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AN OVERVIEW ON ADVANCED HERBAL TECHNOLOGY

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Abstract: The use of natural products in drug development and research is expanding. Because of the differences in their chemical composition, they can have an impact on several targets simultaneously in a complex system. Over the past ten years, there has been a significant advancement in the technology of natural drugs. The safety of herbal medicines may be clarified by looking into historical traditional medical practices. Now is the time to decide what products made with herbal medicine are safe and effective. herbal medicines regional variation exist in endorsement procedure as well as permitted grade. Global harmonisation is contingent upon the World Health Organisation has established exact strategies intended for assessing the efficacy, security, and calibre of herbs. The progress of science and technology encroaches on herbal remedies. DNA fingerprinting, metabolomics, chemometrics, X-ray diffraction, differential pulse polarography, and other recent developments are noted. Chromatography methods and capillary electrophoresis. There are also reports of contributions made to the standardisation of herbal medicines.

Keywords : herbal remedies. DNA fingerprinting, metabolomics, chemometrics, X-ray diffraction, differential pulse polarography natural drugs

INTRODUCTION:

Herbal medicines have become more and more popular recently because of all of their benefits. Standardisation is an essential step in creating a consistent chemical profile, uniform biological activity, or degree of excellance programme for the production of herbal medications. Herbal medicines were among the first known forms of treatment for humans. People from many cultures have used herbs all over antiquity[1] .The India has some of the richest, primogenital, and greatest assorted societies with ongoing traditions of using medicinal plants. A botanical or based on plant preparation is referred to as "herbal," whereas a drug with nutritional, medicinal, or preventive qualities is referred to as medicine. herbal medicine are referred that the substances derived from plant that have nutritional ,therapeutic,or preventive qualities. An interdisciplinary area within herbal medicine is called herbal remedy and Ayurveda. since it encompasses entire areas of herbal medicine associated with botanical, research on therapeutic plants, phytochemistry, agricultural science, Unani medicine, Ayurveda, natural chemistry, phytochemistry, phytotherapy, and botanical medicines biochemistry and biotechnology. The main problem with modern medicine is that its side effects can endanger patients' lives. Like any other synthetic drug, herbal medicine has a list of side effects. Therefore, assessing their clinical safety and effectiveness is crucial.In recent years, there has been a growing appreciation for the potential of natural products, herbal remedies, and traditional medicines to prevent and treat human ailments. Finished herbal goods are herbal preparations made from one or more plants. In addition Nevertheless, end products or mixture of herbs that include separated herbal elements or active ingredients—such as synthetic compounds—are not recognised as herbal. the active ingredients, end herbal products and herb mergers also contain excipients. Unprocessed plant parts, like leaves, flowers, fruit, seeds, stems, wood, bark, roots, rhizomes, or other plant parts, can be whole, broken up, or ground up to make herbs[2]

Fig no.1 **PLANT IDENTIFICATION:**

Identification of plant is fundamental task and systematics main goals. Classification and nomenclature are both involved in the process of identification, even though it is a distinct activity. Finding the similarities or differences between two elements—that is, whether they are the same or different—is the essence of identification. The process of comparing an unidentified plant specimen with a known specimen and determining that the two components are classification is another aspect of the same; that is, correctly determining that an unknown is a affiliate of the similar collection (class, species, intimate, etc.) as a recognised species, the data kept in organization schemes develops accessible as well as relevant to the given material[3].

Various techniques for identifying plants:

1) **Determination by expert**: it is the utmost dependable and precise method of identification. The expert has characteristically produced actions of the group under question, and the expert's taxonomic concept is included in more recent floras or manuals.

2) **Recognition:** This is predicated by vast previous experience with the appropriate plant group.

3)**The use of similar device and keys**: The most popular approach is by far the use of keys and similar devices, which don't require the knowledge, skills, or time needed for comparison and recognition[4].

AUTHENTIFICATION OF PLANT:

In order to guarantee that the right plant parts and its species are utilised as unprocessed materials for herbal formulation, herb verification is a quality assurance(QA) procedure. For herbal medicines to be safe and effective, proper authentication of their raw materials is essential.

Microscopic: This method makes it possible to thoroughly examine microscopic features. Using a compound microscope, histological analysis is required for this method.it is used to determine the starch ,calcium oxalate crystals ,lignified and non lignified fibers etc[5].

Macrosccopic: Examining entails contrasting metaphors of the herbal or botanic medicine in floras or monographs with morphological traits that are noticeable to the unaided appreciation or at less magnification. Features like size, form, and colour of leaves, flowers, or fruits are examples of often employed in identification by macroscopic means.

Molecular marker: Since DNA-based markers are not impacted by age, environmental variables, or physiological conditions, they are unquestionably higher level markers and superior to other marker systems. This is because DNA-based markers are created by examination of the exclusive inherent assembly. Furthermore, these type of marker found are not tissue specific and found at any phase of plant growth. When testing the authenticity of hundreds of samples at once, DNA-based technology can be more effective, accurate, and affordable than phenotypic and chemical markers because it can be automated. DNA-based medicinal plant authentication will greatly increase the therapeutic potential and financial success of herbal medicines and neutraceuticals by serving as a useful tool for quality control (QC) and protection monitoring[6].

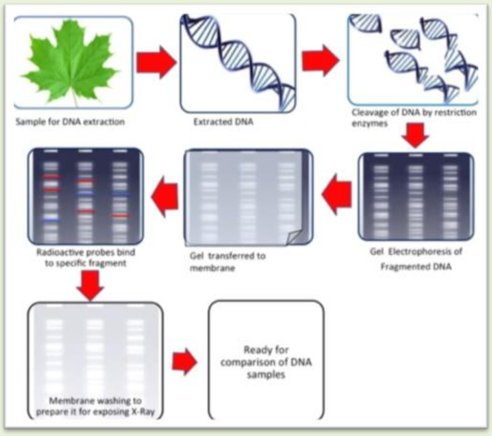

Fig 2: DNA marker (RFLP)

DIFFERENT EXTRACTION METHODS:

1. **Maceration method**: Maceration is a straightforward method used to extract compounds from plant material. In this process, the plant substance is soaked in a chosen solvent, like ethanol or water, over an extended period. During this soaking time, the solvent gradually interacts with the plant material, dissolving and extracting the desired compounds. While maceration is a simple and cost-effective technique, it requires more time compared to some other methods. The slower process, taking days to weeks, allows for a thorough extraction of various compounds, including essential oils and bioactive substances, from plants[7].
2. **Infusion method:** The infusion method is a straightforward way to extract compounds from plant materials. it start by placing finely chopped or crushed plant material in a container. Then, hot water is discharged and the mixture is left to steep for a specific time. The heat helps in drawing out flavors, aromas, and other beneficial compounds from the plants. After steeping, the liquid is separated from the plant material through straining or filtering. This method is commonly used for making herbal teas, capturing flavors, and is particularly gentle, making it suitable for heat-sensitive compounds[8].
3. **Decoction method:** The decoction method is a traditional way to extract compounds from plant material, especially tougher parts like roots or bark. In this process, the plant material is simmered or boiled in water for an extended period. Unlike infusion, decoction involves using low heat for a more prolonged duration, allowing the breakdown of tough cell walls and facilitating the extraction of various compounds into the water. After simmering, the liquid is strained to separate it from the solid plant material. This method is often used for extracting medicinal compounds and flavors from hard or woody plant parts, as it can handle higher temperatures effectively.
4. **Digestion:** In the digestion method for plant extraction, the plant extract is immersed in a liquid like water or alcohol. Unlike quick boiling, this process involves gentle heating over a prolonged period. The slow application of heat during digestion helps break down cell walls, allowing for a thorough extraction of various compounds from the plant into the solvent. After this extended soaking and heating, the liquid is separated from the solid plant material through straining or filtering. This method is commonly used to extract medicinal components, flavors, and aromatic substances from plants, emphasizing a gradual and thorough extraction process[9].

EXTRACTION BY SUPERCRITICAL FLUID:

SFE is method for draw out compounds from plants by utilizing a supercritical fluid, typically carbon dioxide (CO2). In this process, CO2 is pressurized and heated until it reaches a state that combines both liquid and gas properties, forming a supercritical fluid. This fluid is then employed to selectively extract anticipated mixtures from the plant substantial[10].It has advantages such as targeted compound extraction, minimal environmental impact, and the absence of residual solvents in the final product. It finds application in extracting essential oils, flavors, and bioactive compounds from various plants. The supercritical fluid easily permeates plant materials, and by adjusting pressure and temperature, specific compounds can be precisely extracted. While SFE has benefits like selective extraction, its equipment can be expensive, and optimization is crucial for efficiency. Despite these considerations, it remains a favored method in industries dealing with botanical and natural products due to its clean and targeted extraction[11]

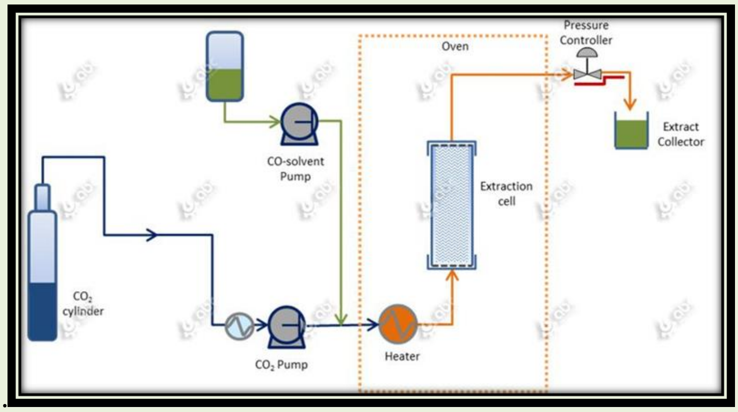

Fig 3 SFE equipment

MICROWAVE ASSISTED EXTRACTION (MAE):

MAE is a technique for extract compounds after plants by utilizing microwave energy to enhance the extraction process. In this method, plant extract is mixed with a various solvent in a sealed flask, and exposure to microwave radiation raises temperature and pressure, aiding in the breakdown of cell walls and facilitating the release of target compounds into the solvent.

MAE offers advantages such as reduced extraction time, improved efficiency, and flexibility with different solvents. It's especially useful for extracting compounds sensitive to heat. Careful control of microwave parameters is crucial to prevent degradation of delicate compounds. MAE applications industries like herbal medicine, food, and natural product extraction[12]medicine, food, and natural product.

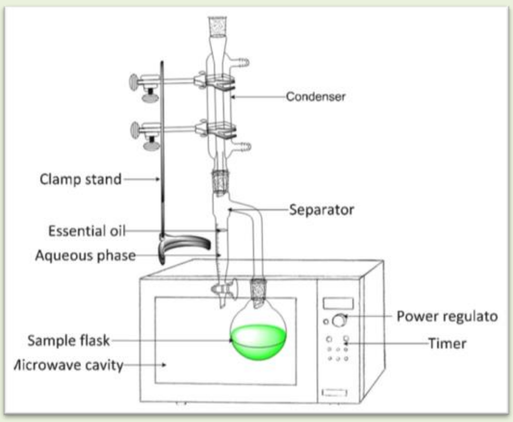

Fig 4 MAE equipment

ULTRASOUND ASSISTED EXTRACTION:

UAE is a technique used to extract compounds from plants by exposing the plant material to ultrasonic waves. In this method, plant material is immersed in a solvent, and ultrasonic waves induce cavitation – the formation and collapse of small bubbles in the solvent. This cavitation process enhances the penetration of the solvent into plant cells, facilitating the release of bioactive compounds. It has benefits such as quicker withdrawal times, yield is higher, and solvent usage is reduced. It has particularly advantageous for extracting compounds sensitive to heat since it operates at lower temperatures.Careful control of ultrasonic parameters is essential to optimize extraction efficiency. UAE is widely applied in industries dealing with herbal extracts, essential oils, and various bioactive compounds due to its effectiveness in extracting a broad spectrum of plant constituents[13].

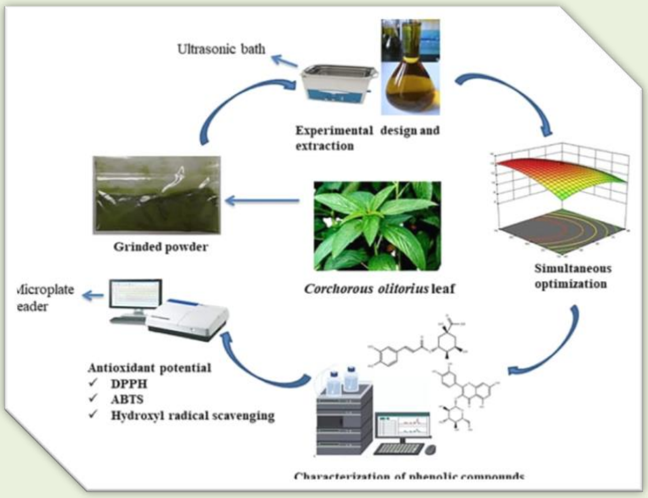

Fig 5 UAE process

ISOLATION AND PURIFICATION TECHNIQUES:

To isolate compounds from plant material, various techniques are commonly employed:

Distillation: Heating helps vaporize volatile compounds, which are then condensed back into liquid form. This is ideal for extracting essential oils.

Extraction: Solvents dissolve and extract specific compounds. Methods include maceration, percolation, or Soxhlet extraction.

Filtration: Separating solid plant material from liquid extracts using techniques like gravity or vacuum filtration.

Crystallization: Allowing dissolved compounds to form crystals for isolation.

Precipitation: Inducing solid particle formation for separation via methods like centrifugation.

Ultrasonication: Enhancing extraction by using ultrasonic waves to promote cavitation and improve solvent penetration into plant cells.These techniques, used alone or in combination, cater to the diverse properties of compounds and plant materials during the isolation process.

Chromatography: Components move through a medium at different rates, allowing separation based on properties like size or polarity.

Chromatographic techniques are instrumental in isolating compounds from plant extracts due to their effectiveness in separating complex mixtures. Here's how these techniques are specifically applied to plant isolation:

High-Performance Liquid Chromatography (HPLC): it is Widely used tecnique it provide precise separation and quantification of various plant compounds, offering high-resolution analysis of substances like phenolics, alkaloids, and flavonoids.

Gas Chromatography (GC): Particularly valuable for volatile compounds, GC is employed to analyze essential oils and other aromatic components in plants.
Preparative Liquid Chromatography: A scaled-up version of HPLC, it enables the isolation of larger quantities of specific plant compounds for further exploration.
Flash Chromatography: Quick purification of compounds on a larger scale, often applied in the early stages of isolation from plant extracts.
Thin-Layer Chromatography (TLC): Useful for rapid and qualitative separation of compounds in plant extracts, especially during the initial screening of extracts.
Column Chromatography: Applied on a larger scale, it involves loading plant extracts onto a column for the separation of compounds based on their different elution rates.
Affinity Chromatography: A technique leveraging specific interactions between biomolecules in plants and ligands on the stationary phase, enabling the separation of specific mixtures[14].

THIN LAYER CHROMATOGRAPHY:

This is an early-stage technique for isolating and analyzing compounds from plant extracts. Here's a simplified explanation:
Application: A small amount of the plant extract is placed as a spot near the base of a thin layer of adsorbent material on a flat surface.
Development: The slide is set in a cavity with a mobile phase or solvent and solvent moves up the plate, carrying plant compounds with it.
Separation: Different compounds in the plant extract move at various rates on the plate due to their interactions with the stationary phase, creating separate spots.
Visualization: After removing the plate, compounds are visualized using methods like UV light or staining, providing distinct spots.
Identification: Calculating the Rf value helps compare and identify compounds based on their travel distances relative to the solvent front.
TLC is a quick and cost-effective method that offers a preliminary analysis of plant extracts, guiding further isolation or purification steps in the study of plant compounds[15].

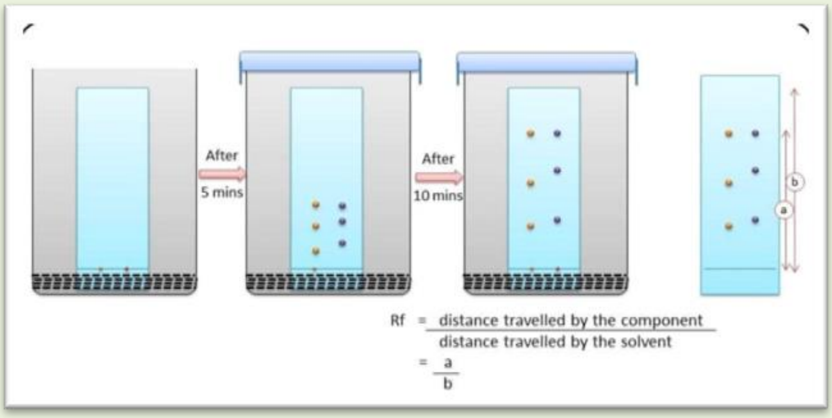

Fig 6:Steps involved in TLC

COLUMN CHROMATOGRAPHY:

Column chromatography is a crucial method for isolating and purifying compounds from plant extracts.The simplified overview of the process:
Column Packing: A column is filled with a stationary phase, like silica gel. The plant extract is carefully added to the top of the column.

Elution: A mobile phase, usually a solvent or a solvent mix, is passed through the column. This mobile phase interacts with plant compounds, causing them to move down the column at different rates based on their affinity for the stationary phase.
Fraction Collection: Different compounds separate as the mobile phase moves through, and fractions are collected at specific intervals.
Analysis: Each fraction is analyzed to identify the presence of specific compounds, often using techniques like TLC or spectroscopy.
Recovery: Fractions containing the desired compounds are combined, and the solvent is evaporated to obtain the purified compound.
Column chromatography is a powerful tool for obtaining purified compounds from plant extracts, making it a standard method in the isolation process. It provides researchers with a refined and concentrated sample for further study or application[16].

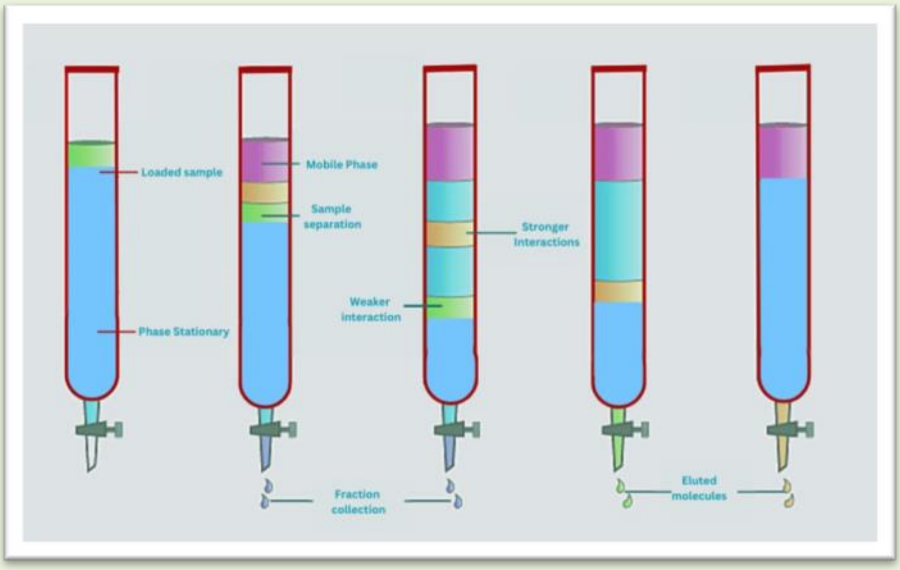

Fig 6 column chromatogaphy

HIGH PERFORMANCE LIQUID CHROMATOGRAPHY:
HPLC is typically employed for analyzing the composition of compounds in plant extracts rather than their isolation. However, by adapting the system for preparative purposes, HPLC can be used to isolate specific compounds on a larger scale.
The simplified explanation:
Setup: Preparative HPLC involves using a modified system with a larger column for separation and a more substantial sample injection.Loading the Sample: The plant extract is injected into the HPLC system, where it traverses a column filled with a stationary phase, causing compounds to separate based on their interactions.
Elution: A mobile phase, usually a solvent or solvent mix, moves through the column, leading to the separation of different compounds.
Collecting Fractions: Fractions containing the target compound are collected as they elute from the column.
Analysis and Purification: Each fraction is analyzed to confirm the presence of the desired compound. Fractions with the target compound are combined, and the solvent is removed to obtain a more concentrated and isolated form of the compound.

While HPLC is primarily known for analysis, its adaptability for preparative purposes makes it valuable for isolating specific compounds from plant extracts, facilitating further research or applications in fields like natural product exploration or drug development[17].

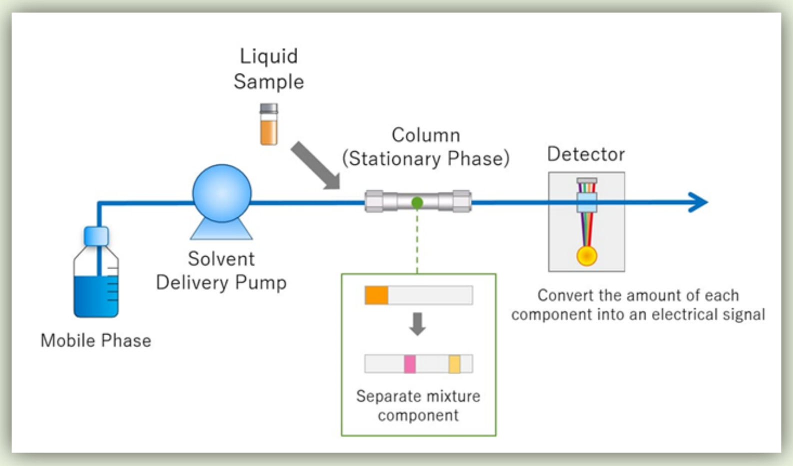

Fig 8: HPLC

HIGH PERFORMANCE THIN LAYER LIQUID CHROMATOGRAPHY:

This is commonly used to analyze the components of plant extracts, but it can be adapted for a semi-preparative approach to isolate specific compounds on a smaller scale. Here's a simplified explanation:
Application: The plant extract is applied as spots on a thin layer of chromatographic material.
Development: The plate is put in a chamber with a solvent system. As the solvent moves up the plate, it separates the compounds in the plant extract.
Visual Inspection: After development, the plate is examined visually to identify spots corresponding to different compounds.
Collection: The areas on the plate corresponding to the target compound are either scraped off or eluted, collecting the material in a suitable solvent.
Concentration: The collected material is concentrated by evaporating the solvent, resulting in a more purified form of the compound.
While HPTLC isn't the primary method for large-scale isolation, it can be a starting point for quick screening or obtaining small amounts of purified compounds for further study. For larger-scale isolation, additional purification steps like column chromatography are typically employed[18]

PURIFICATION TECHNIQUES FOR ISOLATION OF COMPOUND:

After isolating a compound from a plant extract, several purification techniques are commonly employed to enhance its purity. Here's a simplified overview:
Recrystallization: Dissolving the compound in a suitable solvent and allowing it to form purified crystals through cooling or evaporation, effective for impurity removal.
Column Chromatography: Adjusting conditions or elution solvents in the column chromatography setup to further separate and purify the compound.
Flash Chromatography: A quicker version of column chromatography, aiding in rapid separation and purification.
Distillation: Utilizing differences in boiling points to separate and purify the compound through vaporization and condensation.
Crystallization: Inducing the formation of crystals through solvent systems, separating the purified crystals from impurities.

Liquid-Liquid Extraction: Partitioning the compound between two immiscible solvents based on differences in solubility, effectively isolating impurities.

Chromatographic Techniques (HPLC): Using High-Performance Liquid Chromatography not just for analysis but also for final purification, ensuring high resolution and efficiency.

The choice of purification method depends on the compound's characteristics, the impurities present, and the desired purity level. Often, a combination of these techniques is applied sequentially for optimal purification[19].

METHODS FOR STANDARDIZATION OF HERBAL DRUGS:

Standardizing herbal formulations is a vital process aimed at maintaining consistency and quality in herbal products. Here's a simplified breakdown of the key steps involved:

- **Select Quality Raw Materials:**
  - ✓ Choose high-quality herbs or botanicals from reliable sources.
  - ✓ Verify and authenticate raw materials to ensure their identity and quality.
  - ✓ Optimize Extraction and Manufacturing:
  - ✓ Use standardized extraction methods for consistent herbal extracts.
  - ✓ Follow good manufacturing practices to uphold quality during production.
- **Chemical Profiling:**
  - ✓ Analyze the formulation's chemical composition using techniques like chromatography and spectroscopy.
  - ✓ Identify and quantify active compounds for therapeutic effects.
- **Quantitative Analysis:**
  - ✓ Establish measurable parameters for specific compounds, setting acceptable concentration limits.
- **Thorough Quality Control:**
  - ✓ Conduct rigorous quality control tests, including microbial and contaminant checks.
  - ✓ Adhere to regulatory standards and guidelines.
- **Bioassays and Pharmacological Testing:**
  - ✓ Evaluate the formulation's biological activity to align with its intended effects.
  - ✓ Correlate chemical composition with therapeutic benefits.
- **Stability Studies:**
  - ✓ Assess the herbal formulation's shelf life and stability under various storage conditions.
  - ✓ Monitor changes in composition, appearance, and efficacy over time.
- **Comprehensive Documentation:**
  - ✓ Keep detailed records of raw materials, manufacturing processes, and quality control results.
  - ✓ Develop standard procedures for consistent production.
- **Regulatory Compliance:**
  - ✓ Ensure adherence to regulatory requirements for herbal products in the targeted market.
- **Consistent Batch Production:**
  - ✓ Enforce stringent quality controls to achieve consistent batches.
  - ✓ Manage variations in raw materials and production processes.

Through these steps, herbal formulations are standardized, ensuring each batch meets specified quality standards. This process is crucial for establishing the effectiveness and safety of herbal products, both in traditional and modern medicine, providing consumers with reliable and trustworthy remedies[20].

IMPORTANCE OF STANDARDIZATION:

Standardization in the realm of plants and herbal products is paramount for several reasons:

Consistent Quality: Standardization ensures uniformity in the composition of herbal products, guaranteeing consistent quality and effectiveness across different batches.
Safety and Efficacy: By defining standards for active compounds, it safeguards the efficacy and safety of herbal formulations, instilling confidence in consumers.
Regulatory Adherence: Compliance with regulatory standards is a must for herbal products, and standardization facilitates adherence, preventing legal issues and ensuring consumer well-being
Authenticity Assurance: Standardization protocols for plant identification and authentication prevent the use of incorrect species or adulterants, preserving the authenticity of herbal products.
Research Foundation: Standardization provides a stable foundation for research and development in herbal medicine, allowing for consistent comparison and advancement in the field.
Quality Control: Benchmarks set by standardization aid in rigorous quality control, helping manufacturers monitor and maintain the excellence of both end products and raw material
Global Trade Facilitation: Harmonized standards ease international trade, offering a common ground for evaluating and comparing herbal products, thereby supporting market access and competitiveness.
In summary, standardization in the plant domain ensures that herbal products are of high quality, authentic, and safe, contributing to their acceptance and growth in various industries and among consumers globally[21].

CONCLUSION: Since the beginning of human history, people have used plants, herbs, and ethnobotanicals to promote health and treat illness all over the world. The foundation of contemporary medicine is derived from plants and other natural sources, which also perform a significant role in the production of commercial drug preparations. Plants are the source of about 25% of medications that are prescribed globally. Herbs are still frequently used in medicine instead of pharmaceuticals. For some people, using herbal medicine is the best course of action. Herbs are utilised by others as a complementary treatment to traditional medications. Advanced herbal drug technology integrates modern scientific and technological tools to elevate the development and application of herbal medicines. Standardization and quality control,biotechnology for plant cultivation, formulation development,herbal bioinformatics are the key areas where this technology is making difference.

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