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Asmana Shaikh
Department, Siddhi's Institute of Pharmacy, Nandgaon. Tal. Murbad, Thane, Maharashtra, India

Samidha Sonakmble
Department, Siddhi's Institute of Pharmacy, Nandgaon. Tal. Murbad, Thane, Maharashtra, India

Dakshata Bhosale
Department, Siddhi's Institute of Pharmacy, Nandgaon. Tal. Murbad, Thane, Maharashtra, India

Shraddha Kamble
Department, Siddhi's Institute of Pharmacy, Nandgaon. Tal. Murbad, Thane, Maharashtra, India

Srushti Bhoir
Department, Siddhi's Institute of Pharmacy, Nandgaon. Tal. Murbad, Thane, Maharashtra, India

Tejaswini Asawe
Department, Siddhi's Institute of Pharmacy, Nandgaon. Tal. Murbad, Thane, Maharashtra, India

Corresponding Author:
Asmana Shaikh
Department, Siddhi's Institute of Pharmacy, Nandgaon. Tal. Murbad, Thane, Maharashtra, India

A review article on advance herbal technology

Asmana Shaikh, Samidha Sonakmble, Dakshata Bhosale, Shraddha Kamble, Srushti Bhoir and Tejaswini Asawe

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Abstract
Advanced Herbal Technology include introduction to herbal technology. In this review we are going to learn about Different Method of Identification much as expert determination, comparison, recognition, use of keys and similar device. Different method of authentication such as microscopic examination, microscopic examinations, chromatography chemical method, Different Method of Extraction such as maceration, infusion ,digestion, decoction, percolation, hot continuous extraction, Soxhlet extraction, Isolation Techniques, Different Chromatographic Techniques such as Thin layer chromatography, High performance liquid chromatography, Column chromatography, High performance thin layer chromatography. It also include different Methods for Standardization which is important for both qualitative and quantitative value of following product which is related with the quality, efficacy, safety and reproducibility. It's main goal is to maintained safety, purity, potency. WHO guidelines help Standardization of herbal drug. The guidelines contained identity of drug, characters of drug, pharmacological parameters, Toxicity detail-heavy etals, microbial contamination. Factors which affect the quality control of herbal drug are microscopic evaluation, foreign matter, Ash content, heavy metals, pesticides resides. Parameters of Standardization and quality control of herbal drugs, morphology and organoleptic evaluation, microscopic and histological evaluation, physical evaluation, chemical evaluation. Implementation of advanced herbal technology aims to isolate compound effectively with less amount of waste and eco-friendly procedure while doing a research extraction process should consume less amount of solvent. Advanced Herbal Technology act as bridge to joint traditional knowledge with modern science which is necessary to ensure safety, quality, and effectiveness of herbal drug. In this review we are going to observe how the modern scientific technique will affect the traditional knowledge in positive way, such as modern method of extraction, purification, Standardization and formulation are useful spectroscopy are used to analyse chemical composition of drug. Advanced herbal drug technology matters because it helps make herbal medicines safe, effective and reliable.

Keywords: Advanced herbal drug technology, ash content, chromatography, heavy metals, toxicity

Introduction
Herb is the plant material which is derived from parts of plant which might be fragmented, entire or in powered form. Because of their therapeutic importance considered as a source of nutrition. 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 in order to get the maximum benefit from these herbal medicines. As per the world Health Organization (WHO) Herbal medicines are all those medicines which are obtained from the plant, parts of plant and herbal preparations in the last decade there have been significant advances in herbal medicine technology. The traditional drug system dating back to ancient civilizations could demonstrate the safety of herbal medicines. It is time to make decisions about the safety and efficacy of herbal medicine.
As technology advancement continue, future herbal technology will likely expand into areas such as metabolomic, chemometric analysis, enzyme- assisted extraction, and even further integration with biotechnological and nanotechnological approaches. This will enhance the

discovery and development of novel herbal therapeutics. Incorporating nanotechnology can improve this stability, bioavailability, targeted delivery of Herbal compounds. These advancement allow pre size control over release profile and enhance therapeutic effect.

Fig 1: Botanical Materials

Different Methods of Identification of Plant

Identification of experimental material is one of the most fundamental requirements of any field in the life sciences. The discovery and naming of living organisms (any life form including plants, animals or microbes) has attracted much attention throughout history. Identification is "the process of assigning a specimen to a (pre-existing) taxon". Plant species have been considered the basic unit of biodiversity and it is the level at which most evolutionary studies have focused. The want for plant species identity is each various and widespread, and consists of programs for plant breeding, agricultural seed industry, meals processing, conservation biology, forensic evaluation and lots of different components of plant science. Traditionally, identity of plant species has relied closely on morphological characters.

Methods of Identification of Plant

1. Expert determination
2. Recognition
3. Comparison
4. Use of Keys and Similar Devices (Synopses, Outlines, etc.)

Expert Determination

The best method of Identification is expert determination of reliability or accuracy. In general, experts have produced treatments (monographs, reviews, synopses) of the group in question, and the most recent floras or handbooks are likely to contain the expert's taxa concepts. This method requires more time of the expert for the identification. It causes the delay in identification of plant.

Recognition

It approaches skilled determination in reliability. This can be supported extensive, past expertise of the symbol with the plant cluster in question.

Comparison

A third method is to compare an unknown with named specimens, photographs, illustrations, or descriptions. Although this is a reliable method, it can be time- consuming or practically impossible due to the lack of suitable reference materials.

Use Key And Similar Devices (Synopses, Outlines, etc.)

This is with the aid of using some distance the Maximum extensively used technique and does now no longer require the time, materials, or revel in concerned in Assessment and recognition. Recently, the polyclave identification, Peck-a-boo or Window Card Key, and computerized identification are investigated as a modern method of identification.

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 substitute's users and industry. Therefore, the authentication of medicinal plants is of paramount importance. Morphological, anatomical, chemical and DNA markers solve the problem by distinguishing real material from adulterants, substitutes and counterfeit drugs.

Methods of Authentication

Macroscopic Examination

It involves the comparison of morphological characters which might be visible with the bare eye or below low magnification with descriptions of the plant or botanica drug in Floras or Monographs. Characters consisting of size, form and coloration of Leaves (or leaf fragments), flora or Culmination are usually utilized in macroscopic identification.

Microscopic Examination

It focuses on anatomical structures in plant material that are only visible with the help of a microscope. Features such as the shape and structure of the trichomes (hairs), the arrangement of the stomata in the epidermis, the presence or absence of compounds such as mucus, starch or lignin, or the presence of tissues with characteristic cells could be used for microscopic identification of herbal medicinal products.

Chromatography

Chromatography is the separation of chemical compounds in a mixture. There are several chromatographic techniques, but they are all based on the same basic principles. Thin layer chromatography (TLC) is commonly used to authenticate herbs, and most herbal pharmacopoeia monographs include a TLC identification test. TLC separates mixtures of compounds to leave a "fingerprint" of the separated compounds on a silica gel-coated plate. This fingerprint may be as compared with that of a true pattern or natural reference compounds. High- overall performance liquid chromatography (HPLC) is every other form of chromatography broadly used in the authentication and evaluation of natural substances.

Chemical Methods

Useful for profiling, detecting adulterants, and ensuring quality.

Spectroscopic Methods
Provide molecular fingerprints and structure elucidation

Genetic & Molecular Methods
Highly accurate for species identification, even in processed sample.

Isotope and Elemental Analysis

i) **Stable Isotope Ratio Analysis (SIRA)**
Analyses the ratios of stable isotopes like 13C, 15 N, 180, and 2H to determine the geographical origin and detect adulteration.

ii) **Inductively Coupled Plasma Mass Spectrometry (ICP-MS)**
Measures trace elements and heavy metals, which can be indicative of the geographical origin or contamination of herbal materials.

Bioassay and Immunoassay Methods

i) Enzyme-Linked Immunosorbent Assay (ELISA)

Function

a) Antigen- Antibody Reaction: The ELISA method relies on the specific binding of antibodies to antigen.

b) Enzyme Labelling: An enzyme is linked to the antibody, which converts a substrate into a detectable produc.

c) Detection: The enzyme activity is directly proportional of the analyte.

1.3 Different Extraction Methods
"Extraction*"*, as the term is used in pharmacy, involves the separation of medicinally active parts of plant or processes.

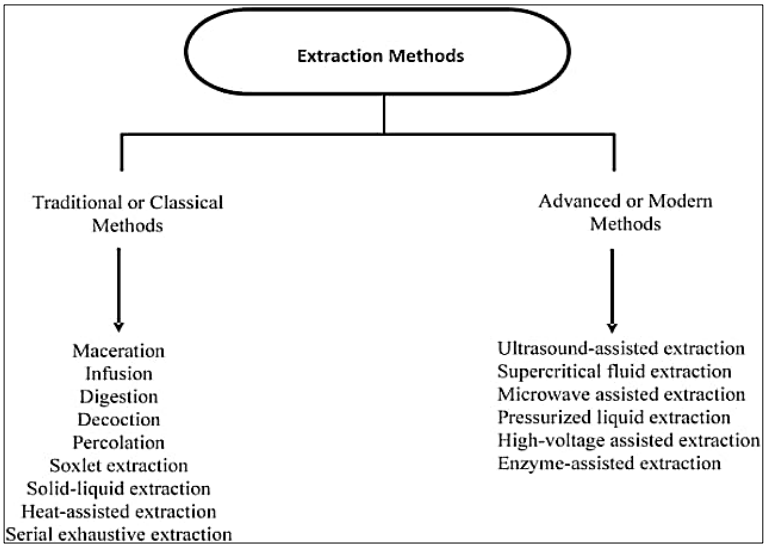

Fig 2: Different Methods of Extraction

Maceration
In maceration, the powered drug is placed with a solvent in a stoppered container and allow to stand at room temperature for least 3 days with frequent agitation. Then, this mixture is strained, Marc is pressed and the liquid is clarified by filtration.

Infusion
Fresh infusions are prepared by briefly soaking the raw drug in cold or boiling water. These are diluted solutions of the easily soluble components of raw drugs

Digestion
The digestion is like a maceration, only difference is that in digestion gentle heat is used during the extraction process. Due to the heat solvent efficiency to menstruum is enhanced.

Decoction
In this system, the crude drug is boiled in a specified extent of water for a defined time; it's far then cooled and strained or filtered.

This Process is appropriate for extracting water-soluble, heat-strong constituents. This system is generally utilized in training of Ayurvedic extracts called "quath" or "kawath". The beginning ratio of crude drug to water is fixed, e.g. 1: four or 1:16; the extent is then delivered right all the waydown to one-fourth its authentic volume with the aid of using boiling all through the extraction process. Then, the extract is filtered.

Percolation
Percolation is an extractive method this is performed at room temperature and that actually means "pass A liquid thru a strong cloth drop via way of means percolator and immersed in a suitable solvent for 24 to 48 hours, then collect the percolates at the bottom of the percolator**.** During the percolation process, new solvent must constantly be added to the top of the percolation apparatus. It is more efficient than the immersion method due to the difference in concentration maintained throughout the process. However, this procedure is complex and consumes a lot of solvent and Time.

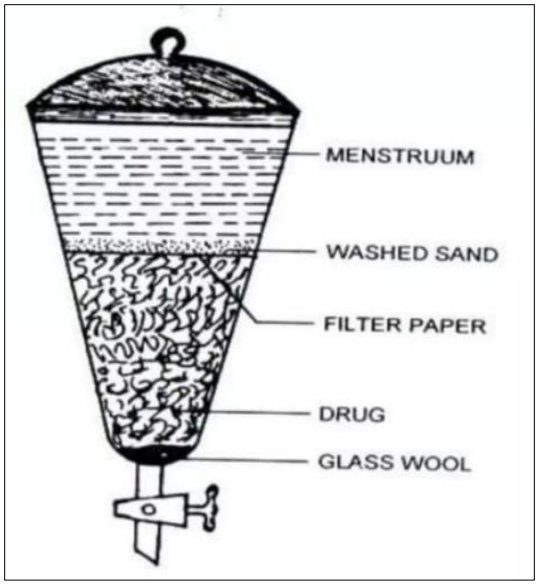

Fig 3: Percolation

Hot Continues Extraction [Soxhlet Extraction]

The process of transferring the partially soluble components of a solid to the liquid phase using a Soxhlet extractor. The principle of solvent extraction is extremely simple. The aim is to dissolve (solvate) a target molecule or group of compounds (solutes) with a liquid (solvent) and remove it from solid plant material. The solvent is then separated from the solute to concentrate the solute.

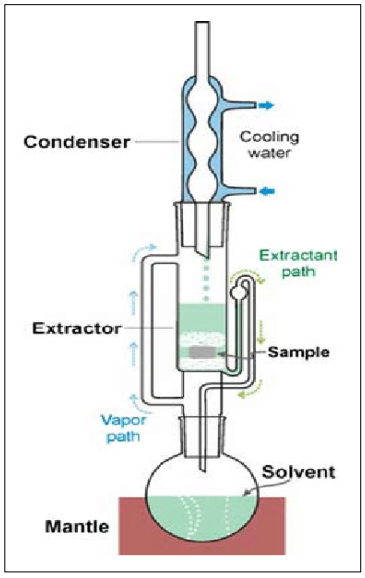

Fig 4: Soxhlet Apparatus

1.3.7 Counter Current Extraction

In Counter Current Extraction (CCE), wet raw material is pulverized by toothed disc disintegrators to create a fine slurry. In this process, the material to be extracted is moved in one direction (usually in the form of a fine slurry) in a cylindrical extractor where it comes into contact with the extraction solvent. The more the source material is agitated, the more concentrated the extract becomes.

1.3.8 Ultrasound Extraction

The process entails using ultrasound with frequencies starting from 20 kHz to 2000 kHz; this will increase the permeability of cell partitions and produces cavitation. The principle behind UAE is based on the phenomenon known as acoustic cavitation, which is the formation, growth, and collapse of microbubbles in a liquid medium due to the applied ultrasound waves.

- **Working of ultrasonic extraction:**

1. **Ultrasonic Transducer:** Converts electrical energy into high-frequency sounds waves (20-40kHz).
2. **Probe Or Bath:** The transducer is attached to probe or bath, which transmitted the sound waves to the sample**.**
3. **Sample Container:** The sample is placed in a container, typically made of stainless steel or glass.
4. **Solvent:** A solvent is add to the sample to facillate extraction.

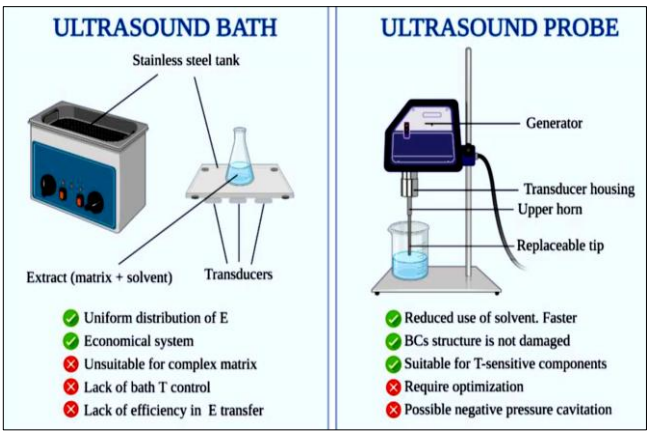

Fig 5: Ultrasonic Extraction

- **Ultrasonic Extraction Process:-**

1. **Sample Preparation:** Grind the sample (plant material, tissue, etc.) increase surface area.
2. **Solvent Selection:** Choose a suitable solvent (e.g. water, ethanol and methanol) based on the target compound's solubility.
3. **Ultrasonic Treatment:** Place the sample -solvent mixture in an ultrasonic bath or use a probe sonicator**.**
   - **Frequency:** 20-40kHz.
   - **Power:** 100-500 W
   - **Time:** 10-60 minutes

4. **Extraction:** The ultrasonic waves disrupt cell wall, releasing the target compound into the solvent.
5. **Filtration:** Filter the mixture to separate the extract from the solid residue.
6. **Concentration:** Concentrate the extract using technique like rotary evaporation or freeze -drying.

- **Principle Ultrasonic Extraction**
  Acoustic Cavitation
- **Formation of Microbubbles:** When ultrasound waves pass through a liquid, they create alternating high-pressure (compression) and low-pressure (rarefaction) cycles. This leads to the formation of microscopic bubbles in the liquid.
- **Growth and Collapse:** These bubbles grow over successive cycles and eventually collapse violently when they reach a certain size, especially in the low-pressure phase. The collapse generates intense localized conditions, such as High temperatures (up to 5000 K), High pressures (over 1000atm), Strong shear forces and shock waves.
- **Disruption of Cell Walls:** The mechanical effects of cavitation (shear forces, microjets, and shockwaves) help disrupt the cell walls of the plant or biological material. This process increases cell permeability and releases intracellular compounds into the solvent.
- **Improved Mass Transfer UAE:** Enhances the mass transfer between the solvent and the target material due to: Micro-mixing caused by ultrasonic agitation, increased solvent penetration into the sample matrix, reduced diffusion boundaries, which accelerates the extraction process.
- **Supercritical Fluid Extraction:** The principle of supercritical fluid extraction (SFE) is to use pressurized fluids with properties of both liquids and gases to separate compounds from a mixture without altering the compound's nature. In the supercritical state, the supercritical fluid comes into contact with plant tissue. the most common SF being CO2.

General Isolation Techniques

The isolation and purification of bioactive compounds from plants is a technique that has seen new developments in recent years. This modern technique offers on the one hand the possibility to keep pace with the development and availability of many advanced bioassays and on the other hand offers precise isolation, separation and purification techniques. 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. In vitro 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. There are a few elements that make it not possible to discover very last strategies or protocols.

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.

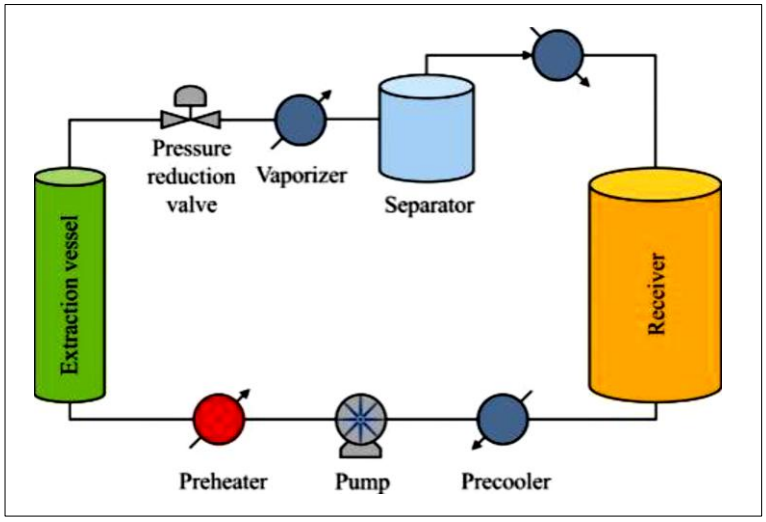

Fig 6: Supercritical Fluid Extraction

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 analysts from the sample matrix into the solvent.

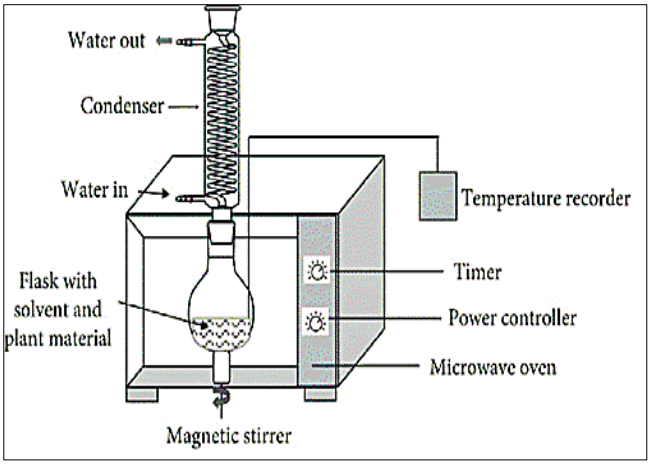

Fig 7: Microwave Assisted Extraction

Working Of (MAE)

- **Sample preparation:** Prepare the sample by adding reagent.
- **Extraction:** Expose the microextraction device to the sample, and analyte are extracted into the stationary phase.
- **Desorption:** Analyte are desorbed from the microextraction device into a chromatographic system.
- **Analysis:** The extracted analytes are analysed using chromatography or other detection techniques.

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Thin Layer Chromatography (TLC)

TLC is a simple, fast and inexpensive method that gives the researcher a quick answer as to how many components are in a mixture. TLC principle is based on Adsorption 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. Additional tests include spraying phytosanitary products that cause colour changes corresponding to the phytochemical present in a plant extract; or viewing the plate under ultraviolet light. This has also been used to confirm the purity and identity of isolated compounds.

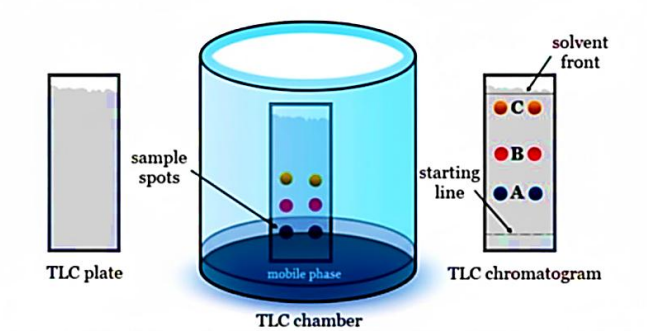

Fig 8: Thin Layer Chromatography

High Performance Liquid Chromatography (HPLC) High Performance Liquid Chromatography [HPLC] is principle is based on adsorption as well as chromatogram.

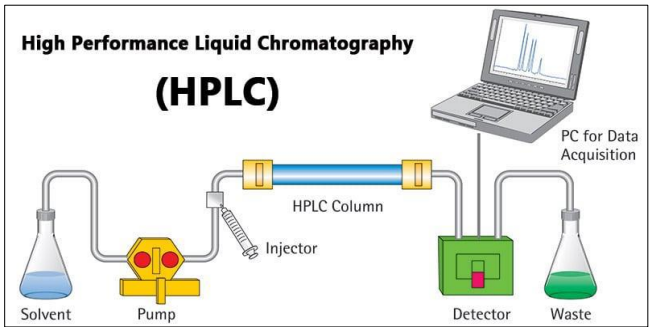

Fig 9: High Performance Liquid Chromatography

Principle Of HPLC: When each component dissolved in the mobile phase passes through the stationary phase, the size and strength of each component's interaction with the stationary phase are different Therefore, the residence time of these components in the stationary phase is different, flowing out from the Stationary phase at different times one after another.

Column Chromatography: Column chromatography in chemistry is a chromatography technique used to isolate a Single chemical compound of a mixture. It is based on principle of Adsorption Mixture of components dissolved in the M.P is introduced in to the column. Components moves depending upon their relative affinity.

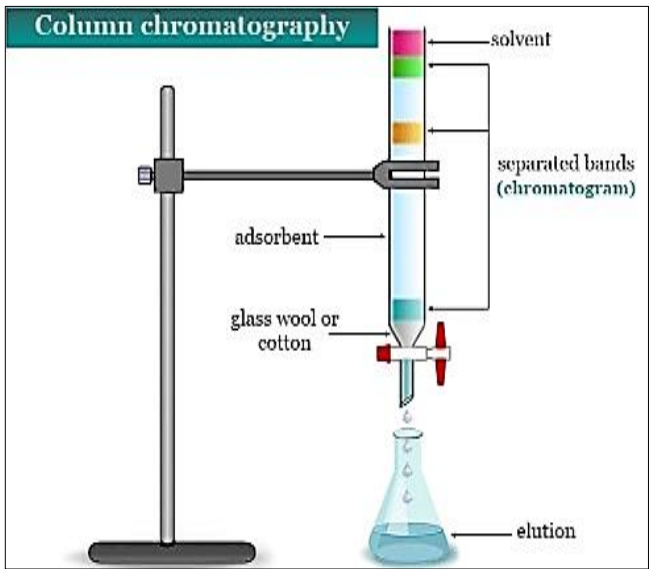

Fig 10: Column Chromatography

High Performance Thin Layer Chromatography (HPTLC): High Performance Thin Layer Chromatography (HPTLC) technique is a 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. The principle of HPTLC is based on adsorption chromatography, and sometimes partition chromatography, depending on the nature of the stationary and mobile phases.

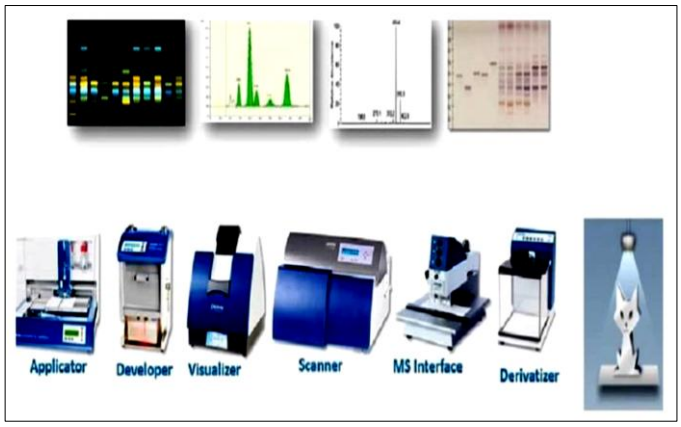

Fig 11: High Performance Thin Layer Chromatography

Principle of HPTLC

1. Chromatography is a physical process of separation in which the components to be separated are distributed between two immiscible i.e. the principle of separation is adsorption.
2. The mobile phase solvent flows through because of capillary action. The compounds move according to their affinities towards the adsorbent.
3. The components with the more affinity towards the stationary phase travels slower. The components with lesser affinity towards the stationary phase travels faster.
4. Thus the components are separated on a chromatographic plate.

Purification Techniques for Isolated Phytoconstituents

Phytochemical separation is a process 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, and ultrafiltration and high-performance liquid chromatography, droplet counter current chromatography also play an important role in the separation of phytochemicals.

Introduction to Different Techniques of Characterization of Bioactive Constituent

Bioactive compounds are molecules that interact with living tissue components and produce a positive effect on human health. They can be found in vegetables, animals, or microbes and include polyunsaturated fatty acids, peptides, polyphenols, vitamins, and carotenoid.

Liquid Chromatography: It is a technique used to separate, identify, and quantify components in a liquid mixture. It's widely used in pharmaceutical, biotechnology, and environmental monitoring. The main method for analysing bioactive compounds in biomass.

Spectroscopy

Is the study of the interaction between matter and electromagnetic radiation? It's a powerful analytical technique used to identify and quantify molecules. Used to measure total phenolic content and antioxidant capacity.

Hyphenated Chromatographic Techniques

Is the combine the separation power of chromatography with the detection and identification capabilities of spectroscopy or other methods? These techniques have revolutionized the analysis of complex samples, enabling researcher to identify and quantify components with unprecedented accuracy and sensitivity. Combines analytical techniques with spectroscopic methods to generate chemical and bioactivity information

Fourier Transform Infrared Spectroscopy (FTIR)

FTIR is a technique used to analyse the infrared spectrum of a sample, providing information about its molecular structure and composition. A high-resolution analytical tool that can identify chemical constituents and elucidate structural compounds.

Scanning Electron Microscopy (SEM)

Is a powerful technique used to produce high resolution image of a sample's surface topography and composition. By scanning a focused electron beam across the sample, SEM provides detailed information about the sample's morphology, texture and elemental composition. Used to observe changes in the morphology of sample.

Standardization

The standardization of herbal medicines is the process of prescribing a set of standards or inherent characteristics, constant parameters, final qualitative and quantitative values that include a guarantee of quality, efficacy, safety and reproducibility. It is the process of developing arid agreeing on technical standards.

Need of Standardization

In the global perspective, there is shift regulatory agencies strictly follow various quality standards prescribed for raw materials and finished products in pharmacopoeias, formulations and manufacturing operations through statutory good manufacturing practices to maintain purity, safety, potency and effectiveness. These procedures would logically apply to all types of medicines, whether they belong to the modern medical system or to one of the traditional systems. The popularity of the herbal products gets increased in all over the world, one of the barriers to their acceptance is the lack of a standard quality control profile. The quality of the herbal medicinal product, i.e. the profile of the components in the final product, has an impact on ineffectiveness and safety.

Standardization of Single Drug or Compound Formulations

The natural formulation in general may be standardized as to formulate the medicament the use of raw material collected from distinctive localities and a comparative chemical

efficacy of various batches of components are to be observed. The preparations with higher scientific efficacy are to be selected. All the ordinary physical, chemical and pharmacological parameters are checked for all of the batches as a way to pick the very last finished product and to validate the entire production process. Standardization is a critical thing for preserving and assessing the fine and protection of the polyherbal components as those are mixtures of multiple herbs to gain the choice healing effect. Minimizes batch to batch variation; assure safety, quality and efficacy of compound Formulation.

WHO Guidelines For Herbal Drug Standardization

- Reference to the identity of the drug. Botanical Evaluation- sensory characters, foreign organic matter, histochemical evaluation, quantitative measurements etc.
- Refers to the physicochemical character of the Drug. Physical and chemical identity, Chromatographic fingerprints, ash values, Extractive values, moisture content, volatile oil and Alkaloidal assays, quantitative estimation protocols Etc.
- A reference to the pharmacological parameters, biological activity profiles, bitterness values, Haemolytic index, astringency, swelling factor, Foaming index etc.
- Toxicity details- pesticide residues, heavy metals, Microbial contamination like total viable count, Pathogens like E. coli, Salmonella, P. aeruginosa, S. aureus, Enterobacteria etc.
- Microbial contamination.

Critical Factor Affecting on Quality Control of Herbal Drug

Microscopic Evaluation

Quality control of herbal drugs has traditionally been based on the appearance and today microscopic Evaluation is indispensable in the initial identification of herbs, as well as, in identifying small fragments of crude or powdered herbs, and detection of foreign matter and adulterants. Presence of certain microscopic structures such as leaf stomata can be used to identify the plant part used.

Herbal drugs should be made from the stated part of the Plant and be devoid of other parts of the same plant or other plants. They should be entirely free from moulds or insect including excreta and visible contaminant such as sand stones, poisonous and harmful foreign matter and chemical residues.

Ash Content

To determine ash content, the plant material is burnt and the residual ash is measured as total and acid-insoluble ash. Total ash is the measure of the total amount of material left after burning and includes ash derived from the part of the plant itself and acid-insoluble ash.

Heavy Metals

Contamination by toxic metals can either be accidental or intentional. Contamination by heavy metals such as Mercury, lead, copper, cadmium, and arsenic in herbal remedies can be attributed to many causes, including environmental pollution, and can pose clinically relevant dangers for the health of the user and should therefore be limited.

Pesticide Residues

Even though there are no serious reports of toxicity due to the presence of pesticides and fumigants, it is important that herbs and herbal products are free of these chemicals or at least are controlled for the absence of unsafe levels.

Standardization and Quality Control of Herbal Drugs: Parameters

According to WHO, standardization and quality control of herbals is the process involved in the physicochemical evaluation of crude drug covering aspects, such a selection and handling of crude material, safety, efficacy and stability assessment of finished product, documentation of safety and risk based on experience, provision of product information to consumer and product promotion. Attention is normally paid to such quality indices Such as:

Morphology and Organoleptic Evaluation

It includes the morphological characters like colour, Odour, taste, shape, size etc. Detail characteristics includes fractures, texture and venation**.**

Microscopic and Histological Evaluation

These are important in both whole drug and powdered drug. It mainly includes study of characteristics like parenchyma, trichomes, calcium oxalate crystals, vascular bundle arrangement, stomata and fibres. Microscopic determination such as vein islet number, stomatal index stomatal number, vein termination number.

Physical Evaluation

It includes the various physical parameters like moisture content, solubility, viscosity, refractive index, melting point, optical rotation, ash values, extractives and foreign organic matter.

Chemical Evaluation

Qualitative tests comprise of various chemical tests to identify the nature of compounds present in the crude drugs.

1. **Test for Alkaloids:** Mayer's test, Dragendroff's test, Hager's test, Wagner's Test
2. **Glycosides and sugars:** Bontrager's test, Molisch's test, killer killini test.
3. **Test for Phytosterols:** Liebermann's and Burchard tests.
4. **Test for Tannins and Phenols:** Ferric chloride test.

Chromatographic Techniques

The Chromatographic techniques are the new and most common methods. Used to separate, identify and quantify the plant constituents. It consists of various methods which are as follows:

1. TLC (Thin Layer Chromatography)
2. HPLC (High Performance liquid chromatography)
3. Column Chromatography.
4. HPTLC (High Performance Thin Layer Chromatography)
5. GAS-LIQUID Chromatography

Biological Parameters

It consists of following evaluation methods

1. Bitterness value
2. Haemolytic activity
3. Swelling index
4. Foaming index
5. Pesticides residue Heavy metals
6. Microorganisms

7. Aflatoxins
8. Radioactive substances

Toxicological Studies
This helps to determine the pesticide residues, potentially toxic elements, safety studies in animals like LD50 and Microbial assay to establish the absence or presence of potentially harmful microorganisms.

Scope
Advanced Herbal Drug Technology focuses on applying modern scientific, analytical, and technological methods to traditional herbal medicines. It bridges Ayurveda and modern pharmaceutical science.

Standardization of Herbal Drugs
Ensuring quality, purity, safety, and efficacy of herbal medicines
Development of standards: physicochemical, phytochemical, chromatographic profiles
Use of technologies like HPLC, GC-MS, LC-MS, and FTIR

Novel Herbal Drug Formulations
Creating improved delivery systems such as:
These improve absorption, stability, and therapeutic effect.

Herbal Drug Research and Development
- Identifying new bioactive molecules from plants
- Preclinical & clinical research on efficacy
- Screening for anti-inflammatory, anticancer, antimicrobial, wound-healing properties, etc.

Quality Control and Regulatory Affairs
Development of Good Manufacturing Practices (GMP) for herbal products
Regulatory guidelines from.
- AYUSH
- WHO
- CDSCO
- Ensuring safety through toxicity studies

Industrial and Pharmaceutical Applications
- Growth of herbal cosmetic, nutraceutical, and Ayurvedic drug industries
- Large-scale production technologies:
- Extraction
- Purification
- Standardization
- Packaging & stability testing

Global Market Expansion
Increasing demand for herbal medicines internationally
Opportunities in export, regulatory compliance, and international certification (WHO, FDA)

Integration with Biotechnology
Plant tissue culture Genetic engineering to enhance active phytochemicals Biosynthesis of natural compounds Metabolite engineering

Research Career Opportunities
Students can work in Herbal drug R&D labs
- Ayurvedic pharmaceutical companies
- Cosmetic industries
- Nutraceutical manufacturing
- Quality control laboratories
- Academia & research institutes.

Implementation
The implementation of advanced herbal technology in semester research aims to efficiently isolate bioactive compounds while maintaining their potency, minimizing waste, and ensuring eco-friendly processes. Conventional and modern methods like decoction, infusion, maceration, supercritical fluid extraction, ultrasound-assisted extraction, and microwave-assisted extraction enhance yield, reduce time, and use less solvent.
In research project Purification techniques will play a critical role to ensure the safety, efficacy, and quality of herbal medicines. These techniques help remove contaminants, impurities, and unwanted components, enhancing the therapeutic potential of herbal drugs.
Physical Purification techniques like washing, sorting, sieving, and filtration remove physical impurities such as dirt, stones, and microbial contaminants.
Precipitation and Crystallization techniques are used to purify alkaloids, glycosides, and other compounds by separating impurities based on solubility differences as well as Steam Distillation is effective for isolating volatile oils and removing impurities. In research project Purification techniques will play a critical role to ensure the safety, efficacy, and quality of herbal medicines. These techniques help remove contaminants, impurities, and unwanted components, enhancing the therapeutic potential of herbal drugs.
Physical Purification techniques like washing, sorting, sieving, and filtration remove physical impurities such as dirt, stones, and microbial contaminant.

Literature Review
1) **Mr. Karanda Sankalp Santosh & Ms. Adsul P. S. (2023) [15].**
   Studied the Herbal drug technology is used for converting botanical materials into medicines, where standardization and quality control with proper integration of modern scientific techniques and traditional knowledge is important. In the present scenario, the demand for herbal products is growing exponentially throughout the world and major pharmaceutical companies are currently conducting extensive research on plant materials for their potential medicinal value. Herbal drug technology is used for converting botanical materials into medicines, where standardization and quality control with proper integration of modern scientific techniques and traditional knowledge is important.
2) **Showkat et al. (2022) [5]**
   Highlighted medicinal plant are widely used, but adulteration poses safety risk. Authentication using morphological, chemical and especially DNA markers is essential, with DNA markers preferred for their accuracy. Verified herbarium specimens are still needed for final conformation.
3) **Gavali Pratiksha Suresh &, Garute Komal Somnath (2022) [5].**
   Reviewed Herbal medicine refers to plant based substances with nutritive, cursive, or preventive

properties. It bridges traditional and modern science, covering areas like botany, pharmacognosy, Ayurveda and biotechnology. It plays a key role in promoting natural healing and holistic health.

4) **Prashant et al. (2012) [4].**
Reviewed standardization is an essential measurement for ensuring the quality control of the herbal drugs. "Standardization'' expression is used to describe all measures ,which are taken manufacturing process and quality control leading to a reproducible quality.

5) **SM Kazi et al. (2004) [2]**
Explore the details about the Different methods of identification of plant and plant preparation, herbs are used as adjunct therapy to conventional pharmaceutical. Selection criteria for substances of herbal origin relevant for standardization and quality control of herbal. Medicines. General considerations in the standardization and quality control of herbal materials.

Conclusion

Advanced Herbal Drug Technology is the field that combines traditional practices with modern pharmaceutical practices, enhancing the potential of herbal treatments in mainstream healthcare. By studying advanced herbal drug technology, we identify, formulate, and analyse herbal medicines safely and effectively, meeting the standards required for modern therapeutic applications. Advanced Herbal Technology represents a significant evolution in the field of herbal medicine and natural product research, combining traditional knowledge with cutting-edge scientific techniques. This interdisciplinary approach enhances the extraction, analysis, formulation, and therapeutic efficacy of herbal products, ensuring their safety, quality, and consistency.

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