

Review: Ethnopharmacology: Bridging Traditional Knowledge and Modern Science

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ABSTRACT

Ethnopharmacology, derived from the Greek words "ethno" (people, nation, tribe) and "pharmacology" (study of drugs), examines how human societies utilize natural resources such as plants, fungi, animals, and minerals for medicinal purposes. This field bridges traditional herbal knowledge with modern pharmacological science, aiming to integrate ancient wisdom with contemporary research methods. Ethnopharmacology seeks to document traditional medicine practices, understand cultural uses of natural remedies, and identify potential pharmaceuticals from these sources. It emphasizes ethical use, fair rewards for communities, and integration with modern healthcare. With historical roots in Central and Eastern Europe, and influences from Greek and Roman cultures, ethnopharmacology continues to explore the potential for improving global healthcare by linking traditional wisdom with modern science. This review offers a snapshot of the field's achievements and future directions.

Keywords- Ethnopharmacology, Traditional Knowledge, Modern Science, Therapeutic properties, Future Paths.

I. INTRODUCTION

Traditional medicine incorporates plants, animal parts, minerals, spiritual therapies, techniques, and physical exercises to cure, diagnose, and prevent ailments and preserve total health [1]. More than 80% of the world's population in over 170 of WHO's 194 Member States currently use some form of traditional medicine, such as herbal medicine, yoga, Ayurveda, acupuncture and acupressure, and indigenous therapies [2]. Integration of Traditional and Modern Medicine The fusion of traditional and modern medicine might have three different meanings [3]. First, it might involve incorporating traditional medicine into the traditional health-care system [4]. The individual recognizes the practice of traditional medicine, and its use is integrated into the mainstream of the health-care system [5].

Traditional medicine has long been a part of the Region's organizational health-care system, although in various forms [6]. Second, it might indicate the combination of ancient and modern medical practices [7]. In fact, numerous medical doctors who are well-versed in traditional medicine have attempted to incorporate traditional medicine therapies into their daily practice [8]. In some regions, traditional and contemporary medicine exist together [9]. Studies have also found that many patients rely on both traditional and modern therapy [10]. Third, it might indicate the blending of traditional and modern medicine in their own fields of medical study [11]. Although traditional and modern medicines emerged in different cultural contexts and are at various stages of scientific development, they have many characteristics [12]. Efforts have been made to incorporate the two fields to develop a new branch of

medical science that incorporates elements through both [13].

Ethnopharmacology contributed to find and evaluate many pharmaceuticals derived from traditional therapies [14]. There are diverse range of drugs and therapeutic compounds that have been discovered or obtained through ethnopharmacological research, highlighting the valuable contributions of traditional medicine to modern healthcare in [Table1]. The most recent developments in extraction methods have allowed

for the review of conventional knowledge, the recognition of plant extract chemical components, identification of "active compounds," and development of new medications. These technologies include semi-bionic extraction, supercritical fluid extraction, microwave, ultrasonic, and enzyme-assisted extraction, molecular distillation, membrane separation, and advanced instrumentation such as HPLC-MS, LC-MS, GC-MS, NMR, and crystallography [15].

Table 1: Diverse range of drugs and therapeutic compounds that have been discovered or obtained through ethnopharmacological research.

Sr. No	Name of Herb	Latin Name	Derived /Origin	Treatment
1	Artemisinin	Artemisia annua	Artemisia plant	Malaria
2	Quinine	Cinchona officinalis	Bark of cinchona tree	Malaria and Babesiosis
3	Vinblastine	Vinblastinum	Madagascar periwinkle plant	Cancer including leukemia
4	Morphine	Papaver somniferum	Opium poppy	Pain reliever
5	Aspirin	Acidum acetylsalicylicum	Bark of willow tree	Pain reliever
6	Paclitaxel	Taxus brevifolia	Pacific yew tree	Cancer like breast, lungs
7	Quercetin	Quercetinum	Plants like onions, apples	Cardiovascular and Cancer
8	Curcumin	Curcuma longa	Turmeric plant	Antioxidant
9	Ginsenosides	Panax ginseng	Ginseng roots	Improve cognitive functions
10	Echinacea	Echinacea purpurea	Echinacea plant	Boost immune system

II. ROLE OF ARTIFICIAL INTELLIGENCE (AI) IN ETHNOPHARMACOLOGY

Ethnopharmacology, or the interdisciplinary study of traditional medicines in their cultural contexts, occurs at which is the intersection of traditional knowledge and modern science. As the field of study develops, artificial intelligence (AI) emerges as a potent tool, transforming numerous parts of ethnopharmacological research [16]. When it comes to discovering and obtaining information and resources relevant to their scientific field, ethnopharmacologists face a number of obstacles [17]. The volume of sources that must be watched, the range of formats used, and the varying quality of language use across sources all create "big data" issues in data analysis. The purpose of this study is to determine what and how artificial intelligence can effectively support specialists in the work of conducting ethnopharmacological literary works research [18]. One of the most difficult challenges with ethnopharmacology is bridging ancient medical practices with modern healthcare systems [19]. AI can help by connecting and evaluating traditional knowledge against current scientific findings [20]. AI techniques might help to build comprehensive databases that connect ancient cures to their scientifically proved effects, allowing

healthcare doctors to make more educated judgments about adopting traditional medicines into current medical practice [21]. Also, with the help of AI we can build a medicinal plant database for preserving Ethnopharmacological Knowledge [22].

III. METHODOLOGY IN ETHNOPHARMACOLOGY

This interdisciplinary methodology combines ethnographic, botanical, chemical, and pharmacological methods to explore and understand the use of natural substances in traditional medicine like bioassay, ethnographic method, Anthropological methods etc. [23]. Anthropology's unique contributions are the conceptual and practical resources that enable for in-depth ethnography of plant use that correlates with laboratory and clinical examinations of plant elements and activities. This contributes to ethnopharmacology by connecting bioscientific research to traditional empirical knowledge [24]. In Bioassay method fractionation according to bioassays was held in which the dried whole extract was fractionated with increasing polarity solvents until the metabolites were exhausted [25].

Four phases were created (hexane, dichloromethane, ethyl acetate, and n-butanol). The solvent was extracted from the obtained samples using a rotary evaporator (IKA-Werke, Germany). The yield of

dried phases was calculated after they were kept at 4 degrees Celsius. A sample from each phase was re-dissolved in ethanol, and qualitative tests for tannins (gelatin and ferric chloride) and flavonoids (Shinoda) were performed [26,27]. Phases that tested positive were then examined for antibacterial efficacy and cytotoxicity [28]. Where antibacterial activity was detected, a column chromatography separation was performed to elucidate the structure and identify the present chemicals. In column chromatography, methanol was employed as mobile phase and Sephadex as stationary phase [29]. The eluates were pooled based on their thin layer chromatography performance, and the spots were seen using ultraviolet light at 254 and 365 nm (TE-540, Tecna, Brazil) and iodine vapors [30].

Isolated compounds were studied using infrared (IR) spectroscopy, optical rotation, mass spectrometry, and ¹H and ¹³C nuclear magnetic resonance (NMR), either uni- or bi-dimensional. IR spectra were obtained in potassium bromide (KBr) at a ratio of 0.5 mg sample to 100 mg KBr (FTIR-8400S, Shimadzu, Japan). Varian NMR Systems (USA) used a spectrometer at 500 MHz (¹H) and 125 MHz (¹³C) to record uni- or bi-dimensional ¹H and ¹³C NMR spectra. Solvents used included deuterated pyridine (Pyridine-D₅, CIL, Cambridge Isotope Laboratories, Inc.) and deuterated dimethyl sulfoxide (DMSO-D₆, CIL, Cambridge Isotope Laboratories, Inc.).

Mass spectra were acquired by direct injection into an LC-MS (amaZonX, Bruker, USA) with an electrospray ionization mode and a mass range of 70 to 1000 m/z. The mass spectra of samples were compared to those took place in the National Institute of Standards and Technology's LC-MS database (Wiley 275), as well as data published in the literature. This optical rotation values [α]_D of pure molecules in methanol (1 mg/mL) have been measured using a P-2000 polarimeter (Jasco, Japan) at 589 nm. Of the isolated compounds, the primary component was tested using the same technique (activity/toxicity) as the entire extract or stages. The primary distinction was the concentration used in the diffusion disk method, which was 20 mg/mL compared to 100 mg/mL [31].

Ethnopharmacology serves as a critical link between ancient medicinal knowledge and modern scientific innovation. For the industry, particularly in pharmaceuticals, nutraceuticals, and cosmetics, this field offers a wealth of opportunities to discover and develop new products. Here's an in-depth look at how ethnopharmacology bridges traditional knowledge and modern science from an industry perspective [32]. Technological advancements are revolutionizing ethnopharmacology by integrating traditional knowledge with cutting-edge science.

This synergy not only preserves and validates ancient practices but also drives innovation in drug discovery and personalized medicine [33]. Advanced digital databases and bioinformatics tools facilitate the

systematic collection, storage, and analysis of ethnopharmacological data. Examples include the Traditional Knowledge Digital Library (TKDL) and various ethnobotanical databases [34]. Geographic Information Systems (GIS) technology helps in mapping and analyzing the geographical distribution of medicinal plants and traditional practices, providing insights into regional biodiversity and conservation status [34].

IV. DATABASES AND TECHNOLOGICAL ADVANCEMENTS

1. **Ethnobotanical Databases:** Digital databases compile traditional knowledge about medicinal plants, including their uses, preparation methods, and observed effects. These databases facilitate the sharing of information between researchers and help preserve indigenous knowledge. Examples include the Traditional Knowledge Digital Library (TKDL) and the NAPRALERT database [35].
2. **CRISPR and Genetic Engineering:** CRISPR technology allows for precise editing of the genomes of medicinal plants and microorganisms. This can be used to enhance the production of desirable compounds or to produce new compounds with improved therapeutic properties [36].
3. **Genomics and Bioinformatics:** Advances in genomics and bioinformatics have enabled researchers to analyze the genetic makeup of medicinal plants and microorganisms. Techniques like next-generation sequencing (NGS) allow for the identification of active compounds and their biosynthetic pathways. Bioinformatics tools help in managing and interpreting vast amounts of genetic data, leading to a better understanding of the genetic basis of traditional medicines [37].
4. **Metabolomics:** This technology involves the comprehensive study of metabolites in biological systems. By using techniques like mass spectrometry (MS) and nuclear magnetic resonance (NMR) spectroscopy, researchers can profile the metabolites in medicinal plants and understand their effects on the human body. Metabolomics provides insights into the chemical diversity of traditional medicines and their mechanisms of action [38].
5. **High-Throughput Screening (HTS):** HTS technologies enable the rapid testing of thousands of natural compounds for biological activity. Automated systems can screen large libraries of extracts and compounds to identify those with potential therapeutic effects. This accelerates the discovery of new drugs from traditional medicinal sources [39].
6. **Computational Chemistry and Molecular Docking:** These techniques allow researchers to simulate the interaction between bioactive compounds and target proteins. Molecular docking studies help predict the binding affinity and efficacy

of natural compounds, guiding the development of new drugs based on traditional medicine [40].

7. **Nanotechnology:** Nanotechnology is being used to improve the delivery and efficacy of natural products. Nanoformulations can enhance the bioavailability and stability of medicinal compounds, making them more effective. For example, nanoparticles can be designed to target specific tissues or cells, reducing side effects and increasing therapeutic benefits [41].

V. CONCLUSION

To summarize, the convergence of traditional knowledge with modern scientific advances in ethnopharmacology marks a historic moment, bringing in a new era of healthcare innovation and cultural preservation. We are not only discovering the scientific basis of traditional medicines using sophisticated technologies such as genomics, metabolomics, and artificial intelligence, but we are also appreciating and valuing indigenous people's wisdom. Ethnopharmacology also enables us to discover the collective wisdom of previous and present generations, opening the way for a more inclusive, sustainable, and culturally sensitive approach to healing. By accepting this link between tradition and innovation, we embark on a journey of comprehensive well-being for both people and ecology.

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