI is used to combine engineering principles into the drug development to overcome challenges faced in Ayurveda Pharmaceuticals. This can be achieved by way of applicability of AI in the different sectors of Ayurveda pharmaceuticals. An attempt has been made in this article to examine challenges with probable solutions by using Artificial Intelligence for global acceptance of Ayurveda.

KEYWORD: This can be achieved by way of applicability of AI in the different sectors of Ayurveda pharmaceuticals.

INTRODUCTION

Ayurveda is one of the most recognized and admired existing health systems in the world with fundamental principles and theory based practices. In Sanskrit definition of the Ayurveda is Science of Life.^[1] Ayurveda's theoretical foundations, logic and epistemology are reflected in the popular six Darshanas, principally the logic of Sankhya darshana and Nyaya Vaisheshika darshana.^[2] Its main goal is to extend lifespan of human subjects and to maintain and promote their positive health.^[3] It is mentioned in most of the classic texts of Ayurveda.^[4] Surprisingly, Ayurveda is the capacity to cure various chronic conditions that are untreatable by other available medical systems, such as allergic diseases, skin problems, neuromuscular diseases, cancer, obesity, arthritis, and asthma.^[5] Unluckily, this invaluable gift from our ancestors is disappearing due to lack of empirical evidence of many ideas. Consequently, evidence-based research is the need of the hour for global acceptance and recognition of Ayurveda, which requires ongoing research methodology developments.^[6] In Ayurveda, medicine is considered as the first important patient management tool in the hands of a

physician and therapist.^[7] This tool is used precisely on the basis of many signs and symptoms and patient's examination, if not done so it is likely to cause adverse reaction who is receiving it.^[8] The information related to drugs and formulations along with diagnosis and management of disease^[9] accompanied with techniques of health maintenance through observance of proper daily and seasonal routines can be found in large number of classical and other literary works.^[10]

Pharmaceutical department in Ayurveda with more than five thousand permutation and combinations are utilized in day today practice for cure the various diseases.^[11] They can be of any nature, plant, animal or mineral product, each substance has to undergo a specific process to obtain a form of palatable medicine. Such process is known as Ayurveda pharmaceuticals i.e., 'Bhaishajya Kalpana'.^[12] The final product which finally use by the patient is known as medicine. Ayurvedic formulations include syrups, medicated oils, medicated soaps, capsule, creams, eye drops, freshly extracted plant juice, ointments, etc.^[13] However, there are five basic classical types called as 'Panchavidha kashaya kalpana' namely-

Swarasa, Kalka, Kashaya, Hima, Phanta; from which all other drug formulations or forms are created or developed.^[14] In ancient time and few Ayurveda physicians even in this era,^[15] prepare medicines on their own, by considering various aspects such as Dosha dominancy in patient, Prakruti- genomic constitution, Desha- geographical condition, disease status, age of the patient, patient strength, seasonal difference etc.^[16] Due to the increasing popularity of Ayurvedic medicine and its acceptance across the world, there is a need for modernization and the use of modern techniques in Ayurveda Pharmaceuticals.^[17] This discipline is timeless, it is comprehensive and useful holistic sciences that has gained popular recognition and support.^[18] Rasashatra department of Ayurveda, documents monographs of 84 inorganic drugs and over 2000 compound formulations using 84 drugs and over 350 herbs.^[19] Rasaushdhis in the form of many bhasmas (single metallo-organic drugs) viz. Abhraka (Biotite mica), Suvarna (Gold- Au), Rajata (Silver- Ag), Makshika (Chalcopyrite- CuFeS₂), Galena (PbS) and kalpas (metallo-herbal compound formulations) viz. Laxmivilas rasa, Sootashekhar vati, Chandraprabha vati, Mahayogarj guggulu etc. they are praised for their low dose and rapid action. They are preferred over herbal medicines to treat various known disease conditions and also provide options for new emerging health problems.

Need for Updating in Pharmacopoeia

Ayurvedic Pharmacopoeia of India (API) contains standards for the quality of Ayurvedic medicine and substances (included under the Drugs and Cosmetic Act, 1940.) The branch of AYUSH, Ministry of Health and Family Welfare, Government of India, publishes the API.^[20] Nomenclature, part used, ingredients, range of application, contraindications, side effects, compatibility with other drugs, dose, use, and activities of the herb are covered in herbal monographs.^[21] Data on bioassays and standardization of single herbs mentioned in Ayurvedic Pharmacopoeia of India is a precious tool to ensure quality standards of finished formulations.^[22] Although traditional medicines related to drug and cosmetics are mandated by the provisions of the act, these processes are rarely used by companies dealing with Ayurvedic formulations.^[23] In order to improve the scientific accountability of Ayurvedic medicine, there is a need to update Indian Ayurvedic medicine.^[24] Many herbal medications are not included in the Indian Ayurvedic Pharmacopoeia but are used as ingredients in the final formulations.^[25] Preparation of updated or additional Ayurvedic Pharmacopoeia containing data on medicinal plants not listed in Indian Ayurvedic Pharmacopoeia is the need of the hour.^[26]

Areas for Improvement: Instead of competing and turning to Western medicine, the Ayurvedic scholars should work to increase the acceptance of Ayurvedic medicines without compromising the basic principles of Ayurveda.^[27] Some key factors responsible for

backwardness of Ayurveda should be noted and future strategic plans worked out.^[28]

- **Desire to Get Deep Knowledge:** Although Ayurveda may sound unscientific to many, it is a highly scientific and subtle science that requires deep understanding to practice.^[29] Unfortunately, we have very few intellectuals who try to understand the Basic Ayurvedic principles as it is a fantastic science so common people cannot fully understand it.^[30] This is one of the major areas to be worked upon by Ayurveda research scholars.^[31]
- **Thorough Research:** Only a few institutes have well-established research infrastructure for exclusive research in Ayurveda.^[32] Experienced researchers and scholars with knowledge of modern technology should be very clear on how to carry out their valuable research outputs on our medicines, data collection and documentation.^[33]
- **Need for Cooperation and Willingness** of Biomedical Scientists who should avoid undue skepticism and prejudice.^[34]
- **More Documentation of Emergency Medicines:** Today we have a lot of Ayurvedic emergency and lifesaving medicines that work fast in very low doses, but are poorly documented. So, it becomes a real limitation and overcoming it is the need of the hour.^[35]
- **Need for Availability of Pure Medicines:** Ayurveda relies on nature for most its medications. Today, we have relatively few medicinal herbs, and the once we have are of poor quality due to adulteration and other reason.^[36]
- **Need to Overcome Illiegal Marketing Strategies and Advertising Propaganda** by some doctors, companies or hospitals with hundred percent or permanent cures also disadvantageous from the patient, client or consumer perspective.^[37] Such practices should be checked and banned. This can be prevented by taking up strict measures, advice and thorough documentation.^[38]

Artificial Intelligence is currently trending. We are building brains with AI, which is a technology that allows machines to think, act and become intelligent like humans. It is a combination of a human cognitive abilities and the intelligence of machine's and programs.^[39] AI is being created by studying how the human brains think, how it learns, how it makes decisions, how it works, solves real-world problems and verifies the results. To save the cost optimization process; many industries are benefiting from AI. The AI can be of various types (4 main types) and can be implemented as most desired as per requirement.

Expert system: It is a behavioral concept that mimics human behavior for making decisions, reasoning, and solving complex problems.^[40]

Fuzzy logic: It is defined as the concept of human thinking to make decisions in every situation. He makes decisions logically according to yes/no or true /false possibilities.^[41]

Neural network /ANN (Artificial neural network): Simulates a real human network by following the working of the human brain.^[42] In ANN, neurons behave as biological neurons, and those nodes are connected to each other through links for communication or interaction. They accept node data and perform different operations and produces output as node value.^[43]

Robotics: An important part of AI where an artificial agent works in the real-world environment and interacts with surrounding environment it is a man-made machine that mimics human thought processes; simply put, it is a machine of human intelligence.^[44] AI has many benefits, including reducing errors, increasing power, and increasing worker efficiency and helping to solve new problems, Improved interfaces as well as better handle information.^[45]

Although the principles of Ayurveda are immortal, the current scientific trends need to be marked contemporary with the integration of technology and mainstreaming of our science globally.^[46] It is time to debate the prospects of Ayurveda's revival, also the issues and solutions that need to be addressed to achieve international standards and be global acceptance as a mainstream healthcare profession employing AI.^[47] With expanding interest and acceptance, advanced approaches focus on the formal scopes of worldwide competitive marketing sectors should be developed in order to reap its future prospects in global economic front simultaneously.^[48] Tough revisions on Ayurveda epistemology, minimum standards and need of statutory bodies, planning commissions, culminating the serious flaws in graduate level Ayurveda education and upgrading and strengthening existing Research & Development institutions through vertical consolidation & clustering of related bodies, and other donation adding to its viability should be at the forefront of corrections. Well-structured and concrete collaborations across nations via MoU will also have influence on implementing its power globally. Thus, ayurveda in the current global trend proposes a various approach towards the nurturing & globalization using AI, making it minor and adaptable in the international scenario. Implementing AI in various sectors of Ayurveda for wider acceptance is done in following manner.^[49]

AI in Rasa-shastra

To combat the problems of quality control, safety and efficacy it is possible to create standard study protocols where the use of new machinery will help us to

understand the complex processes.^[50] In the light of new developments regarding bio-inorganicals, Rasashastra can give inspiration to new leads. Quality Control and standardization have always been issues regarding Bhasmas and Rasaushdhis owing to lack of standard protocols. However, during last couple of decades Rasaushadhis have been targeted on safety issues. A big number of articles on Rasaushadhis, including Bhasmas in indexed journals, are available.^[51] These papers cover a wide range of topics, with this characterization, toxicity studies, clinical studies, physico-chemical evaluation, development of standard operating procedures for validation, free radical scavenging activities, other antioxidant activities, disease-specific pharmacological activities, and a few comparative studies with modern medicines. It is waste to highlight that the Rasashastra bhasmikan procedure converts solid visible form into the solid form nano size, whereas modern chemical techniques use metal in ionic form to obtain metal nano particles.^[52] Bioavailability research on around 50 inorganic materials were included in WHO study issued in 2000, which helped in development of the mostly recent studies on Bio-Inorganics.^[53]

AI in Bhaishajya Kalpana

The various aspects related to drug formulation, preparation, storage etc., are all dealt in this sub-division.^[54] It is equally important to evaluate the medicinal characterization, dosage, clinical trials, disease specific mode of action, development of standard operating procedures for validation, preservation and packaging the final products for public use as per modern parlance.

Drug discovery in Ayurveda and its Components

It is anticipated that machine learning and other technologies will make the search for novel medications in Ayurveda more inexpensive, efficient, effective, and timely.^[55] Artificial intelligence (AI) and machine learning will bring in this new era of efficient, rational, and skilled drug discovery.^[56] Using AI to find patterns hidden in massive amounts of data is crucial for drug discovery because these patterns can be utilized for:^[57]

1. Identifying traditional medications using their Sanskrit names and the several forms of the same plant family that are available.^[58]
2. A thorough explanation of medications, encompassing botanical data and details on Rasa, Guna, Virya, Vipaka, and Prabhava, as well as their global standardization.^[59]
3. Once the medications have been identified and described, we can utilize them directly to treat the illness.^[60]
4. Regarding the drug discovery side of things, information gathered from publications, patents, clinical trials, patient files, and Samhitas will be fed into an artificial intelligence platform that will yield drugs that are already well-known^[61] and documented in classical literature in addition to

practical applications.^[62] As a result, a cloud-based depiction of more than one billion known and disrupted relationships between biological components—such as genes, tissues, organisms, illness symptoms, and potential medications—is produced.^[63] Similar to a search engine, this may be queried to create knowledge graphs.^[64]

As a result, this engine might offer a variety of choices, including stronger alternative medications, to treat the same illness when requested for information about it.^[65] This way, it will all come down to advanced pattern recognition when we construct them and evaluate them in clinical trials.^[66] The groundbreaking finding of monoamines in *Rauwolfia serpentina* ushered in a new era of Ayurvedic pharmacology.^[67] Up until that point, the benefits of Ayurveda in natural product research and medicine were mostly overlooked, understudied, and unacknowledged.^[68] Reverse pharmacology, a strategy inspired by classical knowledge that contributed to the discovery of reserpine, is currently being used with success.^[69]

Prakriti One of the distinctive ideas presented in Ayurveda is called Prakriti. Every Dosha, or a mixture of two or all three, determines it. A person's predominant Dosha or Doshas can be ascertained with the help of a prakriti study.^[70] Given that sickness results from an imbalance in Dosha, a more thorough comprehension of Prakriti facilitates the development of a personalized treatment plan.^[71] By developing a clinical decision support system with Prakriti as its main instrument to achieve higher acceptability, this function can be enhanced. Ayurvedic digitization trends are being actively set by a variety of governmental and nongovernmental organizations.^[72] Information must be gathered, arranged, and distributed with economy and efficiency, taking into account the knowledge and abilities of the portal or program manager.^[73] Ayurvedic doctors can use a variety of computer-based methods that are intended to help them identify, communicate, and evaluate data in order to provide proper diagnosis and treatment.^[74] There are numerous programs available on the market that provide digital Ayurvedic supported systems, such as Aushadhakosh, Dosha evaluation, Prakriti assessment, RASEX, RUDRA, etc. On the internet, the system is aided by numerous dot coms and bloggers (Technoayurveda, Ayurhelp, Ayurvedic treatment, Chakrapani, etc.), as well as e-Journals, e-books, and indexing units (DHARA, AYUSH Research portal, TKDL).

AYUSH Research portal The Central Council for Research in Ayurveda and Siddha (CCRAS) established the AYUSH Research Portal, which is intended to disseminate research findings in the field of AYUSH researchers and affiliated faculties.^[75] Content for the portal is provided by all AYUSH Research councils, National Institutes, and Drug Standardization Laboratories.^[76] It is structured to support

interdisciplinary research and attempts to make the study findings accessible. Of the 5605 items in the portal's entire collection, 10751 are related to Ayurveda.^[77]

DHARA which stands for "Digital Helpline for Ayurveda Research Articles," is Sanskrit for "flow." It is an extensive online indexing service for research articles on Ayurveda.^[78] It is the first and only all-inclusive online indexing service devoted only to papers about Ayurvedic research.^[79] The Central Council for Research in Ayurvedic Science (CCRAS) in New Delhi, The Ayurveda Trust in Coimbatore, and the Swiss Medical Academy (SAMA) in Switzerland collaborated to produce it. This partnership aims to assess research related to Ayurveda.^[80] DHARA contains 7619 items at a glance, with full text available for 2588 of them.^[81]

TKDL stands for **Traditional Knowledge Digital Library**. The Council of Scientific and Industrial Research (CSIR), the Ministry of Science and Technology, and the Department of AYUSH in the Ministry of Health and Family Welfare collaborated to produce the TKDL initiative. The CSIR is where this project is being worked on.^[82] Using information technology tools and an inventive classification system called Traditional Knowledge Resource Classification,^[83] the Traditional Knowledge Digital Library has overcome barriers related to language and format by methodically and scientifically converting and organizing the available contents of ancient texts on Indian Systems of Medicines, such as Ayurveda, Siddha, Unani, and Sowa Rigpa, as well as Yoga, into five international languages: English, Japanese, French, German, and Spanish. (TKRC).^[84] As of the time of writing, the TKDL database had transcriptions of more than 3.6 lakh formulas and practices. Furthermore, global definitions and standards for the development of TK databases based on TKDL specifications have been created by the TKDL.^[85] The WIPO Intergovernmental Committee (IGC) on Intellectual Property and Genetic Resources, Traditional Knowledge, and Folklore Expression reached a consensus on this during its fifth session in 2003.^[86]

The Ayurvedic Formulary of India (AFI) is a singular attempt in that it compiles the fragmented data on different formulations found in traditional Ayurvedic books in a way that is appropriate for developing pharmacopoeia standards and also satisfies the requirements of the Drugs and Cosmetics Act.^[87] According to the original reference book, a list of therapeutic indications has also been provided for the different formulations. The original Shlokas of reference form, from which the formulations were generated, have been appended to the formulations for convenient reference.^[88] Other plant parts have been recommended for the various formulations due to the unavailability of roots and barks as well as the nation's regulatory laws. Consequently, there's no chance of adulteration.^[89] The second redesigned edition of AFI is now more international quality, user-friendly, and informative for

users worldwide. Scientists and Ayurvedic practitioners can now use this book.^[90]

E-books, also known as Samhita, Shabdakosha, or compilation books, are generally used to describe printed works that have been carefully rearranged in an electronic format after being assessed for both general and particular format. This allows us to obtain in many formats. These days, e-books assist us not only with reading texts but also with conducting thorough text searches.^[91] Our science, which has an extensive body of literature in Sanskrit poem form, has extremely specific needs, such as searching for the specific text element that contains the Key Word in the Context (KWIC) and citing a specific verse in the concordance form.^[92] Although there have been a lot of printed books published, this category of books is increasingly becoming more widely available in electronic form.^[93] There are currently a number of e-Samhitas available, including the Charaka Samhita, Sushruta Samhita, Ashtanga Hrudaya, and others.^[94] Ayurvedic dictionaries in the form of Shabdakosha are also readily available, and a number of compilation books are utilized extensively as reference materials.^[95]

RUDRA a clinical research program called RUDRA monitors the outcomes of Ayurvedic treatment therapies in regular practice.^[96] In order to produce preliminary epidemiological, safety, and efficacious data, the Ayurvedic Trust in Coimbatore launched the RUDRA (Random Uninterrupted Documentation for Retrospective Analysis) Program, which aims to chronicle ongoing clinical practice in the field of Ayurveda.^[97] This program is being experimented with by the following Ayurvedic institutions:^[98] the Department of Ayurveda at KMC in Manipal, the Central Research Institute of Ayurveda in New Delhi, the Institute for Post Graduate Research and Training in Ayurveda in Jamnagar, the National Institute of Ayurveda in Jaipur, and Sreedhareeyam Eye Hospital in Kottanattukulam. The Outpatient Department uses the RAPID ASSESSMENT METHOD (RAM) to complete RUDRA documentation.^[99] RAM is divided into three levels: 1) recording just patient complaints; 2) recording patient complaints and researcher observations in general; and 3) recording complaints, observations, and diagnosis.^[100]

AyuSoft NGO in Pune, India; the University of Pune's Department of Ayurveda and Multidisciplinary School The development of this interactive program was done in cooperation with Jnana Prabodhini, an of Health Sciences; and CDAC, Pune.^[101] This innovative multifaceted endeavor offers comprehensive medical solutions grounded in conventional medicine and facilitates the making of anticipated more informed, accurate, and expeditious health decisions. Researchers, practitioners, and hospitals may be among the software's end users.^[102] Among the uses are case analysis, research, diagnosis, and treatment; dietary and lifestyle

advice; personal management information system; multimedia-based encyclopedia; and textual and analytical report tool.^[103]

Prakriti Vichaya An inventive and knowledgeable software called Prakriti Vichaya provides services on several Ayurvedic functions, including Prakriti (Constitution), dietary recommendations, guidance on daily routines, the probability of an illness, and suggested preventative actions.^[104]

Kosha Aushadha The Triskandha-Kosha project is an appropriate approach that, based on the original classical texts—the Charaka Samhita, Sushruta Samhita, Ashtanga Samgraha, and Ashtangahridaya—provides the categorized material in a readily accessible manner. The project's objective is to compile all references from classic works pertaining to the Lakshana (symptoms and indications), Aushadha (medicine or therapy), and Hetu (causes) of health and illnesses.^[105] Based on the literature listed above, this offers classified data on all illnesses. Researchers now spend a great deal less time, effort, and money as a result of this. Furthermore, it creates new avenues for Ayurvedic research.^[106] This contributes to the creation of effective treatments as well as the understanding of diseases from an Ayurvedic perspective, including cancer, heart disease, chronic renal failure, and others. The Diagnostic & Treatment Software, which explores the abundance of Ayurvedic knowledge from the texts, is based on this database and will be a valuable tool for Ayurvedic practitioners using the texts online for a particular patient.^[107] From the perspective of patent and IPR issues, the project has a very high potential and will greatly benefit the country in preventing bio-piracy.^[108]

RASEX Government Ayurveda College, Trivandrum, in association with CIRA (Center for Information Research and Action) and CDAC (Center for Development of Advanced Computing), Thiruvananthapuram, created and developed this ground-breaking program in 1992. This software uses a computer to match medicinal properties with pharmacological aspects. After gathering, classifying, and conserving every pharmacological and therapeutic characteristic of a single rasa drug, a database was created using DBase III plus.^[109] This package compiles and presents a list of prescription drugs that adhere to the doctor's guidelines.^[110]

AyushEHR AyushEHR, a cloud-based EHR program developed by HealtheLife, is a standard-compliant application intended for the provision, recording, and verification of AYUSH services. Experts in clinical informatics with both domestic and foreign experience have developed this program.^[111] AyushEHR was developed in accordance with Indian and international EHR standards following a careful examination and study of several internationally accessible EHR programs. Unlike other EHR software that non-allopathic practitioners find challenging to use, the focus has been

on Ayurvedic practitioners. The software has a strong emphasis on advancing Indian traditional healthcare methods through technology.^[112] AyushEHR centers care around the patient and gives healthcare professionals the resources they need to deliver individualized treatment in line with the authentic Ayurvedic tradition. It seeks to promote the acceptance and implementation of Ayurvedic therapies by producing documentation throughout the care process.

Additional Research Areas: There are some areas that could be looked at and resolved to enhance the use, accessibility, and efficiency of Ayurveda.^[113] The possibilities include computer-assisted medical decision-making, program-based medications, robot-monitoring, robot-diagnostics, including tele-consultation, computers in clinical laboratories, networking rural clinics with major medical facilities, and links for emergency and consultant services. Virtualization technology for visualizing human anatomy and dissection; Prakriti Analysis with DNA Imprinting; computerized medicine dispensing following software-based 3D scanning for diagnosis; Computer-Aided Learning in the Medical Curriculum; networks connecting hospitals, clinics, medical schools, universities, researchers, and healthcare providers to share data via Geographic Information Systems (GIS); Remote Information Services and Decision Support Tools for Patient Care.^[114]

CONCLUSION

The Ayurvedic pharmaceutical industry faces a number of problems that artificial intelligence can help with, including widespread drug availability, quality control, standardization, palatability, dosage consistency across formulations, uniform drug supply, safety, and efficacy. This essay aims to assess obstacles in the field of Ayurvedic pharmaceuticals and provide plausible remedies through the use of artificial intelligence in order to promote Ayurveda's global adoption.

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