JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue

JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)

An International Scholarly Open Access, Peer-reviewed, Refereed Journal

BRIDGING TRADITION AND SCIENCE: A COMPARATIVE STUDY OF TRADITIONAL AND MODERN HERBAL MEDICINE

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Abstract : Traditional and contemporary methods of herbal therapy have both played important roles in the prevention and treatment of disease, making it an essential component of international healthcare systems. While modern herbal medicine integrates scientific validation, standardization, and pharmacological breakthroughs to ensure efficacy and safety, traditional herbal therapy is founded on centuries-old knowledge and holistic therapeutic traditions. The effectiveness, safety, and integration of traditional and contemporary herbal medicine are examined in this review, which also highlights important pharmacognostic concepts, phytochemical analysis, quality assurance, and toxicological issues.

Concerns about herb-drug interactions, contamination, and toxicity are raised by the absence of standardization, regulatory control, and clinical validation, despite the fact that traditional medicine has offered insightful therapeutic insights. Modern herbal medicine, on the other hand, uses pharmacovigilance systems, Good Manufacturing Practices (GMP), and sophisticated extraction methods to improve uniformity and dependability. To guarantee the quality, safety, and effectiveness of herbal products globally, regulatory frameworks have been established by agencies including the European Medicines Agency (EMA), the U.S. Food and Drug Administration (FDA), and the World Health Organization (WHO).

A harmonized approach combining traditional wisdom with scientific advancements can pave the way for a comprehensive, evidence-based healthcare system that prioritizes safety, efficacy, and accessibility. Future research focusing on biotechnological advancements, artificial intelligence in drug discovery, and personalized herbal formulations will further enhance the credibility and therapeutic potential of herbal medicine. The integration of traditional and modern herbal medicine presents an opportunity for holistic, patient-centered healthcare solutions.

Keywords: Herbal medicine, traditional medicine, modern herbal medicine, phytochemical standardization, pharmacognosy, drug safety, toxicity, herb-drug interactions, regulatory frameworks, pharmacovigilance, clinical validation, holistic healthcare.

I. INTRODUCTION

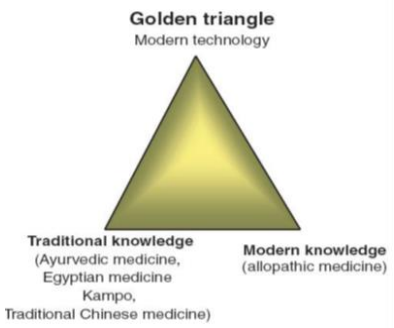
People have been using plants to heal for generations. Throughout history, plant products, whether they be food ingredients or botanical powders and potions, have been utilized to treat and prevent illnesses with differing degrees of effectiveness. The Sumerians are the first people to write about medical plants at least 5000 years ago, and archeological evidence points to far older therapeutic plant use. When Friedrich Bayer and Co. brought synthetic acetyl salicylic acid (aspirin) to the globe in 1897, the long-standing connection between plants and human health started to weaken. Residents of the new and old worlds separately discovered aspirin as a treatment for fevers and pains. It is a safer synthetic version of salicylic acid, an important element in willow bark[(1)].

The use of plants, plant parts, water or solvent extracts, essential oils, gums, resins, exudates, or other sophisticated products derived from plant parts for therapeutic purposes to support different physiological systems in a proactive manner, or, in a more traditional medical sense, to treat, cure, or prevent disease in humans or animals, is known as herbal medicine[(2).] According to the World Health Organization, between 70 and 80 percent of people worldwide, especially in poorer nations, receive their main medical treatment from non-conventional medicine. Alternative therapies and the therapeutic use of natural products, particularly those derived from plants, have gained popularity in recent years[(3,4)].

Relationship between Ayurveda and modern medicine :

One of the main ancient medicinal systems in India, Ayurveda, has yielded several helpful leads for the creation of drugs to treat chronic illnesses. Hippocrates declared about 250 years ago, "Let food be thy medicine and medicine be thy food"[(5)]. The New Millennium Indian Technology Leadership Initiative (NMITLI) of the Council for Scientific and Industrial Research (CSIR) is in the process of developing standardized herbal formulations.

Figure 1. Relationship between Ayurveda and modern medicine.



Currently, Japan, Hong Kong, Korea, and Singapore are the biggest importers of herbal medicine, accounting for 66% of China's exports of botanical drugs, while the United States is the largest market for Indian botanical products, accounting for roughly 50% of total exports[6].

TRADITIONAL HERBAL MEDICINE:

Traditional medicine (TM) is defined as a collection of long-standing healthcare practices and products, often referring to medical knowledge developed by indigenous cultures that incorporates spiritual treatments, nature-based remedies, and manual techniques designed to treat illness or preserve well-being[7]. TM is typically practiced outside of allopathic medicine, the dominant medical system in the developed world, which includes traditional Chinese medicine (TCM), traditional Arabic medicine (Unani), and traditional Indian medicine (Ayurveda)[7].

The World Health Organization (WHO) defines Traditional Medicine as "the sum total of the knowledge, skills and practices based on the theories, beliefs and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health, as well as in the prevention, diagnosis, improvement or treatment of physical and mental illnesses". TM practices, particularly comprehensive medical systems such as traditional Chinese Medicine and Ayurveda[8,9].

Products having a long history of widespread usage are typically safe when taken as directed at standard therapeutic dosages, according to many proponents of herbal medicines[10]. Traditional medicine is the culmination of generations of indigenous medical practitioner therapeutic experiences. Organic materials, minerals, and medicinal herbs are all included in the traditional treatments. Only traditional medicines that predominantly employ preparations of medicinal plants for therapeutic purposes are considered herbal pharmaceuticals. Therefore, the rich traditions of ancient civilizations and scientific heritage have been the source of herbal medicines and traditional medicaments[11].

Kinetic interactions of herbal medicines with conventional medicines

Herbal medicines are often used concomitantly with conventional drugs, making potential pharmacokinetic interactions a cause for concern. Herbal drug co-administration with medicines of narrow therapeutic indices (e.g., digoxin, warfarin) raises even deeper safety concerns. Common herbal medicines known to interact with conventional drugs include St. John's wort (Hypericum perforatum L.), ginkgo (Ginkgo biloba L.), ginger (Zingiber officinale Rosc.), ginseng (Panax ginseng C.A. Meyer) and garlic (Allium sativum L.) St. John's wort, an herbal antidepressant, is possibly the most notorious example. It is a potent inhibitor of CYP3A4, and when co-administered with drugs metabolized by this enzyme, it decreases their clearance and increases their plasma concentrations (AUC).

Because St. John's wort also induces the expression of CYP3A4 and the transmembrane transporter protein PgP (P-glycoprotein) in the liver and intestines, previous and repeated administrations have opposite effects; enhancement of clearance and decrease in AUC. The kinetic and clinical effects of a number of drugs that are substrates for CYP3A4 are altered by St. John's wort, and these drugs include cyclosporine, midazolam, oxycodone, methadone, imatinib, finasteride, bupropion, tracolimus, digoxin, atorvastin, and verapamil, among others.

Herbal products and their components have the ability to change the expression and/or activity of transmembrane transporters and drug-metabolizing enzymes. This can change kinetic parameters like AUC, C max, and T max as well as drug elimination, metabolic activation (i.e., the transformation of a precursor into its active metabolite), presystemic clearance, and bioavailability. The toxicity and/or clinical effectiveness of traditional medications may eventually change as a result of all these effects. Thus, it is crucial to understand how herbal remedies may either inhibit (when taken together) or increase the expression (after prior and/or repeated administration) of important drug-metabolizing enzymes (such as CYP3A4, 2D6, 2C9, 2C19, and 2A6) when taken with prescription medications.

Table 1: History of important events in Herbal drug standardization

YEAR	IMPORTANT EVENTS	REF
2011	Draft Guidance for Industry: Dietary Supplements: New Dietary Ingredient Notifications and Related Issues." The document was published in the Federal Register on Tuesday, July 5, 2011.	12
2011	An EU directive passed in 2004 erects "disproportionate" barriers against herbal remedies by requiring them to be "licensed" before they can be sold. It's called the Traditional Herbal Medicinal Products Directive (THMPD), Directive 2004/24/EC.	13
2009	USP. United States Pharmacopeia 32/National Formulary 27. Rockville, MD: The United States Pharmacopeial Convention; 2009.	14
2009	AYUSH department with collaboration with Quality Council of India (introduced certification scheme for AYUSH drug products	15
2007	WHO Guidelines on good manufacturing practices (GMP) for herbal medicines. Geneva, Switzerland: World Health Organization; 2007.	24
2007	WHO. Guidelines for assessing quality of herbal medicines with reference to contaminants and residues. Geneva, Switzerland: World Health Organization; 2007.	23
2006	The manufacture of herbal medicines	22
2005	National Policy on Traditional Medicine and Regulation of Herbal Medicines - Report of a WHO Global Survey	21
2004	In Canada, the Natural Health Products Regulations (NHPR) [13] under the Food and Drugs Act came into force on 01 January 2004.	20
2004	WHO guidelines on safety monitoring of herbal medicines in pharmacovigilance systems.	19
2003	WHO. Guidelines on good agricultural and collection practices (GACP) for medicinal plants. Geneva, Switzerland: World Health Organization; 2003.	18
2003	Department of Indian Systems of Medicines & Homoeopathy (ISM&H) established in 1995 renamed into Department of Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homoeopathy (AYUSH)	17
2002	Analytical approaches like Herbo print use three-dimensional HPLC and attempt to develop tools for activity-based standardization of botanicals.	16
2002	The Indian Herbal Pharmacopoeia. Mumbai, Indian Drug Manufacturer's Association, 2002.	25
1999	World Health Organization (WHO) had given a detail protocol for the standardization of herbal drugs comprising of a single content.	26
1996	World Health Organization has recommended the drug control agency to regulate the quality and safety profile of herbal products.	27
1995	A separate Department for Indian Systems of Medicine and Homeopathy (ISM&H) now known as AYUSH (Ayurveda, Yoga, Unani, Siddha, Homoeopathy) was established in March 1995 to promote indigenous systems.	28

MODERN HERBAL MEDICINE:

According to the World Health Organization, traditional medicine encompasses a variety of health practices, methods, knowledge, and beliefs that include spiritual therapies, manual techniques, exercises, and medicines derived from plants, animals, and/or minerals. These practices can be used alone or in combination to treat, diagnose, or prevent illness as well as to maintain overall health. In accordance with their definitions, WHO has supplied a few terminology pertaining to herbal medications. Herbs, herbal ingredients, herbal preparations, and final herbal products are all considered herbal medicines. It is customary in several nations for herbal remedies to use natural organic or inorganic active substances that are not derived from plants, such as mineral and animal elements. Herbs can be whole, broken, or powdered plant parts, such as leaves, flowers, fruit, seeds, stems, wood, bark, roots, rhizomes, or other plant parts. In addition to plants, herbal materials include gums, fresh juices, essential oils, fixed oils, resins, and dry herb powders. The basis for finished herbal products are herbal preparations, which can include tinctures, extracts, fatty oils, and comminuted or powdered herbal materials. Finished herbal products are herbal preparations made from one or more herbs; if more than one herb is used, the term "mixture herbal product" can also be used. Finished herbal products and mixture herbal products may contain excipients in addition to the active ingredients; however, they are not considered herbal if they contain chemically defined active substances, such as synthetic compounds or isolated constituents from herbal materials. Herbal medicines are used extensively in a variety of traditional medical practices and therapies, including Chinese medicine, Ayurveda, Unani, Naturopathy, Osteopathy, and homeopathy[29]. The practice of prescribing a set of standards or intrinsic features, consistent

parameters, and definite qualitative and quantitative values that convey an assurance of quality, effectiveness, safety, and repeatability is known as standardization of herbal medicines. It is the process by which technical standards are created and accepted. Experiments and observations are used to determine specific criteria, which would then result in the prescription of a collection of traits displayed by the specific medications. Standardization is therefore a tool in the process of quality control[30]. "Standardization is the body of knowledge and control required to produce material of reasonable consistency," according to the American Herbal Product Association. This was accomplished by applying quality assurance techniques to manufacturing and agricultural processes in order to reduce the inherent variation of natural product composition[31]. All steps done during the production process and quality control that result in a reproducible quality are referred to as "standardization." Additionally, it covers the whole field of research from a plant's conception to its use in medicine. It also entails combining herbal medications or herbal drug preparations or adding excipients to get the herbal drug preparation up to a specified content of a component or a, respectively[32]. A drug's "evaluation" includes confirming its identification, assessing its quality and purity, and identifying any adulteration[33].

Historical Context and the Evolution of Herbal Medicine

With origins in ancient societies like China, Egypt, and India, herbal medicine has a long history spanning thousands of years. Based on practical information that was passed down through the centuries, several plants were utilized to heal ailments. However, the popularity of herbal therapy declined in the 20th century with the introduction of modern medications. There has been a recent upsurge as patients and medical professionals look for complementary or alternative therapy. The pharmacodynamics of herbs and their molecular mechanisms of action are explored in modern herbal medicine, which is distinguished by scientific confirmation. Additionally, there is a rising emphasis on individualized, holistic treatment through the integration of herbal therapies with traditional therapy.

Pharmacological Properties of Herbs

Many herbs have active compounds that are responsible for their therapeutic effects, according to recent research. These consist of:

1. Alkaloids - Found in plants like Opium poppy and Coca, alkaloids have significant effects on the neurological system and ma beutilizedforpaintreatmentorasstimulants.

2. Flavonoids: Found in many fruits and plants, such as green tea and ginkgo biloba, these substances have anti-inflammatory, anti-cancer, and antioxidant qualities.

3. Terpenoids – Found in essential oils of plants like Peppermint and Lavender, these have a range of therapeutic effects, including antimicrobial and anti-inflammatory actions.

For instance, Turmeric (Curcuma longa) contains curcumin, a powerful antioxidant and anti-inflammatory agent. Studies show that curcumin can help manage conditions like osteoarthritis, depression, and even some cancers[34].

Clinical Evidence and Efficacy

Several plants medicinal properties have been validated by clinical trials:

1. Echinacea: Commonly used to treat and prevent colds, this plant may shorten the duration of cold symptoms, according to multiple studies[35].

2. St. John's Wort: The potential of this plant to treat mild to severe depression has been well investigated. Research suggests that it can be as effective as conventional antidepressants with fewer adverse effects.

3. Ginkgo Biloba: This plant is well-known for its potential to enhance cognition. Research has demonstrated that it can improve memory and cognitive function, particularly in older adults.

More thorough, extensive clinical trials are still required to confirm these findings and create thorough guidelines for the use of herbal medicine, even with encouraging results.

Toxicological Concerns in Herbal Medicine

1. **Herbal Compound Side Effects and Toxicity**
   - **Hepatotoxicity:** Examples include the possibility for liver damage caused by pyrrolizidine alkaloids, which are included in several traditional Chinese remedies (such as Senecio species).
   - **Nephrotoxicity:** Urothelial cancer and renal failure have been related to aristolochic acid, which is found in Aristolochia species.
   - **Neurotoxicity:** Seizures and abnormalities of the neurological system can result from consuming too much of some plants high in alkaloids, such as Ephedra spp.
   - **Carcinogenicity:** Certain herbal substances have been found to be carcinogenic, including safrole from sassafras oil.

2. **Herbal-Drug Interactions**
   - **Anticoagulant Interactions**: Ginkgo biloba, Garlic (Allium sativum), and Ginger (Zingiber officinale) may increase bleeding risks when taken with anticoagulants.
   - **Cytochrome P450 Modulation**: Herbs such as St. John's Wort (Hypericum perforatum) induce CYP3A4 enzymes, decreasing the effectiveness of medications like warfarin and oral contraceptives.

3. **Contaminants and Adulteration**
   - **Heavy Metals:** Traditional Chinese and Ayurvedic medications may include lead, mercury and arsenic.
   - **Microbial Contamination**: Bacterial and fungal contamination might result from inadequate storage conditions.

The use of corticosteroids, non-steroidal anti-inflammatory medicines (NSAIDs), or other medications to increase effectiveness is known as synthetic adulteration.

Regulatory Aspects of Herbal Medicine

1. Global Regulatory Frameworks

• **World Health Organization (WHO) Guidelines**: Offers global benchmarks for the efficacy, safety, and quality of herbal medicines.

• **US Food and Drug Administration (FDA):** Post-market monitoring is used to regulate herbal products under the Dietary Supplement Health and Education Act (DSHEA).

• **European Medicines Agency (EMA):** Herbal medicines must have proof of traditional usage and scientific confirmation.

• **China, India, and Japan:** Safety precautions particular to each nation are provided by the AYUSH (India), Pharmacopoeia of China, and Kampo medicine guidelines (Japan) regulations.

2. Standardization and Quality Control

- The uniformity and purity of manufacturing are guaranteed by Good Manufacturing Practices (GMP).
- Identifying marker chemicals and establishing acceptable limits is known as phytochemical standardization.
- **Toxicology testing**: clinical and preclinical research to provide safety profiles[36,37,38].

CONCLUSION:

In order to improve healthcare worldwide, it is crucial to combine historical knowledge with scientific discoveries, as demonstrated by the comparison of traditional and contemporary herbal therapy. Based on factual knowledge, traditional herbal therapy has been practiced for millennia and has profound roots in indigenous and cultural customs. However, questions concerning safety, effectiveness, and possible toxicity are raised by the absence of standardization, quality control, clinical validation.

In order to guarantee therapeutic consistency, safety, and efficacy, modern herbal medicine integrates phytochemical analysis, sophisticated formulation techniques, and stringent clinical trials. The global acceptance and legitimacy of herbal medicines have been greatly enhanced by the standardization of herbal formulations, Good Manufacturing Practices (GMP), and regulatory frameworks. Despite these developments, issues such as herb-drug interactions, contamination, and adulteration still continue, needing continual study and regulatory control.

There is a lot of potential for holistic, patient- centred therapy alternatives when herbal medicine is combined with traditional healthcare. In order to guarantee safety, effectiveness, and international uniformity, regulatory agencies such as the FDA, EMA, and WHO are essential. To close the gap between ethnopharmacological knowledge and contemporary medicine, cooperation between scientists, medical professionals, and traditional practitioners is crucial.

Looking ahead, biotechnological developments, the use of artificial intelligence in medication discovery, and customized herbal formulations are key components of herbal medicine's future. A complete, evidence-based healthcare system that puts efficacy, safety, and accessibility first will be made possible by a coordinated strategy that blends conventional knowledge with scientific confirmation.

ACKNOWLEDGEMENT:

I'm very thankful to Department of Pharmacognosy. The Tamil Nadu Dr.M.G.R Medical University, Swamy Vivekanandha College of Pharmacy. I would also like to thank the Management, for providing the necessary facilities to carry out this work.

CONFLICT OF INTEREST:

We declare that we have no conflict of interest.

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