

Research Article

Herbal Medicine: Scientific Validation and Future Prospects

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Abstract

Herbal medicine has been a cornerstone of traditional healing systems for centuries, offering therapeutic benefits derived from natural plant compounds. Despite its widespread use, scientific validation remains crucial for integrating herbal medicine into modern healthcare. This review explores the necessity of evidence-based research, focusing on methods such as phytochemical analysis, preclinical studies, and clinical trials to assess efficacy and safety. Successful examples, including artemisinin for malaria and curcumin for inflammation, highlight the potential of herbal compounds in modern medicine. However, several challenges hinder the standardization and global acceptance of herbal medicine. Variability in plant composition due to environmental factors, lack of standardized extraction techniques, and safety concerns, such as herb-drug interactions, pose significant barriers. Regulatory frameworks vary across countries, further complicating approval processes and commercial applications. Despite these challenges, advancements in biotechnology, nanotechnology, and artificial intelligence (AI) are shaping the future of herbal medicine. AI-driven drug discovery and big data analytics are enhancing the identification of bioactive compounds, while personalized medicine approaches are improving treatment outcomes. The integration of herbal medicine with conventional healthcare, particularly in chronic disease management, presents promising opportunities. To ensure the global acceptance of herbal medicine, rigorous scientific validation, improved regulatory frameworks, and interdisciplinary research are essential. Future efforts should focus on bridging the gap between traditional knowledge and modern scientific approaches to maximize the therapeutic potential of herbal medicine in a standardized and evidence-based manner.

Keywords

Herbal Medicine, AI-driven Drug Discovery, Public Health, Global Health Security

1. Introduction

Herbal medicine, also known as phytomedicine or botanical medicine, has been an integral part of traditional healthcare systems across civilizations for thousands of years. It involves the use of plant-derived compounds for the prevention and treatment of various ailments [1]. Ancient med-

ical traditions such as Traditional Chinese Medicine (TCM), Ayurveda, and African traditional medicine have long recognized the therapeutic potential of herbs, with documented evidence dating back to as early as 3000 BCE [2]. Despite its deep historical roots, the scientific validation of herbal medi-

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cine remains a critical challenge in modern healthcare, as the efficacy and safety of many plant-based treatments have not been rigorously assessed through standardized research protocols [3]. In recent years, there has been a resurgence of interest in herbal medicine due to growing concerns over the side effects of synthetic drugs, increasing cases of antibiotic resistance, and the rising demand for natural and holistic healthcare solutions [4]. According to the World Health Organization (WHO), approximately 80% of the global population relies on herbal medicine as a primary form of healthcare, particularly in developing countries where access to modern pharmaceuticals is limited [5]. However, to integrate herbal medicine into mainstream healthcare systems, rigorous scientific validation is necessary to establish its pharmacological efficacy, mechanisms of action, and safety profiles.

Scientific validation of herbal medicine involves multiple stages, including phytochemical analysis, preclinical studies, and clinical trials. Phytochemical studies help identify bioactive compounds responsible for therapeutic effects, while preclinical experiments (in vitro and in vivo studies) assess pharmacokinetics, toxicity, and biological activity [6]. Clinical trials further validate the efficacy and safety of herbal formulations in humans under controlled conditions, ensuring their reliability as medical treatments. The success of compounds like artemisinin (derived from *Artemisia annua*) in treating malaria and aspirin (originally derived from willow bark) in pain management highlights the potential of herbal medicine when subjected to rigorous scientific scrutiny [7]. Despite its promise, herbal medicine faces several challenges in achieving scientific validation and regulatory approval. Variability in plant composition due to environmental factors, lack of standardized processing techniques, and the presence of contaminants or adulterants pose significant concerns [8]. Additionally, herb-drug interactions and potential toxicity require thorough investigation to ensure patient safety. Regulatory frameworks vary across countries, creating further hurdles in the acceptance and commercialization of herbal medicines [9]. Looking forward, the future of herbal medicine lies in technological advancements such as biotechnology, nanotechnology, and artificial intelligence (AI)-driven drug discovery. AI and machine learning are revolutionizing herbal research by enabling rapid screening of plant compounds, predicting their pharmacological effects, and optimizing formulations for enhanced bioavailability [10]. Personalized herbal medicine, tailored to an individual's genetic and metabolic profile, also holds significant potential for the future of healthcare.

2. Methodology

The methodology section outlines the research design, data collection, and analysis approaches used to explore the scientific validation, challenges, and future prospects of herbal medicine. Given the interdisciplinary nature of herbal medicine research, this methodology integrates both qualitative

and quantitative methods, drawing from ethnobotanical studies, pharmacological research, clinical trials, and systematic reviews of existing literature.

2.1. Research Design

The current study adopted a systematic review approach, compiling data from peer-reviewed journals, articles, books, and reputable databases (e.g., PubMed, Scopus, Google Scholar) to provide an overview of the scientific validation and future potential of herbal medicine. The goal is to present an evidence-based assessment of current trends, identify gaps in research, and suggest pathways for further exploration in the field.

2.2. Data Collection

Literature Review

- 1) Inclusion Criteria: Only studies published in the past 10 years (2013-2023) in English-language journals and those related to scientific validation, pharmacological studies, clinical trials, and regulatory challenges of herbal medicine were considered.
- 2) Exclusion Criteria: Studies focusing on non-pharmacological aspects of herbal medicine, such as cultural practices or ethnobotanical surveys not tied to scientific evidence, were excluded.

Data Sources:

- 1) Peer-reviewed journals (e.g., *Journal of Ethnopharmacology*, *Phytotherapy Research*, *Planta Medica*)
- 2) Government and regulatory body reports (e.g., WHO, FDA, EMA)
- 3) Clinical trial databases (e.g., ClinicalTrials.gov)
- 4) Online databases (*PubMed*, *Scopus*, *Google Scholar*)

Clinical Trials and Experimental Studies

Data from clinical trials that assessed the efficacy and safety of herbal medicines were included. These trials should have been randomized, controlled, and double-blind, if available, to ensure reliable and reproducible results. Additionally, preclinical studies assessing the pharmacokinetics and toxicity of herbal compounds were reviewed.

Expert Interviews

To complement the published literature, expert opinions from researchers, practitioners, and regulatory bodies in the field of herbal medicine were gathered through interviews. These interviews helped identify current challenges, emerging trends, and the future outlook for herbal medicine in healthcare systems.

2.3. Data Analysis

Qualitative Analysis

- 1) Content Analysis: The data from literature reviews, expert interviews, and regulatory documents were analyzed through content analysis. Themes related to scientific validation, safety concerns, challenges, and fu-

ture prospects of herbal medicine were identified.

- 2) **Comparative Analysis:** Studies examining similar herbal products were compared to assess differences in therapeutic efficacy, dosage, side effects, and quality control practices.

Quantitative Analysis

- 1) **Statistical Analysis:** Where clinical data or trial outcomes were available, statistical tools (e.g., meta-analysis) were applied to evaluate the effectiveness of herbal medicines for specific conditions (e.g., cancer, diabetes, anxiety).
- 2) **Impact Assessment:** Quantitative data on the growth of the herbal medicine market, the number of published studies, and the number of registered clinical trials were analyzed to assess the progress and future trends in the field.

2.4. Ethical Considerations

- 1) **Informed Consent for Expert Interviews:** All experts participating in interviews were provided with clear information about the purpose of the study, and consent was obtained prior to data collection.
- 2) **Confidentiality:** All collected data were anonymized to maintain the confidentiality of participants and the sources of the research.
- 3) **Conflict of Interest:** The researchers ensured that no conflicts of interest were present in the review process by only including peer-reviewed literature and verifying the objectivity of expert sources.

Limitations

- 1) **Language Bias:** Only English-language studies were included, which may exclude relevant research published in other languages.
- 2) **Availability of Data:** A limitation in the availability of high-quality clinical trials and standardized experimental protocols on herbal medicines may have restricted the depth of some sections, especially related to the safety and efficacy of specific herbal products.
- 3) **Data Variability:** The variability in research methods and herbal preparation standards across different studies made it challenging to draw definitive conclusions in certain areas.

3. Herbal Medicine

3.1. The Challenges Faced by Herbal Medical Practitioners

Herbal medicine has been a cornerstone of healthcare systems for centuries, with traditional knowledge forming the basis for many modern pharmaceuticals. Despite its widespread use, a significant gap exists between traditional herbal practices and scientifically validated medicine. The primary

challenge lies in the lack of rigorous scientific validation, which limits the acceptance of herbal medicine in mainstream healthcare. Many herbal formulations lack standardized dosages, quality control measures, and comprehensive clinical trials, raising concerns about their safety, efficacy, and potential interactions with conventional drugs. Regulatory bodies such as the World Health Organization (WHO), the U.S. Food and Drug Administration (FDA), and the European Medicines Agency (EMA) have established guidelines for herbal medicine. However, the variability in plant composition due to environmental factors, inconsistent extraction methods, and the presence of contaminants hinder the development of standardized herbal treatments. Additionally, the absence of large-scale clinical trials further limits the ability of healthcare providers to integrate herbal medicine into evidence-based practice. With increasing global interest in natural and holistic treatments, there is an urgent need to bridge the gap between traditional herbal knowledge and modern pharmacological research. This study aims to address the challenges associated with the scientific validation of herbal medicine by exploring existing research methodologies, identifying gaps in standardization and regulation, and assessing future prospects for integrating herbal medicine into conventional healthcare. By addressing these issues, this research seeks to contribute to the development of safer, more effective, and scientifically validated herbal therapies.

3.2. Scientific Significance of Herbal Medicine

The growing reliance on herbal medicine, both in traditional and modern healthcare systems, necessitates its scientific validation to ensure safety, efficacy, and standardization. According to the World Health Organization (WHO), approximately 80% of the global population, particularly in developing and underdeveloped countries, depends on herbal remedies for primary healthcare. However, the lack of rigorous scientific evaluation prevents their full integration into modern medical practice (Figure 1). The use of herbal medicine and its study is justified for by the following reasons:

- 1) **Bridging the Gap Between Tradition and Science**

Herbal medicine has provided valuable therapeutic solutions for centuries, yet many plant-based treatments lack robust clinical evidence. Scientific validation through phytochemical analysis, preclinical studies, and clinical trials is essential to confirm the pharmacological activity of herbal compounds and facilitate their acceptance in modern medicine.

- 2) **Ensuring Safety and Efficacy**

One of the primary concerns with herbal medicine is the inconsistency in plant composition due to environmental factors, variations in processing methods, and potential contamination. Without proper validation, patients may be exposed to ineffective or harmful treatments. This study aims to highlight the need for standardization and regulatory measures to enhance the safety and reliability of herbal ther-

apies.

3) Addressing Regulatory Challenges

Regulatory bodies such as the U.S. Food and Drug Administration (FDA) and the European Medicines Agency (EMA) have established guidelines for herbal products. However, the lack of uniform global standards creates challenges in quality control and commercialization. This research will explore regulatory frameworks and recommend strategies for improving approval processes for herbal medicines.

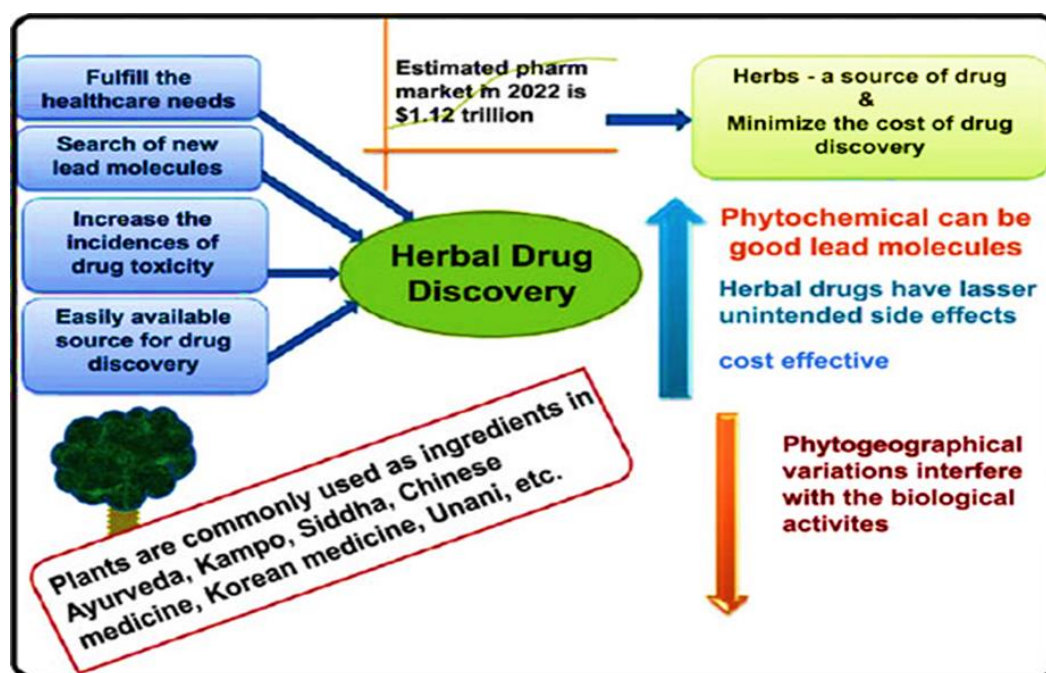
4) Advancing Integrative Medicine

Herbal medicine has shown potential in managing chronic diseases such as diabetes, cancer, and neurodegenerative

disorders. By validating herbal treatments through modern research methodologies, healthcare practitioners can confidently integrate them with conventional therapies, offering patients a broader range of treatment options.

5) Harnessing Technological Innovations

Recent advancements in biotechnology, nanotechnology, and artificial intelligence (AI) are revolutionizing herbal drug discovery. This study will explore how these technologies can enhance the scientific evaluation, formulation, and delivery of herbal medicines, paving the way for innovative and effective plant-based treatments.



Source: [11]

Figure 1. The challenges and perspectives of herbal drug discovery.

3.3. Historical Context and Evolution of Herbal Medicine

Herbal medicine, a foundational element of traditional healing systems worldwide, dates back thousands of years. From the ancient Egyptian use of medicinal plants documented in the Ebers Papyrus (around 1550 BCE) to the Classical Greek medicine of Hippocrates and Galen, plants have been the cornerstone of medical treatments [12]. Over centuries, traditional healers in various cultures, such as Chinese, Indian, and Native American medicine, have documented the therapeutic properties of plants, laying the groundwork for modern pharmacology. With the advent of modern pharmacology, however, herbal medicine saw a decline in favor of synthetic pharmaceutical drugs, due to their perceived higher potency and standardization. Despite this shift, there has been

resurgence in interest in herbal remedies in recent decades, driven by factors such as increasing consumer awareness of side effects associated with synthetic drugs, the global move towards integrative medicine, and the rise of chronic diseases, which require long-term management [13].

3.4. Scientific Importance, Limitations and Prospects of Herbal Medicine

1) Phytochemical and Pharmacological Studies

A significant body of literature has focused on the phytochemical composition of medicinal plants, which includes bioactive compounds responsible for their therapeutic effects. Studies have identified a variety of phytochemicals, including alkaloids, flavonoids, terpenoids, and phenolic compounds, which contribute to the pharmacological activities of herbs [14]. For instance, the alkaloid curcumin from *Curcuma longa*

(turmeric) is widely recognized for its anti-inflammatory and antioxidant properties, with evidence supporting its use in the treatment of osteoarthritis and other inflammatory diseases [15]. Similarly, the flavonoid resveratrol, found in red wine and the roots of *Polygonum cuspidatum*, has garnered attention for its cardiovascular benefits and potential anti-cancer properties. Multiple studies have demonstrated its ability to modulate oxidative stress, inflammation, and gene expression, contributing to its therapeutic potential [16]. Another example is the use of *Ginkgo biloba* in cognitive enhancement and memory improvement, with several clinical trials supporting its efficacy in treating Alzheimer's disease and dementia [17].

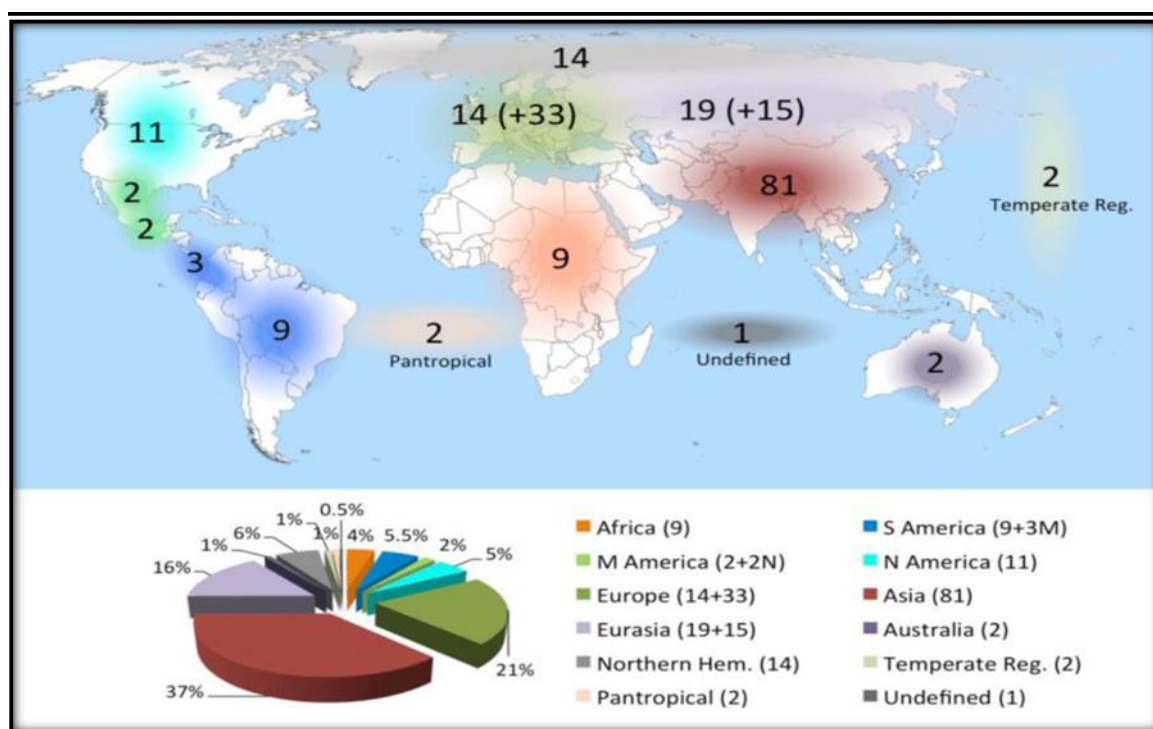
2) Pharmacological Mechanisms and Bioactivity

Research has increasingly focused on understanding the mechanisms through which herbal medicines exert their therapeutic effects. For instance, *St. John's Wort* (*Hypericum perforatum*) has been studied for its antidepressant properties; with studies showing that its active compounds (hypericin and hyperforin) interact with serotonin, dopamine, and norepinephrine receptors in the brain, potentially enhancing mood regulation [18]. Furthermore, *Echinacea purpurea*, commonly used to boost the immune system, has been shown to modulate immune cell activity, particularly enhancing phagocytosis and cytokine production [19]. Many of these mech-

anisms are still being elucidated, with some studies indicating that herbs may act through multiple pathways to exert their effects. For example, *Ginseng* has shown to impact a range of pathways, from neuroprotection to anti-cancer activity, highlighting the complexity of herbal medicines and the necessity of studying their multi-target bioactivity.

3) Clinical Trials and Efficacy

Clinical evidence supporting herbal medicine has expanded significantly in recent years. Systematic reviews and meta-analyses of randomized controlled trials (RCTs) have provided strong evidence for the effectiveness of several herbal treatments. For example, *Black Cohosh* (*Cimicifuga racemosa*) has been shown in clinical trials to alleviate menopausal symptoms such as hot flashes and night sweats [20]. Similarly, *Ginger* (*Zingiber officinale*) has been validated through clinical trials as an effective treatment for nausea, particularly in pregnancy-related morning sickness [21]. Despite this, challenges remain in terms of the quality and rigor of some clinical trials, including small sample sizes, lack of standardization in herbal preparations, and insufficient reporting on adverse effects. This issue is particularly prevalent in herbal medicine research, where different formulations, dosages, and methods of administration can complicate comparisons across studies [22] (Miller *et al.*, 2019).



Source: [5]

Figure 2. Global market statistics for herbal medicines and practices.

4) Regulatory and Safety Issues (Limitations)

The regulation of herbal medicine is one of the most debated areas in the field. Unlike synthetic drugs, which un-

dergo extensive clinical testing and regulatory approval processes, herbal medicines often face challenges in terms of quality control, standardization, and safety evaluation. In

many countries, herbal medicines are considered dietary supplements and thus are not subject to the same rigorous testing required for pharmaceuticals [11]. This lack of regulation has raised concerns regarding the purity, potency, and safety of herbal products available on the market. The issue of adulteration is particularly concerning. In some cases, herbal products have been found to contain heavy metals, pesticides, or other pharmaceutical drugs [17]. Furthermore, interactions between herbal medicines and prescription drugs are not always well-understood, with some herbs such as *Ginkgo biloba* and *St. John's Wort* known to interfere with anticoagulant therapy or anti-depressant medications [23].

To address these challenges, several countries have implemented regulations aimed at ensuring the safety and efficacy of herbal medicines. The European Medicines Agency (EMA) and the U.S. Food and Drug Administration (FDA) have introduced guidelines for herbal products, emphasizing the importance of quality control, good manufacturing practices (GMP), and proper labeling [14]. In addition, the World Health Organization (WHO) has developed guidelines for the

traditional use of herbal medicines, stressing the importance of evidence-based research to validate their safety and efficacy [5].

5) Future Trends and Opportunities

The future of herbal medicine lies in its integration with modern healthcare practices. One emerging trend is the use of phytopharmacogenomics, which combines the study of pharmacogenomics with phytotherapy to understand how genetic factors influence the effectiveness of herbal treatments [24]. Advances in nanotechnology are also promising, as they can enhance the bioavailability and controlled release of herbal compounds, improving their therapeutic outcomes [8, 11]. Additionally, the growing interest in personalized medicine presents an opportunity for herbal remedies to be tailored to individual genetic profiles, improving the precision and efficacy of treatment (Figure 2). The continued rise in consumer demand for natural products, coupled with a better understanding of the science behind herbal therapies, could lead to a stronger role for herbal medicine in integrative and complementary medicine [10].

3.5. Therapeutic Benefits and Concerns of Herbal Medicine

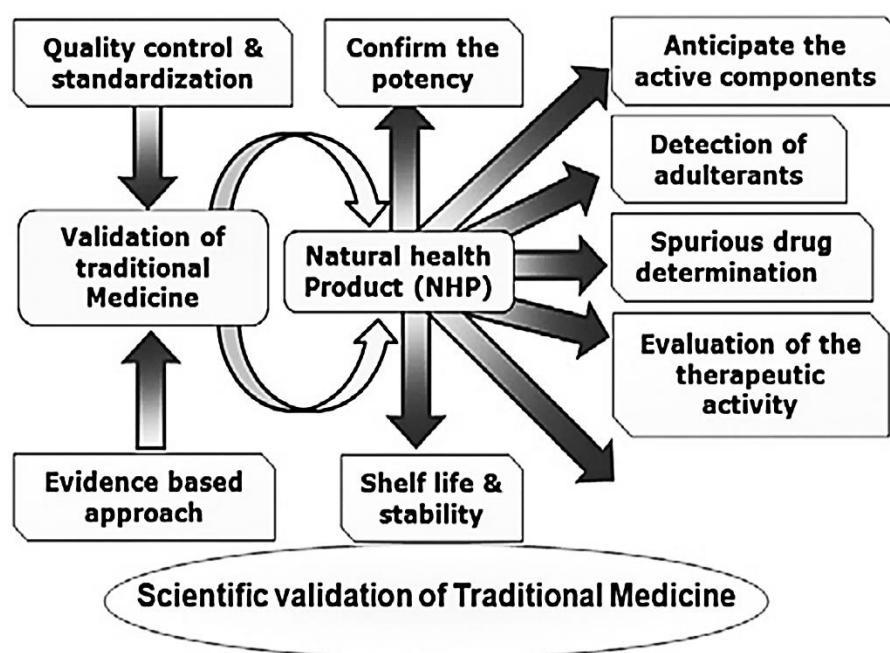


Figure 3. Validation prospective of traditional medicine (Source: 13).

This section provides an in-depth analysis of the findings from scientific studies on the validation and potential of herbal medicines. It emphasizes the promising therapeutic benefits, the challenges in clinical translation, and the need for robust research to facilitate the integration of herbal treatments into mainstream healthcare (Figure 3). Below are some of the highlighted benefits and concerns with regard to the use of herbal medicine:

- 1) A large body of literature demonstrates that herbal medicines offer a wide array of therapeutic benefits, some of which are comparable to, or even exceed, the efficacy of conventional pharmacological treatments. For instance, *Ginkgo biloba* is one of the most studied herbs in the treatment of neurodegenerative conditions like Alzheimer's disease. Clinical trials have shown that *Ginkgo* extract improves cognitive function and reduces

symptoms of dementia [17]. The compound's mechanisms of action include enhancing cerebral blood flow and providing antioxidant protection to neurons, contributing to its cognitive-enhancing effects.

- 2) Another widely used herb is *Curcuma longa* (turmeric), which contains curcumin. Several studies highlight curcumin's anti-inflammatory, antioxidant, and anti-cancer properties. A comprehensive meta-analysis by Hewlings and Kalman [15] showed curcumin's ability to manage conditions such as osteoarthritis, cardiovascular diseases, and cancer. Moreover, its ability to modulate multiple signaling pathways related to inflammation and cell survival underscores its therapeutic potential.
- 3) *St. John's Wort* (*Hypericum perforatum*), commonly used for its antidepressant properties, has also been subjected to numerous studies. A systematic review by Linde *et al.* [18] consolidated findings from multiple clinical trials, concluding that *St. John's Wort* was significantly more effective than placebo and comparable to conventional antidepressants in treating mild to moderate depression. The plant's active compounds, hypericin and hyperforin, modulate neurotransmitter systems such as serotonin, dopamine, and norepinephrine, which are critical in regulating mood.

3.6. Safety Profile and Toxicity Concerns

While the therapeutic benefits of herbal medicines are well-established, safety remains a crucial concern, particularly regarding adverse reactions and interactions with other drugs. The regulation of herbal products is often insufficient, leading to variability in product quality and potential contaminants. For example, *Ginkgo biloba* has been linked to an increased risk of bleeding, particularly when combined with anticoagulants like warfarin [23]. Similarly, *St. John's Wort* is known to interact with a wide range of medications, including antidepressants, antiepileptics, and contraceptives, potentially leading to reduced efficacy or dangerous side effects [23]. Safety concerns are also prevalent in certain herbal products that are contaminated with heavy metals, pesticides, or other pharmaceuticals due to improper cultivation or manufacturing practices. A study by Miller *et al.* [22] found that several commercially available herbal products contained high levels of contaminants, which posed risks to consumers. Ensuring the purity and consistency of herbal medicines through rigorous quality control standards is therefore essential to minimize these risks.

3.7. Challenges in Clinical Validation

One of the most significant barriers to the widespread acceptance of herbal medicines is the difficulty in conducting rigorous clinical trials to validate their effectiveness. As Miller *et al.* [22] suggested, the lack of standardization in the preparation of herbal products, including differences in plant

origin, extraction methods, and dosages, makes it difficult to draw definitive conclusions about their efficacy. Additionally, many herbal treatments have not been subjected to large-scale randomized controlled trials (RCTs), which are considered the gold standard for clinical evidence. A key challenge lies in the complexity of herbal mixtures. Unlike synthetic drugs, which often have a single active ingredient, herbal remedies typically contain multiple bioactive compounds, each of which can contribute to the therapeutic effects. This complexity makes it challenging to identify the specific mechanisms through which these herbs work. Moreover, the synergistic or antagonistic effects of combining different plant components need to be investigated more thoroughly. Atanasov *et al.* [10] emphasize the importance of advanced techniques like pharmacogenomics and phytochemicals in unraveling the complexities of herbal medicine and understanding how specific compounds interact at the molecular level.

The long-standing use of traditional herbal medicines, while promising, often lacks the robust clinical trial data needed to satisfy regulatory authorities. As a result, some herbal products are marketed without adequate proof of safety and efficacy. For example, while *Echinacea* has a long history of use as an immune booster, clinical trials have yielded mixed results, with some studies showing no significant effect in preventing colds [19], while others suggest modest benefits. These inconsistencies highlight the need for more high-quality trials to better understand the true clinical potential of such plants.

3.8. Innovations in Herbal Medicine Validation

Recent advances in biotechnology and nanotechnology have opened up new avenues for the scientific validation and improvement of herbal medicines. Nanotechnology, for instance, can enhance the bioavailability and controlled release of active herbal compounds, making them more effective in treating specific conditions. S ntar [8, 11] explained how nanoparticle-based formulations of herbal medicines can improve the solubility and absorption of poorly water-soluble compounds like curcumin. This innovation could significantly enhance the therapeutic potential of herbal treatments. Another promising approach is phytopharmacogenomics, which integrates the study of genetics with herbal pharmacology. By understanding how individual genetic variations affect the way a person responds to herbal treatments, researchers can develop more personalized and effective herbal therapies [24]. This field could potentially revolutionize the way we approach the use of herbs in medicine by tailoring treatments to individual genetic profiles, much like the growing field of personalized medicine for pharmaceuticals.

3.9. Regulatory Framework and Global Integration

The regulatory framework for herbal medicine varies

widely between countries, which can complicate the global integration of these therapies into healthcare systems. In the European Union, for example, the European Medicines Agency (EMA) requires extensive clinical data and manufacturing standards for the approval of herbal medicinal products [6, 14]. Meanwhile, in the United States, herbal medicines are categorized as dietary supplements, which mean they are not subject to the same rigorous testing requirements as pharmaceutical drugs. This discrepancy in regulation poses challenges in ensuring that herbal products meet consistent quality standards across markets. The WHO's *Traditional Medicine Strategy 2014-2023* outlines a framework for integrating traditional herbal medicine into national health systems. The strategy emphasizes the importance of evidence-based research, regulatory policies, and quality assurance in ensuring the safe and effective use of herbal medicines in both developed and developing countries [5].

4. Recommendations

- 1) **Rigorous Clinical Trials and Research:** There is a need for well-designed, large-scale clinical trials that rigorously test the efficacy and safety of herbal medicines. Such studies should employ randomized controlled trials (RCTs) and long-term follow-up to establish reliable evidence supporting herbal treatments.
- 2) **Standardization and Quality Control:** To address the variability in herbal products, there should be a global push toward the standardization of herbal medicine manufacturing processes. This includes ensuring consistent dosages, identifying and controlling active compounds, and establishing strict protocols to avoid contaminants such as heavy metals or pesticides.
- 3) **Safety and Pharmacovigilance:** Increased efforts are needed to monitor and evaluate adverse effects and herb-drug interactions. A global pharmacovigilance system could help track and manage any risks associated with herbal products. Healthcare providers should be well-informed about potential interactions between herbal medicines and prescription drugs to minimize risks to patients.
- 4) **Regulatory Frameworks:** Governments and health organizations should work towards developing and enforcing clear regulatory frameworks that support the safe and effective use of herbal medicines. The integration of traditional herbal medicine into national healthcare systems should be guided by evidence-based research and clear safety protocols.
- 5) **Leveraging Technological Innovations:** Emphasizing the use of emerging technologies such as nanotechnology and pharmacogenomics can lead to enhanced formulations and personalized herbal treatments. These technologies can increase the bioavailability of bioactive compounds and help tailor treatments to individual patients' needs, improving overall efficacy.

6) **Education and Awareness:** Increasing public and professional awareness about the benefits and risks of herbal medicine is critical. Healthcare providers should be educated on the scientific underpinnings of herbal therapies to offer informed advice to patients. Furthermore, patients should be made aware of the proper use and potential risks of herbal products.

7) **Collaborative Research:** Cross-disciplinary research involving ethnobotanists, pharmacologists, clinicians, and regulatory bodies is necessary to advance the understanding of herbal medicine. Collaboration between the fields of traditional medicine and modern science will enhance the credibility and integration of herbal treatments in global healthcare.

By addressing these key recommendations, herbal medicine can evolve into a safer, more effective, and widely accepted treatment option, complementing conventional pharmaceutical therapies and offering additional choices for patient care.

5. Conclusion

Herbal medicine, rooted in centuries of traditional use, remains a significant aspect of global healthcare. Recent scientific research has confirmed the therapeutic potential of several herbs, such as *Ginkgo biloba*, *Curcuma longa* (turmeric), and *St. John's Wort*, for treating a variety of conditions including neurodegenerative diseases, inflammatory disorders, and depression. However, despite promising evidence, the widespread acceptance and use of herbal medicine in modern healthcare systems face significant challenges. The scientific validation of herbal remedies is often complicated by issues such as the complexity of their chemical compositions, inconsistent product quality, and insufficient large-scale clinical trials. Furthermore, safety concerns related to herbal (natural) and synthetic drugs interaction, potential contaminants, and adverse side effects emphasize the need for stronger regulatory frameworks and better quality control practices. The variation in herbal products, stemming from factors like cultivation methods and extraction techniques, poses a considerable challenge in establishing consistent dosages and predictable therapeutic outcomes. Nevertheless, innovations in fields such as nanotechnology, pharmacogenomics, and precision medicine are driving new possibilities for herbal medicines. These advancements could enhance the bioavailability, efficacy, and safety of herbal treatments, bridging the gap between traditional knowledge and modern scientific methodologies. By addressing the current challenges through continued research and improved regulatory oversight, herbal medicine could significantly contribute to integrative healthcare, complementing existing pharmaceutical therapies.

Abbreviations

AI Artificial Intelligence

TCM	Traditional Chinese Medicine
WHO	World Health Organization
FDA	Food and Drug Administration
EMA	European Medicines Agency
BCE	Before Common Era
GMP	Good Manufacturing Practices
RCTs	Randomized Controlled Trials

Conflicts of Interest

The authors declare no conflicts of interest.

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