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A Review on Advanced Herbal Technology

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Abstract: *In order to improve the safety, effectiveness and standardization of herbal products, Advanced herbal technology which includes sophisticated extraction process, analytical Methodologies, and nanotechonology application which combines contemporary Scientific methods with ancient herbal practices.*

Keywords: Study of advanced herbal technology, different methods of Identification of plants, introduction of different techniques of characterization of Bioactive compounds, WHO guidelines for herbal drug standardization, Estimation of parameter limits used for standardization

I. INTRODUCTION

For thousands of years, nature has provided a variety of medicinal substances. Many contemporary medications are synthetic. As a result, the market's need for herbal formulations rises. As a result, meeting the needs of the public while maintaining the formulation's standards is becoming a challenge. The market's high demand has led to a variety of adulterations in the quality of herbal formulations or crude drugs. Therefore, a variety of sophisticated herbal technologies are developed to help maintain the standard. These technologies aid in the identification, authentication, isolation, purification, and standardization of the raw medication or herb extract. All of these procedures use a variety of traditional and contemporary methods. In order to identify the Expert judgment, identification, comparison, key use, and similar tools and techniques are employed. These days, computerized identification, window card keys, peak-a-boo, and the polyclone approach are employed for identification. Herb authentication is a quality control procedure that guarantees the right species of herb.

Introduction to Herbal Technology

Herbs are plant materials made from plant components, which might be whole, broken, or in a powdered form. Due to their medicinal value, they are regarded as a dietary source. Herbal drug technology is helps in the converting botanical materials into medicines in this Standardization and quality maintenance with modern scientific techniques and traditional knowledge is most important. In herbal medicines the interest of people's is increased significantly in all the countries. The demand of the herbal medicines is enhanced, hence there is need to adoption of proper systemic methods for the identification, authentication, extraction, isolation and purification. It also includes various standardization techniques to ensure quality, purity, safety and potency and to develop modern methods for their quality control to get the maximum advantage of these herbal remedies. The World Health Organization (WHO) defines herbal medicines as any medications made from plants, plant components, or herbal preparations. The technology of herbal medicine has advanced significantly during the past ten years. The safety of herbal remedies may be demonstrated by the conventional drug system that dates back to ancient cultures. The time has come to decide whether herbal medications are safe and effective. (1)

Different methods of identification of plant:

One of the most basic prerequisites for any area of the life sciences is the identification of experimental material. Throughout history, there has been a lot of interest in the finding and naming of living beings, which can include any type of life, such as microorganisms, plants, or animals. "The process of assigning a specimen to a (pre-existing) taxon" is what identifications are.

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There are several methods used to identify herbal plants, each relying on different characteristics of the plants. Here are some common methods:

- Morphological characteristics: Studying the physical attributes of a plant, such as its leaves, flowers, steam, fruits, and roots, is known as morphological characteristics. To identify plants, botanists employ dichotomous keys, which are collections of paired assertions concerning characteristics.
- Microscopic Examination: This entails looking at the cellular makeup of plant parts under a microscope. Certain traits, such as trichomes, stomata patterns, and cell kinds, can make a plant unique.
- Chemical Tests: of chemical assays, particular chemical compounds of plant parts are identified using reagents. Alkaloids, flavonoids, and other secondary metabolites, for instance, can be detected using specific reagents.
- Chromatographic techniques: High-performance liquid chromatography (HPLC) and thin-layer chromatography (TLC) are commonly used to separate and identify the chemical components in plant extracts.
- Genetic methods: To identify a plant's species, DNA barcoding entails sequencing particular DNA regions and comparing the results to a database.
- Sensory Evolution: To aid in identification, skilled botanists and herbalists may employ sensory traits like taste, odor, or feel.
- Digital technology: Plants may be recognized from photos utilizing apps and software that use image recognition.
- Export consultation: For help identifying plants, speaking with a botanist, ethnobotanist, or skilled herbalist can be beneficial.

Methods of identification of plants:

- Expert determination
- Recognition
- Comparison
- Use of Keys and Similar Devices (Synopses, Outlines, etc.)
- Visual observations

Expert Determination:

Expert assessment of accuracy or dependability is the most effective identification technique. Experts have typically written monographs, reviews, and summaries of the group in issue, and their taxonomic principles are probably included in the most recent floras or handbooks.

Recognition:

Accurately identifying plant species is accomplished by a variety of procedures and approaches, frequently for scientific research, conservation, agricultural, or medical applications.

Comparison:

Comparing an unknown with named specimens, pictures, drawings, or descriptions is a third technique. Despite being a responsible approach, the lack of appropriate reference resources might make it time-consuming or nearly impossible.

Use Keys and Similar Devices (Synopses, Outlines, etc.):

This is accomplished with the use of the widely utilized Maximum approach, which no longer necessitates the time, resources, or enjoyment involved in assessment and recognition.

Visual observation:
A common or scientific name must be associated with the plant's recognition of one or more traits, such as size, form, leaf shape, flower color, odor, etc., in order to identify a landscape or garden plant

Authentication of plant:
Medicinal plants have been used for centuries around the world to maintain health and treat diseases, especially chronic ones. However, for reasons of safety and effectiveness, adulteration and the use of fake materials as substitutes have become a major concern for users and industry.

For various uses. It typically involves several steps:

- Botanical Identification: This is the first step, where the plant is identified by a qualified botanist. This involves examining characteristics like leaves, flower, steam and roots.
- Chemical profiling: Analyzing the chemical composition of the plant can help identify authentication of herbal plants is an important process to ensure their safety and efficacy specific compounds and verify its authenticity.
- Microscopic examination: This involves looking at the plant's cellular structure under a microscope. certain characteristics are unique to specific plants species.
- DNA testing: DNA barcoding is a highly reliable method to confirm the identify of a plant. it compares the DNA sequence of a sample to a reference database.
- HPLC and GC-MS analysis: High performance liquid gas chromatographymass spectrometry can be used to identify and quantify specific chemical compounds in the plant.
- Thin-layer chromatography: This method can be used to authenticate plants by separating components in a combination.
- Organoleptic evolution: This entails evaluating the plant's sensory attributes, such as flavor, aroma, and appearance.
- Authentication by experts: Getting confirmation from specialists in botany or herbal medicine might boost your trust in the plant's identity.
- Comparative analysis: Examine the plant sample against herbarium specimens or verified reference samples.
- Consulting Pharmacopoeias and monographs: Pharmacopoeias in several nations offer guidelines for identifying herbal medications

Methods of Authentication:
Macroscopic examination
It entails contrasting descriptions of the plant or botanical medication in floras or monographs with physical characteristics that may be apparent to the naked eye or at low magnification.
Microscopic examination
The focus of microscopic analysis is on plant material's anatomical features that can only be seen under a microscope. The presence or absence of substances like mucus, starch, or lignin, the arrangement of stomata in the epidermis, the form and structure of the trochees (hairs), or the presence of tissues with distinctive cells could all be used to identify herbal medicinal products under a microscope
Chromatography
The process of separating chemical substances in a mixture is called chromatography. Although there are many different chromatographic procedures, they are all founded on the same fundamental ideas. The chromatography includes various techniques like:

- Thin layer chromatography (TLC)
- Gas chromatography
- Liquid chromatography

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- Column chromatography
- High Performance liquid chromatography (HPLC)
- High performance thin layer chromatography (HPTLC)
- Paper chromatography
- Adsorption chromatography
- Ion exchange chromatography
- Partition chromatography
- Gel permeation chromatography

Different extraction methods:

Extraction, as the term is used in pharmacy, involves the separation of medicinally active parts of plant or animal tissues from inactive or inert components through the use of selective solvents in standard extraction processes. The products thus derived from plants are relatively impure liquids, semisolids or powders intended slowly for oral or topical use. These include classes of preparations known as decoctions, infusions, liquid extracts, tinctures, pillar (semisolid) extracts and powdered extracts. Such preparations were popularly called galenic.

Various methods of extraction:

- Maceration
- Digestion
- Percolation
- Solid phase extraction
- Ultrasonic extraction
- Supercritical fluid extraction
- Microwave assisted extraction

Maceration:

Maceration extraction is simple, conventional method for extracting active compounds form plants materials by soaking them in a solvent at room temperature such as methanol, ethanol, ethyl acetate, acetone, hexane, etc.

Digestion:

The main distinction between digestion and maceration is the application of mild heat throughout the extraction process. The heat improves the menstrual solvent efficiency. In this, the samples used are usually brought to boiling point with an acid at a high temperature.

Percolation:

Conventional Chinese medicine is processed using a conventional extraction method called percolation extraction. The extraction solvent is continuously supplied after the powdered medicinal cloth has been placed in a percolation tank. Additionally, percolation extract is collected concurrently. Percolation is an extracting technique that is carried out at room temperature; throughout the procedure, fresh solvent must be continuously introduced to the percolation apparatus' top. Because of the variation in concentration maintained throughout the procedure, it is more effective than the immersion approach. However, this process is time-consuming and solvent-intensive. The extraction process is a method that separates soluble components from plant material using a solvent. A solvent is continuously passed across a bed of stationary plant material in this method. A percolator, a cone-shaped jar with a top lid and a bottom tap, is used to carry out the procedure. Because percolation continuously substitutes a new solvent for the unsaturated one, it is more effective than maceration. Re-percolation lowers solvent consumption by introducing the percolate as the solvent once more.

Fig1: Percolation

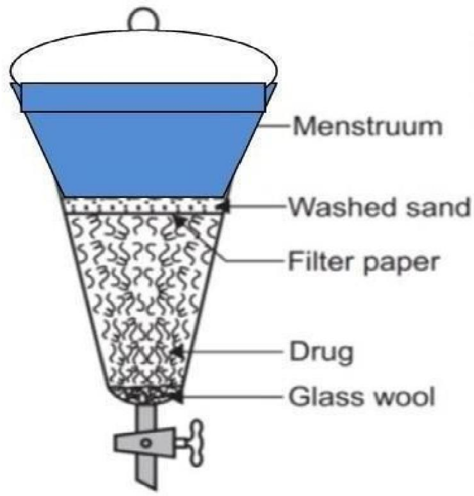

Fig1: Percolation

Solid phase Extraction:

Solid phase extraction technique is an improved form of liquid extraction. It involves passing a sample through a cartridge containing a solid stationary phase. Solid with extraction uses a solid stationary phase and liquid mobile phase to separate analytes based on physical and chemical properties. In this a small column or coated wire is used to extract the drug out of the urine or blood. (19) The extraction can be used to isolate analytes form a wide variety of matrices including urine, blood, water, beverages, soil and animal tissue. It is possible to have an incomplete recovery of the analytes by SPE caused by incomplete extraction. In the case of an incomplete extraction, the analytes do not have enough affinity for the stationary phase and part of them will remain in the permeate. Solid-phase extraction (SPE) is a laboratory technique used to separate and concentrate analytes from a liquid sample by selectively adsorbing them onto a solid phase. It is commonly used in analytical chemistry, environmental testing, and pharmaceutical analysis to purify and concentrate samples before instrumental analysis (such as HPLC, GC, or mass spectrometry).

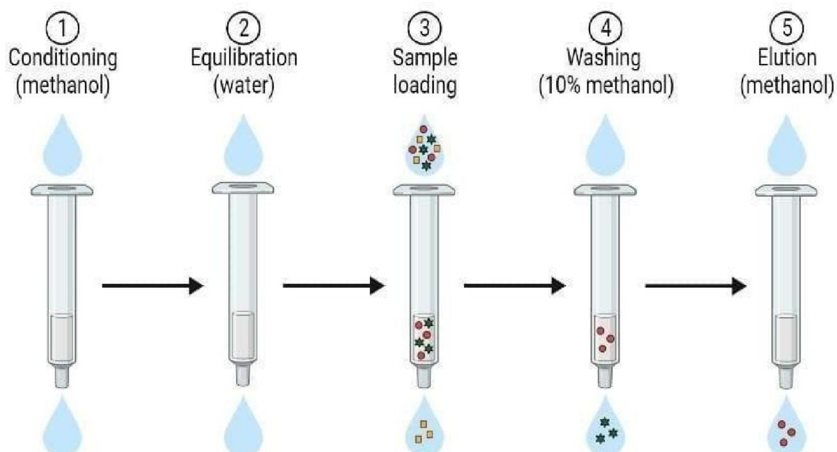

Fig.2 Solid phase extraction

Ultrasonic Extraction:

Ultrasound with frequencies ranging from 20 kHz to 2000 kHz is used in the procedure; this causes cavitation and increases the permeability of cell partitions. The method's large-scale software is limited by its higher costs, even though it is advantageous in certain situations, such as the extraction of rauwolfia root. One drawback of the procedure is the sporadic but thought to be harmful effects of ultrasonic radiation (over 20 kHz) on the active components of medicinal plants, which results in the production of free radicals and unintended changes to the drug molecules. (9)

Ultrasonic extraction (also known as ultrasound-assisted extraction or UAE) is a process that uses high-frequency sound waves (ultrasound) to extract compounds from a material, typically plant-based. This method's effectiveness, reduced solvent consumption, and capacity to protect delicate substances make it popular in the food, pharmaceutical, and cosmetics sectors.

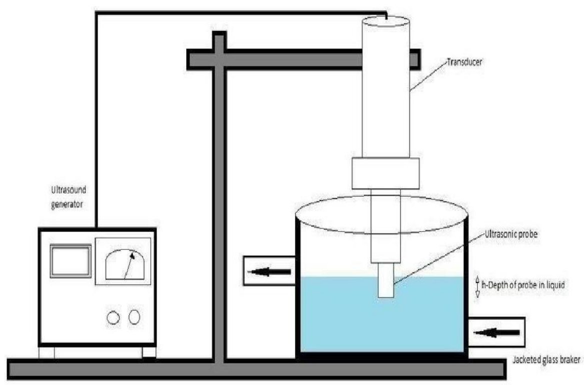

Fig.3 Ultrasonic Extraction

Super critical fluid extraction:

Supercritical fluid extraction (SFE) is a method used to separate components from a mixture using a supercritical fluid as the solvent here are the steps involves:

Preparation of sample: The material containing the target compound is ground or otherwise prepared to increase the surface area. The preparation of a sample for extraction, whether using ultrasonic extraction (UAE) or supercritical fluid extraction (SFE), is a crucial step that affects the efficiency and quality of the extraction process.

Loading into the Extractor: The extraction vessel, which is sealed, is filled with the prepared sample. In both supercritical fluid extraction (SFE) and ultrasonic extraction (UAE), loading the sample into the extractor is an essential step. Proper loading ensures efficient contact between the solvent (or supercritical fluid) and the sample, maximizing yield and quality.

Filling with Supercritical Fluid: A supercritical fluid, usually carbon dioxide (CO2), is pumped into the vessel and heated and compressed to a supercritical state. A crucial phase in the supercritical fluid extraction (SFE) procedure is filling with supercritical fluid. To guarantee effective extraction, the supercritical fluid—most frequently CO_2—is introduced into the extraction system under carefully monitored circumstances.

Extraction: The supercritical fluid passes through the sample, dissolving the target compounds. It then carries them out of the vessel. Extraction in the context of Supercritical Fluid Extraction (SFE) involves dissolving and isolating target compounds from a sample using supercritical CO_2 or other supercritical fluids. Thisstep utilizes the unique properties of supercritical fluids, which combine the diffusivity of gases with the solvent power of liquid.

Separation: The extracted compounds are left behind when the supercritical fluid and extracted compounds are depressurized, enabling the fluid to return to its gaseous state. After the extraction procedure is finished, the required

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components are separated from the solvent (or supercritical fluid). The extraction technique— supercritical fluid extraction (SFE) or ultrasonic extraction (UAE)—determines the procedure.

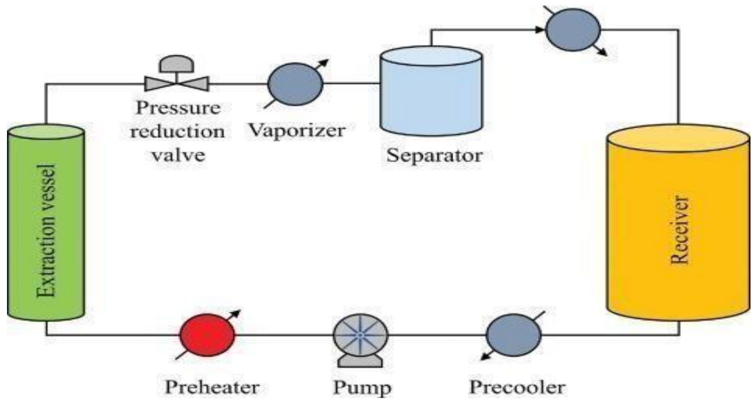

Fig.4: Super Critical Fluid Extraction

Microwave-assisted extraction:

Microwave Assisted Extraction (MAE) is a process that uses microwave energy to heat solvent in contact with a sample to break down analytes from the sample matrix into the solvent. The ability to rapidly heat the sample solvent mixture is inherent in MAE and is the main advantage of this technique. By using closed vessels, the extraction can be performed at elevated temperatures, which accede rates the mass transfer of target compounds from the sample matrix. A typical extraction procedure takes 15 to 30 minutes and uses small solvent volumes in the range of 10 to 30mL. These volumes are approximately 10 times smaller than the volumes used in conventional extraction techniques. In addition, the sample through put is increased because several samples can be taken at the same time. In most cases, analyte recovery and reproducibility are improved compared to traditional techniques, as applications. Microwave extraction is an advanced technique used to extract target compounds from solid or liquid samples using microwave energy. This method utilizes the heat generated by microwave irradiation to enhance the extraction process, making it faster, more efficient, and more environmentally friendly compared to conventional extraction methods. (4)

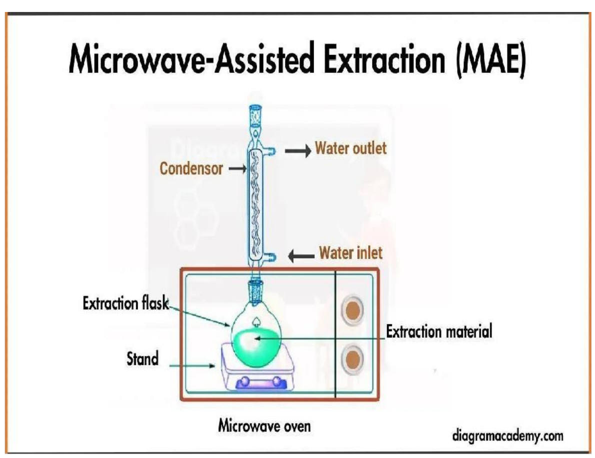

Fig.5: Microwave-Assisted Extraction

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ISOLATION AND PURIFICATION TECHNIQUES

General Isolation techniques:

In recent years, there have been advancements in the technology of isolating and purifying bioactive chemicals from plants. People can now keep up with the development and availability of many sophisticated bioassays thanks to this current approach, which also allows for exact isolation, separation, and purification methods. The aim of the search for bioactive compounds is to find a suitable method that can detect bioactivity in the starting material, such as antioxidants, antibacterial agents or cytostatic, combined with simplicity, specificity and speed. Invitro techniques are generally greater suited than in vivo assays due to the fact animal experiments are expensive, take greater time, and are at risk of moral controversies.

Chromatographic techniques:

It is a common practice in isolation of these bioactive compounds that a number of Different separation techniques such as TLC, column chromatography, flash chromatography, Sephadex chromatography and HPLC, should be used to obtain pure compounds.

High Performance Thin Layer Chromatography (HPTLC):

High Performance Thin Layer Chromatography (HPTLC) technique is as sophisticated and automated form of the thin layer chromatography (TLC) with better and advanced separation efficiency and detection limits and is often an excellent alternative to GC and HPLC. HPTLC is useful in detecting chemicals off or enrich concern. Purification techniques for isolated Phyto constituents Phyto chemical separation is approaches in which plant extract components or active parts are individually isolated and purified into monomeric compounds by physical and chemical methods. Classic isolation methods such as solvent extraction, precipitation, crystallization, fractional distillation, salting and dialysis are still commonly used today. On the other hand, modern separation technologies such as column chromatography, high performance liquid chromatography, ultrafiltration and high-performance liquid chromatography, droplet counter current chromatography also play an important role in the separation of Phyto chemicals.

Fig.6: High Performance Thin Layer Chromatography

Column Chromatography

Column chromatography in chemistry is a chromatography technique used to isolate a Single chemical compound from a mixture. Chromatography is capable of separate materials primarily based totally on differential adsorption of compounds to the adsorbent; compounds pass through the column a exceptional rates, letting them be separated into fractions. The approach may be used on scales from micrograms as much as kilograms. Column chromatography may be performed the us age of gravity to transport the solvent.

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Thin layer chromatography

TLC is a simple, fast and in expensive method that gives their searcher a quick answer as to how many components are in a mixture. TLC is also used to support the identity of a compound in a mixture when comparing the Rf of a compound to the Rf of a known compound. This has also been used to confirm the purity and identity of isolated compounds. TLC works on the principal of adsorption chromatography, where compounds in a mixture are separated based on their different affinities for stationary phase and mobile phase.

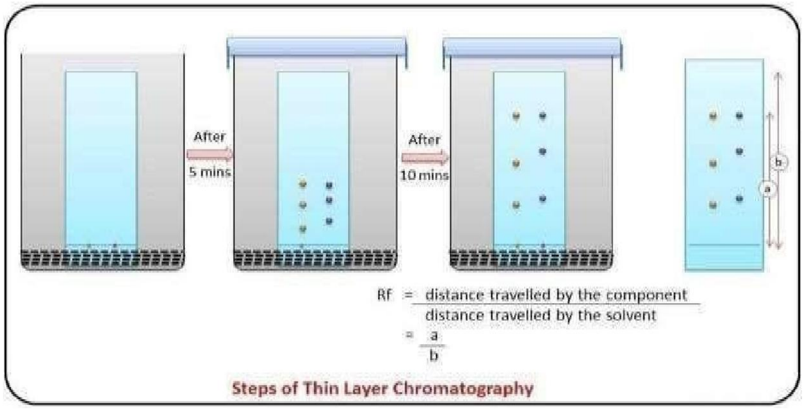

Fig.7: Thin layer chromatography

Purification techniques for isolated Phytoconstituents:

SOXHLET Apparatus: -

A lab instrument called a Soxhlet apparatus is used to carry out liquid-solid extractions, especially when the target molecule is poorly soluble in the solvent. This device is made to use a solvent to continuously extract a desired component from a solid substance. It is frequently used in chemistry to extract non-volatile and semi-volatile chemicals, particularly in industries like food, medicines, and environmental studies. When the target analytes are not easily soluble in the solvent, Soxhlet extraction is a wellestablished and popular technique for removing chemicals from solid samples. Lipids, oils, and other organic substances can be extracted from plant materials, soils, or other solid matrices with remarkable efficiency. The continuous solvent extraction mechanism underlies Soxhlet extraction. (18)

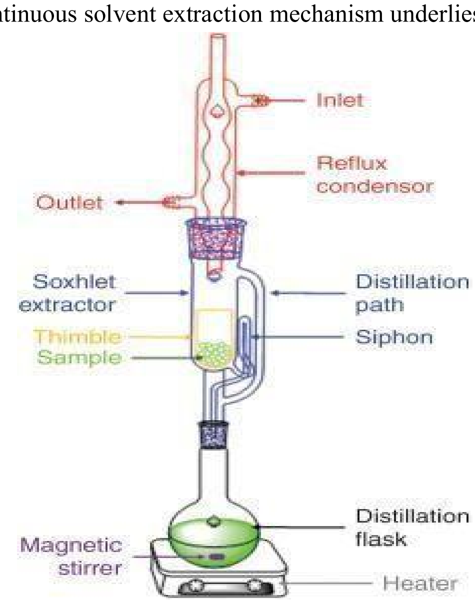

Fig.9: Soxhlet Apparatus

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Advantages of Soxhlet Extraction:

- Efficiency: It is a highly efficient method for extracting compounds from solid samples, ensuring good yields.
- High Efficiency: Soxhlet extraction is highly efficient for extracting compounds from solid matrices, especially when the analyte is not easily soluble in the solvent. The repeated extraction process ensures thorough
- extraction of the target compound.
- Complete Extraction: It's capable of extracting a wide range of compounds, even those with low solubility, as it continually refreshes the solvent.
- Versatility: It can be used for a variety of sample types and is applicable to a wide range of solvent.

Disadvantages of Soxhlet Extraction:

- Time-consuming: Soxhlet extraction can be a lengthy process as it involves multiple extraction cycles and often requires hours to complete.
- Solvent Consuming: It can consume a relatively large amount of solvent, especially in cases where extensive extraction is required.
- Risk of Cross-Contamination: If not properly managed, the repeated cycling of solvent through the sample may introduce the risk of cross-contamination between different samples, especially when dealing with complex mixtures
- Heat Sensitivity: The extraction process involves heating the solvent, which may lead to the degradation or transformation of heat-sensitive compounds, potentially altering the results or losing valuable analytes

Introducing to different techniques of characterization of Bioactive constituent

1. Spectroscopy:

a. Infrared spectroscopy (IR): Analyses the vibrations of atoms in a molecule, providing information on functional groups and structure.

b. Nuclear Magnetic Resonance (NMR): Provides detailed structural information about molecules by measuring the interaction between nuclear spins.

2. Chromatography:

a. High-Performance Liquid chromatography (HPLC): Separates and quantifies components based on their affinity for a stationary phase and mobile phase.

b. Gas chromatography (GC): Separates volatile compounds based on their vapor pressure.

3. Mass Spectrometry (MS):

a. Electrospray Ionization (ESI) and Matrix-Assisted Laser Desorption/Ionization (MALDI): Techniques to ionize and analyse molecules.

b. Gas chromatography-Mass Spectrometry (GC-MS): Combines GC with MS for compound identification.

4. Microscopy:

a. Scanning Electron Microscopy (SEM): Provide high-resolution images of surface.

b. Transmission Electron Microscopy (TEM): Offers detailed images of internal structures at nanoscale.

5. Bioassays:

a. Cell-Based Assays: Evaluate biological activity by observing effects on cultured cells.

b. Qualitative Bioassay: Determine the presence or absence of a biological activity.

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METHODS OF STANDARDIZATION OF HERBAL DRUG

Importance of Standardization:

The process of prescribing a set of standards or inherent features, constant parameters, and final qualitative and quantitative values is known as standardization of herbal medicines. The process of creating and putting into practice standards to guarantee that goods and services are uniform and satisfy specific needs is known as standardization. Innovation, economic expansion, consumer confidence, safety, consistency, risk management, and so forth are all important. In many domains, such as research, business, and industry, standardization is essential because it guarantees consistency, precision, and dependability in procedures, measurements, and final goods. (12)

Problem involved in standardization of herbs standardization of single drugs and compound formulations:

1. Variability in natural source: Herbs are derived from plants, and their potency can vary due to factors like soil quality, climate, and harvesting methods. This natural variability makes it difficult to establish consistent potency levels.

2. Complex chemical composition: Herbs often contain a multitude of compounds, and it can be challenging to identify and quantify all active constituents. Some compounds may be more therapeutically relevant than others.

3. Extraction methods: The process of extracting active compounds from herbs can influence the final product's composition. Different extraction methods may yield different concentrations and profiles of active ingredients.

4. Lack of standardized Analytical Techniques: There may not be universally accepted methods for analysing herbal products. This can lead to discrepancies in reported potency levels across different studies or manufacturers.

WHO guidelines for herbal drug Standardization:

1. Botanical Identify: Ensuring that the correct plant species and plant part are used.

2. Good Agriculture and Collection Practices (GACP): Providing guidance on the cultivation, harvesting and collection of medicinal plants.

3. Good manufacturing practices (GMP): Outlining the standards and procedures for the manufacturing of herbal medicines.

4. Quality Control and Testing: Describing the methods for evaluating the quality, purity and potency of herbal products.

5. Stability studies: Providing guidelines for assessing the stability of herbal formulations under different the storage conditions.

6. Documentation and Labelling: Recommending what information should be included on labels and in product documentation.

7. Safety and Efficacy: Assessing the safety and effectiveness of herbal medicines through scientific studies.

8. Regulatory requirements: Providing guidance for regulatory authorities on the registration and licensing of herbal medicines (16)

Estimation of parameter limits used for standardization:

i. Morphology and Organoleptic valuation: It include the morphological characters like colour, odour, taste, shape, size etc.

ii. Microscopic and histological evaluation: These are important in both whole drug and powdered drug. Microscopic determination such as vain is let number, stomatal index, stomatal number, vein termination number.

iii. Foreign organic matter: This involves removal of matter other than source plants to get the drug in pure form.

iv. Moisture content: Checking moisture content help reduce errors in the estimation of the actual weight of the drug material. Low moisture suggests better stability against degradation of product.

v. Toxicological studies: This aids in identifying pesticide residues, possibly hazardous components, animal safety tests such as LD50, and microbial assays to prove the presence or absence of potentially dangerous microorganisms.

vi. Biological parameters:

a. Bitterness value

b. Haemolytic activity

c. Swelling index
d. Foaming index
e. Pesticides residue
f. Heavy metals
g. Micro organism

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