Medicinal Plants: A Sustainable Source for Drug Discovery and Human Health

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ABSTRACT

In sustainable human health, importance of medicinal plants cannot be underestimated. Medicinal plant drug discovery is now being explored with a multidisciplinary approach incorporating molecular, biological, phytochemical, and botanical methods. Medicinal plant drug discovery uncovered the new and important leads against various types of pharmacological targets like cancer, HIV/AIDS, Alzheimer's, malaria, and pain. The applications of these plants are growing globally because it is extremely cost-effective compared to the synthetic industrial type of drugs. Although medicinal plants are threatened because of human activities and unplanned wild harvesting; hence, it is therefore recommended that intentional steps towards cultivation and domestication are essential for ensuring the perpetual supply of these plant species. In recent times, a number of drugs of plant origin natural product drugs have been presented for clinical trial.

Keywords: Drug discovery, medicinal plants, sustainable, human health.

INTRODUCTION

For thousands of years, medicinal Plants were used as medicines by many people. These medicines were first in the form of crude drugs like tinctures, teas, poultices, powders, and other herbal preparations (Alamgir et al., 2017; Monib et al., 2024). The particular plants to be used and how to apply them for specific conditions were transmitted orally.

Initially, they were crude medicines in the form of tinctures, powders, teas, poultices, and other medicinal herbs (Alamgir et al., 2017; Monib et al., 2024). Oral tradition was used to pass on the exact plants to employ and the use methods for individual ailments (Awoke et al., 2025).

Eventually information regarding medicinal plants was recorded in herbals. In more recent history, the use of plants as medicines has involved the isolation of active compounds, beginning with the isolation of morphine from opium in the early 19th century (Monib et al., 2024). Medicinal plant drug discovery resulted in the isolation of some early drugs like cocaine, codeine, digitoxin, and quinine, as well as morphine, some of which remain in current use (Sinha et al., 2023). Isolation and structural elucidation of pharmacologically active compounds from medicinal plants continue to date. In more recent times, drug discovery methods have been used to standardize herbal medicines, in order to identify analytical marker compounds. The following is a brief overview of the role of medicinal plants in drug discovery such as significant compounds derived from this source, our work on anticancer and cancer chemopreventive drug discovery with medicinal plants, and lastly current challenges in the context of medicinal plant drug discovery. Drug discovery from medicinal plants has come to encompass many areas of investigation and several approaches to analysis.

The procedure generally starts with a botanist, ethnobotanist, ethnopharmacologist, or plant ecologist who harvests and identifies the target plant(s) (Schultz et al., 2023). Harvesting could be for species with known biological activity but from which active compound(s) have not been extracted (e.g., indigenous used herbal medicine) or for taxa randomly collected for a massive screening program. Phytochemists (natural product chemists) make extracts from the plant material, screen these extracts in pharmacologically relevant assays, and initiate the isolation and characterization of the active compound(s) by bioassay-guided fractionation (Dube et al., 2023). Molecular biology has become critical to drug discovery from medicinal plants through the identification and deployment of suitable screening assays aimed at physiologically relevant molecular targets. Pharmacognosy encompasses all of these disciplines into a separate interdisciplinary science.

Importance of medicinal plants in drug discovery
Several approaches have been used to obtain compounds for drug discovery such as isolation from plants and other natural sources, synthetic chemistry, combinatorial chemistry, and molecular modelling (Najmi et al., 2022; Thomford

et al., 2018). In spite of the recent drive by pharmaceutical firms and funding agencies towards molecular modeling, combinatorial chemistry, and other synthetic chemistry methods, natural products, and especially medicinal plants, continue to be a vital source of new drugs, new drug leads, and new chemical entities (NCEs). Plant-based drug discovery has become to involve many interdisciplinary areas and several forms of analysis. The procedure usually starts with a botanist, ethnobotanist, ethnopharmacologist, or plant ecologist who gathers and identifies the targeted plants (N'guessan et al., 2025; Majeed et al., 2025). Collection can include species with established biological activity where active compound(s) have not been extracted or include taxa randomly collected for a mass screening programme. Intellectual property rights of a particular country where plants of interest are being collected need to be respected. Phyto-chemists (natural product chemists) isolate extracts from the plant materials, screen these extracts biologically in pharmacologically relevant assays, and initiate the isolation and characterization process of the active compound(s) by bioassay-directed fractionations. Molecular biology has become integral to medicinal plant drug discovery through the identification and utilization of suitable screening assays aimed at physiologically relevant molecular targets (Noor et al., 2022).

Role of medicinal plants in sustainable human health

Medicinal plants have been used as a drug source by humankind for many thousand years. In fact, ancient man completely relied on plants for his treatment, prevention and other type of medicaments needs, hence using plants as medicines for thousands of years (da Silva et al., 2025). Throughout the evolution of human culture, the application of medicinal plants has been of magical-religious importance and various perspectives towards the notions of health and disease that existed in each culture (Ullah et al., 2025). During the last 3000 years, numerous plants are utilized in medical practices, for example, in Traditional Medicine in China, India and Africa, the majority of which bear therapeutic values that have been established as such through Western standards (Nyirenda et al., 2025). Additionally, various other plants have been utilized over centuries by various cultures that are less likely to be established through western standards. The contribution of medicinal plants to human health is evidently vast. Among such drugs that have been derived from plants are digoxin of Digitalis spp., quinine and quinidine of Cinchona spp., vincristine and vinblastine of *Catharanthus roseus,* atropine of *Atropa belladonna* and morphine and codeine of *Papaver omniferum* (Alamgir et al., 2017; Roy et al., 2019). It is approximately 60% of the drugs that are available in the market or in the process of undergoing clinical trials are of natural origins. Medicinal plants have to provide these compounds for potential new drugs, biomimetic synthesis design, and the exploration of new medicinal properties not yet assigned to compounds known so far. In majority of instances, crude extract of medicinal plants could be utilized as medicaments.

It is estimated that over 400 conventional plants or plant-derived products have been employed in the management of type 2 diabetes globally. Galegine, a compound secreted by the herb *Galega officinalis*, offers a perfect illustration of such a finding (Khezri et al., 2023). Experimental and clinical assessment of galegine established the pharmacological and chemical underpinnings for the development of metformin, the cornerstone therapy of type 2 diabetes. Agents derived from plants are also used in the management of cancer. A number of anticancer agents such as vincristine, taxol, vinblastine, derivatives, irinotecan and topotecan and etoposide from epipodophyllotoxin are in worldwide clinical practice (Sofi et al., 2023). More so, it was used as condiments or flavouring in food, which in turn provides some health value to humans. Demand for a large number of wild plant species is on the rise with expansion in human needs, population and commerce. Plants have supplied humans with most of their basic needs, such as life-saving drugs. Medicinal plants are under threat due to human influence and unregulated wild harvesting, it is thus advisable that concerted efforts towards domestication and cultivation are necessary for sustained supply of these plant species.

Table 1: Medicinal Plants, Active Compounds, and Their Therapeutic Applications

Applications

Medicinal Plant	Active Compound(s)	Therapeutic Use(s)	Reference
Digitalis spp.	Digoxin, Digitoxin	Cardiac disorders (heart failure, arrhythmia)	Alamgir & Alamgir, 2017
Cinchona spp.	Quinine, Quinidine	Antimalarial, Antiarrhythmic	Monib, 2024
Catharanthus roseus	Vincristine, Vinblastine	Cancer treatment (leukemia, lymphoma)	Awoke et al., 2025
Atropa belladonna	Atropine	Pupil dilation, Antispasmodic, Antidote for poisoning	Sinha et al., 2023
Papaver somniferum	Morphine, Codeine	Pain management (analgesic)	Schultz & Garbe, 2023
Taxus brevifolia	Paclitaxel (Taxol)	Breast and ovarian cancer treatment	Dube, 2023
Galega officinalis	Galegine	Development of Metformin (Type 2 Diabetes)	Najmi et al., 2022
Epipodophyllum spp.	Etoposide, Teniposide	Chemotherapy (lung and testicular cancer)	Thomford et al., 2018
Ocimum basilicum	Essential oils (Citral, Linalool)	Antimicrobial, Antioxidant, Anti-inflammatory	N'guessan et al., 2025
Bergenia ciliata	Flavonoids, Tannins	Antibacterial, Antiviral, Anti-inflammatory	Ullah et al., 2025
Dysphania	Ascaridole, P-Cymene	Anthelmintic, Antibacterial	Nyirenda, 2025

ambrosioides			
Glycyrrhiza glabra	Glycyrrhizin, Liquiritin	Hepatoprotective, Antiviral, Anti-inflammatory	Roy et al., 2019
Galega officinalis	Galegine	Anti-diabetic, Insulin Sensitizer	Khezri et al., 2023
Curcuma longa	Curcumin	Anti-cancer, Anti-inflammatory, Antioxidant	Sofi & Tabassum, 2023
Withania somnifera	Withanolides	Adaptogenic, Stress Relief, Immunomodulatory	Jabeen et al., 2024
Eucalyptus spp.	Eucalyptol	Antimicrobial, Expectorant	da Silva et al., 2024
Azadirachta indica	Azadirachtin, Nimbin	Antibacterial, Antifungal, Antiviral	Daruka et al., 2025

Challenges in drug discovery from medicinal plants

In spite of the obvious success of drug discovery from medicinal plants, future research has numerous challenges. Pharmacognosists, phytochemists, and other natural product scientists will have to continually optimize the quality and amount of compounds reaching the drug development stage to keep up with other drug discovery processes (Jabeen et al., 2024). A lot of that time and money is invested in the many leads that get eliminated in drug discovery. Indeed, it is estimated that not more than one in 5000 lead compounds will pass the clinical trials successfully and be cleared for use. Lead identification initiates a long drug development process (Daruka et al., 2025). Lead optimization (including medicinal and combinatorial chemistry), lead development (pharmacology, toxicology, pharmacokinetics, ADME [absorption, distribution, metabolism, and excretion], and drug delivery), and clinical trials all consume a substantial amount of time (Daruka et al., 2025).

Natural products and natural medicines are extremely valuable. Natural products and derivatives have been appreciated for decades as a reservoir for therapeutic agents and structural diversity. Natural products own vast diversity of multidimensional chemical structures; meanwhile, the versatility of natural products as biological function modifiers has also gained significant popularity. Drug discovery is on the verge of being a challenging scientific endeavor to discover solid and sound lead candidates, nothing but the process stream from a natural product screen to a new isolate requiring experience and expertise. Nevertheless, along with their chemical structure diversity and their biodiversity, the creation of new technologies has transformed natural product screening in the discovery of new drugs. Using these technologies provides a singular opportunity to reinstitute natural products as a prime source for drug discovery.

Medicinal plants have been present on earth from previous decades. So, medicinal herbs are of worldwide and utmost significance. The world is adorned with medicinal herbs, which is a great wealth of perseverance (Nyirenda et al., 2025). Each plant is characterized with its own unique different medicinal properties because of active bioactive molecule. In the contemporary system of medicine, natural drug substances have been found to be crucial and play appreciable roles. Their therapeutic role was justified because of the presence of their bioactive molecules. Because of their disease-inhibiting potential, they are greatly beneficial as natural medicines, give fundamental bioactive compounds that are less harmful and more potent, and introduce biological and chemical ways of modification and extraction of natural products into efficacious drug (Nyirenda et al., 2025).

Herbal medicine throughout the world is rooted in traditional medicine. According to the oral survey conducted in most parts of the world, it was stated that folk medicines have a significance and minimum philosophy of their own. Hence, investigation into the chemical composition of the plant and their screening for pharmacology might give us the foundation of establishing a lead molecule by drug discovery from natural sources. Some of the highly significant life-saving drugs have been offered by plants in contemporary medication. But out of the estimated 4-lakh plant species, only 6% have been investigated for their activity and very few less than of 20% have been phytochemically investigated (Alamgir et al., 2017; Monib et al., 2024). Therefore, there is a necessity of exploring the different bioactive fractions and the phytoanalysis and phytopharmacological assessment of herbal drugs for fulfilling the dreams of herbal drug discovery.

Working function of all green herbal medicines from plant origin and manufacture of bioactive compounds in their own way as God's grace and maintain them inside which are extractable and employed raw material as and when needed through several scientific process for different scientific investigations and study of herbal drug development (Alamgir et al., 2017; Monib et al., 2024). Numerous drugs in pharmaceutical compounds possess secondary metabolites of plants which are of utmost significance in drug designing. But, in ensuring that there is an adequate supply of the source material, certain parameters such as environment change, varied geographical distribution, cost of labor, and choice of the superior plant must be looked after by green plant developers in such a way that good plants shall be advantageous for the pharmaceutical industry to formulate good-quality herbal drugs.

Natural products have been, and will remain, an important part of drug discovery and are hence classically touted as the pillars of drug discovery and development. Most drugs found in the market today were isolated from natural sources (Alamgir et al., 2017; Monib et al., 2024). A notable example is the analgesic activity of aspirin , the world's best known and most widely used medicinal agent so far. Its source is plant families Salix spp. and Populus spp. and is

salicin-related. One such good example is the accidental discovery of antibiotic penicillin in the laboratory from fungus *Penicillium notatum*.
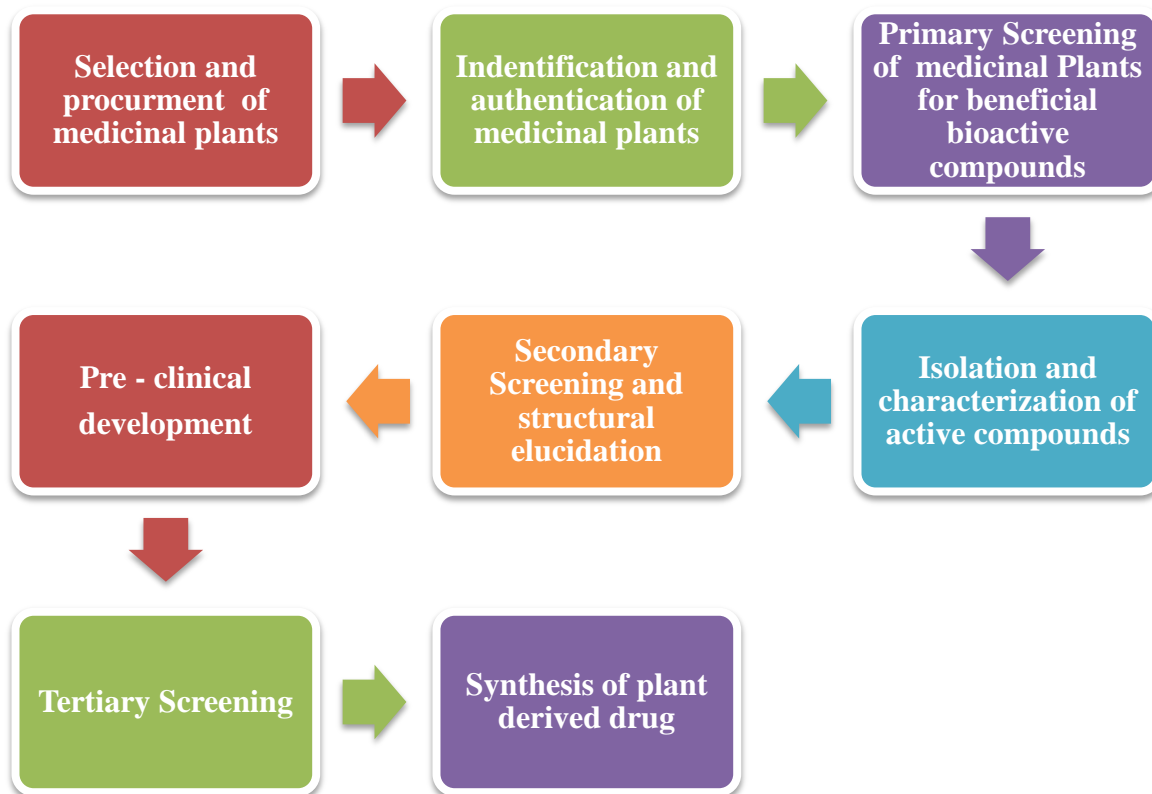

Figure 1: Several approaches for the discovery of drug from natural plants (Koparde et al., 2018).

CONCLUSION

In summary, natural products isolated from medicinal plants (and their derivatives) have yielded many clinically utilized drugs. Despite all the obstacles confronting drug discovery from medicinal plants, natural products isolated from medicinal plants can be anticipated to continue being a vital part of the quest for new drugs.

There is an increase in demand for a myriad of wild plant species due to expansion in human needs, populations and trade. Plants have also offered many of their fundamental human requirements, among them life-preserving medicinal drugs. Yet, medicinal plants are under threat due to human pressure and uncontrolled wild harvesting, thus it is advisable that systematic attempts at domestication and cultivation are crucial in ensuring the consistent supply of such plant species.

With increased interest in herbal drug development with minimal side effects, there are improved chances of investigating the medicinal and other biological activities of erstwhile inaccessible natural products. For establishing its utility, it is imperative to work on visualization and identification of unutilized herbal plants across the globe. Then, it focuses on extraction, its purification, and characterization of phytochemicals, a gift of nature in a rational and scientific manner. There lies an unmet demand for application of the natural products for human kind's good and establishment of new lead for drug discovery. After the phytochemical is isolated, this can be utilized for further investigation through QSAR analysis, molecular modeling, and in vivo studies followed by clinical trial. Natural products success in drug discovery virtually for research institutes and drug manufacturing companies is basically concerned with their potential and advantages to general public that is socio-economic advantages for well-being of general public its well-being is crucial to the world than all reaching reach to your hand if health is first priority. Natural products have intricate chemical structures, varying depending on their different species in nature, and if the available high technology means are utilized, it may result in new discovery of medicines that benefit the entire world. Thus, the world is always gifted with nature, and man is gifted with brain, so let us make use of it to discover new entities that will be available to common people in economical rate and we will be happy to lead a life on this earth. Moreover, natural products have been, and will be, important sources of new pharmaceutical compounds. A long time ago life existed or was extended only because of natural herbs according to references which are available in literature. In the modern era of twenty-first century, no life exists on earth without herbal drugs or products which are derived through natural herbal drug discovery.

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