

A Review On: Herbal Extraction Of *Delonix Regia* Petals For Analgesic Ointment Formulation

Hitashi Randive*, **Premchand Anande¹**, **Gayatri Dongarwar²**, **Dimpal Yesansure³**.

Chhatrapati Shivaji College of pharmacy, Deori (441901).

ABSTRACT

The growing interest in herbal-based therapeutics has encouraged extensive exploration of medicinal plants as potential sources of analgesic agents. *Delonix regia* (family: fabaceae) commonly known as the flame tree, possesses diverse pharmacological properties attributed to its rich phytochemical profile, Including flavonoids, tannins, phenolic compounds and glycosides. The present review aims to highlight the extraction, phytochemical composition and formulation aspects of *Delonix regia* petal extracts for their potential use in analgesic ointment preparations. Various extraction techniques – such as maceration, Soxhlet extraction and solvent based methods have been evaluated for optimal yield of bioactive constituents. The extracted compounds exhibit significant anti-inflammatory and analgesic effects through inhibition of prostaglandin synthesis and modulation of pain mediators. Incorporation of these extracts into topical ointment formulations enhances localized drug delivery, reduces systemic side effects, and provides sustained analgesic action. This review compiles existing research findings on the phytochemical and pharmacological potential *Delonix regia* petals and emphasizes the formulation strategies for developing effective herbal ointments. The study concludes that *Delonix regia* represents a promising natural source for the development of safe, efficient and cost-effective herbal analgesic formulations.

Keywords: *Delonix regia*, Herbal ointment, analgesic activity, petal extract, Safe, Cost effective.

INTRODUCTION

Pain can be defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage. It is a disabling accompaniment of many medical conditions and pain control is one of the most important therapeutic priorities. It is always a warning signal and primarily protective in nature but often causes a lot of discomfort and may lead to many adverse effects[1]. Analgesics are drugs used to treat or reduce pain. Non-steroidal anti-inflammatory drugs have their origin in natural products and many synthetic compounds with similar mechanisms of action have been developed but are associated with serious adverse effects such as ulceration, gastro intestinal bleeding, addictive potential, respiratory distress, drowsiness, nausea etc [2]. There is therefore the need for the search for bioactive compounds from medicinal plants that have analgesic activity with little

or no side effects. The present study was therefore designed to evaluate the analgesic potentials of *Delonix regia* with the aim of establishing the pharmacological basis for its use in treating pains in folkloric medicine.



Fig no : 01 Whole body pain

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

1.1 Rapid or fast and gradual pain are the two primary categories of pain: After a stimulant strike, rapid pain is felt for at least one second, after which its intensity gradually increases over a few seconds or even minutes [3]. Electrical, sharp, tingling, and stabbing pain are some terms used to characterise fast pain. Other labels for slow pain include scorching, throbbing, uncertain, and chronic. This kind of pain can result in excruciating agony and is followed by tissue destruction. This pain can probably certainly be caused by deep organisms or both skin and tissue [4]. Painful mechanical or thermal stimuli are the primary causes of fast pain, whereas painful chemical stimulants are more likely to cause gradual and chronic pain [5].

1.2 Mechanism of pain : Pain is a defence mechanism brought on by inflammation or tissue damage. Chemical mediators such as prostaglandins, bradykinin, and histamine are released when tissues are injured, activating nociceptors (pain receptors). The stimulus is transformed by these receptors into nerve impulses (transduction), which are then sent to the brain via the spinal cord. These signals are interpreted by the brain as pain (perception). Lastly, to lessen the feeling of pain, the body may release endorphins and other natural pain inhibitors (modulation).

1.3 Delonix Regia :

The genus *Delonix* comprises flowering plants that belong to the *Caesalpinioideae* subfamily of the *Fabaceae* family. This genus contains Madagascarnative trees as well as East Africa. The species that is most well-known is *Poinciana* (*D. regia*). The Greek words "deros," which means "obvious," and "onyx," which means "claw," relate to the petals and are the source of the genus name [6]. *Delonix* builds an unarmed tree. Leaves abruptly bipinnate, with many small leaflets and small stipules. Flowers large, showy, in terminal corymbs that have tiny bracts. Very short, five-lobed, valve-like, and almost equal calyxes. Petals are spherical, scaly, clawed, and nearly the same length. The margins are fringed. Ten free,

deteriorated, long removed stamens [7]. The anthers are uniform, whereas the filaments below are hairy. Many of the ovaries are ovulated, and they are sessile. The filamentous style and the stigma is ciliate and terminated [8, 9]. Plant-active compounds and components found in therapeutic plants have been used to treat a variety of illnesses in both people and animals history, from the time of antiquity to the present [10]. According to WHO (2014), there are over 2,50,000 different types of medicinal plants, and the vast majority, particularly more In underdeveloped countries, almost 80% of people rely on herbal therapies to enhance their health [11]. It has been established that herbal medicines are safe, effective, and reasonably priced [12].

Antibacterial, anti-inflammatory, antimicrobial, analgesic, and antioxidant properties are among the notable pharmacological actions of the active ingredients. Antiplatelet, hepatoprotective, antidiabetic, immunotherapeutic, neurological, and carcinogenic effects [13-15]. The modern scientific community has been investigating the medical properties of plants because of their potential for trade, lack of negative side effects, and health benefits. Conventional medical practices are frequently thought to be trustworthy in terms of their effectiveness and low side effects in therapeutic uses [16]. The World Health Organization estimates that some 21,000 plant species are used worldwide in alternative medicine, whereas more than 50,000 plant species are used in conventional medications [17]. Various plant parts, such as the leaves, stem, bark, root, flower, tuber, seed, and other pieces, can be used to make medications. At different times throughout ancient times, a substantial amount—more than 30% of the total plant species—has been used for medicinal purposes. [18]. The approach used to provide drugs for illness and infection in conventional healthcare has been characterized by a greater emphasis on scientific precision and broader applicability when compared to the use of indigenous medicine in practice, especially in developing countries. Most plant species used in traditional medicine have proven to have significant antioxidant qualities [19].



Fig no: 02 DELONIX REGIA FLOWER

Different Species of Gulmohar: [20]

- D. decay (Flamboyant Tree)**
- D. decaryi (Flamboyant Tree)**
- D. elata (White Gul Mohur)**
- D. floribunda (Poinciana)**
- D. leucantha (Poinciana)**
- D. pumila (Poinciana)**
- D. regia (Flamboyant)**
- D. regia 'Kampong Yellow' (Flamboyant Tree)**
- D. regia 'Smathers Gold' (Royal Poinciana)**

Taxonomical Classification: [21]

Domain: - Eukaryota

Kingdom: - Plantae

Subkingdom: - Viridaeplantae

Phylum: - Tracheophyta

Subphylum: - Euphyllophytin

Class: -Spermatopsida

Subclass: - Rosidae

Super order: - Rosanae

Order: - Fabales

Family: - Leguminosae

Subfamily: - Caesalpinioideae

Tribe: - Caesalpinieae

Genus: - Delonix

Specific: - epithet regia - (Hook.) RAF.

Botanical name: - Delonix regia (Hook.) RAF.

1.4 Ointment : Ointments are uniform, thick, semi-solid formulations that are generally greasy in nature, containing a high proportion of oil (approximately 80%) and a smaller amount of water (around 20%). Because of their high viscosity, they are designed for external use on the skin or mucous membranes.

They are commonly used as emollients or as carriers for active substances applied to the skin for protective, therapeutic, or preventive purposes, particularly when occlusive effects are required. Ointments are applied topically to various parts of the body, including the skin, eyes (ophthalmic ointments), chest, vulva, anus, and nasal cavity.

Ointments provide strong moisturizing effects and are especially beneficial for dry skin conditions. They have a low potential for irritation and sensitization since they usually contain very few ingredients, mainly the base oil or fat.



Fig no : 03 Ointment as a Herbal

1.4.1 Types of Ointment :

Ointments can be either medicated or non-medicated.

a) Medicated ointments: These are intended for the delivery of active pharmaceutical ingredients (APIs) to the skin for protective, therapeutic, or prophylactic purposes.

b) Non-medicated ointments: These are mainly used for their physical action and serve as protectants, emollients, or lubricants [22].

1.4.2 Applications :

1. It provides a protective layer on the skin to prevent dryness and irritation.

2.1 Materials :

2. Used to treat skin infections like bacterial or fungal infections.
3. Helps in wound healing by keeping the area moist.
4. Used to reduce inflammation and swelling (anti-inflammatory ointments).
5. Provides relief from pain or itching (analgesic or anti-itch ointments).
6. Used to deliver medicines through skin (topical drug delivery).
7. Used for burns, cuts, and rashes to soothe and heal the skin.
8. Acts as a moisturizer to treat dry or cracked skin.

[2] METHODS AND MATERIALS:

SR NO	INGREDIENTS	ROLE
1	Delonix regia petals extract	Analgesic
2	White soft paraffin	Prevent water loss from skin
3	Liquid parffin	Emollient
4	Cetostearyl alcohol	Emulsifier
5	Hard Parffin	Increase viscosity
6	Wool fat	Penetration enhancer
7	Neem oil	Anti-oxidant
8	Clove oil	Anti-microbial

2.2 Methods :

1. **Collection of plant material:** The *D. regia* plant was chosen in April 2023 in the Purba Medinipur district of West Bengal, India, in the Contai area. The plant's blossoms were picked. Following that, the flowering plant species was identified from the Botanical Survey of India (BSI), located in Howrah, West Bengal, India. The selected flowers were cleansed, rinsed to get rid of any debris, and then placed in a shaded spot to dry entirely. After being pulverized with a mixer grinder, the shade-dried flowers were stored in an airtight plastic carry bag for additional examination.
2. **Extraction procedure:** The crude extract was obtained using a successive solvent extraction process. Crude extracts in different solvents were separated according to their polarity using the Soxhlet equipment. Before the extract in the syphon tube turned colourless, the extractor ran for 18 to 24 hours. Condensed the crude extract in a rotatory evaporator after removing it. For later usage, concentrated extracts were gathered and stored in airtight glass vials.
3. **Phytochemical screening:** Using our previously reported methods [23–28] and conventional guidelines, a phytochemical screening was performed on *D. regia* flowers. The current study used the following methods, resources, and instruments to identify several phytochemicals: The Sinodha test was used to identify flavonoids, the Wagner test was used to identify alkaloids, and the Solkowski inspection was used to identify both terpenoids and steroids. Phenols were identified using the ferric chloride test, sterols were identified using a mixture of glacial acetic acid (GAA) and highly concentrated H₂SO₄ acid, saponins were identified using a foam examine, tannins were identified using alcoholic ferric chloride, amino acids were found using ninhydrine solutions, and carbohydrates were identified using Molisch reagents. A combination of GAA and FeCl₃ was used to identify cardiac glycosides; pure HCl generated a red precipitate and red colour, indicating the presence of both quinones and phlobatannins; and glacial acetic acid was also used to measure oxalate.
4. **Solubility analysis:** *D. regia* solubility analysis was carried out utilizing standard and previously published procedures. [25, 29] The parameters listed below are examined, and the methods they used are described in detail below.
 - 4.1 **Cold water solubility :** Two different beakers were filled with 1 g of finely ground *D. regia* powder. One hundred millilitres of filtered water were added to each beaker. After that, the beakers were placed in a shaker machine for half an hour. The contents were filtered after this period. Once the filtration procedure was complete, the leftover material was heated to 120 °C in a furnace before being weighed. The percentage of water solubility is estimated using the following Equation (1). Solubility in cold water is equal to $\frac{\text{Sample weight after dried}}{\text{Taken sample weight}} \times 100$ (1)
 - 4.2 **Hot water solubility:** Two distinct RB flasks were filled with 1 g of finely powdered *D. regia* flower. 100 mL of hot water was added to each flask, and for two hours, the mixture was swirled at 1000 rounds per minute while being kept at 90 degrees Celsius. The combination was then filtered. The residue of the filtrate was heated to 120 degrees Celsius in a furnace before being weighed. The percentage of hot water solubility is calculated using the following Equation (2). Solubility in hot water = $\frac{\text{sample weight after drying}}{\text{Weight of the sample taken}} \times 100$ (2)
 - 4.3 **Acidic solubility:** Two distinct RB flasks were filled with 1 gm of finely powdered *D. regia* flower. One hundred millilitres of the freshly prepared 1 percent hydrochloric acid solution were added to each flask. After that, the mixture was exposed to acid reflux at 100 degrees Celsius for two hours. The mixture was then allowed to cool before being strained. After being heated to 120 °C in a muffle furnace, the filtrate remnant was weighed. The acidic



solubility of *D. regia* flowers is ascertained using the following Equation(3).
 Acidic water solubility = dried sample weight
 Weight of the sample taken $\times 100$ (3)

4.4 Alkaline solubility: Two distinct RB flasks were filled with 1 g of finely powdered *D. regia* flower. One hundred millilitres of the freshly prepared 1% sodium hydroxide solution were added to each flask. After that, the mixture was refluxed at 100 °C for two hours. The mixture was refluxed, allowed to cool, and then filtered. After the filtrate residue was heated to 120 °C in a furnace, it was weighed. The proportion of alkaline solubility is calculated using the following Equation (4).
 Sample weight after drying equals alkaline water solubility.
 Weight of taken sample $\times 100$ (4)

5. Dry matter (DM): Parts of plant material that have totally dried out are referred to as dry matter. A 100-gram sample was placed in a dry, cleaned, and pre-weighed tray and left for a while in a shaded area. The dried sample was weighed, and the dry matter weight was recorded. Equation (6) provided the formula for calculating dry matter. Dry matter = $WA - WB$
 $WA \times 100$ (6) where, WA is the before weight, and WB is the after weight of the plant powder.

6. Proximate analysis: *D. regia* proximate analysis was carried out utilizing previously established standard procedures. [25, 30- 32]

The parameters listed below are examined, and a description of the methods used is provided below.

6.1 Ash content: One gram of fine powdered *D. regia* flowers is placed in a crucible and exposed to combustion for two hours at 500 degrees Celsius in a muffle furnace. The ash content is then determined using the accompanying Equation (7) after the sample has been allowed to cool to ambient temperature within a desiccator.

$$\text{Ash weight} = \frac{\text{Ash content}}{\text{Weight of dried sample}} \times 100$$
 (7)

6.2 Moisture content: The measurement of moisture content One-gram samples of *D. regia* flowers were placed in each of two crucibles. These samples were subsequently heated to 100 oC for six hours in a muffle furnace. The crucibles were left to cool for the specified amount of time before being weighed. To estimate the moisture content, the following Equation (13) is used.
 Weight of the sample after drying equals moisture content.
 Weight of taken sample $\times 100$ (13)

[3] ETHANOMEDICAL USES:

Many elements of the well-known ethanomedicinal plant *D. regia* have long been used to treat a variety of illnesses (Table 1).

Table 1 Traditional uses of different parts of *D. regia*.

Part	Use
Bark	Antiperiodic, febrifuge [33]
Plant	Rheumatism, spasmogenic [33], cathartic, flatulence [34], emetic, CNS depressant and in the treatment of anaemia and fever.
Flowers	Anthelmintic [33], insecticidal [36], gynaecological disorders or dysmenorrhoea, febrifuge, inflammation, diarrhoea [37-40].
Leaves Root	Bronchitis and pneumonia in infants [41], anti-diabetic [42]. gastric problems, body pain, and rheumatic joints pain [43]. Abdominal pain [44]

Table 2 Alternative uses of various parts of the plant

Part	Use
	The hydrochloric acid extracts of leaves and seeds of <i>D. regia</i> inhibited the corrosion of aluminium in hydrochloric acid solutions (45) Seed gum is used as a binder [46]. At low concentration (1% W/W) it improves the hardness, binding and disintegration properties of
Seeds	fast disintegration tablet while high concentration is used to produce a modified or sustained release tablet formulation [47-48] Commercially, Quetiapine fumarate oral sustained release tablets has been prepared by using seed polysaccharide which avoid side effects and increase patient compliance [49]
	Seed polysaccharide can be used as an excipient for better sustained effect in floating drug delivery systems [50-51] Polymer from seed can be used for pulsatile drug release at colonic site after a predetermined lag time [52]. Carboxymethylated seed gum has been used for the microencapsulation of papain; at gastric pH it releases less papain while at
	Intestinal pH the release of papain is increased [53].
Fruits	Activated carbon prepared from the husk of fruit is used for decolorization and have comparable adsorptive capacity as that of the commercially available products [54] Fruit shell can be used as a biosorbent for sorption of chromium [Cr] from electroplating wastewater and convert it in to less toxic or non-toxic Cr [55]
Pods	Activated carbon produced from pods can be used as an adsorbent for removal of food dyes viz, acid yellow 6 (AY-6), acid yellow 23
	(AY-23), and acid red 18 (AR-18), metals viz, nickel (Ni), lead (Pb) as well as methylene blue from the aqueous solution [56-59]
Flowers	Aqueous extract of flowers is used for the dyeing of silk and cotton fabrics to obtain a bright reddish-brown hue which showed resistance to fading [54-55] and as an additive in herbal sunscreen formulation [62-63].
Bark	Bark is used as a bio monitors and bio accumulators of atmospheric trace metals [64] as well as for the removal of Ni from aqueous solutions through adsorption [65] 5% chloroform extract of bark tissue exhibited potential as a termiticidal agent with 80% mortality in 48 h against termites [66].

[4] BENEFITS:

1. Antibacterial, antifungal, anti-inflammatory, antioxidant, cardioprotective, gastroprotective, and wound-healing are among the therapeutic qualities of Gul mohar.

2. The leaves possess anti-diabetic qualities, and the methanol extract greatly

3. Lowers blood glucose levels.

4. The environment benefits from it.



5. for managing soil erosion.
6. Drawbacks:
7. Wood requires some upkeep and is vulnerable to animals and insects. is the heat tree.
8. Because of the harsh winter, he cannot plant Gulmohar.
9. Crown spread is hard to control.

[5] Subspecies, varieties, forms and cultivars of Delo nix genus:

D. boiviniana (Bail.) Capuron, D. baccal (Chiov.) Baker f. (Poinciana), D. brachycarpa (R.Vig.) Capuron, D. decaryi (R.Vig.) Capuron (Flamboyant Tree), and D. elata (L.) Gamble (Creamy) D. regia Bojer ex Hook. D. floribunda (Bail.) Capuron (Poinciana); D. pumila (Poinciana); Peacock Flower D. tomentosa (R.Vig.) Capuron; D. velutina (R.Vig.) Capuron; RAF. - Royal Poinciana (Flame of the Forest) [67]. D. regia "Kampong Yellow" (Flamboyant Tree); D. regia "Smathers Gold" (Royal Poinciana); D. regia "Supernova"; D. regia var. flavida; D. tomentosa (R.Vig.) Capuron; D. velutina (R.Vig.) Capuron; D. a; D. alata; D. leucantha (Poinciana); D. leucantha bemarkensis; D. leucantha gracilis; D. leucantha, leucantha; D. leucantha subsp. bemarkensis; D. leucantha, leucantha; D. leucantha, leucantha; D. leucantha, leucantha; D. leucantha subsp. Gracilis [68].

[6] Indian species of the genus Delonix:

The genus Delonix in the phylum Eucaesalpineae consists of two species growing in India, Delonix elata and Delonix regia [69].

Delonix elata: Delonix elata (syn. Poinciana elata), commonly known as White Gold Mofur and Family Fabaceae [70]. Subfamily Caesalpiniaceae. In Gujarati, it is known as 'Sandesar'. [71]. Vernacula Name Sanskrit- Siddeshwara [66]; Mumbai- Vayani; Telugu- Vatanaryana; Tamil- Vadanaryana [73] Botanical Description: Erect tree 6-9 m tall. Stem: smooth and gray. Leaves: compound, slender stalk, 10-20 cm long, bipinnate [71, 74, 75].

Another species is Delonix regia Rafin. Delonix Legia Ruffin:

Delonix regia is a flowering plant species. In the traditional medical classification, it belongs to the Caesalpiniaceae family, but in the phylogenetic classification, it belongs to the Fabaceae (legume subfamily). This tree is native to Madagascar. It is a medium-sized ornamental tree, widely planted in streets and gardens in temperate and humid regions of India [76, 77]. Also known as Royal Poinciana or Flamboyant. The plant was previously classified by him in the genus Poinciana after Phillippe de Longvilliers de Poincy (1583-1660), who is credited with introducing the plant to America [78, 79].

[7] Botanical Description:

Gulmohar is an attractive tree that blooms. Gulmohar trees are typically 10–15 (maximum 18) meters tall. Whether spreading, ascending, erect, or decumbent, every stem is woody. Stems and twigs that are young have little to no elaboration. Large trunk facing the base that is inclined and buttressed. [80–81].

Seeds:

Seeds 30-45, hard, greyish, shiny, 2 cm long, oblong, very similar in shape to date seeds, with bony seed coat. Mottled laterally. Weight about 0.4g [82].



Fig no : 04 Seeds

Leaf: Compound leaves have a pinnate form and are distinguished by their brilliant, alternating green colour. They have two pinnate. Twenty to forty pairs of primary leaflets, each further subdivided into ten to twenty pairs of secondary leaflets, adorn each 30- to 50-centimeter-long leaf [83].



Fig no : 05 Leaf

Branches: Lateral branches with a diameter greater than the tree's height and broad, umbrella-shaped branches [83].



Fig no : 07 Branches

Bark: Its smooth, grey-brown, somewhat cracked bark is covered in lenticels. The bark is light brown [84].



Fig no : 08 Bark

Fruit (pods):

When young, they are green and malleable; as they mature, they turn dark brown and become hard and woody. They are 30 to 50 cm long, 3.8 cm thick, and 5-7.6 cm wide before breaking momentarily. After being split horizontally, the seed chambers are then split in half without dehiscing [84].



Fig no : 09 Fuits (Pods)

Root: Flat [85].



Fig no : 10 Roots

[8] Pharmacological Activities of Delonix regia Extracts:

Analgesic Activity

The methanol leaf extract of *Delonix regia* exhibits significant analgesic effects in a dose-dependent manner, comparable to aspirin. This analgesic effect is likely mediated through both peripheral and central mechanisms of pain inhibition, as demonstrated in animal models [86].

Cardioprotective Activity

Leaf extract (DRLE) has shown cardioprotective properties, particularly in rat models of myocardial infarction. The protective effect is attributed to the reduction of oxidative stress and improvement in cardiac biomarkers, suggesting potential use in cardiovascular disease management [87].

Anti-inflammatory and Antioxidant Activities

Multiple studies and reviews report that *Delonix regia* possesses strong anti-inflammatory and antioxidant effects. These activities contribute to its ability to reduce inflammation and oxidative damage, which are central to many chronic diseases [88, 89, and 90].

Antimicrobial Activity

The plant exhibits antimicrobial properties, indicating its potential to combat various microbial infections [88, 90].

Hepatoprotective Activity

Extracts from *Delonix regia* have demonstrated protective effects on the liver, helping to prevent or reduce liver damage caused by toxins or disease [88, 89, and 90].

Wound-Healing Activity

Delonix regia also promotes wound healing, enhancing tissue repair and recovery [88, 89].

Hypoglycemic Activity

The plant shows potential in lowering blood glucose levels, suggesting benefits for diabetes management [88, 89, and 90].

Nutritional and Mineral Benefits

The flowers of *Delonix regia* are rich in minerals and nutrients, indirectly supporting antioxidant capacity and overall nutritional health [91].

[9] FINAL CONCLUSION:

Delonix regia, commonly known as the flame tree, exhibits a broad spectrum of multifunctional

bioactivities that have garnered significant attention in recent pharmacological research. This plant demonstrates notable analgesic, anti-inflammatory, antioxidant, hepatoprotective, anti-diabetic, cytotoxic (anticancer), and protective effects against heavy metal and toxicant exposures [88, 86, 90]. Additionally, it shows potential in relieving symptoms associated with osteoarthritis, making it a promising candidate for diverse therapeutic applications [88, 91].

Many of these pharmacological effects are dose-dependent, with studies often requiring relatively high dosages in rodent models, typically ranging from 100 to 400 mg/kg, to achieve significant results [86, 87]. The bioactive compounds responsible for these effects are primarily phytochemicals such as flavonoids, phenolics, terpenoids, sterols, and ursolic acid [88, 86, and 89]. These compounds have been repeatedly isolated and linked to the various beneficial impacts attributed to *Delonix regia* [86, 89].

Further refinement of extracts, such as flavonoid-rich fractions, has shown enhanced potency for specific effects. For instance, flavonoid-rich extracts are sometimes more effective in providing liver protection, underscoring the importance of targeted extraction techniques to maximize therapeutic potential [86, 89]. This highlights the complexity and richness of the plant's phytochemical profile and the need for detailed studies to isolate and understand the specific components involved [86, 89].

Toxicity studies indicate that *Delonix regia* extracts are relatively safe in rodents, even at high doses. Acute toxicity tests have demonstrated safety at levels as high as 5000 mg/kg [86, 89]. However, while acute toxicity is well-documented, there remains a paucity of detailed chronic toxicity data, which is crucial for long-term safety assessment and potential clinical use [86, 89].

Interestingly, the bioactivity of *Delonix regia* extends beyond the commonly used leaves and flowers. Seed polysaccharides, specifically galactomannan, have also exhibited biological activity, broadening the scope of the plant's active parts available for medicinal use [88].



Several studies support these findings. Modi et al. (2016) emphasize the strong traditional medicinal value of *Delonix regia* and its pharmacological potential, although they call for further studies to validate these effects clinically [88]. Similarly, Havaladar et al. (2024) identified the presence of flavonoids, tannins, glycosides, and alkaloids in the plant, underscoring multiple pharmacological activities but also highlighting a significant gap in toxicity and human trials data [90]. Sharma and Arora (2015) pointed out that while the phytochemicals present in *Delonix regia* have wide therapeutic applications, systematic and comprehensive studies remain scarce [89].

Additional research by Das et al. (2024) revealed that the flowers of *Delonix regia* are rich in minerals and nutrients, suggesting the possibility of their use as dietary supplements, which could provide nutritional as well as medicinal benefits [91]. Moreover, Ezeja et al. (2012) demonstrated that methanol leaf extract has

a significant analgesic effect, providing scientific support for the plant's folkloric use as a pain reliever [86]. Wang et al. (2016) reported that leaf extract (DRLE) protects against cardiac damage, indicating its potential as a cardioprotective drug candidate [92].

Finally, Patel et al. (2024) provided a comprehensive review of *Delonix regia*, highlighting the vast pharmacological potential of the plant while stressing the urgent need for more focused pharmacological and formulation-based research to fully harness and validate its therapeutic benefits [87].

In summary, *Delonix regia* is a plant with multifaceted medicinal properties supported by a variety of phytochemicals. While it shows promise in multiple therapeutic areas and is relatively safe in acute settings, the need for detailed chronic toxicity studies, clinical trials, and advanced pharmacological research remains critical to its development as a reliable therapeutic agent [88, 86, 87, and 90].

Additional Pharmacological Activities & Findings

Study	Activity / Effect	Model / Method	Key Findings / Mechanism Insights
<i>Antinociceptive & Cytotoxic potential of ethanolic extract of D. regia leaves</i> (Parul, Alam, Rana, 2014) (ijpbr.in)	Analgesic (antinociceptive) + Cytotoxicity	In vivo rodent models: writhing & formalin test; in vitro brine shrimp lethality assay	Leaf ethanolic extract at 200 & 400 mg/kg orally: significantly reduces pain in writhing/formalin. Cytotoxicity: $LC_{50} \sim 4.06 \mu\text{g/ml}$ in brine shrimp. Suggests both pain-relief and potential toxic / anticancer activity. (ijpbr.in)
<i>Phyto-screening of root bark</i> (Kavitha Sama, 2024) (irjponline.org)	Identification of bioactive compounds	Qualitative phytochemical tests (various polarity solvents)	Root bark extracts (especially methanol & water) show presence of tannins, terpenoids, alkaloids, glycosides, carbohydrates, sterols . Provides evidence that root bark could be source of several classes of bioactives. (irjponline.org)
<i>Flower extract cytotoxicity</i> (Pusapati et al., 2013) (J Pharm Res Int)	Cytotoxic effect against cancer cell lines	In vitro , MTT assay on human cell lines (MCF-7 breast, HeLa	Hydro-ethanolic flower extract has IC_{50} values: $\sim 141.6 \mu\text{g/ml}$ (MCF-7), 223.7 (HeLa), 173.9 (brain), 168.33 (colon). Also phytochemical



		cervix, brain, colon)	profile: sugars, flavonoids, tannins, steroids, etc. Suggests moderate anticancer potential. (J Pharm Res Int)
<i>Hepatoprotective & cytotoxic activity of flower extracts</i> (El-Sayed et al., 2011) (buescholar.bue.edu.eg)	Hepatoprotection + cytotoxic activity	In vivo rat model (CCl ₄ induced liver damage) + in vitro cytotoxicity on HEPG2 (liver cancer) cells	Isolated compounds like ursolic acid (IC ₅₀ ~0.55 µg/ml) and L-azeditine-2-carboxylic acid showed strong cytotoxicity. Flavonoid rich fraction at 100 mg/kg shows significant hepatoprotection. Indicates strong potential for both prevention of liver damage and anticancer action. (buescholar.bue.edu.eg)
<i>Anti-inflammatory activity</i> (ethanol leaf extract) (PubMed, 2011) (PubMed)	Anti-inflammation	In vivo , rats, carrageenan-induced paw edema & cotton pellet granuloma; acute toxicity in mice	Extract (100-400 mg/kg) shows dose-dependent anti-inflammatory effect; at 400 mg/kg, significant inhibition. Also acute toxicity study: safe up to 5000 mg/kg; no mortality or gross behavioral toxicity up to this high dose. Suggests a good safety margin in rodents. (PMC)
<i>Anti-diabetic potential</i> (Chaturvedi & Suhane, 2014) (irjponline.org)	Hypoglycemic and lipid-lowering effects	In vivo , alloxan-induced diabetic rats	Leaf extract at 100 and 200 mg/kg significantly reduced blood glucose, total cholesterol, triglycerides. Increased total protein. Suggests effect on both glycemic control and lipid profile. (irjponline.org)
<i>Glucose tolerance in hyperglycemic mice</i> (Venkatesh et al., earlier) (PMC)	Hypoglycemic (glucose-lowering) effect	In vivo , glucose-induced hyperglycemic mice	Methanol leaf extract shows dose-dependent reduction in blood glucose: ~42.5% at 400 mg/kg (vs ~47.6% for glibenclamide). Possible mechanisms: increased insulin secretion or enhanced uptake of glucose. (PMC)
<i>Protective effects vs Aluminum chloride (AlCl₃) toxicity</i> (Al-Doaiss et al.) (PubMed)	Protective / anti-toxic effects	In vivo , Wistar rats exposed to AlCl ₃	Methanolic extract + gum Arabic ameliorates AlCl ₃ induced changes: reduces ALT, AST, ALP; improves hematological parameters; reduces biochemical & histopathology damage.

			Suggests antioxidant, protective, possibly chelating effects. (PubMed)
<i>Hepatoprotective & antioxidant vs D-Galactosamine induced oxidative stress</i> (Mishra & Jain, 2021) (ResearchBib)	Hepatoprotection + antioxidant	In vivo , rats exposed to D-Galactosamine; leaves ethanolic extract	Extract contains alkaloids, phenols, flavonoids, triterpenoids; phenolic content ~63.27 mg GAE/g. At 200 & 400 mg/kg, significant protection from hepatic damage and oxidative stress. (ResearchBib)
<i>Galactomannan seed polysaccharide vs osteoarthritis</i> (GM-DR) (2020) (PubMed)	Reducing pain (hypernociception)/joint damage in osteoarthritis	In vivo , rats with sodium monoiodoacetate model; intra-articular administration of galactomannan from seeds	GM-DR (30-300 µg) reduced pain responses and reduced morphological damage in joint tissue (lower histopath score). Suggests anti-arthritis, cartilage-protective potential of seed polysaccharide. (PubMed)
<i>Antioxidant & antimicrobial activity (flowers)</i> (Sabalpara et al., 2025) (journalejnfs.com)	Antioxidant + Antimicrobial	In vitro assays (DPPH, FRAP), tests against foodborne pathogens	Flower extract has notable antioxidant via DPPH/FRAP; suppresses growth of pathogens at higher concentrations. Correlation between phenolic content and activity. (journalejnfs.com)

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