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Short Commentary

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Roadmap for drug discovery from medicinal plants

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Abstract

The discovery of new drugs from medicinal plants offers potential therapeutic solutions for complex diseases, leveraging bioactive compounds derived from traditional knowledge. This road map follows a systematic approach for drug development, starting from the collection and authentication of medicinal plants and progressing through drying, extraction, physicochemical characterization, in vitro and in vivo evaluation, formulation, approval and marketing. This pipeline underlines the steps of discovering modern medicines from traditionally used medicinal plants with modern drug discovery methods, providing a model for developing cost-effective, accessible treatments.

Keywords: Drug discovery; Medicinal plants; In vitro studies; In vivo study; Cytotoxicity.

Introduction

A roadmap for drug discovery from medicinal plants involves a systematic approach to identifying, isolating, and developing bioactive compounds with therapeutic potential. The process starts with ethnobotanical surveys and literature reviews to identify plants with historical medicinal uses [1]. Phytochemical screening follows, involving extraction, isolation, and identification of chemical constituents. Techniques such as chromatography and mass spectrometry are employed to separate and analyze bioactive compounds [2]. In vitro and in vivo testing assess the pharmacological effects, safety, and toxicity of these compounds [3].

Lead optimization is the next stage, where promising compounds are modified to improve efficacy and reduce side effects. This stage involves Structure-Activity Relationship (SAR) studies and computational models to refine drug candidates [4]. Subsequently, preclinical studies are conducted to further evaluate efficacy and safety, before clinical trials in human subjects are pursued. Ultimately, successful compounds progress to regulatory approval processes [5]. This roadmap illustrates the integration of traditional knowledge with modern scientific methods in developing new drugs from medicinal plants.

Major steps of drug discovery from medicinal plants

The drug discovery process from medicinal plants is an intricate and multi-step approach involving initial plant collection, detailed compound extraction, and in-depth evaluation of pharmacological activity. Below is a structured approach to each stage (Figure 1).

Collection of medicinal plants

Objective: To obtain plant materials traditionally known for therapeutic properties.

Process: Medicinal plants are collected from regions where they naturally occur, often guided by ethnobotanical surveys. Knowledge from indigenous communities is essential for selecting species with potential pharmacological value.

Documentation: Location, season, part of the plant collected, and environmental conditions are carefully recorded to

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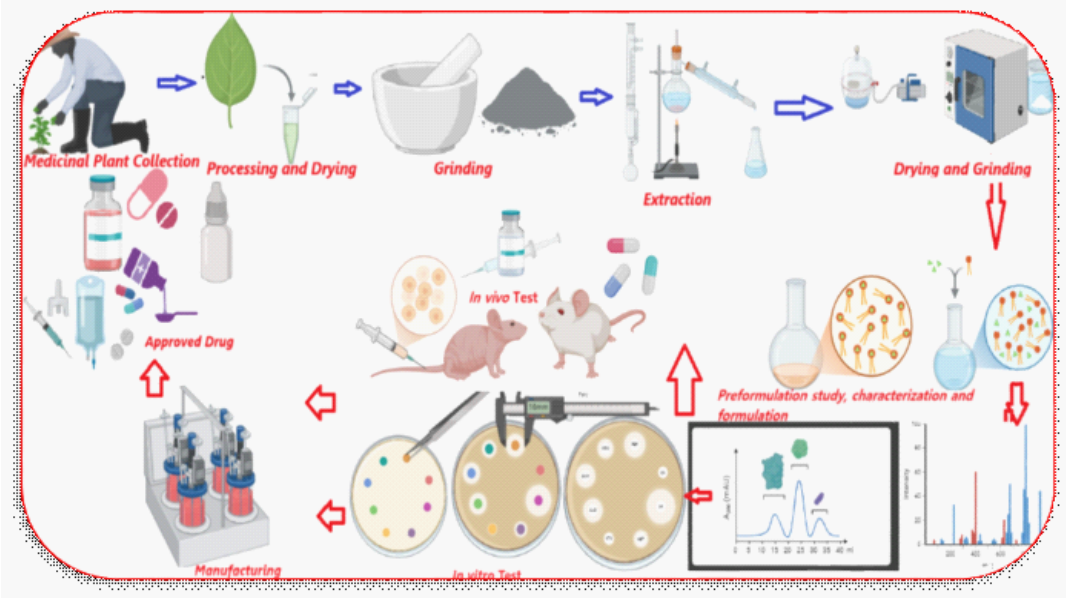

Figure 1: Major steps of drug discovery from medicinal plants.

maintain consistency in sourcing raw materials. Ethnobotanical knowledge has frequently provided leads in drug discovery, particularly in anti-inflammatory and antimicrobial research.

Nomenclature and authentication

Objective: To accurately identify and authenticate plant species.

Process: Botanical experts use morphological and anatomical features to classify plants and confirm scientific names based on international nomenclature standards. Authentication may include DNA barcoding for molecular verification.

Importance: Proper identification ensures reproducibility in research and avoids toxic misidentifications. Accurate taxonomic identification is crucial in avoiding research inconsistencies and ensuring reproducibility [6].

Drying and grinding

Objective: To prepare plant material for extraction by reducing moisture and increasing surface area.

Process: Fresh plant materials are dried under controlled conditions to prevent degradation of active compounds. After drying, the plant material is ground into a fine powder, which facilitates efficient extraction of bioactive compounds. Drying methods affect the concentration of phytochemicals, making controlled drying essential [5].

Extraction of active compounds

Objective: To isolate bioactive constituents from plant materials.

Process: Various solvents (e.g., water, ethanol) are used in techniques like maceration, Soxhlet extraction, and ultrasound-assisted extraction to obtain crude extracts. Fractionation and chromatography may further separate individual compounds.

Outcome: Extracts are prepared for pharmacological testing, and each solvent type targets different compound groups. Extraction techniques significantly impact the bioactivity of the obtained compounds [7].

Physicochemical characterization

Objective: To characterize the chemical structure and physical properties of isolated compounds.

Process: Analytical techniques like HPLC, GC-MS, NMR, and IR spectroscopy help identify and characterize the structure, purity, and stability of bioactive compounds.

Importance: Characterization confirms compound identity and purity, critical for both in vitro and in vivo studies. Physicochemical profiling is essential to assess bioavailability and pharmacodynamics [8].

Drug formulation

Objective: To create a stable, bioavailable, and effective formulation of the drug.

Process: Bioactive compounds are formulated into appropriate drug delivery systems, such as tablets, capsules, or nanoparticles. Stability testing under various environmental conditions ensures the formulation's shelf life and efficacy.

Outcome: Optimized formulations enhance the therapeutic effects of the bioactive compound while maintaining stability. Formulation development is a key step to ensure bioavailability and therapeutic efficacy in clinical applications [9].

***In Vitro* efficacy and safety study**

Objective: To evaluate the bioactivity and cytotoxicity of compounds on cell lines.

Process: Cell-based assays, including MTT and apoptosis assays, measure the compound's effects on cancer, microbial, or immune cells, while toxicity assays help gauge potential side effects.

Importance: In vitro testing is a preliminary yet essential step for identifying safe and effective concentrations for animal

studies. In vitro studies offer rapid, cost-effective insights into drug potential, enabling the prediction of therapeutic effects [10].

***In Vivo* efficacy and toxicology study**

Objective: To assess therapeutic effects, pharmacokinetics, and safety in animal models.

Process: Animal models are treated with the formulation to observe therapeutic effects (e.g., tumor reduction, antimicrobial action). Pharmacokinetic studies track absorption, distribution, metabolism, and excretion (ADME) profiles, and toxicology studies determine the safety of the dosage.

Outcome: These studies inform effective dosing, potential side effects, and the formulation's overall safety profile. In vivo studies are critical in translating in vitro results to potential clinical use [11].

Manufacturing process

Objective: To scale up the production of the drug for larger testing and commercial use.

Process: Good Manufacturing Practice (GMP) guidelines are followed to produce batches under strict quality control. Scale-up involves validating the formulation process, ensuring consistency across larger production batches.

Outcome: Scaled production ensures that the formulation can be mass-produced while meeting regulatory quality standards.

Example Source: GMP compliance is essential in maintaining product integrity and meeting regulatory requirements [12].

Regulatory approval and clinical trials

Objective: To secure regulatory approval and conduct human trials.

Process: After passing animal studies, an Investigational New Drug (IND) application is filed. Clinical trials (Phase I, II, and III) assess safety, efficacy, and optimal dosing in humans, followed by submission for regulatory approval (e.g., FDA, EMA).

Outcome: Successful trials and regulatory review result in drug approval for market distribution. Regulatory approval requires rigorous validation of safety and efficacy through structured clinical trials.

Marketing and post-marketing surveillance

Objective: To launch the drug and monitor its performance in the general population.

Process: After regulatory approval, the drug is marketed to healthcare providers and patients. Post-marketing surveillance tracks long-term effects, adverse events, and real-world efficacy, providing valuable feedback for future improvements.

Outcome: Continuous monitoring maintains patient safety and enhances product development based on real-world data. Post-marketing surveillance plays a vital role in confirming long-term drug safety and efficacy.

Conclusion

This road map presents a structured approach to drug discovery from medicinal plants, emphasizing each phase from plant collection through drug approval and marketing. It presented detailed steps of drug discovery from medicinal plants which is plant-based drug development.

Declarations

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Data availability: We confirm that the data supporting the findings are available in the manuscript or from the corresponding authors upon reasonable request.

We affirm that this manuscript represents valid work and that all authors are accountable for its content.

Consent for publication: We, the above listed author, hereby provide our consent for the inclusion of our personal details, images, within this manuscript submitted by Balisa Mosisa for publication in this journal. We understand that these details may include personal information, photographs, and/or medical data that may directly or indirectly identify us. We confirm that:

1. We have read and understood the manuscript.

2. We are aware that the manuscript may be publicly available as part of a scientific or medical journal accessible worldwide.

3. We are aware that once published, my consent cannot be withdrawn.

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