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From Ethnobotany To Informatics: Reviewing The Evolution And Gaps In Medicinal Plant Databases

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Abstract:
Medicinal plant knowledge has evolved from orally transmitted ethnobotanical traditions to globally accessible digital repositories. This review traces that transition by examining prominent medicinal plant databases from around the world, alongside key Indian initiatives rooted in Ayurveda and regional biodiversity. It compares their structure, attributes, coverage, and usability, identifying strengths in taxonomy and phytochemistry but major gaps in Ayurvedic descriptors, toxicity data, and AI-readiness. While international databases emphasize molecular and genomic data, Indian repositories focus on traditional usage but lack interoperability and standardized schemas. The review highlights the need for a unified, machine-readable, and semantically rich herbal dataset that can bridge classical knowledge with modern informatics, enabling advanced research, safer clinical applications, and AI-driven discovery in herbal medicine.
Keywords: *Medicinal plant databases, Structured datasets, Ayurveda, Ethnobotany, Herbal informatics, Machine learning, Digital health*

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I. Introduction

Background

Medicinal plant knowledge is one of humanity's oldest healthcare foundations. For generations, communities across the world have relied on ethnobotanical traditions to identify and use plants for healing. In India, systems like Ayurveda, Siddha, and Unani formalized this wisdom, classifying plants not only by their botanical features but also by therapeutic actions and attributes such as rasa, guna, veerya, and vipaka.[1]

With the rise of information technology, this traditionally oral and manuscript-based knowledge has steadily moved into digital formats.[2] What was once preserved in field notes and classical texts is now available through searchable, structured repositories. This shift has transformed how medicinal plant information is stored and analyzed, opening the door to AI-driven insights, modern pharmacognosy, and computational biology.[3]

Need for Systematic Organization

Even with ongoing digitization, medicinal plant data remains scattered across multiple databases, each focusing on different aspects—taxonomy, phytochemistry, genomics, or traditional uses.[4] Very few platforms integrate all these dimensions into a single structured system. The lack of interoperability limits cross-disciplinary research and restricts the use of AI, which depends on standardized, machine-readable data.[5]

For Ayurveda, the challenge is even sharper. Many traditional descriptors—like *guna*, *karma*, and system-level effects—are typically captured in narrative form and rarely appear in database schemas.[6] Without consistent attributes and structure, much of this deep traditional insight becomes difficult to use computationally. A harmonized, multi-dimensional organization of medicinal plant data is therefore essential to bridge traditional knowledge with modern bioinformatics.[7]

Aim and Scope of the Review

This review examines how medicinal plant databases have evolved—from ethnobotanical documentation to today's digital repositories—and identifies the structural gaps that persist. It compares major global databases, which often emphasize taxonomy and molecular data, with Indian systems rooted in Ayurveda and regional biodiversity.

The goal is to highlight the absence of a unified, integrative framework that can represent both scientific and traditional knowledge. By mapping the strengths and limitations of existing platforms, the review underscores the need for a machine-readable, semantically rich herbal dataset capable of supporting research, clinical safety, and future AI applications.

The paper is organized into four parts: an overview of global medicinal plant databases, an examination of major Indian repositories, an analysis of their limitations, and finally, recommendations for building an interconnected, scalable system that links traditional wisdom with modern informatics.

II. Global Medicinal Plant Databases

Information about medicinal plants of the world can be accessed online. Initiatives have been taken by WHO and others in order to digitize the taxonomic, geographic, ecologic and pharmacological information about medicinal plants.[8] This information is in the form of text, tables, articles or images. Most of this information is available on the internet.

KNApSAcK Family

The KNApSAcK Family database is oriented more towards chemo-informatics than ethnobotany, offering large tables and searchable interfaces that connect plants with their metabolites. Although the site doesn't present an exact species count upfront, it clearly hosts thousands of plant–compound associations. Attributes include botanical names, families, phytochemicals, etc making it one of the best resources for populating the phytochemistry field. While the database lacks cultural usage or therapeutic notes, its integration of plant and compound data makes it invaluable when linking species to bioactive compounds in a structured dataset.[9]

World Flora Online (WFO)

World Flora Online is a global checklist initiative aiming to catalogue all vascular plants, representing hundreds of thousands of species worldwide. Its format is primarily textual and tabular, with taxonomic pages, accepted names, synonyms and distribution summaries. Though the platform does not focus on medicinal usage. Its main contribution lies in consistent botanical references across dataset.[10]

International Plant Names Index (IPNI)

IPNI is a nomenclatural database containing millions of plant names with details of their publication and authorship. Although it does not quantify species in the same way as a flora, it indexes an enormous number of names globally. Data is presented in structured, text-based records rather than images or descriptive articles. The attributes available here are mainly botanical names, authorship and nomenclatural synonyms, which makes IPNI essential for validating and standardizing plant names before linking them to ethnomedicinal or phytochemical data from other sources.[11]

Plants of the World Online (POWO — Kew)

Plants of the World Online, hosted by Kew Science, provides one of the most comprehensive global plant databases, with taxon pages covering hundreds of thousands of species. Entries are structured with textual descriptions, distribution maps, habitat notes and images. POWO offers attributes such as botanical names, families, distribution ranges and habitat information, though ethnobotanical uses are generally not included. It is particularly strong as a taxonomic and biogeographic reference that can be used to cross-verify nomenclature and ecological ranges.[12]

Tropicos (Missouri Botanical Garden)

Tropicos is a massive botanical database created by the Missouri Botanical Garden, containing millions of specimen and taxonomic records. The data is provided through taxon pages, structured specimen entries, locality notes and images. Tropicos offers botanical names, families, region found and habitat, though it does not emphasize medicinal uses. It is highly useful as a specimen-backed authority that supports georeferenced distribution data, which complements ethnomedicinal sources.[13]

NCBI (National Centre for Biotechnology Information)

NCBI is a global scientific resource that aggregates sequence data, taxonomic records and biomedical literature, rather than a simple plant list. Its coverage is vast, including countless plant species, although not specific to medicinal plants alone. The available data comes in textual records, PubMed articles, sequence datasets and taxonomic information. While attributes like botanical name and taxonomy are direct, medicinal properties, toxicity information, and disease treatments must be extracted from linked articles. NCBI is essential for integrating evidence-based and molecular perspectives into any dataset, especially in linking traditional knowledge with clinical or genomic research.[14]

MEDLINE (via NLM)

MEDLINE, hosted by the U.S. National Library of Medicine, is not a plant database but rather an extensive bibliographic index of biomedical literature. It covers thousands of studies on medicinal plants, though it does not provide species counts directly. The data is purely textual, consisting of abstracts, bibliographic metadata and MeSH terms. Through these, anyone can indirectly extract information about ailments and diseases treated, toxicity reports, pharmacological effects and dosage discussions. While it requires text-mining to structure the information, MEDLINE is indispensable for grounding ethnomedicinal claims in biomedical evidence.[15]

Leafsnap Dataset

The Leafsnap dataset is a research-driven image collection of leaves, initially including around 185 tree species. The data format is primarily high-resolution images of leaves, with species labels attached. Attributes such as botanical names and images (helpful for plant type/parts identification) are present, while ethnomedicinal fields are absent. Its value is methodological — it is ideal for building or training image recognition systems to aid in plant identification, which can then be linked to ethnobotanical datasets.[16]

Flavia Dataset (Kaggle)

The Flavia dataset, hosted on Kaggle, is a classic benchmark in computer vision for plant identification. It consists of scanned images of leaves from 32 species, arranged in folders by class. The data is image-only with species labels, so attributes are limited to botanical name and plant part (leaf). Although it lacks ethnomedicinal information, it is extremely useful for testing classification algorithms and developing models that can later be connected to medicinal plant attributes.[17]

Swedish Leaf Dataset (Kaggle)

The Swedish Leaf Dataset, also available on Kaggle, is another image-based resource created for plant identification tasks. It contains multiple classes of scanned leaves, each associated with its 15 species label. Like Flavia, the dataset is limited to image format, so attributes such as botanical names and plant parts can be extracted, but medicinal or phytochemical information is absent. Despite this, it is a strong tool for image-based research and helps in building the foundations of automated species identification.[18]

Table no 1: Global Medicinal Plant Databases.

Sr. No.	URL	Approx. No. of Species	Information Available	Notes
1	KNApSAcK Family	20,741 species	Phytochemicals, metabolites, links to pathways	Large chemical–bioactivity focused database.
2	WFO Plant List	1.3 million plant names (global)	Accepted names, synonyms, taxonomy	Standardized reference for plant nomenclature.
3	IPNI	1.4 million species names	Plant names, authorship, publication details	Authoritative source on botanical nomenclature.
4	POWO (Plants of the World Online)	1.4 million species	Taxonomy, distribution, images, synonyms	Kew Gardens' global plant knowledge hub.
5	Tropicos	1.4 million names, 80,000 species	Specimen data, taxonomy, distribution	Missouri Botanical Garden's database.
6	NCBI	Not species-specific (genomic level)	Genomics, molecular data, bioinformatics links	Covers DNA sequences, PubMed articles, research-level data.
7	MedlinePlus	20 million entries	Pharmacological uses, safety, side effects	Public health resource by US NLM; focuses on herbal medicine for patients.
8	Leafsnap Dataset	185 species	Leaf images	Image dataset for computer vision plant ID.
9	Kaggle Flavia Dataset	32 species	Leaf images	Popular ML dataset for leaf recognition tasks.
10	Kaggle Swedish Leaf Dataset	15 species	Leaf images	Benchmark dataset for plant identification using ML.

III. Indian Medicinal Plant Databases

India has seen multiple national initiatives to document and digitize its rich traditional knowledge on medicinal plants. Some of the most notable digital resources are available online:

FRLHT / ENVIS on Medicinal Plants

The ENVIS Resource hosted by FRLHT is one of the most authoritative portals on Indian medicinal plants, bringing together diverse content such as images, descriptive texts, state-wise lists, distribution maps and conservation reports. Attributes such as botanical names, families, vernacular names, images, region-wise distribution and even conservation status are available for approx. 6000 species. This platform is particularly valuable because it bridges scientific herbarium data with conservation and traditional knowledge, making it a strong reference point for digitization.[19]

TDU — FRLHT Digital Herbarium

The digital herbarium of The University for Trans-Disciplinary Health Sciences (TDU) and FRLHT makes available thousands of herbarium specimens through an outreach-oriented platform. The 4200 records provide specimen photographs, locality data, botanical names, families and habitat details, which together help populate fields such as region found, plant type and habitat. Unlike many purely textual databases, this herbarium is specimen-driven, which means it provides verifiable, voucher-based records that are extremely valuable for validation and visual training purposes.[20]

Indian Medicinal Plants Database (medicinalplants.in)

The Indian Medicinal Plants Database, developed under NMPB and FRLHT, is a large and systematic compilation covering thousands of species, with more than 7,000 botanical names and a wide set of vernacular terms across Ayurveda, Siddha and Unani systems. The information is available in text form along with images, distribution maps and state-wise coverage. The database provides reliable access to botanical names, local names, families, system of medicine, distribution and sometimes parts used. Its strength lies in the sheer breadth of coverage and the way it organizes data by traditional medical systems, making it ideal for taxonomy and regional mapping tasks.[21]

Medicinal Plants Database by Dinesh Khedkar (MPDB)

The Medicinal Plants Database by Dinesh Khedkar is an independently maintained resource featuring 661 plant records relevant to Indian traditional medicine. It offers simple, text-based profiles covering botanical and vernacular names, plant families, parts used, and basic traditional uses, with images included for some entries. While not comprehensive, MPDB is easy to navigate and useful for quick checks of plant identities, names, and core usage information—making it a helpful starting point for building preliminary medicinal plant datasets.[22]

Botanical Survey of India — Medicinal Plant Database

The BSI Medicinal Plant Database is an Indian government initiative that documents medicinal species with detailed entries. While it has approx. 1915 species, it includes extensive coverage with images, distribution maps and state-wise reports. It include botanical and vernacular names, families, habitat, distribution, availability and sometimes uses and parts used. As an official source, it is especially reliable for confirming occurrence in Indian states like Maharashtra, Telangana, Karnataka, and others.[23]

IMPPAT Database

The Indian Medicinal Plants, Phytochemistry And Therapeutics (IMPPAT) database is one of the most academically significant resources for linking traditional knowledge with phytochemistry. Covering 4010 medicinal plants, it offers structured, searchable information including botanical names, common names, synonyms, families, system of medicine, phytochemicals, and therapeutic uses. Its format includes textual records, tabular phytochemical lists and links to literature. IMPPAT is perhaps the single strongest resource for phytochemicals, ailments/diseases treated, and dosage-related notes, bridging traditional medicine with modern bioinformatics.[24]

NEI-MPDB (NEIST — North East India Medicinal Plant Database)

The NEI-MPDB focuses on the medicinal plants of Northeast India. It has 550 species count. The content is mainly textual, with searchable entries and occasional images. This database offers botanical and local names, regional distribution (specific to the Northeast), uses, ailments cured, parts used, phytochemical information and references. Its strength lies in its geographic specificity, providing a valuable comparison point for cross-regional availability studies.[25]

Ayurwiki

Ayurwiki is a free, community-driven Ayurveda encyclopedia that documents herbs, medicinal plants, and various Ayurvedic concepts. With over 4,300 entries, it offers a mix of textual descriptions, structured sections like "Uses," "Parts Used," and "Chemical Composition," along with images and references. The platform provides details such as botanical and vernacular names, parts used, Ayurvedic properties (rasa, guna, virya, vipaka), chemical constituents, and basic identification traits. Although entries vary in completeness, Ayurwiki serves as a helpful crowd-sourced resource that links classical Ayurvedic information with a more structured, digital format.[26]

SDACH — Dravyaguna Vigyan Blogs (Shri Dhanwantry Ayurvedic College & Hospital)

The Dravyaguna Vigyan blogs on the SDACH website function as an academic outreach platform, offering detailed write-ups on more than 400 medicinal plants along with various Ayurvedic drug concepts. The entries are primarily text-based, presenting narrative explanations of plant taxonomy, classical Ayurvedic properties, therapeutic applications, and occasionally supported by images. Each post typically includes information such as the botanical name, family, parts used, pharmacological actions, Ayurvedic attributes like rasa and virya, morphological features, and basic habitat or distribution notes, with some entries also mentioning chemical constituents. Owing to their academic background, these blogs serve as a valuable bridge—linking traditional textual knowledge with authenticated botanical understanding.[27]

Easy Ayurveda

EasyAyurveda is an educational platform with an extensive blog covering herbs, Ayurvedic health, treatments, home remedies, and lifestyle topics. Its articles are primarily textual and follow a consistent structure, usually detailing medicinal properties, parts used, dosage, side effects, and references, often supported by images. The site provides useful attributes such as botanical and vernacular names, phytochemicals, therapeutic uses, dosage guidelines, toxicity notes, and classical Ayurvedic properties like rasa and guna. Owing to its large volume of accessible content, EasyAyurveda serves as a practical source for gathering usage- and therapy-related information on medicinal plants.[28]

Planet Ayurveda

Planet Ayurveda is another commercial platform offering herbal products and informational write-ups on medicinal plants. A total number of species is 266, since content is organized around marketed products. The data format includes text descriptions, product images and usage recommendations. Attributes like botanical names, common names, dosage forms, claimed therapeutic uses and parts used are available here. Its value lies in providing a market-facing perspective of medicinal plant applications.[29]

Table no 2: Indian Medicinal Plant Databases

Sr. No.	URL	Approx. No. of Species	Information Available	Notes
1	FRLHT ENVIS	6,198 species	Taxonomy, distribution, images, medicinal uses, classical references	One of the most comprehensive Indian biodiversity and medicinal plant databases.
2	FRLH Herbarium (TDU)	4,200 species	Voucher specimens, taxonomy, images	Herbarium records; physical reference collections digitized for access.
3	MedicinalPlants.in	7,263 species	Botanical info, parts used, medicinal properties, images	User-friendly reference site focusing on Ayurveda, Siddha, Unani related plants.
4	Dinesh Khedkar's MPDB	661 species	Taxonomy, family, vernacular names, uses	Structured database by Indian researcher, focusing on plant diversity and uses.
5	BSI Medicinal Plant Database	1,915 species	Botanical names, distribution, conservation status	Official government initiative documenting India's medicinal flora.
6	IMPPAT Database	4,010 species	Phytochemicals, therapeutic uses, target pathways	Integrates Ayurveda with modern cheminformatics, systems biology.
7	NEIST NEIMPDB	550 species	Botanical info, chemical constituents, traditional uses	North-East India–focused plant knowledge repository.
8	Ayurwiki	4,000+ species	Ayurveda concepts, botanical info, guṇa, rasa, karma, formulations	Community-driven wiki resource for Ayurvedic knowledge.
9	SDACH Dravyaguna Vigyan Blogs	400 species	Ayurvedic dravyaguna explanations, textual descriptions	Educational blog-style platform focusing on academic Ayurveda.
10	Easy Ayurveda	200+ species blogs	Classical references, uses, modern interpretations	Simplifies Ayurveda for learners and practitioners; article-based.
11	Planet Ayurveda	266 species	Herbal products, therapeutic info, formulations	Industry-driven site with emphasis on ready-to-use herbal medicines.

IV. Comparative Analysis And Gaps

Limitations of Current Systems

While each of the above efforts contributes important elements to the field, none of them provide a unified, support for digital systems, and therapeutically rich dataset that can serve modern research or healthcare needs. Key limitations include:

Poor Query ability and Search Functionality

Most existing platforms offer simple, keyword-based access. For example, in some of the datasets available online, one can only search using botanical names or common names, or can only select from the given list of names, and these names could be in a language one is not familiar with. Also, there is no support for multi-parametric filtering, cross-attribute search, or semantic linking of therapeutic categories.

Absence of Safety, Toxicity, and Antidote Information

From both clinical and commercial standpoints, understanding the toxicity and dosage thresholds of herbs is vital. However, current datasets do not include structured fields for toxicity risk, organ-specific contraindications, or traditional antidotes despite these being part of classical Ayurvedic teachings.

Incompatibility with Machine Learning and AI Systems

Datasets designed for visual identification (e.g., leaf images) or plain-text summaries are not usable in data mining, clustering, or prediction tasks. They lack structured tables, labelled training data, or annotated relationships between plant attributes and outcomes. This severely limits the scope for developing intelligent applications such as formulation discovery tools, personalized recommendations, or herb-drug interaction models.

Lack of Structured Ayurvedic Parameters

Ayurvedic concepts such as *Rasa* (taste), *Guna* (quality), *Virya* (potency), *Vipaka* (post-digestive effect), and *Karma* (therapeutic action) are often missing or inconsistently mapped. Without these parameters, any herbal dataset is incomplete from an Ayurvedic standpoint and unusable for practitioners or scholars of traditional medicine.

Absence of Multi-Valued and Region-Specific Representation

Ayurvedic plant knowledge is context-sensitive formulations, parts used, and even preparation methods vary regionally. Current platforms do not support multi-valued entries, nor do they enable modelling such cultural and regional diversity.

V. Discussion And The Way Forward: Towards Herbal Informatics

Medicinal plant research is witnessing a major transformation — shifting from traditional, text-based ethnobotanical records to structured, machine-readable frameworks that can power advanced analytics and AI-driven exploration. For centuries, herbal wisdom has been preserved through oral traditions, manuscripts, and field notes, each carrying deep cultural and contextual understanding. While these records remain invaluable, their narrative nature makes them difficult to analyze computationally. As the world increasingly depends on data science and bioinformatics, there is an urgent need to digitize this knowledge systematically, translating centuries of herbal traditions into structured, analyzable formats.

This shift calls for ontology-driven systems that define relationships between plants, phytochemicals, therapeutic actions, and physiological effects. Ontologies enable data interoperability — allowing knowledge from diverse sources to "speak the same language." When connected through the semantic web, medicinal plant data can become part of a dynamic global network where taxonomy, chemistry, and traditional uses are automatically cross-linked. Such semantic integration supports AI-assisted discovery, enabling pattern recognition between Ayurvedic descriptors and modern pharmacological data.

The concept of Herbal Informatics goes beyond mere digitization — it represents the convergence of Ayurveda, bioinformatics, and computational science. By embedding Ayurvedic principles such as Rasa (taste), Guna (qualities), Veerya (potency), and Vipaka (post-digestive effect) alongside bioinformatics parameters like molecular structure, metabolic pathways, and therapeutic outcomes, researchers can create a hybrid knowledge ecosystem. This integrated model can support semantic searches that relate a plant's traditional profile to its bioactive compounds or link formulations to their experimentally validated mechanisms.

Building such systems requires more than data collection; it demands intelligent design. A next-generation herbal database should adopt a multi-layered schema that captures taxonomy, phytochemistry, traditional attributes, safety, and formulation details — all represented in machine-readable formats such as JSON or XML. Validation through herbarium records, classical texts, and peer-reviewed research would ensure scientific accuracy while maintaining traditional integrity. As AI and machine learning advance, these structured, semantically rich datasets could evolve into adaptive systems capable of supporting digital therapeutics, predictive analytics, and personalized herbal care.

Ultimately, the way forward lies in collaboration. Bringing together botanists, Ayurvedic scholars, pharmacologists, and data scientists can help create interoperable datasets that are both culturally grounded and globally usable. The future of herbal informatics will depend on this balance — where traditional knowledge meets digital intelligence to guide safer, smarter, and more holistic healthcare innovation.

VI. Conclusion

The journey of medicinal plant knowledge reflects a remarkable evolution — from ethnobotanical roots grounded in oral tradition to the development of expansive digital repositories that now shape global research. Yet, as this transformation continues, a persistent imbalance remains: databases often emphasize either scientific precision or cultural depth, rarely achieving both. Global platforms excel in molecular and genomic data, while Indian systems preserve Ayurvedic richness but lack structural interoperability.

Addressing this gap requires a unified, AI-ready, and culturally inclusive herbal dataset — one that harmonizes taxonomy, phytochemistry, and therapeutic attributes with the philosophical and diagnostic frameworks of Ayurveda. Such integration would not only preserve traditional wisdom but empower its computational application, transforming herbal knowledge into a living, evolving discipline.

Bridging ethnobotany and informatics is not just a technical challenge but an epistemological one translating traditional wisdom into structured digital knowledge without losing its contextual richness.

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