PHARMACOGNOSTIC AND PHYTOCHEMICAL STUDIES OF AEGLE MARMELOS

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ABSTRACT

The pharmacognostic and phytochemical investigation of Aegle marmelos establishes its authenticity, quality, and therapeutic relevance as a valuable medicinal plant. Detailed macroscopic and microscopic analyses highlight unique identifying characteristics, including specific leaf structure, presence of oil glands, calcium oxalate crystals, lignified tissues, and distinct vascular patterns. These diagnostic markers are crucial for accurate identification and prevention of adulteration.Evaluation of physicochemical constants such as total ash, acid-insoluble ash, extractive values, and moisture content provides important standards for assessing purity and maintaining quality control of the crude drug. Such parameters contribute to ensuring the safety, uniformity, and stability of herbal preparations derived from the plant.Preliminary phytochemical studies indicate the occurrence of multiple bioactive compounds, including alkaloids, flavonoids, tannins, saponins, glycosides, coumarins, terpenoids, and other phenolic constituents. These compounds are associated with a wide range of biological activities such as antidiabetic, antimicrobial, anti-inflammatory, antioxidant, hepatoprotective, and antidiarrheal properties.In conclusion, these findings support the traditional applications of *Aegle marmelos* and provide foundational data for its proper identification, standardization, and therapeutic utilization. Further detailed phytochemical characterization and clinical evaluation are suggested to isolate active principles and better understand their pharmacological mechanisms.

Keywords : Aegle marmelos , Phytochemcial Evaluation, Pharmacognostic Studies

INTRODUCTION

Aegle marmelos (Bael)

Family: Rutaceae
Common names: Bael, Bengal quince, Wood apple, Bel
Sanskrit: Bilva
Hindi: Bel
Tamil: Vilvam

Telugu : Maredu

Botanical Profile

1. Habit and Distribution

Bael is a **moderate-sized deciduous tree** that generally grows about **8–12 meters tall**. It originates from the Indian subcontinent and is commonly cultivated and found in **India, Sri Lanka, Nepal, Bangladesh, Myanmar, and Thailand**. The plant adapts well to dry climates and can survive high temperatures and prolonged drought conditions.

2. Root Characteristics

- Possesses a **strong taproot system**
- Highly tolerant to dry soil conditions
- Roots are valued in traditional medicine

3. Stem and Bark

- Bark appears **pale brown to gray**, with a slightly rough, peeling surface
- Branches often bear **sharp spines**
- Inner bark has a **yellowish tint**
- Produces a sticky gum-like exudate when injured

4. Leaves

- Characteristically **trifoliate** (three leaflets per leaf)
- Emit a pleasant aroma when crushed
- Leaflets are **ovate to lance-shaped**, usually 4–10 cm long
- Leaves are arranged alternately on branches
- Hold religious importance in Hindu traditions

5. Flowers

- Small, **greenish-white**, and fragrant
- Grow in clusters
- Bloom mainly from **March to May**
- Contain both male and female reproductive parts (bisexual)

6. Fruit

- Shape ranges from **round to slightly oval**
- Covered by a **hard, woody outer shell**
- Turns yellow upon ripening
- Inside pulp is **orange, aromatic, and sticky**
- Contains many seeds surrounded by mucilage
- Takes nearly **10–11 months** to fully mature

The fruit is considered the most therapeutically significant part of the plant.

Major Phytochemicals

The plant contains several bioactive compounds, including:

- **Alkaloids** (such as aegeline and marmeline)
- **Coumarins** (e.g., marmesin)
- **Flavonoids**
- **Tannins**
- **Pectin**
- **Volatile oils**
- **Carotenoids**

Therapeutic Applications

Bael is extensively utilized in **Ayurveda, Siddha, and Unani medicine systems**.

Fruit

- Helps manage **diarrhea and dysentery**
- Supports healthy digestion
- Shows anti-inflammatory properties
- Acts as a gentle laxative when ripe
- Exhibits protective effects against gastric ulcers
- Assists in regulating blood glucose levels

Leaves

- Traditionally used in diabetes care
- Possess anti-inflammatory action
- Employed in ulcer management
- Used in folk remedies for jaundice

Bark

- Applied in treating recurrent fevers
- Considered beneficial for heart health
- Traditionally used for malaria-related symptoms

Roots

- Included in classical herbal combinations such as *Dashamoola*
- Used for inflammatory conditions
- Helpful in certain respiratory ailments

Reported Pharmacological Effects

Modern investigations indicate the plant may have:

- Antidiabetic activity
- Antimicrobial effects
- Antioxidant potential
- Liver-protective properties

- Gastroprotective action
- Possible anticancer potential (ongoing research)

Common Forms of Use

- Fresh bael fruit juice
- Traditional bael sherbet
- Powdered dried fruit
- Leaf decoction
- Bael preserves or candy
- Polyherbal formulations

I. PHARMACOGNOSTIC STUDY

Pharmacognosy involves the scientific study of crude drugs derived from natural sources, especially plants. It includes proper identification, morphological and anatomical evaluation, powder analysis, and physicochemical standardization to ensure purity, authenticity, and quality.

1. Taxonomical Classification

- **Kingdom:** Plantae
- **Order:** Sapindales
- **Family:** Rutaceae
- **Genus:** Aegle
- **Species:** Aegle marmelos

Aegle marmelos Plant Twig

2. Morphological (Macroscopic) Evaluation

(A) Leaves

The leaves are compound and typically trifoliate, consisting of three leaflets attached to a common petiole. They possess a characteristic aromatic smell when crushed and exhibit a mildly bitter taste. The individual leaflets are ovate to lanceolate in shape, measuring approximately 4–10 cm in length. The margins are usually entire but may occasionally appear slightly serrated. The petiole is elongated and slender.

(B) Fruit

The fruit is a large, globular berry with a tough, woody outer shell. It ranges from 5–15 cm in diameter. When ripe, the pulp becomes orange-yellow, soft, and mucilaginous with a pleasant aroma and sweet taste. Unripe fruits are firm and exhibit an astringent taste due to high tannin content.


Aegle marmelos Leaves and Fruit

(C) Bark

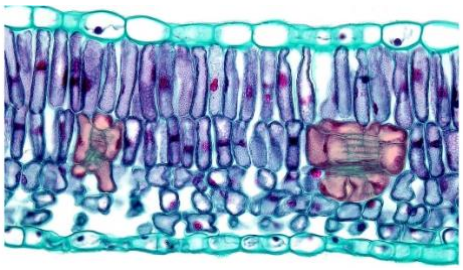
The bark is greyish-brown in color with a rough and somewhat corky surface. It has a characteristic astringent taste and is fibrous internally.

Aegle marmelos Bark

3. Microscopic (Anatomical) Characteristics

(A) Leaf Anatomy

- The epidermis consists of a single layer of compactly arranged cells covered with a thick cuticle.
- Stomata are of the anomocytic type.
- Unicellular covering trichomes are present.
- The mesophyll is differentiated into palisade parenchyma (upper layer) and spongy parenchyma (lower layer).
- Calcium oxalate crystals are distributed within the tissues.
- Secretory oil glands are embedded within the mesophyll region.



Transerse Section of Aegle marmelos Leaf

(B) Transverse Section of Leaf

A transverse section reveals:
Upper epidermis → Palisade tissue → Spongy parenchyma → Lower epidermis
The vascular bundles are collateral and closed, surrounded by supportive tissues.

(C) Fruit Microscopy

The fruit shows a thick epicarp and a mesocarp rich in mucilage-containing cells. Seeds are enclosed within fibrous hairs and embedded in a sticky pulp.

Transverse Section of Fruit Aegle marmelos

4. Powder Analysis

Powder microscopy serves as a key identification method when the crude drug is in powdered form.


Powder Analysis of Aegle marmelos

Leaf Powder

- Green in appearance
- Presence of epidermal fragments with anomocytic stomata
- Calcium oxalate crystals
- Oil gland fragments

Fruit Powder

- Yellowish-brown color
- Presence of sclereids (stone cells)
- Mucilage content
- Fibrous tissue fragments

5. Physicochemical Parameters

These values assist in standardizing crude plant material:

Parameter	Approximate Range
Total Ash	5–7%
Acid-Insoluble Ash	1–2%
Water-Soluble Extractive	15–20%
Alcohol-Soluble Extractive	10–15%
Moisture Content	Less than 10%

Such parameters help detect adulteration and maintain quality consistency.

II. PHYTOCHEMICAL STUDY

Phytochemical analysis identifies bioactive constituents responsible for therapeutic properties.

1. Major Phytochemical Constituents

(A) Alkaloids

Includes aegeline, skimmianine, and dictamnine. These compounds are primarily found in leaves and roots and are associated with metabolic and anti-inflammatory effects.

(B) Coumarins

Marmelosin, marmin, and umbelliferone are important coumarins contributing to antidiarrheal and antimicrobial properties.

(C) Flavonoids

Rutin, kaempferol, and quercetin are present and contribute to antioxidant activity.

(D) Tannins

Abundant in unripe fruits, responsible for astringent and antidiarrheal effects.

(E) Terpenoids

Lupeol and cineole are present and contribute to anti-inflammatory and antimicrobial properties.

(F) Saponins

Present in small quantities.

(G) Volatile Oils

Contain limonene and other aromatic compounds responsible for fragrance and therapeutic potential.

Phytochemical Evaluation Report of Aegle marmelos

S/N	Phytochemical	Aqueous Extract	Ethanol Extract
1	Alkaloids	+	+
2	Flavonoid	+	+
3	Glycosides	+	+
4	Reducing sugar	-	-
5	Saponin	+	+
6	Steroids	+	+
7	Phenols	+	+
8	Terpenoid	+	+
9	Anthraquinones	+	+
10	Tannin	+	+

2. Distribution of Constituents in Different Plant Parts

Plant Part	Predominant Constituents
Leaves	Alkaloids, flavonoids, essential oils
Unripe Fruit	Tannins, coumarins
Ripe Fruit	Pectin, sugars
Bark	Furanocoumarins
Roots	Marmin, skimmianine

3. Preliminary Phytochemical Screening

Standard qualitative chemical tests confirm the presence of various classes of compounds:

- **Dragendorff's test:** Indicates alkaloids
- **Shinoda test:** Confirms flavonoids
- **Ferric chloride test:** Detects phenolic compounds and tannins
- **Liebermann–Burchard test:** Identifies steroids and terpenoids
- **Foam test:** Suggests presence of saponins

5. Pharmacological Importance of Key Compounds

Compound	Reported Activity
Aegeline	Hypoglycemic effect
Marmelosin	Antidiarrheal
Skimmianine	Anti-inflammatory
Rutin	Antioxidant

Compound	Reported Activity
Lupeol	Anticancer and anti-inflammatory

III. STANDARDIZATION AND QUALITY CONTROL

To ensure authenticity and therapeutic consistency, the following evaluations are performed:

- Detailed macroscopic and microscopic examination
- Determination of ash and extractive values
- Chromatographic fingerprinting
- Heavy metal testing
- Microbial contamination analysis

Conclusion

The pharmacognostic and phytochemical evaluation of Aegle marmelos confirms its identity, purity, and medicinal relevance. Its well-defined anatomical features, measurable physicochemical constants, and rich phytochemical profile support its extensive traditional use and modern pharmacological validation.

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