Pharmacognosy

Pharmacognosy: The study of medicinal drugs derived from plants or other natural sources. The name comes from the Greek words *pharmakon* (drug) and *gnosis* (knowledge).

4.1 Drying, Storage, and Quality Control of Herbal Drugs

The proper processing of crude herbal drugs after harvesting is crucial to preserve their active chemical constituents, prevent degradation, and ensure their safety and efficacy.

A. Drying of Crude Drugs

Drying is the process of removing sufficient moisture from the plant material to prevent microbial growth and the action of enzymes that can degrade the active constituents.

Objectives of Drying:

1. **Preservation:** To prevent decomposition from microbial action (bacteria, fungi) and enzymatic activity.
2. **Concentration of Active Constituents:** To increase the percentage of active compounds by weight.
3. **Ease of Handling and Storage:** Reduces the weight and bulk of the drug, making it easier to store and transport.
4. **Improved Quality:** Prevents changes in color, odor, and taste.

Methods of Drying:

1. **Natural Drying (Sun and Air Drying):**
    - **Sun Drying:** The plant material is spread in thin layers and exposed directly to sunlight.
        - **Advantages:** Inexpensive and simple.
        - **Disadvantages:** Slow, dependent on weather, risk of contamination by dust and insects, and loss of volatile oils and light-sensitive compounds (e.g., in peppermint, digitalis).
    - **Air Drying (Shade Drying):** The material is spread in thin layers on trays or hung in a well-ventilated, shaded area, protected from direct sun and rain.
        - **Use:** Ideal for drugs whose active constituents are sensitive to heat and light, such as leaves with volatile oils (Mentha), flowers, and barks (Cinnamon).
2. **Artificial Drying (Using Heat):**
    - This method uses controlled temperature and airflow for faster and more uniform drying.
    - **Tray Dryer:** The most common type. The drug is spread on trays inside a chamber where hot air is circulated. The temperature can be precisely controlled.
    - **Vacuum Dryer:** Drying is done under reduced pressure, which lowers the boiling point of water. This allows for rapid drying at low temperatures.

    - **Use:** Best for heat-sensitive (thermolabile) compounds like glycosides (e.g., in Digitalis, Senna).
- **Spray Dryer:** Used for drying liquid extracts or infusions. The liquid is sprayed as fine droplets into a chamber of hot air, causing instantaneous drying into a fine powder.
    - **Use:** For producing powdered extracts, enzymes, and milk powder.
- **Freeze Drying (Lyophilization):** The "gold standard" for drying highly sensitive materials. The material is first frozen and then placed under a high vacuum. The frozen water turns directly from a solid (ice) to a gas (vapor) without passing through a liquid phase (sublimation).
    - **Use:** For preserving antibiotics, vaccines, hormones, and other delicate biological products.

B. Storage of Crude Drugs

Proper storage is essential to protect the dried drug from environmental factors that can cause deterioration.

Factors Causing Deterioration:

- **Moisture:** Can lead to microbial growth and enzymatic degradation.
- **Light:** Can cause oxidation and decomposition of photosensitive compounds.
- **Temperature:** High temperatures can accelerate chemical reactions and degrade heat-sensitive compounds.
- **Oxygen:** Can cause oxidation of active constituents (e.g., fats and oils become rancid).
- **Pests:** Insects, mites, and rodents can consume or contaminate the drug.

Ideal Storage Conditions:

- **Containers:** Well-closed, airtight, and light-resistant containers (e.g., amber-colored glass jars, metal tins).
- **Environment:** A cool, dark, and dry place with good ventilation.
- **Temperature:** Generally, below 25°C. Some drugs require cold storage (2-8°C).
- **Protection from Pests:** The storage area should be clean and fumigated if necessary.

C. Quality Control of Herbal Drugs

Quality control ensures that the herbal drug meets established standards of identity, purity, and quality. This is more complex than for synthetic drugs due to the natural variability of plant materials.

Key Evaluation Parameters:

1. **Organoleptic Evaluation:** Using the senses to evaluate the drug.
    - **Macroscopic:** Color, odor, taste, size, shape, and surface characteristics.
    - **Microscopic:** Using a microscope to identify cellular structures, trichomes, stomata, and other diagnostic features specific to the plant.
2. **Physical Evaluation:**

- **Moisture Content:** Determines the amount of water in the drug (using methods like Loss on Drying). High moisture content indicates improper drying.
- **Ash Values:** Determines the amount of inorganic material (minerals) present.
    - **Total Ash:** Total inorganic material.
    - **Acid-Insoluble Ash:** Measures the amount of silica (sand, soil), indicating contamination.
- **Extractive Values:** Determines the amount of active constituents soluble in a specific solvent (e.g., water, alcohol).

3. **Chemical Evaluation:**
    - **Qualitative Tests:** Simple chemical tests to identify the presence of specific classes of phytochemicals (e.g., alkaloids, glycosides, tannins, flavonoids).
    - **Quantitative Tests (Assay):** Determines the exact amount or concentration of specific active constituents.
4. **Chromatographic and Spectroscopic Techniques (Modern Methods):**
    - **Thin Layer Chromatography (TLC) / High-Performance TLC (HPTLC):** Used to create a unique "fingerprint" of the plant extract, which helps in identification and quantification.
    - **High-Performance Liquid Chromatography (HPLC):** A highly precise method for separating, identifying, and quantifying individual chemical constituents.
    - **Gas Chromatography (GC):** Used for volatile compounds like essential oils.
5. **Biological Evaluation (Bioassay):**
    - This is used when the active constituents are difficult to isolate or quantify chemically. The potency of the drug is determined by its effect on a living system (e.g., microorganisms, isolated animal tissues, or whole animals).
    - **Example:** Testing the antibacterial activity of a plant extract on a specific bacterial culture.

4.2 Extraction Process and Isolation of Active Ingredients

Extraction: The process of separating medicinally active constituents from plant or animal tissues using selective solvents.

Goal: To obtain a concentrated extract containing the desired phytochemicals while leaving behind the inactive, inert material (known as the *marc*).

A. Choice of Solvent

The choice of solvent is critical and depends on the polarity and solubility of the target compounds.

- **Water (Aqueous):** For highly polar compounds like tannins, gums, and saponins.
- **Alcohol (Ethanol, Methanol):** A universal solvent that can extract a wide range of compounds (alkaloids, glycosides, flavonoids).
- **Ether, Chloroform, Hexane:** Non-polar solvents used for extracting oils, fats, waxes, and non-polar alkaloids.

B. Extraction Processes (Methods)

1. **Infusion:** The plant material is placed in a pot and steeped with cold or hot water for a short period (like making tea). Used for delicate drugs with water-soluble constituents.
2. **Decoction:** The crude drug (usually hard materials like wood or bark) is boiled in a specified volume of water for a defined time. The solution is then cooled and strained.
3. **Maceration:** The drug is placed in a stoppered container with the solvent and allowed to stand at room temperature for a period of at least 3 days, with frequent agitation. The liquid is then strained off.
4. **Percolation:** A highly efficient method where a coarse powder of the drug is packed into a column (a percolator). The solvent is slowly passed through the column, continuously extracting the constituents as it flows down. The extract (percolate) is collected at the bottom.
5. **Soxhlet Extraction (Continuous Hot Extraction):** The most efficient method for extracting compounds that are not heat-sensitive. The drug is placed in a thimble inside the Soxhlet apparatus. The solvent is heated, its vapor rises, condenses, and drips back onto the drug, extracting the constituents. When the chamber fills, the extract is siphoned back into the flask. This process repeats automatically, allowing for efficient extraction with a small amount of solvent.
6. **Supercritical Fluid Extraction (SFE):** A modern, "green" technology. It uses a supercritical fluid, most commonly **carbon dioxide (CO2)**, as the extraction solvent. Above its critical temperature and pressure, CO2 behaves like a liquid (dissolving substances) but diffuses like a gas (penetrating the material easily).
    - **Advantages:** Non-toxic, non-flammable, and leaves no solvent residue. The solvent is easily removed by simply reducing the pressure.
    - **Use:** Ideal for extracting heat-sensitive compounds like flavors, fragrances, and for decaffeinating coffee.

C. Isolation of Active Ingredients

After obtaining the crude extract, the next step is to separate and purify the individual active compounds. This is a multi-step process.

General Strategy:

1. **Fractionation:** The crude extract is separated into different fractions based on the polarity of the compounds. This is often done using **liquid-liquid extraction** or **column chromatography**.
    - For example, an alcohol extract can be partitioned between a non-polar solvent (like hexane) and a polar solvent (like water). The non-polar compounds will move to the hexane layer, while polar compounds remain in the water layer.
2. **Chromatography for Purification:** The fractions are further purified using various chromatographic techniques.
    - **Column Chromatography (CC):** A glass column is packed with an adsorbent material (like silica gel or alumina). The fraction is loaded onto the column, and a solvent (mobile phase) is passed through it. Compounds separate based on their

affinity for the adsorbent and the solvent, and are collected in different test tubes as they exit the column.

- **Thin Layer Chromatography (TLC):** Used for monitoring the separation process and checking the purity of the collected fractions.
- **High-Performance Liquid Chromatography (HPLC):** Preparative HPLC is used for the final purification of compounds to a very high degree of purity.

3. **Crystallization:** The purified compound is dissolved in a suitable solvent and allowed to cool slowly, causing it to form pure crystals. Crystallization is a powerful purification technique.
4. **Structure Elucidation:** Once a pure compound is isolated, its chemical structure is determined using advanced spectroscopic techniques like:
    - **Mass Spectrometry (MS):** Determines the molecular weight and formula.
    - **Nuclear Magnetic Resonance (NMR) Spectroscopy (^{1}H-NMR, ^{13}C-NMR):** Provides detailed information about the arrangement of atoms in the molecule.
    - **Infrared (IR) Spectroscopy:** Identifies the functional groups present.
    - **UV-Visible Spectroscopy:** Provides information about conjugated systems in the molecule.