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Pharmacological and pharmaceutical aspects of herbal medicines: A review

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Abstract
Herbal medicine has been a cornerstone of traditional healthcare systems for thousands of years, with a rich history and cultural significance in many parts of the world, including India. The World Health Organization defines herbal medicine as the use of plants, plant extracts, and other plant-based materials for therapeutic purposes. Herbal medicines have been used to treat a wide range of ailments, from digestive disorders to respiratory diseases and cardiovascular conditions. Pharmacological aspects of herbal medicines including the bioactive compounds present in herbal medicines, such as alkaloids, terpenes, and flavonoids, have been shown to possess anti-inflammatory, antioxidant, and antimicrobial properties. This review aims to provide an overview of the traditional medicinal practice of Ayurveda, the mechanisms of action of herbal medicines, and their therapeutic applications. Also discuss the pharmaceutical aspects of herbal medicines, including extraction and isolation methods, formulation and delivery systems, quality control and standardization. With the growing interest in traditional and complementary medicine, herbal medicines offer a promising approach to healthcare, with potential benefits including reduced side effects and improved overall well-being.

Keywords: Ayurveda, herbal medicine, pharmacological aspects, pharmaceutical aspects

1. Introduction
The World Health Organization (WHO) defines herbal medicine as the use of herbs, herbal supplies, herbal preparations, and finished herbal products that include active ingredients derived from plants, other plant components, or a combination of these. These herbs are made from plant stems, leaves, flowers, roots, and seeds [1]. Herbal medicine's historical relevance serves as an example of the long-standing connection between people and nature in the quest for health and wellbeing. Many civilizations throughout the world have recognized and utilized plants' healing properties throughout history [2]. One of the oldest forms of medicine that people have ever encountered is herbal therapy, which uses whole plants or plant parts to treat a variety of crippling diseases or promote overall health [3]. Further to various cultural and socioreligious behaviors, the Indian subcontinent's auxiliary or traditional medical system has a major effect on healthcare [4]. Herbal medicine and pharmaceuticals are two separate but related areas of healthcare. Herbal medicine uses traditional plant-based ingredients, whereas pharmaceuticals, which are manufactured in labs, provide specific treatments. In recent years, there has been a growing interest in the integration of herbal therapy with pharmaceuticals in conventional treatment. By exploring benefits and challenges, this review clarifies their current condition [5]. An overview of the traditional medicinal practice known as Ayurveda. Ayurveda an ancient medicinal system deeply embedded in Indian philosophy and culture is a lasting monument to the tremendous knowledge of our previous generations. With a more than 5,000-year history, Ayurveda is a way lifestyle that offers a comprehensive understanding of the connection between the body, mind, and spirit. It is more than just a medical system [6]. Herbal preparations have been used for ages to treat a variety of skin conditions and have a variety of therapeutic qualities [7]. Aromatic and medicinal plants are great sources of ingredients for making new medications and healing the body and psyche. In modern medicine, as well as in the home and hospital, the use of botanicals, aromatherapy, crude pharmaceuticals, and a number of other therapies has grown in popularity. Preventative medicine also benefits from these natural medicines and treatments [2]. The key components are nano-herbal formulations, which use nanotechnology to improve the effectiveness and distribution of medicinal agents, making it easier to combine traditional herbal treatment with new technologies.

The shortcomings of traditional herbal medicine, such as the use of ingredients with poor bioavailability and preparation instability, were immediately addressed by these formulations [8]. More than 35,000 different plants are used to make around half of today's medications. Millions of people in China and India rely on traditional herbal medicine (THM) to meet 50% of their basic healthcare requirements. There are over 140 novel medications in use in China that are either chemically modified or derived from plants. Compared to methods like chemical synthesis or random screening, the extensive clinical expertise with conventional medications facilitates effective drug development. This method lowers toxicity risks, which are major obstacles in drug discovery, and saves time and money [5]. Throughout human history, herbal remedies have been used in medicine for thousands of years. Each part of natural herbs, including leaves, flowers, buds, pollen, fruits, skins, seeds, stems, roots, rhizomes, bark, and even whole plants, has unique medicinal properties and can be used for medicinal purposes [9]. Promising substitutes with fewer adverse effects and a more comprehensive approach to treatment are provided by herbal medicine, primarily from traditional systems. These treatments appeal to people looking for safer, long-term options for managing urticaria because they concentrate on reestablishing the body's equilibrium, regulating immunological reactions, and lowering inflammation [10]. Since ancient times, plants have been traditionally employed for medical reasons, both directly and by extraction. Known as secondary metabolites, phytochemicals are compounds produced by plants that are used extensively in traditional medicine [11]. Herbal medications are substances produced from plants that are mostly used orally and have a proven track record of long-term therapeutic effectiveness [12]. Since ancient times, herbal remedies have been used to cure a variety of illnesses, including skin conditions. However, because they lack focused delivery, they can harm healthy cells. Herbal medications delivered using nanotechnology offer focused delivery without endangering healthy or uninfected bodily cells [13].

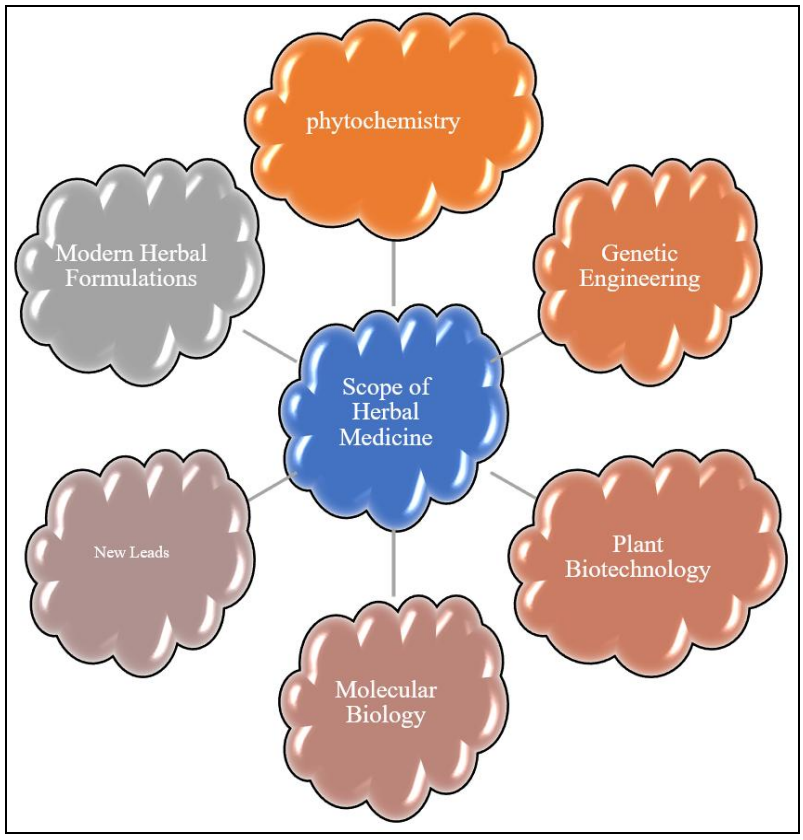

Fig 1: Scope of herbal medicines [5]

Over the past few decades, there has been a lot of interest in developing a new drug delivery system (NDDS) for herbal medications [14]. Ayurvedic businesspeople are promoting knowledge of the effectiveness and capacity of conventional medical systems, dissatisfaction with allopathy, coordinated side effects, government assistance, expanding research and development, etc. [3]. Any plant or plant part valued for its medicinal, savory, or aromatic qualities might be considered an herb. Herbal medicine, often known as herbalism, is the practice of employing plants or plant-based materials for their therapeutic or medicinal effects. Plant fragments or unprocessed extracts containing a variety of components that combine to form herbal medicines. While any part of the plant may be used to make herbal medicines, the most commonly utilized parts are the leaves, roots, bark, seeds, and flowers. These herbal remedies can be applied directly to the skin, ingested, diluted, or inhaled [15]. Because of its healing, restorative, and health-promoting qualities, herbal therapy has significantly improved human health. Herbal medicine includes herbs, herbal components, herbal preparations, and prepared herbal products that contain active compounds of plants or other materials. It is often referred to as botanical medicine, phytomedicine, or phytotherapy. Several studies indicate that traditional people use plant-based preparations or herbal remedies to treat digestive system diseases all over the world [16]. Due to their varied pharmacological properties, herbal medicines have been used by people all over the world, and their demand has been rising due to their positive health effects [17].

2. Advantages of herbal medicines [18]

1. A natural, broad approach to medical treatment is frequently provided by herbal remedies, which often treat the body as a whole rather than just treating its symptoms. Many herbs provide multiple therapeutic benefits that address the root causes of disease.
2. When compared to pharmaceutical medications, herbal remedies often have fewer and milder side effects. This is due to their plant-based origin and the fact that they often include a wide variety of substances that complement the body.
3. Compared to traditional drugs, herbal remedies are frequently less expensive. The cost can be further decreased by growing several herbs in home gardens. Additionally, they are generally accessible in a variety of forms, including tinctures, teas, and capsules.
4. The immune system is known to be strengthened and supported by a variety of herbs. Better general health and an enhanced capacity to fend off diseases may result from this.
5. A lot of herbs may help the body before sickness occurs by acting as preventative measures. Many ancient medicinal systems, such as Ayurveda and ancient Chinese Medicine (TCM), are based on this fundamental idea.

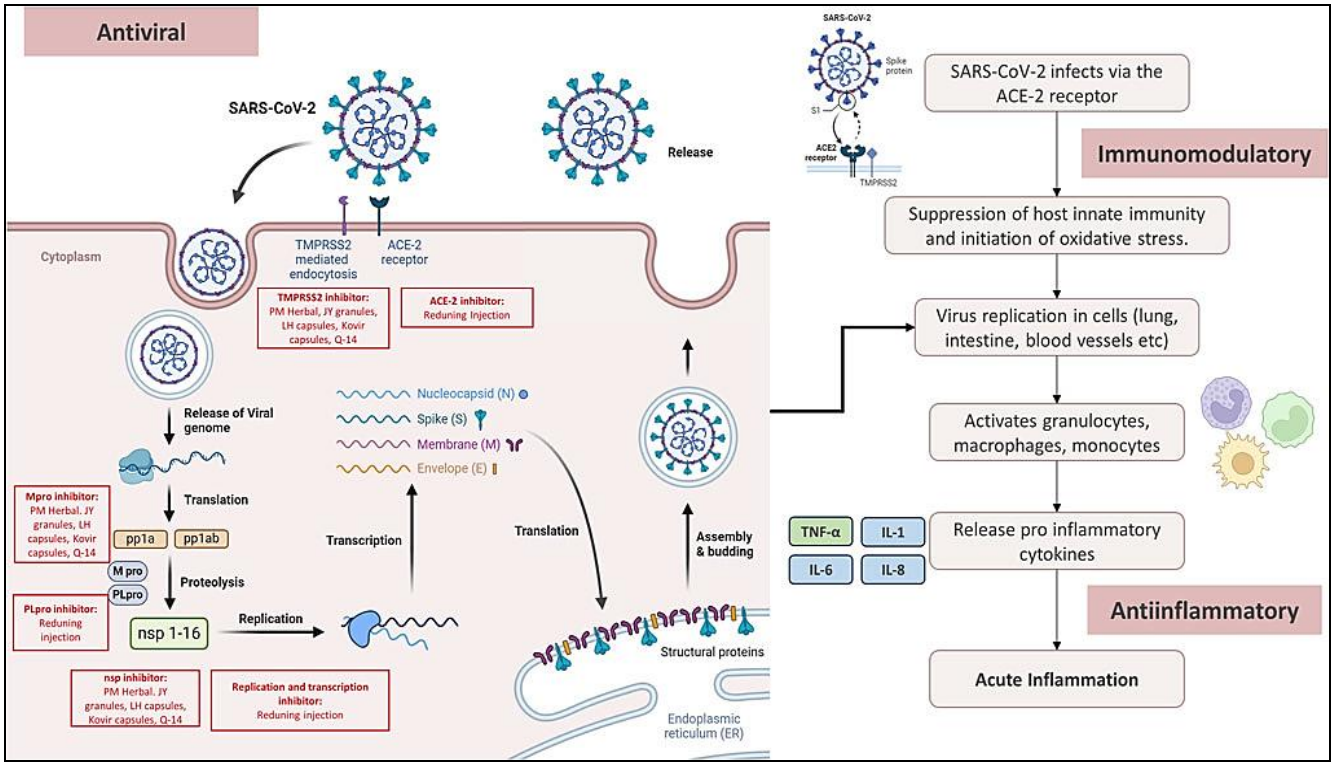

Fig 2: The mechanism of herbal medicines for COVID-19 [19]

3. Pharmacological Aspects of Herbal Medicines

3.1 Bioactive compounds in herbal medicines

Terpenes, terpenoids, phenylpropanoids, and other elements are the four structural categories into which the chemical components of essential oils may be divided [20]. Fruits, nuts, roots, vegetables, herbs, and spices are rich sources of bioactive components, particularly polyphenols and non-starch polysaccharides [21].

1. Alkaloids

Alkaloids are "cyclic compounds containing nitrogen in a negative oxidative state, which is of limited distribution among living organisms," according to Dr. S. William Pelletier [22]. An estimated 12,000 distinct alkaloids with a variety of biological actions, including vasodilatory, neuroprotective, antibacterial, and anticancer properties, can be produced by plants [9]. Alkaloids have a wide range of pharmacological activities, such as antioxidant, anti-inflammatory, anti-bacterial, and anti-cancer effects. Additionally, alkaloids are important in the therapy of neurological conditions [23]. Alkaloids effectiveness in treating diseases, especially cancer, where new mechanisms of action are essential for overcoming resistance and improving patient outcomes, is increased by ongoing research into these chemicals, which also refines current ones [24].

2. Terpenes

The main components of EOs are terpenes or isoprenoids, which are molecules with carbon backbones of 2-methylbuta-1,3-diene (isoprene units) that may be rearranged into cyclic structures. The structural variety of terpenes is mostly caused by the quantity of isoprene units. Monoterpenes (C10), sesquiterpenes (C15), diterpenes (C20), triterpenes (C30), tetraterpenes (C40), and one isoprene unit (C5) combine to make hemiterpenes [20]. Other terpenoids include meroterpenoids, which are hybrid secondary metabolites that are partially produced from terpene biosynthesis but are created by mixed biosynthetic routes, and norterpenoids, which are terpenes that have lost a methyl group. In contrast to typical terpenoids, norterpenes and meroterpenes have distinct structures and have been identified in sponges [22]. Oridonin has been shown to considerably increase p38 phosphorylation and contribute to cancer cell death in studies on colon and pancreatic tumors [25].

3. Flavonoids

The health advantages of flavonoids, which are polyphenolic chemicals, are widely recognized [26]. Flavonoids feature two

phenyl rings (C6-C3-C6) and a C15 backbone [27]. Plants include a family of secondary chemicals called flavonoids. They may be found in many different plant components, including fruits, leaves, flowers, and stems. Their yellow pigment qualities are the reason for their moniker. Scientific studies that have shown that these chemicals have anti-inflammatory, antioxidant, antibacterial, and antiviral qualities have validated their pharmacological effects. Three natural substances that may be utilized to treat AD will be discussed in this article [23]. Through a variety of methods, such as apoptosis induction, cell proliferation inhibition, angiogenesis suppression, and signaling pathway modulation linked to cancer progression, flavonoids have demonstrated anti-cancer benefits. Quercetin, for example, has been shown to limit cell proliferation and cause apoptosis in a range of cancer cell lines [24].

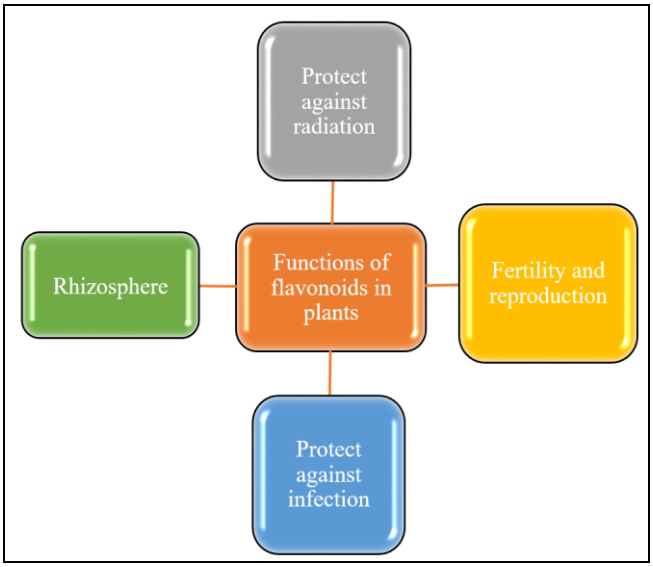

Fig 3: Functions of flavonoids in plants [28]

3.2 Mechanisms of action of herbal medicines

1. Anti-inflammatory

The host's defensive reaction to foreign invaders is inflammation, which is often brought on by tissue injury and/or microbial infection. Acute and chronic inflammatory diseases that result in severe or persistent tissue damage can be caused by dysregulation of inflammatory responses [20]. In a dose-dependent way, the ethanolic extract of C. morifolium (CM-E) dramatically decreased the generation of inflammatory mediators [26]. Non-Steroidal Anti-Inflammatories: To reduce the adverse effects of chronic steroid use, research is being conducted to develop innovative anti-inflammatory medications that are not corticosteroids. Small molecule therapy: These medications may offer a viable alternative to biologics or conventional therapy by concentrating on specific inflammatory pathways that are associated with asthma [29].

3.3 Therapeutic applications of herbal medicines

1. Digestive disorders

Large, insoluble food molecules are broken down into smaller, water-soluble food molecules during the intricate process of digestion. The soluble food molecules then go to the small intestine, where they absorb nutrients before being transported to various regions of the body via blood circulation. The continual provision of energy for growth, development, differentiation, and other bodily functions including repair, reproduction, and breastfeeding is the primary function of digestion. The neurological, hormonal, and immunological systems are among the many bodily systems and functions that are significantly impacted by digestion [17]. Treatment depends on the diagnosis, but in general, treatment options include proper diet, medications prescribed by a doctor, surgery, and swallowing therapy. The use of complementary treatments such as medicinal plants and traditional medicine is also effective in reducing the symptoms of these disorders if they are operated under the supervision of a specialist and their arbitrary use is avoided, especially for children [30].

2. Respiratory diseases

Anti-inflammatory medications are also necessary for the treatment of respiratory conditions. To prevent the decline in lung function observed in several individuals, it is necessary to fight lung inflammation and refrain from remodeling and deteriorating lung tissue [31]. A significant worldwide health issue, respiratory problems are among the main causes of illness and death that impact individuals of all ages. They affect the lungs, the bronchi and bronchioles, the big and small airways, and the nasal passages. They might have a traumatic, inflammatory, allergic, infectious, or neoplastic etiopathology. One of the most frequent causes of hospital visits or admissions globally is acute or chronic respiratory problems. The most prevalent respiratory diseases are lung cancer, cystic fibrosis, pneumonia, pulmonary TB, bronchial asthma, COPD, and pneumoconiosis [32].

3. Cardiovascular diseases

Since they come from natural sources, herbal medicines are sometimes thought of as safer substitutes for allopathic drugs. Even though they are usually regarded as harmless, herbal medications might have negative side effects if used improperly. An elevated risk of cardiovascular events is one of the worst negative effects that can result from long-term usage or overdosing on these herbal drugs. According to WHO standards, standard pharmacovigilance methods are crucial for the control, application, naming, and public perception of herbal medications [33].

4. Pharmaceutical Aspects of Herbal Medicines

4.1 Extraction and isolation methods for bioactive compounds

1) Solvent extraction

To isolate and characterize bioactive compounds from plants as possible lead compounds in the drug discovery process, this review aims to discuss the steps involved in obtaining pure compounds from crude plant extracts. These steps include the combination of extraction/sample preparation tools and analytical techniques [34]. Over time, scientists have developed a variety of techniques to separate and purify the different chemicals found in plant materials from both plants and meals. Numerous factors, such as the extraction technique, raw materials, and solvent selection, affect the extraction of biologically active chemicals [35]. Following the collection of plant material, the next step involves the extraction of bioactive compounds from the plant matrix. Depending on the properties of the plant material and the chemical makeup of the chemicals, several approaches may be employed to accomplish this goal. Common methods of substance extraction include maceration, in which the plant material is immersed in an appropriate solvent; Soxhlet extraction, which offers continuous solvent extraction; and

supercritical fluid extraction, which selectively extracts chemicals using supercritical fluids [2]. To maximize their potential uses and achieve the appropriate qualities, bioactive components must be extracted from natural sources. To effectively separate and concentrate these essential components from their sources, several sophisticated extraction techniques have been developed over traditional approaches [36]. Natural molecules known as bioactive compounds have anti-inflammatory, antibacterial, and antioxidative properties, among other health advantages. These substances are essential for maintaining human health since they strengthen the immune system, fight oxidative stress, and may even prevent a number of diseases. According to a thorough investigation, a variety of bioactive substances, including phenolics, flavonoids, and tannins, may be successfully extracted from the waste of the fruit and vegetable processing sector [37].

2) Chromatography

Various chromatographic techniques are used to separate and identify plant components. Thin Layer Chromatography (TLC): Used to screen bioactive chemicals initially.

The Benefits: These techniques offer accurate identification of plant and bioactive markers [38]. Chromatographic techniques are essential for creating more effective procedures for the separation of natural substances. Apart from these techniques, the isolation of secondary metabolites using countercurrent liquid–liquid separation (CCS) has proven to be highly effective [39].

4.2 Formulation and delivery systems for herbal medicines

1) Tablets and capsules

To improve the absorption of active ingredients like *curcumin*, traditional herbal tablets and capsules are being reformulated with bio-enhancers like *piperine* (from black pepper). Modern pills and capsules guarantee that patients obtain greater therapeutic advantages even at lower dosages by mixing these herbal constituents with bio-enhancers [10].

4.3 Quality control and standardization of herbal medicines

1) HPLC (High-Performance Liquid Chromatography)

In the late 1960s and early 1970s, High-Performance Liquid Chromatography (HPLC) was created. It is currently widely used for separations and purifications in a number of industries, such as the food, pharmaceutical, biotechnology, environmental, and polymer sectors. In the last ten years, HPLC has emerged as the preferred technique for analyzing a broad range of substances [40]. offers accurate phytochemical analysis, both quantitatively and qualitatively [38]. For such issues, liquid chromatography has shown itself to be a successful remedy. A durable retention and elution procedure is essential to liquid chromatography separation [41].

2) GC-MS (Gas Chromatography-Mass Spectrometry)

Gas chromatography-mass spectrometry (GC-MS) is a method used to analyze volatile compounds, such as essential oils.

Applications: Effective for complex or processed formulations that contain multiple plants [38].

5. Conclusion

Herbal medicine offers a wealth of opportunities for the development of new therapeutic agents and approaches to healthcare. The rich history and cultural significance of herbal medicine in traditional healthcare systems, such as Ayurveda, highlight the importance of preserving and promoting traditional knowledge. The bioactive compounds present in herbal medicines have shown promising therapeutic effects, and their mechanisms of action are being increasingly understood. However, there is a need for further research into the pharmaceutical aspects of herbal medicines, including quality control and standardization, to ensure their safe and effective use. As the world moves towards a more holistic approach to healthcare, herbal medicines are likely to play an increasingly important role in promoting health and well-being. The full potential of herbal remedies and the development of new, sustainable, and effective healthcare approaches can be achieved by combining traditional knowledge with modern science.

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