

# A Review of Herbal Technology

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**Abstract- Herbal Drug Development Plant Selection and Identification** The first step is identifying a plant with potential medicinal properties. Ethnobotanical surveys, historical use, and scientific literature guide this process. **Extraction and Isolation of Active Constituents** Different extraction methods (e.g., solvent extraction, steam distillation, supercritical fluid extraction) are employed to isolate the active ingredients from plant material. Techniques like chromatography and spectroscopy are used to identify and purify these compounds. **Standardization** Standardization ensures that a herbal product contains a consistent amount of active compounds in each batch. This is crucial for reproducibility and efficacy. **Preclinical Studies** Laboratory testing on animals and in vitro models to assess the biological activity, toxicity, and pharmacokinetics of the herbal product. **Clinical Trials** Human trials are conducted to evaluate the safety, efficacy, and dosage of the herbal drug. **Technological Approaches in Herbal Drug Development** **Extraction Techniques** **Solvent Extraction** The most common method, where solvents like ethanol or water are used to extract bioactive compounds. **Supercritical Fluid Extraction (SFE)** Uses supercritical CO<sub>2</sub> as a solvent, offering a cleaner and more efficient extraction method. **Microwave-Assisted Extraction (MAE)** Uses microwave energy to enhance the efficiency of the extraction process. **Ultrasonic Extraction** Utilizes high-frequency sound waves to enhance solvent penetration and compound release. **Formulation Development** Herbal products may be formulated into various forms

**Index Terms-** Herbal Dugs Porcessing Technology Quality Control

## I. INTRODUCTION

Herbal Drug Technology is an interdisciplinary field that merges traditional herbal medicine, pharmacognosy, and modern pharmaceutical technology. It focuses on the study, development, and formulation of plant-based drugs, including their bioactive compounds, therapeutic potential, and methods of application. With the increasing demand for natural health solutions and the growing recognition of the efficacy of plant-derived remedies, this field plays a crucial role in advancing herbal medicine as a legitimate part of contemporary healthcare.[1]

## II. HERBAL MEDICINE

Herbal medicine, also referred to as phytotherapy, involves using plant-based materials and extracts for medicinal purposes. These plant-derived treatments have a long history, spanning various cultures worldwide, and have gained increasing recognition as natural therapeutic options.

Herbal medicines can be categorized into three types:

- **Crude Drugs:** These consist of whole plant parts or dried materials from the plant.

- **Herbal Extracts:** These are concentrated preparations that isolate the active compounds from plants.
- **Formulations:** These are finished products made from single or multiple plant extracts, sometimes combined with other substances.[2]

### Core Concepts

- **Phytochemistry:** This is the study of plant chemicals, particularly those that are biologically active and responsible for their therapeutic properties.
- **Pharmacognosy:** This branch of pharmacology focuses on the study of natural substances, especially plant-derived drugs, their properties, and their uses.

### Phytochemical Components in Herbal Medicines

Plants contain a variety of chemical compounds, many of which have medicinal effects. These compounds are typically categorized into several groups:

- **Alkaloids:** Nitrogen-containing compounds known for their pharmacological activity (e.g., morphine, caffeine).
- **Flavonoids:** A group of polyphenolic compounds with antioxidant and anti-inflammatory properties (e.g., quercetin, catechins).

- **Terpenoids:** A large family of organic compounds, including volatile oils and cannabinoids (e.g., menthol, cannabis compounds).
- **Glycosides:** Compounds where a sugar molecule is attached to a non-sugar component (e.g., saponins, cardiac glycosides).
- **Phenolics and Tannins:** These substances have antioxidant and anti-inflammatory effects (e.g., curcumin in turmeric, tannins in tea).
- **Essential Oils:** Volatile aromatic compounds typically extracted by steam distillation (e.g., lavender, eucalyptus).[3]

These compounds work together, often synergistically, to produce the therapeutic effects of herbal medicines.

### Herbal Drug Development Process Plant Selection and Authentication

The process begins with selecting appropriate plants, guided by traditional knowledge or scientific research. Authenticating the plant species is critical and may involve examining morphological features, using DNA barcoding, or conducting chemical profiling to confirm the plant's identity.[4]

### Extraction and Isolation

After selecting the plant material (leaves, roots, flowers, etc.), the active compounds are extracted using various methods:

- **Solvent Extraction:** Using solvents such as ethanol, methanol, or water.
- **Steam Distillation:** Primarily used for extracting essential oils.
- **Supercritical Fluid Extraction (SFE):** Involves using carbon dioxide at high pressure as a solvent.
- **Cold Pressing:** Often used to extract oils from seeds.

The aim is to concentrate and isolate the bioactive compounds, which can then be further processed.[5]

### Standardization

Standardization ensures that each batch of a herbal product contains the same concentration of active ingredients. Techniques such as High-Performance Liquid Chromatography (HPLC) or Gas Chromatography (GC) are used to quantify these compounds. Pharmacological testing is also essential to confirm the therapeutic efficacy of the extract.

### Formulation Development

Formulation is the process of creating a finished herbal product. This involves designing suitable forms for the delivery of the active ingredients, which may include:

- Tablets and capsules for powdered extracts.
- Syrups and tinctures for liquid extracts.
- Topical creams, gels, or ointments for skin applications.

- Teas or infusions for oral use.[6]

Formulation also involves considering factors like bioavailability (how well the body absorbs the active ingredients), stability, and ease of use.

### Quality Control and Testing

To ensure the safety and efficacy of herbal medicines, quality control is essential. This includes a variety of tests:

- **Purity and Potency Testing:** Ensuring the herbal product contains the correct concentration of active compounds.
- **Microbial Testing:** Checking for harmful microorganisms.
- **Heavy Metal Testing:** Ensuring there are no toxic metals like lead, arsenic, or mercury in the product.
- **Stability Testing:** Confirming that the product retains its effectiveness over time.
- **Safety and Toxicity Testing:** Both in vitro (laboratory) and in vivo (animal) studies are conducted to ensure the product does not cause harm.[7]

### Regulatory Aspects

Herbal medicines are subject to regulation in most countries, although the regulatory frameworks vary. For instance:

- **Good Manufacturing Practices (GMP):** Ensures that herbal medicines are produced in a consistent and safe manner.
- **Product Labeling and Claims:** Regulations prevent companies from making unsubstantiated claims about the medicinal properties of their products. Clear labeling is required.
- **Clinical Trials:** Many herbal products undergo clinical trials to assess their safety and efficacy. However, the standards for herbal medicines are often less stringent than for conventional pharmaceutical drugs.[8]

Regulatory bodies such as the FDA in the United States, the EMA in Europe, and the TGA in Australia all have guidelines for the approval and monitoring of herbal products.

### Pharmacovigilance and Safety of Herbal Medicines

Despite their natural origin, herbal medicines can cause side effects or interact with conventional medications. Pharmacovigilance is the practice of monitoring the safety of herbal medicines post-market to detect any adverse effects or interactions.[9]

Some safety concerns include

- **Herb-drug Interactions:** Certain herbal ingredients can influence the metabolism of pharmaceuticals, potentially leading to harmful interactions.
- **Toxicity:** Some plants contain naturally occurring toxic compounds (e.g., Aconitum species).[10]

- **Adulteration:** The addition of synthetic substances to herbal products to increase efficacy or reduce costs can pose safety risks.

### Emerging Trends in Herbal Drug Technology

The field of herbal drug technology is evolving rapidly, with several key trends shaping its future:

- **Biotechnology:** Genetic modifications of plants to increase the production of specific therapeutic compounds (e.g., overproduction of alkaloids).
- **Nanotechnology:** The use of nanocarriers like liposomes or nanoparticles to enhance the bioavailability and controlled release of active ingredients.[11]
- **Personalized Medicine:** Tailoring herbal treatments to an individual's genetic profile or health needs.
- **Herbal Genomics:** Advancements in genomic tools allow for a deeper understanding of plant genetics, helping to optimize the development of herbal medicines.

Herbal Drug Technology is an ever-expanding field that blends traditional plant knowledge with modern scientific techniques. It plays a pivotal role in developing effective, safe, and standardized herbal medicines. As global interest in natural remedies continues to rise, the need for rigorous scientific validation, robust regulatory frameworks, and quality control will become even more critical to ensure that herbal medicines are both effective and safe for widespread use.[12]

The Herbal Drug Manufacturing Industry plays a critical role in global healthcare, producing plant-based medicines and supplements. With the increasing demand for natural remedies, it is essential for manufacturers to follow stringent regulations to ensure that herbal products are safe, effective, and consistently of high quality. These guidelines govern various stages of the production process, from raw material sourcing to packaging, labeling, and post-market surveillance. Below is an in-depth overview of key guidelines and best practices in the herbal drug manufacturing industry.[13]

### Regulatory Frameworks for Herbal Drug Manufacturing

Regulatory bodies in different regions set the standards for herbal drug manufacturing. Their goal is to ensure that products are safe, of high quality, and effective, while safeguarding consumers from substandard or contaminated products.

### Good Manufacturing Practices (GMP)

GMP is a critical aspect of any pharmaceutical and herbal drug manufacturing process. It ensures that products are consistently produced and controlled to quality standards throughout every step of the production cycle.

### GMP Guidelines

- **Facility Standards:** The manufacturing facility must be clean, organized, and well-maintained. It should be designed to prevent cross-contamination between herbal products and other substances.
- **Raw Material Authentication:** Manufacturers must use only verified, high-quality raw materials. Documentation from suppliers, such as certificates of origin and quality, must accompany each batch of raw herbs.
- **Process Control:** All stages of production should be controlled with clearly defined parameters (e.g., temperature, humidity, and time) to maintain product quality.
- **Employee Training:** Personnel must be well-trained in GMP principles, including hygiene practices, proper handling of materials, and equipment maintenance.[14]

### International and National Regulatory Authorities

Several organizations regulate herbal medicines, ensuring their safety and efficacy:

- **World Health Organization (WHO):** WHO provides international guidelines for traditional medicine, including quality, safety, and efficacy standards for herbal products.
- **U.S. Food and Drug Administration (FDA):** The FDA regulates herbal products under the Dietary Supplement Health and Education Act (DSHEA). The FDA also enforces Current Good Manufacturing Practice (CGMP) regulations for dietary supplements.
- **European Medicines Agency (EMA):** In Europe, the EMA oversees herbal medicinal products. The European Pharmacopoeia defines quality standards for herbal medicines used in pharmaceuticals.
- **Therapeutic Goods Administration (TGA):** In Australia, the TGA is responsible for regulating herbal medicines, ensuring that they meet safety and quality standards.

Each of these agencies issues specific guidelines to which manufacturers must adhere, ensuring compliance with regulatory requirements.[15]

### Raw Material Sourcing and Authentication

The quality and authenticity of raw materials are crucial for the production of safe and effective herbal products. The following steps are essential:

### Herb Identification and Authentication

- **Botanical Identification:** Accurate botanical identification is essential to ensure that the correct plant species is used. Methods like morphological identification, DNA barcoding, and chemical profiling are employed for this purpose.

- **Supplier Documentation:** Manufacturers must ensure that raw material suppliers provide valid certificates of authenticity, detailing the origin, cultivation, and quality of the herbs.[16]

#### Quality Assurance of Raw Materials

- **Contaminant Testing:** Raw herbs must be tested for harmful contaminants such as heavy metals (e.g., lead, mercury, arsenic), pesticides, and microbial contaminants (bacteria, fungi).
- **Standardization:** Herbs should be standardized to ensure that they contain consistent levels of active ingredients in each batch. This may involve quantifying key bioactive compounds (e.g., alkaloids, flavonoids, terpenoids).

#### Herbal Drug Production and Processing

The production of herbal medicines involves various processes that ensure the proper extraction and formulation of active ingredients.[17]

#### Extraction and Isolation of Active Ingredients

Several extraction methods are used to isolate bioactive compounds from plant material:

- **Solvent Extraction:** Using solvents like ethanol, methanol, or water to extract active compounds.
- **Supercritical Fluid Extraction (SFE):** Uses supercritical CO<sub>2</sub> to extract sensitive compounds without the need for high temperatures.
- **Cold Pressing:** Used primarily for extracting oils from seeds or fruits.
- **Steam Distillation:** Common for isolating essential oils from aromatic plants.

The choice of extraction method depends on the plant material and the desired bioactive compounds.[1]

#### Formulation Development

Herbal medicines are formulated into various dosage forms, such as:

- **Tablets and Capsules:** Typically for dried herbal extracts or powdered herbs.
- **Syrups and Tinctures:** For liquid herbal extracts.
- **Topical Products:** Creams, ointments, and gels.
- **Teas and Infusions:** For oral consumption of plant material.[2]

Manufacturers must ensure that the formulation is stable, effective, and safe for consumer use. The choice of excipients (inactive ingredients) must be carefully considered to ensure they do not interfere with the bioactivity of the herbal compounds.

#### Standardization of Active Ingredients

Standardization ensures that each batch of herbal drug contains a consistent amount of the active ingredients. High-Performance Liquid Chromatography (HPLC), Gas Chromatography (GC), and Thin-Layer Chromatography (TLC) are modern techniques used to quantify active compounds.

#### Quality Control and Testing

Quality control (QC) is an essential aspect of herbal drug manufacturing. Several tests ensure that the final product is both safe and effective.[3]

#### Purity and Potency Testing

- **Active Ingredient Quantification:** Techniques like HPLC or GC are used to measure the concentration of active compounds.
- **Microbial Testing:** Products must be tested for bacterial, fungal, and yeast contamination to ensure they are free from harmful microorganisms.
- **Heavy Metal Testing:** Herbal products must be tested for toxic metals (e.g., lead, arsenic, mercury) to ensure they are within safe limits.[4]

#### Stability Testing

Herbal products should undergo shelf-life testing to assess their stability under different conditions (e.g., temperature, humidity, light exposure). The packaging material must also protect the product from degradation.[5]

#### Adulteration Testing

Manufacturers must ensure that products are not adulterated with foreign substances. Methods such as chemical analysis and DNA fingerprinting help detect adulteration and ensure the purity of the product.

#### Packaging, Labeling, and Storage

Proper packaging, labeling, and storage are vital to maintain the safety, integrity, and quality of herbal medicines.[6]

#### Packaging

- Packaging materials should be tamper-evident and compatible with the herbal product. They must protect the product from exposure to moisture, light, and air, which could degrade the active ingredients.

#### Labeling

- The product label must provide clear and accurate information, including the product name, ingredients, dosage instructions, expiry date, and batch number. Labels should also specify storage conditions and precautions for safe use.
- Herbal products should not make unverified health claims. Regulatory authorities often require that claims of

therapeutic benefits be substantiated by scientific evidence.[7]

#### Storage

- Herbal products should be stored in cool, dry, and dark environments to prevent degradation of active ingredients. Manufacturers must implement effective inventory management to ensure that products are used within their shelf life.

#### Pharmacovigilance and Post-Market Surveillance

After herbal products are released to the market, manufacturers must continue monitoring their safety and efficacy through pharmacovigilance.

- **Adverse Event Reporting:** Manufacturers must set up systems to track and report any adverse reactions associated with their products.
- **Ongoing Monitoring:** Post-market surveillance is essential for identifying any long-term safety issues, potential herb-drug interactions, or unanticipated adverse effects.

#### Emerging Trends in Herbal Drug Manufacturing

As the herbal drug industry evolves, several innovative trends are shaping the future:

- **Nanotechnology:** Advances in nanotechnology are allowing for the development of nanocarriers that enhance the bioavailability and controlled release of herbal compounds.[8]
- **Biotechnology:** Genetic engineering and other biotechnological advances can enhance the production of specific active ingredients in plants, as well as the development of biopharmaceuticals from plant sources.
- **Sustainability:** There is a growing emphasis on sustainable sourcing of raw materials, ensuring that plants are cultivated responsibly and that natural resources are not over-exploited.

The herbal drug manufacturing industry is governed by a complex set of guidelines and regulations that ensure the safety, quality, and efficacy of herbal products. Manufacturers must adhere to Good Manufacturing Practices (GMP), follow stringent quality control protocols, and ensure the authenticity of raw materials. With the increasing popularity of herbal medicines, adherence to these standards is essential to maintain consumer trust and meet global regulatory requirements.[9]

The future of the herbal drug manufacturing industry will be shaped by technological advancements in biotechnology, nanotechnology, and sustainable practices, along with an ongoing commitment to consumer safety and scientific validation.

The global market for herbal products is expanding rapidly, driven by increasing consumer interest in natural health alternatives and wellness. These products, which include raw herbs, extracts, essential oils, teas, powders, and other plant-based items, are sought for their medicinal, therapeutic, and cosmetic benefits.

#### Global Market

Herbal products are diverse, encompassing goods used in traditional medicine, dietary supplements, and cosmetics. This sector is experiencing growth, fueled by heightened awareness of health, wellness, and the risks associated with synthetic products.

#### Market Segments

- **Herbal Supplements and Medicines:** This includes items such as tablets, capsules, powders, tinctures, and syrups derived from plants. They are commonly used to address specific health concerns like digestion, immune support, and stress relief.
- **Herbal Teas:** Popular herbal teas such as chamomile, mint, ginger, and green tea have strong international demand.
- **Essential Oils:** These are extracted from plants and herbs, widely used in aromatherapy, skincare, and personal care products.[10]
- **Herbal Cosmetics and Skincare:** Herbal ingredients like aloe vera, lavender, turmeric, and neem are increasingly used in beauty and personal care products.
- **Herbal Raw Materials:** Whole herbs and dried plants are frequently traded internationally for further processing or local use.

#### Market Drivers

- **Growing Health Consciousness:** A rise in consumer preference for natural, plant-based alternatives is fueling demand for herbal products.
- **Cultural Traditions:** Many cultures have long histories of using herbs for medicinal or cosmetic purposes, continuing to influence market trends.
- **Regulatory Focus:** Increased interest in these products has led to more stringent regulations to ensure their safety and efficacy.
- **Scientific Validation:** Ongoing research supports the therapeutic benefits of herbs, further boosting consumer trust and adoption.[11]

#### Export and Import Markets

The flow of herbal products between countries is shaped by factors like local regulations, international trade agreements, and consumer demand.

### Leading Exporters of Herbal Products

- **India:** A significant exporter of Ayurvedic products, herbal teas, and essential oils, India supplies both raw herbs and finished goods to markets like the U.S., Europe, the Middle East, and Asia.
- **China:** As a global leader in the production of medicinal plants, China is a key exporter, particularly in the field of traditional Chinese medicine, including herbal formulas.
- **Southeast Asia:** Countries like Indonesia, Malaysia, and Thailand are crucial exporters of raw materials like citronella and patchouli essential oils, and medicinal herbs.
- **Africa:** South Africa and Kenya, for instance, export herbal products such as rooibos tea and other plant-based wellness products.[12]
- **Latin America:** Countries like Brazil, Mexico, and Ecuador are known for herbs like guarana and maca, and other indigenous Amazonian plants.

### Leading Importers of Herbal Products

- **United States:** The U.S. is a major importer of herbal supplements, teas, and essential oils, driven by increasing interest in natural health solutions.
- **Germany:** Known for its herbal medicines, particularly traditional European products, Germany plays a major role in the importation of herbal goods.
- **European Union:** The EU imports a wide variety of herbal products for both pharmaceutical and wellness purposes.
- **Japan:** With its deep-rooted tradition in herbal medicine (notably Kampo), Japan imports large quantities of herbs, teas, and supplements.
- **South Korea:** The growing demand for herbal supplements and cosmetics has made South Korea a key importer, especially from China and Southeast Asia.
- **Middle East:** Countries like Saudi Arabia and the UAE are witnessing increased demand for herbal wellness products due to cultural preferences for traditional medicines.[13]

### Regulatory Considerations

The international trade of herbal products is highly regulated, with rules varying from country to country. Below are some key regulations for major markets:

#### United States

The FDA (Food and Drug Administration) oversees dietary supplements, including herbal products. These products don't require FDA approval before entering the market but must comply with Good Manufacturing Practices (GMP).

- **Herbal Remedies:** They must not make unsubstantiated health claims without FDA approval.[14]

### European Union

The European Medicines Agency (EMA) regulates herbal medicines in the EU. Herbal products can be sold as Traditional Herbal Medicinal Products (THMP) if they have a usage history of at least 30 years, with 15 of those years being within the EU.

Herbal teas, oils, and supplements are governed by food laws, which enforce specific standards for safety, labeling, and quality.

#### India

Ministry of AYUSH (Ayurveda, Yoga, Unani, Siddha, and Homeopathy) governs the production of herbal products in India, setting standards for both domestic use and exports.

The Indian Council of Medical Research (ICMR) helps to research and validate the medicinal efficacy of herbs.

#### China

- The State Administration for Market Regulation (SAMR) oversees the regulation of herbal products, and the Chinese Pharmacopoeia sets official standards for the quality of Chinese herbal medicines.[15]

### Other Countries

- Most countries have specific health or food safety agencies responsible for regulating herbal products. Additionally, products may require certification, such as USDA Organic or EU Organic certifications, especially for organic or sustainably sourced goods.

### Emerging Trends in Global Herbal Trade Sustainability and Ethical Sourcing

- As consumers become more environmentally aware, there is an increasing demand for sustainably sourced herbs. Certification programs like Fair Trade and Rainforest Alliance are gaining traction.
- Ethical sourcing is also a priority, with greater focus on fair labor practices and conservation efforts to protect endangered species of plants.[16]

### Digitalization and E-commerce

- The rise of e-commerce platforms like Amazon, Alibaba, and specialized wellness stores has made it easier for herbal products to reach international markets.
- These digital platforms also enable small-scale producers from developing countries to connect directly with global consumers, bypassing traditional retail channels.

### Innovative Product Development

- The blending of traditional herbal knowledge with modern scientific techniques is driving innovation. For example, herbal-infused beauty products, plant-based

protein supplements, and multifunctional herb blends (e.g., turmeric, ginger, and black pepper combinations) are increasingly popular.[17]

#### Challenges in Herbal Export/Import

- **Quality Control:** Ensuring the quality and purity of herbal products during transportation and throughout the supply chain can be difficult, particularly for perishable raw materials.
- **Counterfeit Products:** The growing trade in herbal products also faces the issue of counterfeit or adulterated goods, which can undermine consumer trust and safety.
- **Regulatory Hurdles:** As governments tighten regulations, herbal exporters and importers may encounter additional compliance costs and potential trade barriers, especially for emerging markets.[18]

### III. CONCLUSION

The global herbal products market continues to grow rapidly, driven by rising demand for natural health alternatives. Countries with rich herbal traditions, like India, China, and Southeast Asia, remain key exporters, while developed markets like the U.S., EU, and Japan continue to be major importers. As consumer interest in sustainable, ethical, and scientifically validated herbal products rises, the market is expected to see more innovations and growth. However, success in the herbal trade requires navigating complex regulatory environments, ensuring product quality, and embracing new trends in e-commerce and sustainability

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