

A REVIEW: -DIFFERENT EVALUATION METHODS OF CRUDE DRUGS

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Corresponding author Email : dipalidhumal2912@gmail.com**ABSTRACT:**

Evaluation is a methodical determination of subject's merit, worth and Greatness, using criteria governed by a set of standards. The aim of this review is to provide knowledge on importance of crude drug evaluation, and different evaluation methods available. This abstract provides a concise overview of different methods employed for the evaluation of crude drugs. These methods encompass a range of analytical techniques, including macroscopic and microscopic examination, organoleptic assessment, physicochemical analysis, and chromatographic profiling. Each method serves a specific purpose, contributing valuable information about the identity, purity, and potential therapeutic properties of crude drugs. Additionally, advancements in technology have led to the adoption of modern techniques such as spectroscopy and molecular biology for more precise and comprehensive evaluations. The selection of appropriate evaluation methods depends on the nature of the crude drug, the desired information, and the regulatory requirements. This abstract aims to highlight the diverse approaches available for the evaluation of crude drugs, emphasizing the importance of a holistic and multidimensional assessment to ensure the quality of these essential natural resources.

Keywords: *Evaluation methods, Crude drugs, organoleptic evaluation, microscopic evaluation*

Introduction:

Crude drug evaluation is a process of assessing and analyzing natural substances derived from plants, animals, minerals, or other sources for their medicinal or therapeutic properties. These substances, known as crude drugs, form the basis for the development of many pharmaceuticals and traditional medicines. The evaluation involves a series of steps aimed at determining the quality, purity, potency, and safety of the crude drug. Here is an introduction to the key aspects of crude drug evaluation:

❖ Identification:

- The first step in crude drug evaluation is the accurate identification of the plant, animal, or mineral source. Taxonomic classification and botanical or zoological authentication are essential to ensure the correct species is being used.

❖ Collection and Harvesting:

- Proper harvesting and collection techniques are crucial to maintain the quality of the crude drug. Factors such as the stage of plant development, time of harvesting, and processing methods can significantly impact the final product.

❖ Morphological and Microscopic Examination:

- Microscopic examination of the crude drug involves studying the cellular structure and morphology using a microscope. This helps in verifying the authenticity and quality of the drug.
- ❖ **Chemical Evaluation:**
 - Chemical analysis is performed to identify and quantify the chemical constituents which are present in the crude drug. This may involve techniques such as chromatography, spectrophotometry, and various chemical tests.
- ❖ **Physicochemical Properties:**
 - Determining the physical and chemical properties of the crude drug, such as solubility, density, moisture content, and pH, provides valuable information about its stability and potential applications.
- ❖ **Therapeutic Efficacy:**
 - Assessing the therapeutic efficacy involves studying the Pharmacology of the crude drug. This may include in vitro and in vivo experiments to understand the potential benefits and mechanisms of action.
- ❖ **Toxicological Evaluation:**
 - Safety is a critical consideration in crude drug evaluation. Toxicological studies help determine the potential adverse effects and establish safe dosage levels.
- ❖ **Quality Control:**
 - Establishing quality control measures ensures consistency and uniformity in the production of crude drugs. This involves setting standards for various parameters and regularly monitoring the manufacturing process.
- ❖ **Regulatory Compliance:**
 - Adherence to local and international regulations is essential in the evaluation of crude drugs. This includes compliance with Good Manufacturing Practices (GMP) and other relevant guidelines.
- ❖ **Documentation and Record Keeping:**
 - Keeping comprehensive records of the entire evaluation process is crucial for traceability, quality assurance, and regulatory compliance.

Crude drug evaluation is a multidisciplinary approach that combines botanical, pharmacological, chemical, and toxicological principles to ensure the safety and efficacy of natural substances used in traditional and modern medicine. This process plays a vital role in the development of herbal medicines and supplements, contributing to the overall quality and effectiveness of healthcare products derived from natural sources.

Crude drug:

A naturally occurring substance derived from plants, animals, or minerals that is used in its unrefined or raw form for medicinal or therapeutic purposes is known as crude drug. These substances are often the starting materials for the development of pharmaceutical drugs. Crude drugs may consist of entire plants, plant parts, animal tissues, or minerals, and they have been used for various medicinal, healing, or cultural practices for centuries.

Here are some key points about crude drugs:

- ❖ **Plant-Based Crude Drugs:**

- Many crude drugs are derived from plant sources. This includes parts of plants such as roots, stems, leaves, flowers, fruits, and seeds.
- Examples of plant-based crude drugs include cinchona bark (source of quinine), opium poppy latex (source of opium alkaloids), and foxglove leaves (source of digitalis glycosides).



❖ **Animal-Based Crude Drugs:**

- Some crude drugs are derived from animal sources. This may include parts of animals, such as glands, organs, or secretions.
- Examples of animal-based crude drugs include thyroid glands (source of thyroid hormones), liver extracts, and bee venom.

❖ **Mineral-Based Crude Drugs:**

- In some traditional medicine systems, minerals are used in their raw form or after minimal processing.
- Examples include various types of clays, sulfur, and certain metals.

❖ **Traditional Medicine:**

- Crude drugs have been historically used in traditional medicine systems around the world. Indigenous cultures often have extensive knowledge of the medicinal properties of local plants, animals, and minerals.

❖ **Raw and Unprocessed:**

- Unlike refined pharmaceutical drugs, crude drugs are typically used in their raw and unprocessed form. They may be dried, powdered, or used as decoctions or infusions.

❖ **Pharmacologically Active Compounds:**

- The therapeutic effects of crude drugs are often attributed to the presence of pharmacologically active compounds, such as alkaloids, glycosides, flavonoids, and other secondary metabolites.

❖ **Quality Control:**

- The quality of crude drugs can vary based on factors such as plant species, growing conditions, harvesting methods, and storage. Quality control measures are essential to ensure the safety and efficacy of crude drugs.

❖ **Modern Drug Development:**

- Many modern pharmaceutical drugs have their origins in crude drugs. The active ingredients extracted from crude drugs are often isolated, purified, and modified to create more standardized and targeted medications.

It's important to note that while crude drugs have contributed significantly to the development of pharmacology and medicine, their use should be approached with caution. The potency and safety of crude drugs can vary, and their use may be associated with certain risks. In modern medicine, the

emphasis is often on the development of standardized and regulated pharmaceuticals to ensure consistent quality and safety[1]

Evaluation methods for crude drugs:

The assessment of the quality, identity, purity, and sometimes the potency of plant or animal materials used in traditional medicine, herbalism, or other applications are involves in evaluation of crude drugs. Here are some common methods of evaluating crude drugs:

1. Macroscopic Evaluation:

- Organoleptic Evaluation: This involves assessing the sensory properties of the crude drug, such as color, odor, taste, and texture.
- Morphological Evaluation: Examining the external physical characteristics of the plant or animal material, including size, shape, surface features, and other visible attributes.

Macroscopic evaluation of crude drugs involves the examination of visible parameters such as size, shape, color, odor, taste, and texture without the aid of a microscope or other sophisticated instruments. This initial assessment is crucial for identifying and characterizing raw plant materials or other natural substances used in traditional medicine or pharmacognosy. Here are some key aspects of macroscopic evaluation for crude drugs:

- Organoleptic Properties:
 - Color: Note the color of the crude drug, which can vary widely and may indicate the presence of specific compounds.
 - Odor: Assess the smell of the crude drug, as certain aromas can be characteristic of particular plant species or chemical constituents.
 - Taste: While not always practical or safe, tasting a small amount of the crude drug can sometimes provide additional information.
- Size and Shape:
 - Size: Measure the size of the entire crude drug or its various parts (leaves, roots, seeds, etc.).
 - Shape: Observe the overall shape of the crude drug, as well as the shape of individual components.
- Texture:
 - Evaluate the texture of the crude drug. Is it powdery, fibrous, spongy, or hard? This information can be important for processing and formulation.
- Surface Features:
 - Examine the surface features of the crude drug. Are there hairs, crystals, or other distinguishing characteristics?
- Consistency:
 - Assess the consistency of the crude drug. Does it have a uniform texture, or are there variations?
- Foreign Matter:

- Check for the presence of foreign matter, such as soil, insects, or other contaminants, which may affect the quality of the crude drug.
- **Moisture Content:**
 - Note the moisture content of the crude drug, as this can impact storage and shelf life.
- **Packaging and Storage:**
 - Evaluate the packaging and storage conditions. Improper storage may lead to deterioration of the crude drug.
- **Botanical Identification:**
 - Compare the macroscopic features with botanical descriptions or reference samples to confirm the identity of the crude drug.
- **Physical Examination:**
 - Conduct a physical examination to identify any deformities, damages, or irregularities in the crude drug.

Macroscopic evaluation is often the first step in quality control for herbal medicines and natural products. While it provides valuable information, it is important to complement this with other analytical techniques, such as microscopic examination, chemical analysis, and chromatography, for a comprehensive understanding of the composition and quality of crude drugs. Additionally, adherence to established pharmacopoeial standards and guidelines is essential for ensuring the safety and efficacy of herbal products.[2]

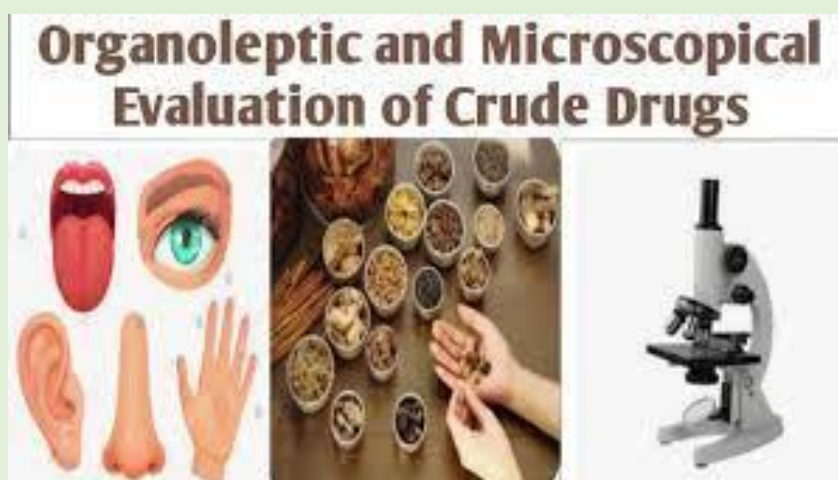


Fig 1 Evaluation of crude drugs

2. Microscopic Evaluation:

- **Microscopy:** Using a microscope to examine the internal cellular structure of the crude drug. This helps in identifying specific cellular features that are characteristic of particular plant species.

Microscopic evaluation of crude drugs involves the examination of plant tissues and cellular structures using a microscope. This type of analysis provides detailed information about the anatomical features of the plant material, which can aid in the identification, authentication, and quality assessment of crude drugs. Here are the key steps and considerations for microscopic evaluation of crude drugs:

- **Sample Preparation:**

- Obtain a representative sample of the crude drug, including various parts such as leaves, stems, roots, or seeds, depending on the plant species.
- Clean the sample to remove any extraneous matter, dust, or contaminants.
- Sectioning:
 - Prepare thin sections of the plant material using a microtome or other cutting methods. Thin sections allow for better visualization of cellular structures.
 - Different parts of the plant may require different sectioning techniques. For example, leaves may be sectioned differently than roots.
- Staining (optional):
 - Staining may be used to enhance the visibility of specific cellular components. Common stains include safranin, toluidine blue, and iodine.
- Mounting:
 - Mount the prepared sections on glass slides using a suitable mounting medium. This helps preserve the integrity of the tissues and facilitates microscopic examination.
- Microscopic Examination:
 - Use a light microscope to examine the prepared slides. Start with low magnification (e.g., 10x) to get an overview and then switch to higher magnifications (40x, 100x) for detailed observations.
 - Focus on various anatomical features such as trichomes, stomata, vessels, parenchyma cells, fibers, and other structures

Microscope can also be used for a quantitative evaluation of drugs and adulterated powders. This is done by counting a specific histological feature such as,

- Vein-islet index
- Palisade ratio
- Stomatal number
- Stomatal index
- Quantitative microscopy
- Refractive index

Stomatal number evaluation is a method used in plant anatomy and pharmacognosy to assess the quality of crude drugs, particularly those derived from plant sources. Stomata are small pores on the surface of plant leaves and stems that play a crucial role in gas exchange and water regulation. The stomatal number can provide valuable information about the plant's growth conditions, environmental factors, and sometimes even its identity. Here's a basic outline of how stomatal number evaluation is conducted for crude drugs:

Steps for Stomatal Number Evaluation:

- Sample Preparation:
 - Obtain a representative sample of the crude drug, usually consisting of leaves or stems.
 - Clean the sample to remove any extraneous matter such as dirt or debris.
- Slide Preparation:

- Take a small section of the plant material and prepare a thin, transparent section. This is typically done using a microtome to obtain thin slices.
- The section can be mounted on a glass slide using a suitable mounting medium.
- **Staining (Optional):**
 - Staining may be performed to enhance the visibility of stomata. Common stains include safranin, toluidine blue, or iodine.
- **Microscopic Examination:**
 - Place the prepared slide under a light microscope.
 - Focus on the epidermal layer of the plant material, which is where stomata are typically found.
 - Count the number of stomata within a defined area. This is usually done using a calibrated eyepiece or a specialized counting grid.
- **Calculation:**
 - Calculate the stomatal number per unit area. This can be expressed as the number of stomata per square millimeter or another defined unit.
 - The stomatal density can be indicative of environmental conditions, as well as provide information about the plant's adaptation to its habitat.

Considerations:

- **Variability:** Stomatal number can vary between different plant parts (e.g., upper and lower leaf surfaces) and between different species.
- **Factors Affecting Stomatal Number:**
 - Environmental conditions such as light intensity, humidity, and temperature.
 - Plant age and growth conditions.
 - Genetic factors.
- **Comparisons:**
 - Stomatal number can be compared with established standards or with samples of known quality to assess the crude drug's quality.
 - **Record Keeping:**
 - Maintain detailed records of the methodology used, including any staining procedures, and the calculated stomatal numbers.

In pharmacognosy, this type of evaluation helps in establishing quality control measures for herbal medicines and ensuring that the crude drug meets the required standards. It's important to note that stomatal number evaluation is just one aspect of the overall quality assessment of crude drugs, and it should be combined with other analytical methods for a comprehensive evaluation.

Stomatal index :

Stomatal index evaluation is another important parameter used in the quality assessment of crude drugs, especially those derived from plant sources. The ratio of the number of stomata to the total number of epidermal cells in a given area is called Stomatal index (SI). This index provides

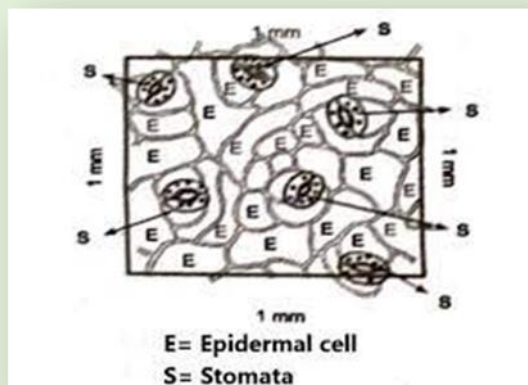
information about the plant's adaptation to its environment and can be used to assess the authenticity and quality of herbal materials. Here's an outline of the steps involved in stomatal index evaluation:

Steps for Stomatal Index Evaluation:

- **Sample Preparation:**
 - Obtain a representative sample of the crude drug, typically leaves or stems.
 - Clean the sample to remove any extraneous matter.
 - **Slide Preparation:**
 - Prepare thin, transparent sections of the plant material using a microtome.
 - Mount the sections on glass slides using a suitable mounting medium.
 - **Microscopic Examination:**
 - Examine the slides under a light microscope, focusing on the epidermal layer.
 - Count the total number of stomata in a specified area.
 - Count the total number of epidermal cells in the same area.
 - **Calculation of Stomatal Index:**
 - Use the formula:
Stomatal index(S.I.)= $S/(E+S) \times 100$
Where, S=Number of stomata per unit area
E= Number of epidermal cells in the same unit area
This will give you the stomatal index as a percentage.
 - **Multiple Measurements:**
 - Take measurements from multiple areas on the slide to account for variability.
 - Calculate the average stomatal index.
 - **Comparison and Interpretation:**
 - Compare the obtained stomatal index with established standards or with samples of known quality.
 - Interpret the results in the context of the plant's adaptation to environmental conditions. For example, plants adapted to arid environments may have a lower stomatal index.
 - **Record Keeping:**
 - Maintain detailed records of the methodology, measurements, and calculations.
- Considerations:**
- **Variability:** Stomatal index can vary between different plant parts and between different species.
 - **Factors Affecting Stomatal Index:**
 - Environmental conditions, such as light intensity, humidity, and temperature.
 - Genetic factors.
 - Developmental stage of the plant.
 - **Comparisons:**
 - Stomatal index results can be compared with established standards or with samples of known quality.
 - **Quality Control:**

- Stomatal index evaluation is one of the parameters used in quality control of herbal drugs to ensure consistency and authenticity.

It's important to note that stomatal index evaluation, when combined with other morphological and anatomical analyses, provides a comprehensive picture of the quality of a crude drug. Additionally, the interpretation of stomatal index results should consider the specific characteristics and adaptations of the plant species being evaluated.[3]



Vein-islets index :

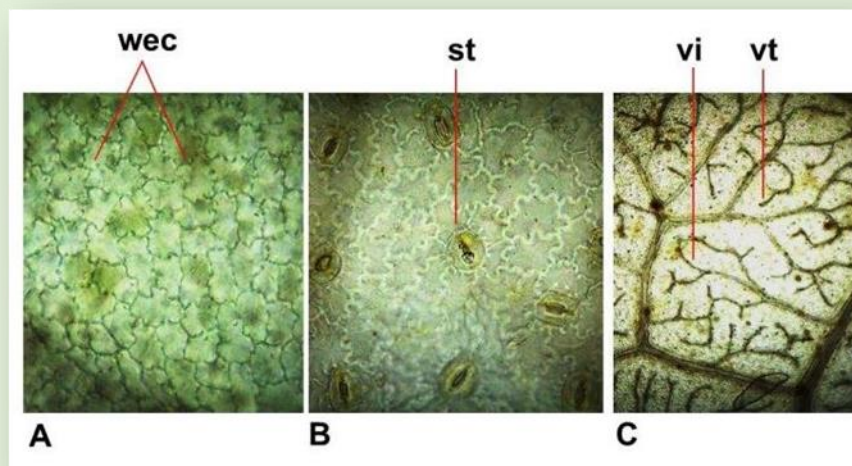
The term "vein islet index" is not a commonly recognized parameter in the field of pharmacognosy or plant anatomy. It's possible that there might be a typographical error, or it may refer to a specific characteristic used in a particular study or context.

If you are referring to a parameter related to veins in plant leaves, there are a few possibilities:

- Vein Density:
 - This involves measuring the number of veins per unit area on a leaf. The vein density can be indicative of the vascular architecture and might be relevant in assessing the quality of a crude drug.
- Vein Islet Density:
 - It might refer to the density or distribution of areas enclosed by veins on a leaf. These areas, sometimes called areoles, are often surrounded by veins in a specific pattern.

If you have a specific method or context in mind related to "vein islets index," I would recommend consulting the literature or research papers where this term is used. The specific method for evaluating such an index would depend on how it is defined in the context of a particular study.

If you provide more details or clarify the term, I'd be happy to help further. Alternatively, you may want to consult specific pharmacognosy or plant anatomy references that discuss the analysis of leaf characteristics in the evaluation of crude drugs



Palisade ratio :

The palisade ratio is a parameter used in the analysis of plant anatomy, particularly in the assessment of the leaf structure. The palisade parenchyma is a layer of elongated, closely packed cells found in the upper part of the mesophyll in plant leaves. The palisade ratio refers to the ratio of the length of palisade cells to the total thickness of the mesophyll.

Here's a general outline of how you might evaluate the palisade ratio in a crude drug sample:

Steps for Palisade Ratio Evaluation:

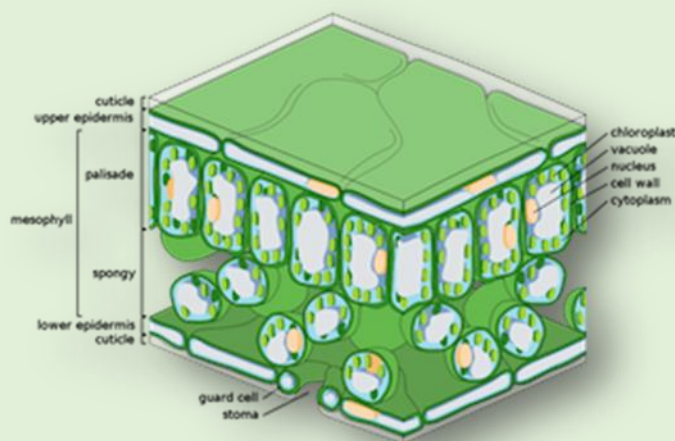
- **Sample Preparation:**
 - Obtain a representative sample of the crude drug, typically leaves.
 - Clean the sample to remove any extraneous matter.
- **Sectioning:**
 - Use a microtome to prepare thin sections of the plant material, including the leaves.
- **Slide Mounting:**
 - Mount the sections on glass slides using a suitable mounting medium.
- **Microscopic Examination:**
 - Examine the slides under a light microscope.
 - Focus on the leaf sections and specifically on the palisade parenchyma.
- **Measurement:**
 - Measure the length of the palisade cells.
 - Measure the total thickness of the mesophyll (including palisade and spongy parenchyma layers).
- **Multiple Measurements:**
 - Take measurements from multiple areas on the slide to account for variability.
 - Calculate the average palisade ratio.
- **Comparison and Interpretation:**
 - Compare the obtained palisade ratio with established standards or with samples of known quality.

- Interpret the results in the context of the leaf structure and its potential impact on the medicinal properties of the plant.
- Record Keeping:
 - Maintain detailed records of the methodology, measurements, and calculations.

Considerations:

- Variability: Palisade ratio can vary between different plant species and even within the same species due to environmental factors.
- Factors Affecting Palisade Ratio:
 - Environmental conditions such as light intensity, temperature, and water availability.
 - Plant age and growth conditions.
- Quality Control:
 - Palisade ratio evaluation is one of the parameters used in quality control of herbal drugs to ensure consistency and authenticity.

It's essential to note that the palisade ratio, when combined with other anatomical and morphological analyses, contributes to a comprehensive understanding of the plant material's quality and potential medicinal properties. If you have a specific context or method in mind, consulting relevant pharmacognosy literature or research papers may provide more detailed information.[4]

**Refractive index :**

The refractive index is a measure of how much a substance can bend or refract light. It is a physical property that can be used in the analysis of various materials, including crude drugs. The refractive index of a substance is typically determined by comparing the speed of light in a vacuum to its speed in the substance.

Here's a basic outline of how you might perform refractive index evaluation of a crude drug:

Steps for Refractive Index Evaluation:

- Sample Preparation:
 - Obtain a representative sample of the crude drug. The sample may need to be in a liquid or semi-liquid form for refractive index determination.
- Refractometer Setup:

- Use a refractometer, which is an optical instrument designed to measure the refractive index of a substance.
- Calibrate the refractometer using a standard reference material or distilled water.
- Application of Sample:
 - Place a small amount of the prepared sample on the glass surface of the refractometer.
- Reading the Refractive Index:
 - Close the cover plate to spread the sample thinly on the glass surface.
 - Look through the eyepiece of the refractometer and focus on the boundary line between the light and dark areas.
 - Determine the refractive index value where the boundary intersects the scale.
- Temperature Correction (if necessary):
 - Some refractometers may provide a temperature scale. If your sample has a different temperature than the calibrated temperature, corrections may be needed.
- Multiple Measurements:
 - Take multiple readings to ensure accuracy and reproducibility.
 - Calculate the average refractive index.
- Comparison and Interpretation:
 - Compare the obtained refractive index with established standards or with samples of known quality.
 - Interpret the results in the context of the specific characteristics of the crude drug.
- Record Keeping:
 - Maintain detailed records of the methodology, readings, and calculations.

Considerations:

- Temperature: The refractive index can be temperature-dependent, so it's essential to consider and correct for temperature variations if necessary.
- Calibration: Regular calibration of the refractometer using standard reference materials is crucial for accurate measurements.
- Sample State: The sample may need to be in a liquid or semi-liquid state for refractive index determination. If the crude drug is solid, it may need to be dissolved or extracted into a suitable solvent.

Refractive index determination is just one of the many analytical methods used in the quality assessment of crude drugs. It provides information about the optical properties of the substance, which may be useful in identifying and characterizing materials. Always refer to established procedures and standards in pharmacognosy or analytical chemistry for specific guidance on the evaluation of crude drugs using refractive index.

- Identification and Authentication: - Compare the observed microscopic features with reference materials, botanical monographs, or taxonomic descriptions to identify and authenticate the crude drug.
- Quantitative Analysis:
 - Assess quantitative parameters such as the size and density of specific cells, which can contribute to the overall quality characterization of the crude drug.

- . Documentation:
 - Document your observations systematically, including detailed descriptions and drawings if necessary. This documentation is crucial for quality control and regulatory compliance.
- Use of Specialized Microscopy Techniques:
 - Depending on the specific requirements, specialized microscopy techniques such as polarized light microscopy (PLM) or fluorescence microscopy may be employed for certain types of analysis.
- Quality Control Standards:
 - Adhere to established pharmacopoeial standards or regulatory guidelines for microscopic evaluation. These standards may provide specific criteria for the identification and quality assessment of crude drugs.
- Microscopic evaluation is an integral part of the pharmacognostic analysis of medicinal plants and crude drugs. It aids in ensuring the correct identification of plant material and contributes to the overall quality control of herbal products.[5]

3. Chemical Evaluation:

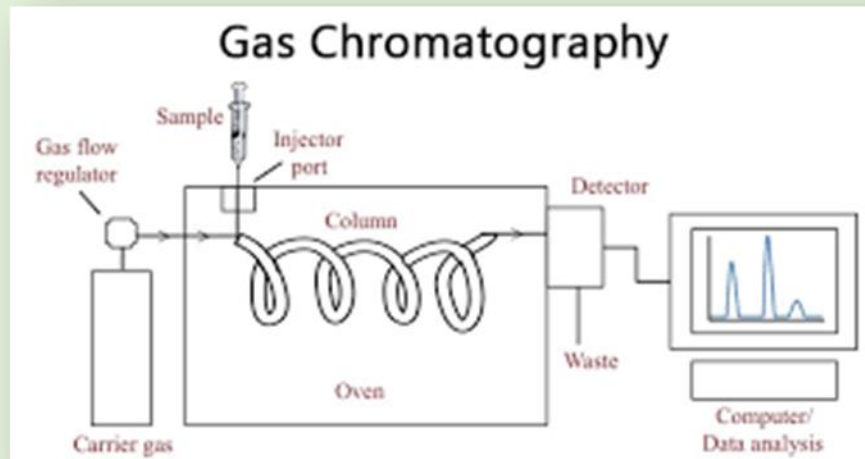
- Chemical Tests: Employing specific chemical reagents to identify the presence or absence of certain chemical constituents, such as alkaloids, flavonoids, tannins, and others.
- Thin-Layer Chromatography (TLC): Separating and identifying different chemical components in a crude drug based on their mobility on a thin layer of adsorbent material.
- High-Performance Liquid Chromatography (HPLC) or Gas Chromatography (GC): Quantitative analysis of specific chemical compounds within the crude drug.

Chemical evaluation of crude drugs involves the analysis of the chemical constituents present in the raw plant material. This process is crucial for assessing the quality, authenticity, and potential therapeutic value of medicinal plants. Various analytical techniques are employed to identify and quantify the chemical compounds within crude drugs. Here are key methods used in the chemical evaluation of crude drugs:

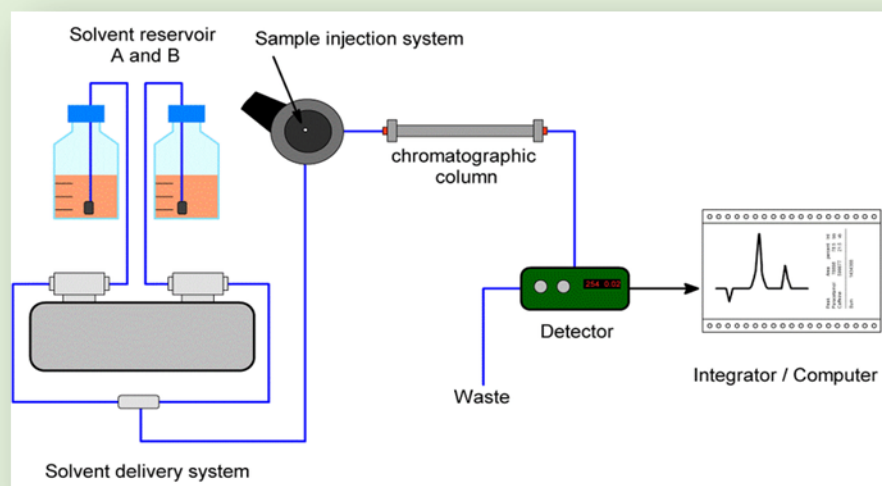
- Phytochemical Screening:
 - Preliminary tests to identify the presence of major classes of compounds, such as alkaloids, flavonoids, tannins, saponins, glycosides, terpenoids, and others. These tests provide a broad overview of the chemical composition.
- Chromatographic Techniques:
 - Thin Layer Chromatography (TLC): Separates and identifies individual compounds based on their migration on a thin layer of adsorbent.
 - Column Chromatography: Separates complex mixtures using a column filled with an adsorbent material, allowing for the isolation of individual compounds.

- High-Performance Liquid Chromatography (HPLC): Separates and quantifies compounds in a liquid sample based on their interaction with a stationary phase.
- Gas Chromatography (GC):
 - Separates volatile compounds based on their vaporization and interaction with a stationary phase. It is particularly useful for analyzing essential oils and other volatile constituents.
- Spectroscopic Techniques:
 - Ultraviolet-Visible (UV-Vis) Spectroscopy: Measures the absorption of light by compounds, providing information about their presence and concentration.
 - Infrared (IR) Spectroscopy: Identifies functional groups in compounds based on their absorption of infrared radiation.
 - Nuclear Magnetic Resonance (NMR) Spectroscopy: Provides detailed information about the molecular structure of compounds.
- Mass Spectrometry (MS):
 - Determines the mass-to-charge ratio of ions, helping identify and quantify compounds based on their mass spectra.
- Elemental Analysis:
 - Determines the elemental composition of the crude drug, which can be important for quality control.
- Quantitative Analysis:
 - Involves the quantification of specific compounds known to have therapeutic effects. For example, quantifying the amount of active alkaloids in a medicinal plant.
- Total Phenolic and Flavonoid Content:
 - These assays measure the overall content of phenolic and flavonoid compounds, which are known for their antioxidant properties.
- Microbial and Heavy Metal Analysis:
 - Ensures that crude drugs are free from harmful microorganisms and contaminants, such as heavy metals, which may affect safety.
- Isolation and Characterization of Bioactive Compounds:
 - Isolation of specific bioactive compounds from crude drugs and their further characterization to understand their pharmacological properties.

It's important to note that the choice of analytical techniques depends on the nature of the crude drug, the compounds of interest, and the specific goals of the evaluation. Additionally, adherence to pharmacopoeial standards and regulatory guidelines is crucial to ensure the quality and safety of herbal products.[6]



Gas chromatography



HPLC

4. Physicochemical Evaluation:

- Moisture Content: Determining the amount of water present in the crude drug.
- Ash Content: Assessing the total mineral content in the crude drug after burning.
- Extractive Values: Measuring the amount of soluble material extracted from the crude drug using different solvents.

Physicochemical evaluation of crude drugs involves the assessment of various physical and chemical properties of the raw plant material. These evaluations help in characterizing the quality, purity, and potential efficacy of the crude drug. Here are some key physicochemical parameters commonly considered during the evaluation:

- **Moisture Content:**
 - Determination of the amount of water present in the crude drug. Excessive moisture can lead to microbial growth, degradation of active compounds, and affect the overall stability of the material.
- **Ash Content:**
 - Measurement of total ash, acid-insoluble ash, and water-soluble ash provides information about the inorganic content of the crude drug. It can indicate the presence of inorganic impurities and is used for quality control purposes.
- **Extractive Values:**
 - Solvent extractive values help determine the amount of soluble constituents in the crude drug. This information is useful for understanding the extractable components and can be indicative of the drug's potential medicinal value.
- **Foreign Organic Matter:**
 - Examination for the presence of foreign organic matter, such as extraneous plant parts, insects, or other contaminants, which can impact the quality of the crude drug.
- **Swelling Index:**
 - Measures the extent of swelling of the crude drug in a particular solvent. This property is useful for assessing the swelling behavior of materials like gums and mucilage.
- **pH Value:**
 - Measurement of the acidity or alkalinity of the crude drug. The pH can influence the stability and solubility of certain compounds.
- **Specific Gravity:** - Determination of the specific gravity of the crude drug provides information about its density relative to the density of water. This property can be useful for assessing purity.
- **Bulk Density and Tapped Density:**

These parameters provide information about the packing properties of the crude drug, which can influence the flowability and compaction during manufacturing processes.

- **Particle Size and Distribution:**
 - Analysis of the particle size and distribution of the crude drug. This can impact dissolution rates, bioavailability, and the overall effectiveness of the material.
- **Color and Odor:**
 - Subjective evaluation of the color and odor of the crude drug, which can be indicative of its identity and quality.
- **Viscosity:**
 - Measurement of the viscosity of liquid extracts or formulations. This parameter is important for understanding the flow characteristics of the material.
- **Solubility:**

- Assessment of the solubility of the crude drug in different solvents. This property is crucial for the development of pharmaceutical formulations.
- **Refractive Index:**
 - Measurement of the refractive index provides information about the optical properties of the crude drug and can be used for identification.
- **Conductivity:**
 - Determination of the electrical conductivity of aqueous extracts, which can be influenced by the presence of ions and other dissolved substances.

These physicochemical evaluations are essential for establishing quality control standards for crude drugs, ensuring consistency in manufacturing, and verifying compliance with regulatory requirements. Standardized methods and procedures are often outlined in pharmacopoeias and other regulatory documents to guide the evaluation process.[7]

▪ **5. Biological Evaluation:**

- **Bioassays:** Assessing the pharmacological or biological activity of the crude drug to validate its traditional or claimed medicinal properties.
- **Toxicity Testing:** Evaluating the safety of the crude drug through toxicity studies.

Biological evaluation of crude drugs involves assessing the biological activities and potential therapeutic effects of the raw plant material. This type of evaluation is important for understanding the pharmacological properties of crude drugs, identifying potential therapeutic uses, and ensuring the safety of herbal remedies. Here are key aspects of biological evaluation for crude drugs:

- **Antioxidant Activity:** - Assessment of the ability of crude drugs to neutralize free radicals, which can contribute to oxidative stress. Common assays include DPPH (2,2-diphenyl-1-picrylhydrazyl) scavenging and total antioxidant capacity.
- **Anti-Inflammatory Activity:**
 - Evaluation of the ability of crude drugs to reduce inflammation, often measured by inhibiting inflammatory markers or pathways.
- **Antimicrobial Activity:**
 - Testing the crude drug against a range of microorganisms (bacteria, fungi, viruses) to assess its potential as an antimicrobial agent.
- **Antiviral Activity:**
 - Specifically assessing the ability of crude drugs to inhibit viral replication or entry into host cells.
- **Anticancer Activity:**
 - Evaluation of the potential of crude drugs to inhibit the growth of cancer cells or induce apoptosis. Cell culture and animal studies are commonly used for this purpose.
- **Antidiabetic Activity:**
 - Testing the effect of crude drugs on blood glucose levels and insulin sensitivity to assess potential antidiabetic properties.
- **Antihypertensive Activity:**
 - Evaluation of the ability of crude drugs to lower blood pressure, often through vasodilation or other mechanisms.

- Antispasmodic Activity:
 - Testing the crude drug's ability to reduce smooth muscle spasms, which can be relevant for gastrointestinal or respiratory conditions.
- Immunomodulatory Activity:
 - Assessing the impact of crude drugs on the immune system, including effects on immune cell function and cytokine production.
- Neuroprotective Activity:
 - Evaluation of the ability of crude drugs to protect nerve cells from damage, which may have implications for neurodegenerative diseases.
- Wound Healing Activity:
 - Testing the crude drug's potential to accelerate the healing of wounds, often assessed through in vivo models.
- Analgesic Activity: - Evaluation of the ability of crude drugs to reduce pain perception, commonly assessed using animal models.
- Hepatoprotective Activity:
 - Assessing the impact of crude drugs on liver function and protection against liver damage.
- Renoprotective Activity:
 - Evaluation of the ability of crude drugs to protect the kidneys from damage, particularly relevant in conditions affecting renal function.
- Toxicity Studies:
 - Determining the safety profile of crude drugs through acute and chronic toxicity studies.[8]

Biological evaluation is often conducted through in vitro studies using cell cultures, as well as in vivo studies using animal models. These evaluations help establish the pharmacological profile of crude drugs and contribute to the development of evidence-based herbal medicine. It's important to note that biological evaluations should be complemented by other analyses, such as chemical and physicochemical evaluations, to gain a comprehensive understanding of the crude drug's properties.

6. Quality Standards and Specifications:

- Reference Standards: Comparing the crude drug with established reference standards to ensure conformity.
- Monographs: Following pharmacopeial monographs or other established standards that provide detailed specifications for the quality of crude drugs.

Quality standards and specifications for the evaluation of crude drugs are essential for ensuring the identity, purity, and potency of medicinal plant materials. These standards help maintain consistency and safety in the production of herbal products. Here are key elements of quality standards and specifications for crude drug evaluation:

- Botanical Identification:

- Clear botanical identification of the plant material is fundamental. This involves using taxonomic keys and reference samples to confirm the correct species.
- **Macroscopic Evaluation:**
 - Standards for the physical characteristics, such as size, shape, color, and texture, based on the plant part (leaves, roots, seeds) are established. These standards serve as a reference for quality control.
- **Microscopic Evaluation:**
 - Microscopic features, including cell morphology, presence of specific structures (trichomes, stomata), and cellular arrangement, are defined. Reference images may be provided for comparison.
- **Chemical Composition:**
 - Quantitative and qualitative specifications for key chemical constituents are established. This may include limits for moisture content, ash content, and the presence of specific phytochemicals (alkaloids, flavonoids, etc.).
- **Physicochemical Properties:**
 - Standards for physicochemical parameters such as moisture content, ash values, extractive values, pH, specific gravity, and others are defined. These standards help assess the overall quality and purity of the crude drug.
- **Microbial Limits:**
 - Specifications for microbial contamination, including limits for bacteria, fungi, and other microorganisms, are established to ensure the safety of the crude drug.
- **Heavy Metals:**
 - Maximum permissible levels of heavy metals, such as lead, arsenic, mercury, and cadmium, are defined to prevent toxicity issues.
- **Pesticide Residues:**
 - Standards for acceptable levels of pesticide residues are set to ensure that the crude drug is free from harmful agricultural chemicals.
- **Radioactive Contamination:**
 - Limits for radioactive contamination are established to prevent the presence of harmful radioisotopes.
- **Foreign Organic Matter:**
 - Specifications regarding the presence of foreign matter, such as other plant parts or contaminants, are outlined.
- **Uniformity of Batch:**
 - Criteria for the consistency of batches, ensuring that different lots of the same crude drug exhibit similar characteristics.
- **Storage and Packaging Requirements:**
 - Guidelines for the proper storage conditions and packaging materials to maintain the integrity of the crude drug are specified.
- **Reference Standards:**
 - Use of reference standards, such as authenticated herbarium specimens or chemical markers, to compare and verify the identity and quality of the crude drug.
- **Documentation and Record-Keeping:**

- Establishing procedures for documentation, record-keeping, and reporting of results to ensure traceability and accountability.
- Compliance with Regulatory Standards: - Adherence to relevant pharmacopoeial monographs or regulatory guidelines to meet national and international standards.

Quality standards and specifications for crude drug evaluation are often outlined in pharmacopoeias, monographs, and regulatory documents specific to a region or country. These standards are continually updated and revised based on scientific advancements and emerging quality control practices in the field of herbal medicine. Manufacturers and producers of herbal products must comply with these standards to ensure the safety, efficacy, and consistency of their products.[9]

7. DNA Barcoding:

- Molecular Techniques: Using DNA barcoding to identify and authenticate plant species by analyzing specific regions of their DNA.

DNA barcoding is a molecular biology technique used for the identification and authentication of plant species, including those used as crude drugs in traditional medicine. It involves the sequencing of short, standardized DNA regions from a specimen and comparing the obtained sequences with reference databases to confirm the species. DNA barcoding has become an important tool in the quality control and evaluation of crude drugs, addressing challenges related to morphological similarities and the presence of powdered or processed plant materials.[10]

Here's how DNA barcoding is typically applied in the evaluation of crude drugs:

- Selection of DNA Barcode Region:
 - Choose a standard DNA barcode region that is short, easily amplifiable, and exhibits sufficient variability between species. Commonly used regions include the *rbcL* (chloroplast ribulose-1,5-bisphosphate carboxylase/oxygenase large subunit) and *matK* (chloroplast maturase K) genes, as well as the internal transcribed spacer (ITS) regions of nuclear ribosomal DNA.[11]
- Sample Collection and DNA Extraction:
 - Collect representative samples of the crude drug from different batches or sources.
 - Extract DNA from the collected samples using suitable methods, ensuring high-quality DNA for subsequent amplification.
- Polymerase Chain Reaction (PCR) Amplification:
 - Amplify the selected DNA barcode region using PCR with primers specific to the targeted region. This step generates copies of the DNA region of interest.
- Sequencing:
 - Sequence the PCR-amplified DNA region using DNA sequencing technologies. This generates the unique genetic code for each sample.
- Data Analysis and Comparison:
 - Compare the obtained DNA sequences with reference sequences available in comprehensive databases such as GenBank, BOLD (Barcode of Life Data Systems), or other relevant databases. This step helps identify the species of the plant material.
- Species Identification:

- Confirm the identity of the species based on the comparison of DNA sequences. If the sequence matches a known reference, it provides strong evidence for the correct identification of the plant species.
- Quantitative PCR (qPCR) for Adulteration Detection:
 - In addition to qualitative identification, quantitative PCR methods can be employed to detect and quantify the presence of potential adulterants in crude drugs.[12]

The application of DNA barcoding in the evaluation of crude drugs offers several advantages, including:

- Accuracy and Precision: DNA barcoding provides a high level of accuracy in identifying plant species, even when dealing with processed or powdered materials.
- Robustness: DNA barcoding is robust and less affected by external factors such as environmental conditions compared to traditional morphological identification.
- Standardization: The use of standardized DNA barcode regions allows for consistent and comparable results across different laboratories.[13]

However, it's important to note that DNA barcoding should be used in conjunction with other evaluation methods, such as chemical, microscopic, and physicochemical analyses, to obtain a comprehensive understanding of the quality and authenticity of crude drugs. Additionally, the availability of well-curated reference databases is crucial for accurate species identification.[14]

8. Quantitative Analysis:

- Quantitative Determination: Measuring the concentration of specific constituents in the crude drug, which is particularly relevant for assessing potency or ensuring consistency in herbal formulations.

Quantitative analysis of crude drugs involves determining the amounts or concentrations of specific chemical constituents present in the raw plant material. This type of analysis is crucial for assessing the potency and consistency of herbal products, ensuring that they meet defined quality standards. Here are common methods used for quantitative analysis in crude drug evaluation:[15]

- High-Performance Liquid Chromatography (HPLC):
 - Principle: Separates and quantifies individual compounds in a mixture based on their interactions with a stationary phase and a mobile phase.
 - Applications: Widely used for quantifying active compounds such as alkaloids, flavonoids, polyphenols, and other phytochemicals.[16]
- Gas Chromatography (GC):
 - Principle: Separates and quantifies volatile compounds in a sample based on their vaporization and interaction with a stationary phase.
 - Applications: Suitable for the analysis of essential oils and other volatile components in crude drugs.
- Liquid Chromatography-Mass Spectrometry (LC-MS):

- Principle: Combines the separation capabilities of liquid chromatography with mass spectrometry for compound identification and quantification.
- Applications: Useful for analyzing a wide range of compounds, including secondary metabolites and bioactive constituents.[17]
- UV-Visible Spectrophotometry:
 - Principle: Measures the absorption of ultraviolet or visible light by compounds in a sample.
 - Applications: Often used for quantifying specific compounds with characteristic absorption spectra, such as phenolic compounds.
- Fluorescence Spectrophotometry:
 - Principle: Measures the fluorescence emitted by certain compounds when excited by light of a specific wavelength.
 - Applications: Particularly useful for quantifying fluorescent compounds like certain alkaloids.[18]
- Atomic Absorption Spectroscopy (AAS):
 - Principle: Measures the absorption of specific wavelengths of light by metal atoms, allowing for the quantification of trace elements.
 - Applications: Used to determine the concentration of heavy metals in crude drugs.
- Inductively Coupled Plasma Mass Spectrometry (ICP-MS):
 - Principle: Measures the mass-to-charge ratio of ions generated from a sample in an inductively coupled plasma.
 - Applications: Suitable for the analysis of metals and metalloids at trace levels.
- Titration Methods:
 - Principle: Involves the controlled addition of a reagent to react with a specific compound in the sample until the reaction is complete.
 - Applications: Used for quantifying certain chemical constituents, such as alkaloids.[19]
- Nuclear Magnetic Resonance (NMR) Spectroscopy:
 - Principle: Utilizes the magnetic properties of atomic nuclei to provide information about the molecular structure of compounds.
 - Applications: Can be used for quantitative analysis of specific compounds in a mixture.
- Kjeldahl Method:
 - Principle: Determines the nitrogen content in a sample, often used for estimating protein content.
 - Applications: Applied in the analysis of plant materials to estimate protein content.[20]

It's important to select the appropriate method based on the specific compounds of interest and the characteristics of the crude drug. Validation of the chosen method, adherence to standard operating procedures, and calibration using reference standards are critical for accurate and reliable quantitative analysis in crude drug evaluation. Additionally, these methods are often used in combination to provide a more comprehensive assessment of the chemical composition of the crude drug.[21]

9. Physical Evaluation:

Size and Shape Analysis: Using instruments to measure physical characteristics, such as particle size and shape.

Physical evaluation of crude drugs involves the examination of various external characteristics and properties of the raw plant material without using sophisticated instruments. This type of assessment provides valuable information about the appearance, texture, and other physical attributes of the crude drug. Here are key aspects of the physical evaluation of crude drugs:

- **Organoleptic Properties:**
 - **Color:** Observe the color of the crude drug. Different plant parts and species may exhibit varying colors, and changes in color can indicate age, storage conditions, or processing.[22]
 - **Odor:** Assess the aroma of the crude drug. Specific odors can be characteristic of certain plants and are often used in the identification process.
 - **Taste:** While tasting is not always practical or safe, the taste of some crude drugs can be indicative of their quality or medicinal properties.
- **Size and Shape:**
 - Measure and record the size of the crude drug, including the length, width, and thickness. Observe the overall shape, as well as the shape of individual parts (leaves, roots, seeds).
- **Texture:**
 - Assess the texture of the crude drug by touching or pressing it. Note whether it is powdery, fibrous, spongy, or hard. Texture can impact the handling and processing of the material.
- **Consistency:**
 - Examine the consistency of the crude drug. Determine if it has a uniform texture or if there are variations in its physical properties.
- **5. Surface Features:**
 - Observe any surface features, such as the presence of hairs, crystals, or distinctive markings. These features can be useful in the identification of the plant material.
- **Moisture Content:**
 - Evaluate the moisture content of the crude drug. Excessive moisture can lead to microbial growth, spoilage, and degradation of active compounds.
- **Foreign Matter:**
 - Check for the presence of foreign matter, such as dirt, insects, or other contaminants. Foreign matter can affect the quality and safety of the crude drug.
- **Packaging and Storage:**
 - Assess the condition of the packaging and storage. Proper packaging is essential to prevent contamination, and the storage environment can impact the stability of the crude drug.
- **Fracture Characteristics:**
 - If applicable, observe the fracture characteristics of the crude drug, especially in the case of roots or barks. Different plant parts may exhibit distinct fracture patterns.

- Density:
 - Measure the density or mass per unit volume of the crude drug. Density can be an important parameter for quality control and standardization.
- Physical Form:
 - Describe the physical form of the crude drug, whether it is in the form of a powder, dried leaves, roots, or other plant parts. The physical form can influence its preparation and use.[23]
- Uniformity:
 - Assess the uniformity of different batches of the crude drug. Consistency in physical characteristics is important for ensuring quality and efficacy.

Physical evaluation is often one of the initial steps in the overall assessment of crude drugs. It provides valuable information for identification, quality control, and standardization of herbal materials, contributing to the safety and efficacy of herbal products.^[24]

10. Packaging and Storage Evaluation:

Assessment of Packaging: Ensuring that the crude drug is stored in appropriate conditions and that the packaging meets quality standards to prevent contamination and deterioration.

The choice of evaluation methods depends on the nature of the crude drug, its intended use, and the specific requirements of regulatory authorities or quality control standards. It's common for a combination of these methods to be employed for a comprehensive evaluation of crude drug.

The packaging and storage evaluation of crude drugs is an important aspect of quality control to ensure that the raw plant material maintains its integrity, potency, and safety throughout its shelf life. Inadequate packaging or improper storage conditions can lead to degradation, loss of efficacy, or contamination of the crude drug. Here are key considerations for evaluating the packaging and storage of crude drugs:[25]

- Packaging Integrity:
 - Check the integrity of the packaging material. Ensure that there are no visible signs of damage, such as tears, punctures, or leakage, which could expose the crude drug to external contaminants.
- Protection from Light:
 - Evaluate whether the packaging provides protection from light exposure. Light-sensitive compounds in crude drugs can degrade when exposed to sunlight or artificial light. Opaque or light-resistant packaging is often preferred.
- Protection from Moisture:
 - Assess the packaging's ability to protect the crude drug from moisture. Excessive humidity can lead to mold growth, degradation of active compounds, and the formation of clumps or aggregates.
- Protection from Air/Oxygen:

- Determine whether the packaging provides a barrier against air and oxygen. Exposure to air can lead to oxidation, affecting the stability of certain compounds in the crude drug.
- Protection from Contaminants:
 - Ensure that the packaging minimizes the risk of contamination from external sources, such as dust, insects, or other foreign matter.[26]
- Seal Integrity:
 - Check the integrity of seals on the packaging to prevent air and moisture ingress. Damaged seals can compromise the quality of the crude drug.
- Labeling:
 - Examine the labeling on the packaging to ensure that it includes essential information, such as the botanical name of the plant, batch/lot number, manufacturing date, expiration date, storage conditions, and any relevant safety instructions.
- Storage Conditions:
 - Evaluate whether the crude drug is stored under appropriate conditions. Follow recommended storage conditions, such as temperature and humidity levels, to prevent deterioration.
- Container Material:
 - Consider the material of the container itself. Glass, plastic, or metal containers may be suitable depending on the properties of the crude drug and the storage requirements.
- Ventilation:
 - Assess the packaging for adequate ventilation. Some crude drugs may release volatile compounds during storage, and proper ventilation can prevent the buildup of gases.
- Resealability:
 - For multi-use packaging, check if it is designed for resealing. Resealable packaging helps maintain the quality of the crude drug after initial opening.
- Compliance with Regulatory Requirements:
 - Ensure that the packaging complies with relevant regulatory requirements and standards for herbal products. This may include Good Manufacturing Practices (GMP) guidelines.
- Batch Traceability:
 - Confirm that the packaging includes batch information, allowing for traceability and recall if necessary.
- Absence of Pests:
 - Inspect the packaging for signs of pests or rodents. Adequate packaging should prevent infestations during storage.[27]

Regular monitoring and periodic inspections of both packaging and storage conditions are crucial for maintaining the quality of crude drugs. It is essential for manufacturers and distributors to adhere to good storage practices and follow recommended guidelines to ensure the safety, efficacy, and stability of herbal products throughout their shelf life.

Conclusion :

In conclusion, the diverse methods of evaluating crude drugs play a pivotal role in ensuring their quality, safety, and efficacy. Whether through macroscopic examination, microscopic analysis, chemical assays, or biological testing, each approach provides unique insights into the characteristics of crude drugs. Employing a combination of these methods allows for a comprehensive understanding, aiding in the standardization and quality control of these essential natural resources in the pharmaceutical and herbal industries.

Result:

The evaluation methods for crude drugs yield valuable results essential for assessing their quality. Macroscopic examination provides insights into physical attributes, while microscopic analysis reveals cellular structures. Chemical assays detect and quantify specific constituents, ensuring consistency. Biological testing assesses pharmacological activity. Integrating these methods enables a holistic evaluation, ensuring the potency, authenticity, and safety of crude drugs in diverse applications, from traditional medicine to pharmaceuticals

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