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Review Article

In-vitro Propagation of Pharmacologically Important Medicinally Plants Producing Bioactive Compounds

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ABSTRACT

In-vitro plant propagation is one of the promising strategies for sustainable production of medicinal plants. Plant tissue culture involves *in-vitro* propagation of plant parts under controlled conditions. It is a very useful technique for fundamental and applied research and has many commercial uses. Medicinal plants have been used to treat many diseases since decades. They are enriched with pharmacologically important bio-active compounds. These bio-active compounds can be used to treat different human ailments. Because of over-exploitation of these medicinal plants, there is a need to sustain their production. The most commonly used medicinal plants are Aconite, Alfa Alfa , Aloe Vera, Borage, Comfrey, Ephedra, Germander, Ginkgo biloba, Neem, Licorice, Isapghul, Sassafras, Senna, St. John's wort ,Neem ,Tulsi. The current review gives insights into important compounds produced by popular medicinal plants. Some of the important bioactive compounds are taxol, methane, acetic acid, carotenoids, flavonoids, carnitine, choline, dithiolthiones, phytosterols, phytoestrogens, glucosinolates, polyphenols, and taurine. The review also focuses on *in-vitro* propagation of medicinally important plants to ensure their availability irrespective of seasonal and geographical constraints.

INTRODUCTION

Medicinal plants are important in evolution of human civilization. Humans have relied on nature for their fundamental necessities throughout history, including medicines, shelters, food, fragrances, clothing, flavours, fertiliser, and ways of transportation. Medicinal plants continue to play an important role in the healthcare system for large swaths of the worldwide population, particularly in areas where herbal medicine has a long history of use. The discovery and acceptance of these plants' medicinal and economic advantages is growing in both developed and emerging countries [1]. There are around half a million plants on the planet, the most of which have yet to be researched for their therapeutic properties. Medicinal plants have a bright future ahead of them, and their untapped medical potential might be essential in the treatment of current and future studies [2]. Medicinal herbs have shown to be the only effective treatment for a variety of fatal diseases, including cancer and diseases caused by viral infection, such as hepatitis and AIDS [3]. These Plants are no longer just important in health care, but they are also finest source of safe future medication. Despite the fact that we now have a lot of contemporary medications at our disposal, it is quite critical to find and cultivate novel helpful agents [4]. It is believed that just one-third of all known human illnesses have an appropriate treatment. As a result, the war against illnesses must continue unabated. Because of the modest side effects and synergistic action of the combination of components, traditional plant medicines continue to have a major role in the modern pharmaceutical industry [5]. Medicinal herbs have played an important part in the formation of human civilization, including religions and other rites. Many contemporary medications, such as aspirin, are derived indirectly from medicinal plants. Garlic, for example, is a food crop with therapeutic [6]. The study of therapeutic plants aids in the understanding of plant toxicity and the protection of humans and animals from natural toxins. Plants produce secondary metabolites, which are responsible for their therapeutic benefits [7]. These plants play significant role in a variety of sectors, including sufficient chemicals, cosmetics, medicines plus medications. In the search for bioactive chemicals, traditional healers frequently employ modern research including bioassay-guided fractionation of medicinal plants. As a result, numerous novels medically significant molecules have been isolated [8]. Due to the committed efforts of researchers, a great number of powerful medicines, healing indications, and many new pharmacologically dynamic components discovered from herbal medicines. In 1826, E. Merck of Germany began mass- producing morphine on an industrial scale, marking the beginning of the commercialization of plant-derived medicines [9].

Importance of Medicinal Plants

Plants are necessary for life to exist. Medicine is built on the foundation of plants. Traditional medicinal plants are the source of a number of significant medicines that are still in use today. Medicinal plants plays an important role in the creation novel drugs [10]. Phytoconstituents research has recently provided effective therapies for diseases that the synthetic drug industry has been unable to address [11]. In the search for novel medicines, ethnobotany and ethnopharmacology have emerged as major sources of information, leading to various sources and classes of chemicals [12]. Pharmaco chemistry is a more sophisticated component of the pharmaceutical sciences, and research on structure-activity correlations and their influence on the creation of new medicines have made it one of the most important and therefore noteworthy accomplishments [13]. If there were no plants on the world, it is difficult to imagine how the human race would survive. Plants have been essential to humans from the beginning of humanity. Medicinal plants are a popular source of medicine. In ancient medicinal systems like Ayurvedic, Unani, and Chinese traditional medicine, herbs have been used to cure ailments as well as to restore and strengthen body systems. A beneficial interaction with the body's chemistry was always the aim when employing plants [14].

Safety and Toxicity of Medicinal Plants

Medicinal plant types that are widely utilized for the cure of definite illnesses have been found. Many medicines are derived from biologically active plant compounds, and the active chemicals present in them are responsible for their therapeutic properties [15]. The primary change among utilizing medical plant or chemical medication is most traditionally qualified doctors lack proper plant teaching [16]. In practice, however, three categories of herbs may be distinguished from a safety standpoint. There are a few plants in the first category that have near pharmaceutical quantities of toxic components and should not be used internally by untrained people unless in homoeopathic potencies. *Atropa belladonna*, *Arnica* sp., *Aconitum* spp, and *Digitalis* spp are among examples. Herbs in the second group have very strong effects, frequently producing nausea or vomiting. They are totally safe when used under the right circumstances. *Lobelia* and *Eonymus* spp. are two examples. Different countries have their own set of paradoxes. Ephedra, for example, is prohibited in the United Kingdom, maybe with good reason, yet is readily available in the United States. There is an idiosyncratic grouping of plants that display certain forms of toxicity in the third category, which has some scientific validity [17].

Commonly Used Medicinal Plants

Aconite, Alfa Alfa, Aloe Vera, Borage, Calamus, Chaparrel, Coltsfoot, Comfrey, Ephedra, Germander , Ginkgo biloba, Ginseng, Licorice, Isapghul, Sassafras, Senna, Silybum marianum, St. John's wort ,Neem, Tulsi etc.

S. no.	Common Name	Source and Family	Parts Used
1	Aleppo Oak	*Quercus infectoria Fagaceae*	*Galls*
2	Aloe/kumara	*Aloe vera. Aloe barbadensis Liliaceae*	*Aq. Extract & juice of leaves*
3	Bael	*Aegle marmelos (Rutaceae)*	*Methanolic extract of root.*
4	Ginkgo(GB)	*Ginkgo biloba Ginkgoaceae*	*Ethanolic extract of stem*
5	Liquorice	*Glycyrrhiza glabra Leguminosae*	*Vacuumdried Ethanolic extract of bark & root*
6	Myrobalan harda	*Terminala chebula Combretoreceae*	*Alcoholic extract of leaves & fruit*
7	Neem	*Azardica indica Meliaceae*	*Methanol extract of leaves*
8	St. John wort	*Hypericum mosorence Hypericaceae*	*Methanolic extract of leaves.*
9	Tulsi	*Ocimumtenuiflorum, Ocimumsanctum Labiateae*	*Ethanolic extract of whole part*
10	Turmeric	*Curcuma longa Zingiberaceae*	*Rhizomes*

Table 1: Medicinal plants with wound healing activity

Secondary Metabolites of Medicinal Plants

The vast array of secondary metabolites (SMs) that plants produce as living chemical factories serve as the foundation for many commercial pharmaceutical drugs and herbal remedies made from medicinal plants. In addition to having significant value in the food and pharmaceutical sectors, many of the chemical components of medicinal plants also contain biological activity that may increase human strength [18]. They also have significant value in the perfume, agrochemical, and cosmetic industries. Alkaloids, terpenoids, and phenylpropanoids are only a few of the SMs whose potential as potential therapeutics are being investigated. There are a few fundamental points to mention regarding new technologies that are being used and that are required to further medicinal plant research [19]. To start, the word "metabolome" now refers to ALL of a cell's tiny molecules. A few more broad remarks on the new technologies that are being employed and that are required to further the study of medicinal plants are in order before we delve into how the plant retains its secondary metabolites. Starting with the definition, the word "metabolome" now refers to ALL of a cell's tiny molecules, and it is the fourth element of a "systems" approach to biology, after genomics (DNA), transcriptomics (RNA), and proteomics [20]. Given the complexity of these extracts and the fact that most assays can only handle a few dozen fractions at a time, it is obvious that our current abilities to link a particular chemical structure to a particular clinical effect are severely constrained if more than one compound is required to elicit an effect [21]. The best opportunity for such a study may be provided by recent developments in high-throughput model organisms with neurological systems resembling those of the brain (e.g., Drosophila). SMs have altered a plant's growth and ability to survive under stressful circumstances throughout time. In the plant domain, there are around 100,000 SMs that are exclusive to certain taxonomic collections. Based on their metabolic functions (isoprenoids), phenolic compounds (flavonoids and phenylpropanoids), nitrogen having chemicals and terpenes are the three primary families of SMs in plants [22]. Although SMs biosynthesis and growth research has advanced, it is still rare to find articles on the developmental and environmental variables that affect SM production and growth in medicinal plants. Based on their chemical structures, secondary plant metabolites are categorized into a variety of classes. Nature of secondary plant metabolites described in this chapter as a foundation for a study of the main groups of therapeutically important compounds. The following are examples: phenolic, alkaloids, saponins, terpenes, lipids and carbohydrates [23].

In-vitro Propagation of Medicinal Plants

Since beginning of time, medicinal plants have attracted man's interest [24]. Medicinal plant use has a long history in almost every society. with plant extracts accounting for approximately 85% of traditional medicine [25]. Combining *in-vitro* production and cryopreservation techniques might help preserve the richness of medicinal plants used in the area. Plants play an important part in discovery of novel healing agents, and medicines produced from greater plants have a long history in medicine . Many molecules utilized in modern medicine have a complicated structure, making chemically manufacturing these bioactive substances at a low cost difficult. Medicinal riches are quickly depleted as a result of deforestation [26].

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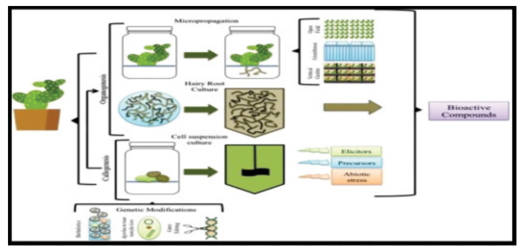

Figure 1: *In-vitro* plant tissue culture

Many important Chinese traditional medicinal herbs have shown to be beneficial when grown *in-vitro*. Each bioactive chemical has its unique set of properties. Due to its unique mode of action on the microtubular cell system, Taxol (plaxitaxol), a complex diterpene alkaloid discovered in the bark of the Taxus tree, is one of the most promising anticancer therapies [27].

Species	Mode of regeneration
Aconitum carmichaeli	Anther → Callus →SE →Plant STP, AB→ Multiple Shoot →Plant
Adenophora triphylla	SI→ Adventitious root → Multiple Shoot →Plant
Alpinia galangal	Rhizome bud → Multiple Shoot →Plant
Angelica acutiloba	Pedicel → Callus → Somatic embryos → Plant Pedicel → Callus → Cell clumps → Somatic embryos →Plant Flower Bud→ Callus→ Embryoid →Plant
Angelica sinensis (Oliv.) Diels	Immature embryos → Callus → Cell suspension → Cell clumps → Somatic embryos →Plant Immature embryos → Callus → Cell suspension → Somatic embryos →Plant
Aralia cordata	Inflorescence bud → Cell clumps → Somatic embryos →Plant
Artemisia annual	Leaf→ Callus,Shoot→Plant
Astragalus membranaceus	Shoot tip→ Multiple Shoot →Plant
Gentiana triflora	Leaf,S, Root→ Adventitious shoot →Plant
Gentiana triflora	Leaf→ Protoplast→ Shoot →Plant

Table 2: In-vitro studies in some of the important traditional Chinese medicinal plants and their related species

In-vitro Propagation of sea lavrnder (_Limonium wrightii_)

They are herbaceous perennial plants native to Japan's islands, as well as the southern Taiwanese islands of Lanyu and Lutao [28]. It produces naturally among the rocks, and a few farmers Lutao Island use seeds to cultivate it on a small scale [29]. Utilizing main and lateral branch tips, leaf bases, and explants from inflorescence nodes, we created a standard procedure for the efficient in vitro cultivation of this medicinal plant. After two months of culture, the explants on Murashige and Skoog's media (MS basal medium) supplemented with 8.87 M N6 - benzyladenine (BA) and 1.07 M a-naphthaleneacetic acid generated adventitious shoots (NAA).

***In- vitro* Propagation of lady bell (*Adenophora triphylla*)**

Popular names for *Adenophora triphylla* include "sha shen" in Taiwan, China, and the Japanese Ryukyus and Bonin Islands. Triphylla's fleshy roots, which also contain saponins and insulin and have antifebrile pharmacological effect, have also been used as an expectorant to treat chronic bronchitis and whooping cough. It has an antimicrobial effect as well as stimulating cardiac contraction. It's also used as a general tonic to re-energize the body. Plant extracts induced apoptosis in human Jurkat T cells, which had tumoricidal effects [30].

***In-vitro* Propagation of Pinellia ternata (*Araceae*)**

It is a Japanese and Chinese medicinal plant that grows wild. *P. ternata* tubers contain homogentisic acid. The tubers are an essential component of "Sho- seiryuto," medication used to cure cold symptoms. Because seedling and bulbil collecting is difficult, the plants are not grown. Because seedling and bulbil collecting is difficult, the plants are not grown. Tubers obtained from naturally occurring plants in the highlands are insufficient. As a result, tissue culture experiments were conducted with the goal of widespread multiplication of this therapeutic plant [31].

CONCLUSIONS

Medicinal plants have long been harvested, eaten, and controlled by local norms and knowledge. They are inextricably linked to local livelihoods. Traditional treatments should be managed since they are empirical and knowledge-based, frequently culturally inherited, and vital to pharmacology and local livelihoods. Traditional treatments, on the other hand, are being undermined as a result of shifting lifestyles, views, societal changes, and acculturation. Plants are abundant sources of pharmaceutically significant chemicals; however, these molecules must be synthesised in the laboratory. Because many secondary plant metabolites cannot be synthesised chemically, micropropagation is an essential technique. Many plant species have yet to be identified, and their therapeutic qualities are unknown; even traditional medicinal treatments are being forgotten. To conserve nature's natural pharmaceuticals, more research and protection of all plant species, especially medicinal plants, is required. Plant tissue culture advances will allow for fast replication and long-term usage of therapeutic plants for future generations. Even if the plant parent material is overexploited, slow-growing, or low-yielding plant, *in-vitro* tissue culture remains a viable technique for the creation of structurally complex and high-value natural products. Nonetheless, due to difficult costs, an in vitro culture cost–benefit analysis is advised before implementation. Similarly, employing plant culture systems to produce medicines can have a number of advantages, including cost savings, speed, minimal human pathogen load, and scalability. All of these benefits are particular to herb products and reliant on manufacturing efficiency as compared to alternatives. Moreover *in-vitro* propagation is a promising strategy to obtain valuable medicinal plants irrespective geographical or seasonal constraints.

Conflicts of Interest

The authors declare no conflict of interest

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