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THERAPEUTIC INSIGHTS INTO *DELONIX ELATA* (L.) GAMBLE: PHYTOCHEMISTRY, PHARMACOLOGY, AND ANALYTICAL METHODS"-A REVIEW

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ABSTRACT

Delonix elata (L.) Gamble, commonly known as White Gulmohur, is a medicinal tree of the Fabaceae family valued in traditional medicine for treating rheumatism, joint pain, and inflammatory disorders. Ethnobotanical reports emphasize its use in rural and Siddha practices, particularly in southern India. Phytochemical studies have revealed diverse constituents including flavonoids (quercetin, luteolin, rutin), triterpenoids (lupeol, betulinic acid), phenolic acids (caffeic and gallic acid), steroids, tannins, alkaloids, saponins, and glycosides. These bioactive compounds contribute to a broad spectrum of pharmacological activities such as anti-inflammatory, analgesic, antioxidant, antimicrobial, antidiabetic, hepatoprotective, and wound-healing effects, which are comprehensively discussed in this review. Extraction techniques ranging from maceration and Soxhlet methods to advanced ultrasound-assisted and supercritical fluid extraction have been employed to obtain its phytoconstituents. Analytical profiling through GC-MS, HPLC, and FTIR confirmed therapeutic compounds like caffeic acid and apigenin. Pharmacological studies indicate that D. elata mediates its effects by modulating inflammatory pathways, including inhibition of cyclooxygenase enzymes, nitric oxide, and pro-inflammatory cytokines (TNF-α, IL-6). These findings validate its ethnomedicinal claims and highlight its potential as a natural anti-inflammatory agent. Nevertheless, despite strong preclinical evidence, standardized formulations and clinical studies remain limited. Future research should focus on developing safe, effective, and standardized preparations of *D. elata* for integration into modern medicine.

KEYWORDS: *Delonix elata*, phytochemistry, anti-inflammatory, pharmacological activities, extraction techniques, ethnomedicine, Analytical techniques.

INTRODUCTION

Inflammation is a natural defense mechanism of the body against tissue injury or infection, but when it becomes prolonged or uncontrolled, it contributes to the progression of chronic illnesses such as arthritis, diabetes, and certain cancers. Anti-inflammatory activity is defined as the ability of a compound to modulate or suppress inflammatory mediators, often by targeting cyclooxygenase (COX) enzymes, nitric oxide synthesis, and pro-inflammatory cytokines. While synthetic drugs like non-steroidal anti-inflammatory drugs (NSAIDs) and corticosteroids show strong therapeutic efficacy, their extended plant-based use is associated with significant side effects, creating a need for safer alternatives.

Several medicinal plants, including *Curcuma longa* (turmeric), *Zingiber officinale* (ginger), *Boswellia serrata* (Indian frankincense), and *Withania somnifera* (ashwagandha), have been widely recognized for their anti-inflammatory activities due to their diverse phytoconstituents. Among them, *Delonix elata (L.) Gamble*, commonly called White Gulmohur, has a long history of use in Indian traditional medicine systems such as folk and Siddha remedies for alleviating joint pain and rheumatism. Phytochemical investigations of this plant have identified flavonoids, triterpenoids, phenolics, and saponins, which contribute to its anti-inflammatory, antioxidant, and analgesic potential. Research findings further validate its ethnomedicinal use, highlighting *D. elata* as a promising natural source for developing safer anti-inflammatory agents. (Figure-1&2).

Figure-1 Trees of *Delonix elata.*

Figure-2 Flowers of *Delonix elata.*

PLANT PROFILE

Delonix elata.

BIOLOGY

Delonix elata is a deciduous tree with hermaphroditic flowers. It typically blooms during the hot season or at the onset of the rainy season around December in East Africa and from August to March in India. Its fruits usually mature between May and July.[3]

SCIENTIFIC SYNONYMS

1. *Poinciana elata*
2. *Caesalpinia elata*[4]

TAXANOMICAL CLASSIFICATION

Table 1: Taxonomical classification.[5]

Kingdom	Plantae
Subkingdom	Viridaeplantae
Phylum	Tracheophytes
Class	Equisetopsida C. Agardh
Order	Fabales
Family	Fabaceae
Subfamily	Caesalpinioideae
Genus	Delonix
Species	*Delonix elata (L.) Gamble*

VERNACULAR NAME

- Tamil : Vadhanarayanan, Perungondrai.
- English : Yellow Gulmohur, Tiger bean, Creamy peacock flower.
- Hindi : Waykaran, Sandeshra
- Sanskrit : Siddhesvara[6]

ECOLOGY AND DISTRIBUTION

D. Elata is indigenous to several African nations, including Congo, Djibouti, Uganda, Kenya, Sudan, Somalia, Ethiopia, Tanzania, and Egypt. It has also been introduced and grows outside its native range in places like India, Sri Lanka, and Zambia. The species is widely cultivated across tropical regions. It was first brought to India in 1792, introduced at the Calcutta Botanical Garden, and is now well established in the western parts of the country. The typical habitat consists of red soils, often rocky and shallow. It thrives in hot, dry Acacia-Commiphora bushland, at elevations between 100 and 1400 meters, with average annual temperatures around 27 °C and rainfall near 580 mm. However, *D. Elata* does not tolerate waterlogged conditions.[7]

MORPHOLOGY HABIT

Delonix elata is a medium-sized, deciduous tree that usually grows between 6 and 15 meters tall, occasionally reaching up to 20 meters under favorable conditions. It develops a broad, umbrella-shaped or spreading crown, with branches that extend outward or hang slightly downward. Valued for its graceful appearance, it is frequently cultivated as an ornamental species and along roadsides in tropical and semi-arid regions. During dry seasons, the tree becomes leafless, which enhances the visibility of its striking blossoms. Adapted to arid conditions, it flourishes in dry deciduous forests, rocky landscapes, and roadside habitats. The species favors well-drained soils such as sandy, loamy, or gravelly types.

BARK

In *Delonix elata*, the bark is initially smooth when the tree is young, but with age, it turns rough and flaky. Its coloration generally varies from grey to pale or ash-brown. The outer layer is thin, soft, and slightly corky, often showing vertical fissures as the plant matures. Beneath the surface, the inner bark is fibrous and yellowish-white, producing a sticky, mucilaginous exudate when cut. Traditionally, the gum obtained from the bark is valued for soothing wounds and is used as a demulcent.

Figure 4: Bark of *Delonix elata.*

LEAVES

The foliage is compound and bipinnate, typically extending 15–30 cm in length. Each leaf bears 4–12 pairs of pinnae, and every pinna carries 10–25 pairs of smaller leaflets. These leaflets are linear-oblong to oblong in shape, measuring about 4–17 mm long and 1.25–5 mm wide. The apex may be rounded or slightly tapering, while the base is rounded or gently narrowed. The surfaces are bright green on the upper side and paler beneath, with fine hairs and smooth margins.

Figure 5: Leaves of *Delonix elata.*

FLOWERS

The species produces showy blossoms arranged in terminal racemes or corymbose panicles, generally appearing from March to June. Flowers are large, bisexual, and bilaterally symmetrical, usually 5–8 cm across. Petals are creamy-white to pale yellow with occasional pink or apricot tinges and have a wavy or crinkled margin. The upper petal is often smaller and may display distinct color patterns. Each flower possesses 10 free stamens with long reddish filaments that extend beyond the corolla, ending in dorsifixed anthers. The ovary is positioned superiorly, covered with hairs, and connected to a slender thread-like style.

Figure 6: Flowers of *Delonix elata.*

FRUITS

The fruit is a legume, elongated and flattened in shape, ranging from 13–25 cm long and 2–4 cm wide. As it matures, the pod becomes hard, woody, and turns reddish-brown to purplish- brown. At maturity, the pod naturally splits open to release the enclosed seeds.

Figure-7: Fruits of Delonix elata.

Figure-8: Fruits of Delonix elata (Dried)

SEEDS

Inside each fruit pod, there are usually 4–8 seeds. These are oblong to elliptic, flattened, and protected by a hard seed coat. Their size generally falls between 12–15 mm in length and 5–8 mm in width. The seed color varies from uniform brown to a mottled brown pattern.

Figure 9: Seeds of *Delonix elata.*

ROOT SYSTEM

D. Elata possesses a taproot system accompanied by extensive lateral roots. This root structure is well-suited to arid environments, contributing to its drought resistance. It enables the tree to thrive even in rocky or nutrient-deficient soils.[8] [9] [10]

CULTIVATION

D. Elata is a rapidly growing species that is easily propagated from seeds. It thrives best under full sunlight, making open, sunny areas ideal for planting. Although propagation through cuttings or poles is possible, growing from seeds remains the preferred method. Seeds are often dispersed through animal droppings, where some naturally sprout into seedlings. Regular management techniques such as pollarding, lopping, and pruning is beneficial for growth. To safeguard young plants from grazing animals, protective measures like using browsing barriers are commonly implemented.

PROPAGATION

Primarily propagated through seeds, which benefit from scarification or soaking in warm water to improve germination rates. Seedlings typically sprout within 7 to 15 days.

CHEMICAL CONSTITUENTS

Phytochemical Classes Identified in *Delonix Elata* are, Luteolin, Quercetin, Kaempferol. Lupeol, Botulinic acid. β-sitosterol, Stigmasterol.[11][12] [13]

MEDICINAL USES

1. Anti-inflammatory Activity

The bark and leaves of *Delonix Elata* are used to treat inflammatory conditions such as arthritis and joint pain.[14]

2. Analgesic (Pain-relieving) Activity

The plant extracts are used in traditional medicine for relieving headaches, body aches, and other pain-related conditions.[15]

3. Antimicrobial Activity

Leaf, bark, and flower extracts are used to treat bacterial and fungal infections.[16]

4. Wound Healing

Traditional application of leaf and bark paste over wounds for faster healing.[17]

5. Antioxidant Activity

Used to combat oxidative stress and prevent degenerative diseases.[18]

6. Antidiabetic Activity

Used traditionally in the management of diabetes and high blood sugar.[19]

7. Hepatoprotective Activity

Traditionally used for treating liver disorders.[20]

MATERIALS AND METHODS COLLECTION OF SAMPLES

Fresh plant leaves of *D. Elata* were collected from different places of Sivaganga. The leaves were washed thoroughly with normal tap water followed by sterile distilled water. Then the leaves were shade dried at room temperature. Leaves were crushed to powder using grinding machine. The powdered sample was analyzed for qualitative inorganic compounds.

METHODS OF EXTRACTION

1. MACERATION METHOD

Process: Plant material (leaves, bark, flowers) is dried, powdered, and soaked in solvents like methanol, ethanol, or water at room temperature for 24–72 hours.

Solvents Used: Methanol, ethanol, hydroalcoholic mixtures, or distilled water.

Advantages: Simple, cost-effective, suitable for heat-sensitive compounds.[21]

2. SOXHLET EXTRACTION

Process: Powdered material is placed in a thimble and extracted for 6–8 hours using Soxhlet apparatus.

Common Solvents: Ethanol, methanol, petroleum ether (for sequential extraction). **Advantages:** Yielding exhaustive extracts of polar and non-polar constituents.[22]

ANALYTICAL METHODS

1. Gas Chromatography- Mass Spectroscopy

Gas Chromatography–Mass Spectrometry (GC–MS) is a powerful technique for the separation, identification, and quantification of phytoconstituents in medicinal plants. In the case of Delonix elata (L.) Gamble (Caesalpiniaceae), ethanolic leaf extracts were subjected to GC–MS to determine their bioactive principles.

Sample Preparation

Fresh leaves were shade dried, powdered, and extracted using ethanol in a Soxhlet apparatus.

GC–MS Conditions

Analysis was performed on a Perkin Elmer Clarus 500 system with an Elite-1 capillary column (30 mm × 0.25 mm ID × 1 µm df, 100% dimethylpolysiloxane). Helium served as carrier gas at 1 mL/min. Injection volume was 0.5 µL (split 10:1). The oven was programmed from 110 °C to 280 °C. Spectra were recorded in EI mode (70 eV) scanning 40–550 Da.

Identification

Compounds were identified by comparison with NIST mass spectral library data.[23]

2. COLUMN CHROMATOGRAPHY OF *DELONIX ELATA* BARK

1. Extract Preparation

Dried powdered bark extracted with 70% methanol. Concentrated extract (98 g) subjected to column chromatography.

2. Column Chromatography – First Stage (Cc-1)
Adsorbent
Silica gel (60–120 mesh).
Elution Solvents
Chloroform–Ethyl acetate (ratios from 100:0 → 0:100, v/v). Ethyl acetate–Methanol (ratios from 90:10 → 0:100, v/v).
Fractions Obtained
14 master fractions (MF1–MF14).
Based on TLC profiles, some fractions were combined for further purification.

3. Column Chromatography – Second Stage (Cc-2)
Fractions from ethyl acetate–methanol (70:30, 60:40, 40:60) were combined (7.80 g). Subjected to silica gel (100–200 mesh) column.
Elution
Ethyl acetate–methanol gradient.

4. Column Chromatography – Third Stage (Cc-3)
Fractions from ethyl acetate–methanol (20:80 and 0:100) were combined (8.73 g). Subjected to silica gel (100–200 mesh) column.

Elution
Ethyl acetate–methanol gradient.

3. HPLC ANALYSIS OF *DELONIX ELATA* BARK
Experimental Conditions
Instrument
Shimadzu HPLC system
Column
Reverse phase C18 column (250 × 4.6 mm, 5 µm)
Mobile Phase A
Phosphate buffer (0.14 g KH_2 PO_4 + 0.5 ml H_3 PO_4 in 1000 ml HPLC water)
Mobile Phase B Acetonitrile **Elution Mode** Gradient
95:5 (A: B) → 20:80 (A: B) in 30 min
then 95:5 (A: B) till 40 min

Flow Rate
Not specified (commonly ~1 ml/min in this type of setup)
Injection Volume
20 µL

Detection Wavelength
360 nm (chosen for flavonoid/phenolic detection)

Standards Used
Caffeic acid (phenolic compound) Apigenin (flavonoid compound)
These were run under identical HPLC conditions to determine retention times (Rt).[24]

4. UV VISIBLE SPECTRAL ANALYSIS
Characterization of copper nanoparticles was first carried out using UV-Visible absorption spectrometer 2400PC with a resolution of 1nm between 200 and 800nm possessing a scanning speed of 200nm/min. Absorption spectra of silver nanoparticles formed in the reaction media have absorbance peak at 467nm.

5. FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR)
The characterization of functional groups on the surface of silver nano-particles by flower extracts were carried out a by FT-IR InstrumentIRTRACER-100 Model and the spectra was scanned in the range of 370-4000 cm-1 range at resolution of 4 cm-1. FT-IR gives the information about functional groups that binds during the formation of silver nanoparticles by the action of the different phytochemicals which would acts simultaneously as reducing, stabilizing and capping agent.[25]

RESULTS AND DISCUSSION
ANALYTICAL METHODS
1. GAS CHROMATOGRAPHY- MASS SPECTROSCOPY

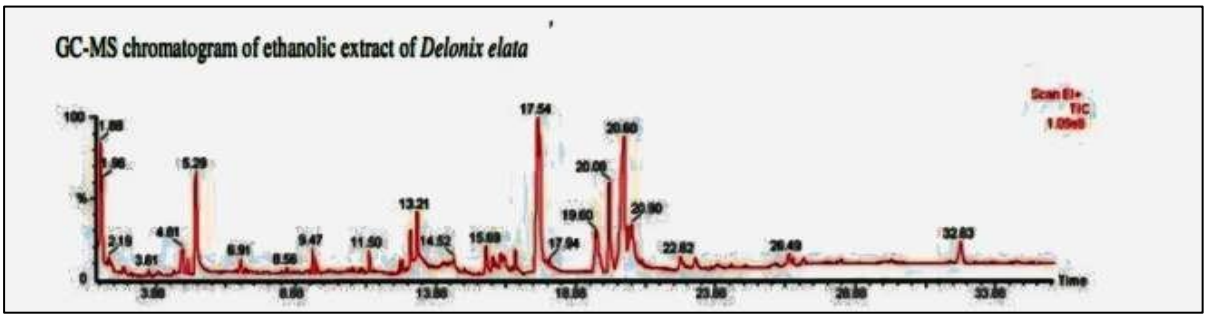

Figure 11: GC-MS chromatogram of ethanolic extraction of *Delonix elata.*

RESULTS
GC–MS analysis of ethanolic leaf extract of *Delonix elata* identified 32 phytoconstituents. The major compounds were Hexadecenoic acid, Z-11- (22.37%), n-Hexadecanoic acid / palmitic acid (16.20%), 1-Butanol, 3-methyl-, format (12.83%), Phytol (6.82%), and Octadecanoic acid / stearic acid (6.56%). The chemical profile was dominated by fatty acids, terpenoids, alcohols, and esters, which correlate with the plant's reported anti-inflammatory, antimicrobial, antioxidant, and membrane-stabilizing properties.[34]

2. COLUMN CHROMATOGRAPHY OF *DELONIX ELATA* BARK

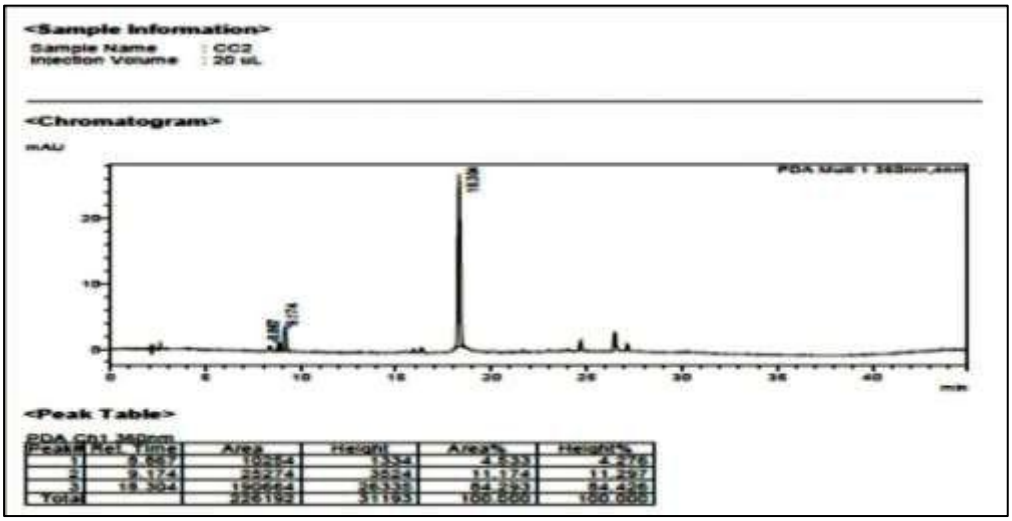

Figure 12: HPLC Chromatogram of CC2 Fraction.

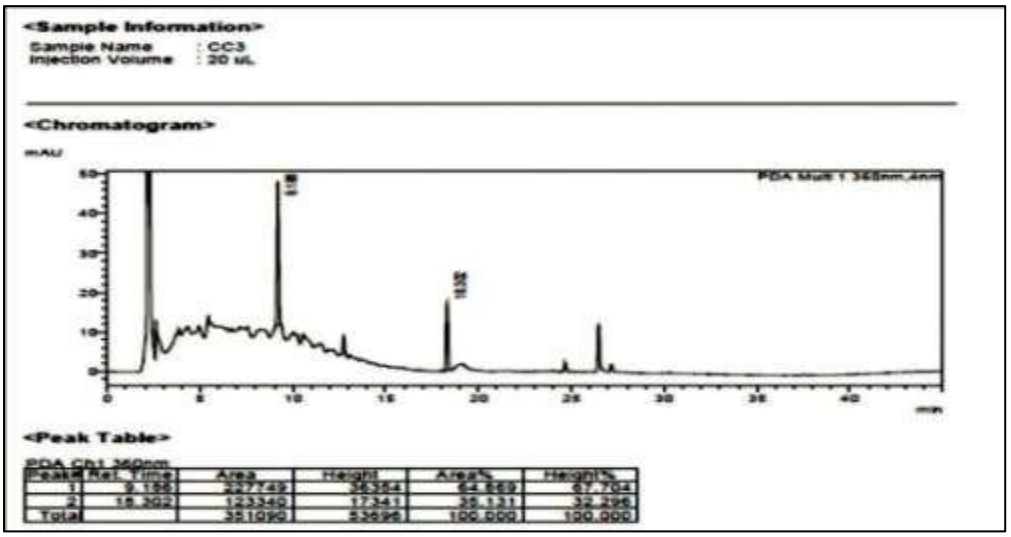

Figure 13: HPLC Chromatogram for CC3 Fraction.

RESULTS

The presence of caffeic acid and apigenin explains the plant's reported anti-inflammatory, anti-arthritic, antioxidant, and immune-modulating activities.

CC-1 → Produced 14 fractions (MF1–MF14). CC-2 → Isolated Caffeic acid (DECP1, 40 mg). CC-3 → Isolated Apigenin (DECP2, 35 mg).

TLC + spectral studies + HPLC confirmed compound identities.[35]

3. HPLC ANALYSIS OF *DELONIX ELATA* BARK

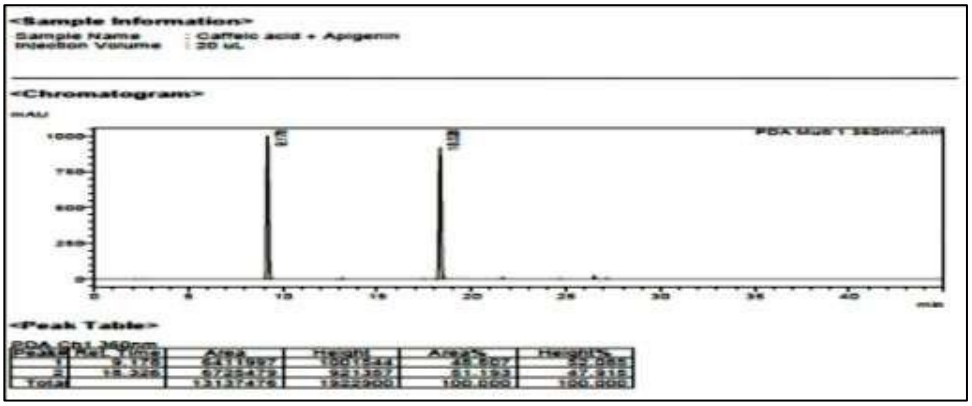

Figure 14: HPLC Chromatograms of Standard Apigenin and Caffeic acid.

RETENTION TIME (Rt) RESULTS

Sample/Fraction Retention Time (Rt, min) Interpretation Standard Apigenin 9.17 min Reference peak.

Standard Caffeic acid 18.32 min Reference peak

DECP1 (Isolated compound 1) 18.30 min Identified as Caffeic acid (matches standard) DECP2 (Isolated compound 2) 9.16 min Identified as Apigenin (matches standard)

CC-2 fraction Major peak at 18.30 min with minor impurity peaks Presence of Caffeic acid CC-3 fraction Peaks at 9.16 min and 18.30 min, plus minor peaks Presence of Apigenin + Caffeic acid.

4. UV VISIBLE SPECTRAL ANALYSIS

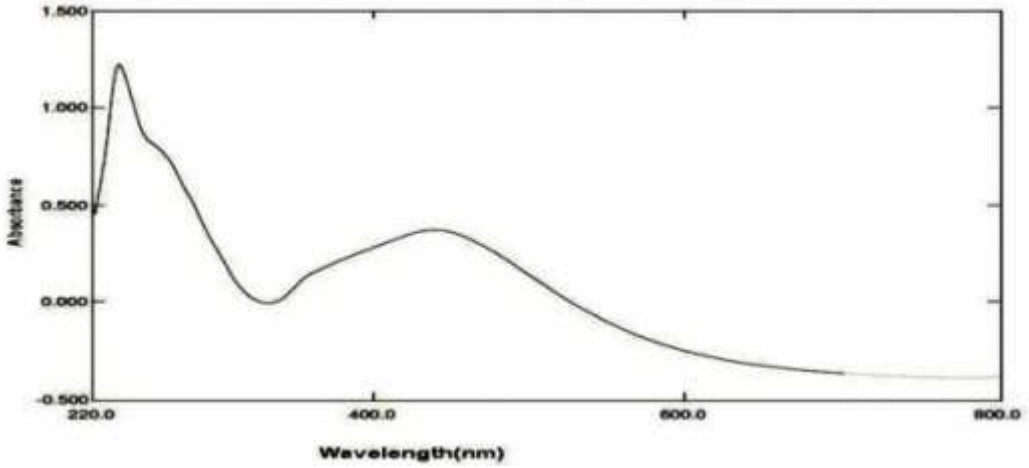

Figure 15: UV- Visible Spectra of Silver nanoparticles.

5. FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR)

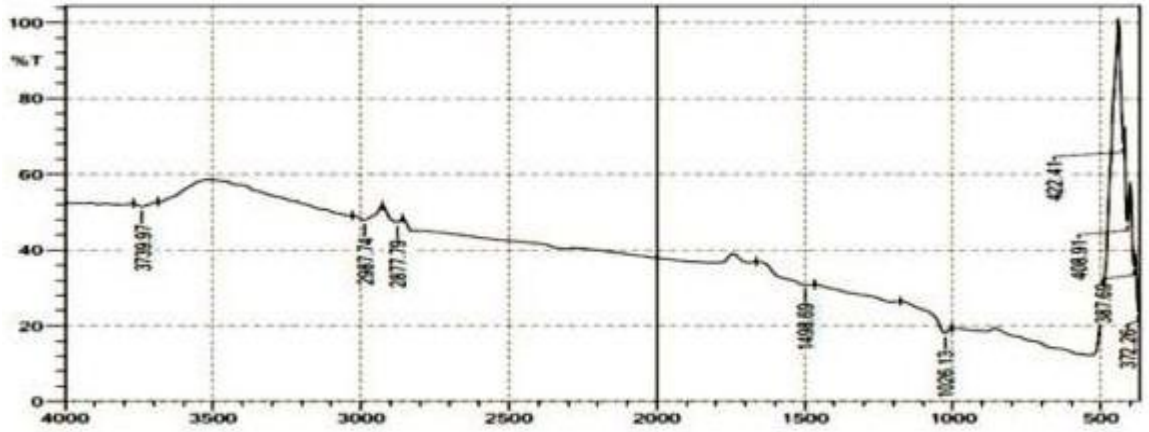

Figure 16: FT-IR Spectrum of Silver nanoparticles.

CONCLUSION

Delonix elata is a traditionally valued medicinal plant enriched with flavonoids, triterpenoids, phenolics, and saponins that contribute to its significant anti-inflammatory activity. Current evidence supports its ability to suppress inflammatory mediators and modulate cytokines, aligning with its ethnomedicinal applications in arthritis and joint-related disorders. While preclinical findings are encouraging, standardized formulations and clinical validations remain scarce. Future research should focus on developing safe and effective dosage forms, such as topical ointments, to facilitate its integration into modern healthcare and improve quality of life for patients with inflammatory conditions.

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