Review Article

Macroscopic and Microscopic Evaluation of Chitrak Plant (*Plumbago zeylanica* l.): A Review for Pharmacognostic Identification

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ABSTRACT

Plumbago zeylanica l., commonly known as Chitrak or Ceylon leadwort, is a well-recognized medicinal plant belonging to the family Plumbaginaceae and extensively used in traditional systems of medicine such as Ayurveda and Siddha. The plant possesses a wide range of pharmacological activities including anti-inflammatory, antimicrobial, antioxidant, digestive stimulant, and hepatoprotective effects, mainly attributed to the presence of its major bioactive compound, plumbagin. Due to the increasing demand for herbal drugs and the risk of adulteration and substitution, accurate identification and standardization of medicinal plants have become essential. Pharmacognostic evaluation plays a crucial role in ensuring the authenticity, purity, and quality of crude drugs.

This review focuses on the detailed macroscopic and microscopic evaluation of different parts of Plumbago zeylanica, particularly the root, stem, and leaves, which are commonly used in herbal formulations. Macroscopic evaluation includes the study of morphological features such as size, shape, colour, surface characteristics, odour, and taste, which provide primary identification markers. Microscopic evaluation involves the examination of internal anatomical structures such as cork cells, cortex, vascular tissues, xylem rays, and calcium oxalate crystals, which serve as diagnostic features for authentication. Additionally, powder microscopy highlights important identifying characters such as lignified fibers, pitted vessels, and starch grains.

The pharmacognostic parameters discussed in this review are essential for the proper identification, quality control, and standardization of Chitrak. Such studies help in preventing adulteration and ensuring the safety, efficacy, and therapeutic reliability of herbal medicines.

This review aims to compile and critically analyse the pharmacognostic characteristics of Plumbago zeylanica for accurate identification. The study is based on previously reported literature and emphasizes key diagnostic microscopic features such as calcium oxalate crystals, lignified fibers, and vascular arrangements, which are essential for authentication and quality control.

Furthermore, the review highlights standard pharmacognostic parameters that can be utilized for monograph development and regulatory standardization. The compiled data may serve as a reference for researchers, academicians, and quality control analysts in the herbal drug industry.

Keywords: Chitrak, pharmacognosy, microscopic evaluation, macroscopic evaluation, medicinal plant, plumbagin.

1. INTRODUCTION

Medicinal plants have been an essential component of traditional healthcare systems since ancient times.[1,2,14] Herbal drugs are widely used due to their natural origin, therapeutic effectiveness, and fewer side effects compared to synthetic drugs.[1,2] However, the increasing demand for herbal medicines has also led to problems such as adulteration, substitution, and contamination.[5-7] Therefore, proper identification and standardization of medicinal plants are necessary.

According to the World Health Organization (WHO), nearly 80% of the global population relies on herbal medicines for primary healthcare. The increasing commercialization of herbal drugs has raised serious concerns regarding quality, safety, and authenticity, thereby necessitating stringent pharmacognostic evaluation methods.

In recent years, pharmacognosy has evolved with the integration of modern analytical techniques such as chromatography and molecular identification, which complement traditional microscopic evaluation. However, classical pharmacognostic parameters remain fundamental due to their cost-effectiveness and reliability in routine drug authentication.

Pharmacognostic evaluation is one of the most important methods used for the identification and authentication of crude drugs derived from plants.[4,12,16] It includes macroscopic, microscopic, and physicochemical analysis. Macroscopic evaluation involves studying the external morphological characteristics of plant parts, while microscopic evaluation involves studying the internal structures of tissues and cells using a microscope.

Plumbago zeylanica is a perennial medicinal herb widely distributed in tropical and subtropical regions[13,26]. In Ayurveda, the plant is commonly referred to as Chitrak and is used for treating digestive disorders, skin diseases, inflammation, and metabolic conditions.[10,26] The root of the plant is considered the most important medicinal part due to the presence of the active compound plumbagin, which possesses strong pharmacological properties.[13,25]

The pharmacognostic study of Chitrak helps in establishing its authenticity and provides important diagnostic characteristics that differentiate it from other species.

Figure 1: Chitrak Plant (*Plumbago zeylanica l.*)

2. Botanical Description of Chitrak

Scientific Classification

- **Kingdom:** Plantae
- **Division:** Angiosperms
- **Class:** Dicotyledonae
- **Order:** Caryophyllales
- **Family:** Plumbaginaceae
- **Genus:** Plumbago
- **Species:** *Plumbago zeylanica l.*

Synonyms: Plumbago alba, Plumbago scandens (reported in some literature).

The genus Plumbago comprises several species, among which *Plumbago zeylanica* is the most therapeutically important due to its high plumbagin content.

Common Names

- Chitrak (Sanskrit)
- White Leadwort
- Ceylon Leadwort
- Chitramul (Hindi)

Habitat and Distribution

The plant is widely distributed in tropical regions including India, Sri Lanka, Southeast Asia, Africa, and Australia. It grows well in wastelands, forest margins, and roadside areas. (10,26)

Morphological Description

Chitrak is a perennial shrub that can grow up to 1–2 meters in height. The plant has slender stems, simple leaves, and white flowers arranged in spikes.

Medicinal Importance

The plant contains several active phytoconstituents such as:

- Plumbagin
- Sitosterol
- Tannins
- Flavonoids
- Alkaloids[5.13.28]

Among these, plumbagin is considered the major bioactive compound responsible for many therapeutic activities including antimicrobial, antioxidant, and anticancer properties. [13,15,28]

The phytochemical profile of *Plumbago zeylanica* has been extensively studied and includes naphthoquinones, glycosides, steroids, and phenolic compounds. Among these, plumbagin (5-hydroxy-2-methyl-1,4-naphthoquinone) is the principal bioactive constituent responsible for most of its biological activities.

3. Macroscopic Evaluation of Chitrak

Macroscopic evaluation involves the examination of external morphological features of the plant parts used as crude drugs.

Macroscopic evaluation, also known as organoleptic evaluation, involves the assessment of crude drugs based on sensory parameters such as colour, odour, taste, size, and texture, which serve as preliminary identification tools.

Root (Chitrak Root)

The root is the most important medicinal part of the plant.

Figure 2: Roots of *Plumbago zeylanica*

Morphological Characteristics

- **Size:** 10–30 cm in length
- **Shape:** Cylindrical and slightly tapering
- **Colour:** Reddish brown externally and yellowish internally
- **Surface:** Smooth with occasional wrinkles
- **Fracture:** Short and fibrous
- **Odour:** Slightly characteristic

- **Taste:** Acrid and pungent

The root bark is thin and can be easily separated from the wood. The presence of a pungent taste is considered a diagnostic feature.

Stem

The stem of Chitrak is slender, branched, and slightly woody.

Characteristics

- Green when young and brown when mature
- Cylindrical in shape
- Smooth surface
- Internodes are clearly visible

Figure 3: Stem of *Plumbago zeylanica*

Source: https://share.google/gJIdTdR525Muz1hXc

Leaves

Leaves are simple and alternately arranged.

Characteristics

- **Shape:** Ovate to oblong
- **Size:** 5–10 cm long
- **Colour:** Dark green
- **Texture:** Smooth
- **Margin:** Entire
- **Apex:** Acute

Leaves are sessile or subsessile. [1,3,4,19]

These macroscopic characteristics serve as primary identification markers and are useful in distinguishing Plumbago zeylanica from its closely related species and possible adulterants.

4. Microscopic Evaluation

Microscopic evaluation provides detailed information about the internal anatomical structure of the plant.

Microscopic evaluation provides detailed insight into the internal anatomical structure of different plant parts and serves as a reliable tool for authentication of crude drugs.[3,4,20,22]

Root Microscopy

The transverse section of the root reveals a well-developed cork (periderm) composed of several layers of rectangular, thick-walled cells forming the outer protective layer. Beneath the cork lies the cortex, which consists of parenchymatous cells containing abundant starch grains and calcium oxalate crystals, often present in rosette form. The vascular region is well developed, with phloem located externally and xylem occupying a major central portion. The xylem consists of vessels, tracheids, and fibers arranged in radial rows. Medullary rays are prominent, extending radially and facilitating lateral transport of nutrients. Secondary growth is clearly observed.

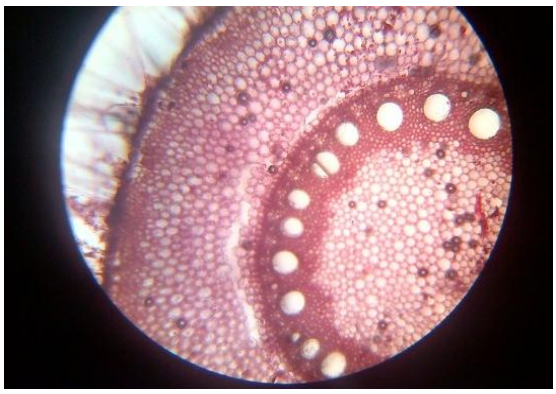

Figure 4: Microscopic Structure of Root

Source: SLIDE PREPARATION - BIOLOGY4ISC

https://share.google [EcVVnjQaJIFL4rGtB

Cork (Periderm)

- Outermost protective layer
- Consists of several layers of rectangular cells
- Cells are thick-walled and compactly arranged

Cortex

- Located below the cork
- Composed of parenchyma cells
- Contains starch grains and calcium oxalate crystals

Phloem

- Present below the cortex
- Consists of sieve tubes, companion cells, and phloem fibres

Xylem

- Occupies a large portion of the root
- Consists of vessels, tracheid, and xylem fibers
- Vessels are arranged in radial rows

Xylem Rays

- Radial bands of parenchyma cells
- Important for lateral conduction of nutrients

Medullary rays are uniseriate to multiseriate and extend radially. Secondary growth is prominent with well-developed vascular tissues. Calcium oxalate crystals are present in the cortex region in the form of rosettes.

Stem Microscopy

The stem shows a single-layered epidermis covered with a cuticle. Below the epidermis lies the cortex, composed mainly of parenchyma cells. Collenchymatous tissues may also be present, providing mechanical support. Vascular bundles are arranged in a ring and are collateral and open in nature. Lignified fibers are present, contributing to structural strength. A well-defined central pith composed of parenchymatous cells is also observed.

- Epidermis with cuticle
- Cortex composed of parenchyma cells
- Collenchyma present below the epidermis
- Vascular bundles arranged in a ring
- Central pith composed of parenchyma cells

Presence of lignified fibers provides mechanical strength. Vascular bundles are collateral and open in nature. Secondary thickening may be observed in mature stems.

Leaf Microscopy

The leaf exhibits a typical dorsiventral structure with distinct upper and lower epidermis. The epidermis is covered with a protective cuticle. Stomata are predominantly present on the lower epidermis and are of the anisocytic type. The mesophyll is differentiated into palisade parenchyma, consisting of elongated chloroplast-rich cells, and spongy parenchyma, which contains loosely arranged cells with intercellular spaces for gaseous exchange. Vascular bundles are embedded within the mesophyll.

Epidermis

- Upper and lower epidermis present
- Covered with cuticle
- Stomata present mainly on lower surface

Mesophyll: Divided into two layers:

- **Palisade parenchyma:** elongated cells rich in chloroplasts
- **Spongy parenchyma:** loosely arranged cells with air spaces[3,4,20,22]

Vascular Bundles

Contain xylem and phloem tissues responsible for transport of water and nutrients. [3,4,20,22]

Stomata are of anisocytic type. Cuticle is moderately thick, preventing water loss. Presence of trichomes may be observed in some specimens.

Histochemical analysis helps in identifying specific chemical constituents within plant tissues Lignin is detected in vascular tissues, starch grains in cortical cells, and calcium oxalate crystals in parenchymatous regions These findings further support pharmacognostic identification.[4,12]

5. Powder Microscopy

Powder microscopy is an important technique used for the identification of crude drugs in powdered form. The powdered sample of *Plumbago zeylanica* exhibits characteristic features such as lignified fibers, pitted vessels, cork cells, calcium oxalate crystals, and starch grains Stone cells (sclereids) may also be observed These diagnostic features remain intact even after grinding and are useful in detecting adulteration and ensuring authenticity of the plant material.

Characteristic features observed include:

- Lignified fibers
- Pitted vessels
- Cork cells
- Calcium oxalate crystals
- Starch grains
- Stone cells (sclereids)

These features help identify the plant material even after grinding. [4,21]

The presence of diagnostic features such as lignified fibers, sclereids, and calcium oxalate crystals in powdered form confirms the authenticity of the drug even in adulterated samples.

Powder analysis can be further supported by sieving and particle size determination, which enhances reproducibility in quality control procedures. [4,21]

6. Physicochemical Evaluation

Physicochemical evaluation plays a crucial role in determining the purity, quality, and standardization of crude drug. The following parameters are commonly evaluated:

- Ash values (total ash, acid-insoluble ash): Indicates presence of inorganic matter
- Extractive values (alcohol-soluble and water-soluble extractives): Provide information about amount of active constituent present
- Moisture content (loss on drying): Prevent microbial growth and degradation
- pH determination: Important for stability and formulation purpose

7. Quantitative Microscopy

Quantitative microscopy involves the measurement of specific leaf constants that are useful for identification and standardization. These include:

- Stomatal number and stomatal index
- Vein-islet number
- Vein termination number
- Palisade ratio

These parameters provide quantitative standards for the authentication of plant material.

8. Fluorescence Analysis

Fluorescence analysis is a valuable pharmacognostic tool used for the identification of crude drugs based on their fluorescence properties under visible and ultraviolet light. The powdered drug of *Plumbago zeylanica* exhibits characteristic fluorescence when treated with different chemical reagents These fluorescence patterns serve as an important parameter for detecting adulteration and ensuring drug identity.

9. Pharmacological Activities

The medicinal plant exhibits various pharmacological activities due to the presence of bioactive compounds.

- **Anti-inflammatory activity:** Reduces inflammation and swelling. [18,29]
- **Antimicrobial activity:** Effective against several bacteria and fungi. [17,32]
- **Digestive stimulant:** Stimulates appetite and improves digestion.
- **Antioxidant activity:** Helps neutralize free radicals.[15,30]
- **Hepatoprotective activity:** Protects liver cells from damage. [31]

The pharmacological activities of *Plumbago zeylanica* are mainly attributed to plumbagin, which exhibits its effects through mechanisms such as inhibition of inflammatory mediators, antimicrobial action via disruption of microbial cell membranes, and antioxidant activity by scavenging free radicals.

Several in vitro and in vivo studies have demonstrated the efficacy of plumbagin in modulating signaling pathways involved in inflammation and cancer progression. It has been reported to inhibit NF-κB activation and induce apoptosis in various cancer cell lines.

10. Toxicity and Safety Profile

Despite its therapeutic benefits, excessive use of *Plumbago zeylanica* may cause irritation, burning sensation, and gastrointestinal disturbances due to the presence of plumbagin. Therefore, proper dosage and standardization are essential for safe use.

Toxicological studies indicate that plumbagin exhibits dose-dependent toxicity; therefore, controlled usage is recommended. Standardization and proper formulation are essential to minimize adverse effects.

11. Importance of Pharmacognostic Evaluation

Pharmacognostic studies are essential for:

- Identification of authentic plant material
- Prevention of adulteration
- Standardization of herbal drugs
- Quality control of herbal formulations
- Ensuring safety and therapeutic efficacy[6,7,23]

Such studies help maintain the quality and purity of medicinal plant products.

Pharmacognostic evaluation forms the basis for inclusion of medicinal plants in pharmacopoeias and is essential for meeting international regulatory guidelines such as those prescribed by WHO and AYUSH.

12. Industrial Applications

Due to its diverse pharmacological properties, *Plumbago zeylanica* has significant industrial applications It is widely used in pharmaceutical formulations for digestive and anti-inflammatory preparations. In the nutraceutical industry, it is utilized for its health-promoting properties Additionally, it finds applications in cosmetic formulations due to its antioxidant activity. Standardized extracts of the plant are increasingly being used in herbal product development

13. Future Prospects

Future research on *Plumbago zeylanica* should focus on advanced phytochemical investigations, clinical trials, and development of novel drug delivery systems Molecular techniques such as DNA barcoding can be employed for accurate identification. Further studies on pharmacokinetics and toxicology are also necessary to ensure safe therapeutic use and global acceptance.

CONCLUSION

Macroscopic and microscopic evaluation of Chitrak provides important diagnostic characteristics for its identification and authentication. The external morphological features such as root colour, size, and shape along with internal anatomical structures such as cork cells, vascular tissues, and calcium oxalate crystals are useful markers for pharmacognostic standardization. Proper identification of medicinal plants like Chitrak is essential for maintaining the quality and safety of herbal medicines used in traditional and modern health.

The present review highlights the importance of detailed pharmacognostic evaluation in ensuring the authenticity and quality of *Plumbago zeylanica*. Comprehensive macroscopic, microscopic, and physicochemical studies provide reliable parameters for identification and standardization. Further advanced studies including

phytochemical profiling, molecular characterization, and clinical validation are necessary to fully explore its therapeutic potential

The integration of traditional pharmacognostic techniques with modern analytical approaches will further enhance the standardization and global acceptance of herbal medicines.

Standardization of herbal drugs is a critical step toward their global acceptance and commercialization.

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