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Calotropis Gigantea-From Traditional Wisdom to Modern Therapeutics: A Holistic Review of its Phytochemical and Pharmacological Potential

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Abstract: *Calotropis gigantea Linn, commonly known as milkweed, is an important medicinal plant with a long history of use in traditional medical systems such as Unani, Ayurveda, and Siddha. It is originally native to regions of India, China, and Malaysia, but it is now widely distributed across many parts of the world. Almost all parts of this plant are utilized for therapeutic purposes and are key ingredients in several Unani formulations used to manage a variety of ailments.*

Classical Unani literature describes this plant as possessing numerous medicinal properties, including anthelmintic, appetite-stimulating, carminative, astringent, tonic, expectorant, emetic, diaphoretic, anti-inflammatory, sedative, wound-healing, antidotal, and digestive actions. Traditionally, it has been employed in the treatment of diseases such as asthma, abdominal pain, cholera, menstrual disorders, and dental problems.

Phytochemical studies have revealed the presence of compounds such as giganteol, α- and β-calotropenol, β-amyrin, and other bioactive constituents. Scientific research has demonstrated that Calotropis gigantea exhibits a wide range of pharmacological activities, including anti-asthmatic, antioxidant, antibacterial, antiviral, wound-healing, anti-inflammatory, antidiarrheal, hepatoprotective, and antidiabetic effects. The latex, leaves, flowers, bark, and roots of the plant are commonly used in traditional remedies to treat various health conditions..

Keywords: Calotropis gigantea, phytochemicals, pharmacological activities, phytochemistry

I. INTRODUCTION

Plants that possess therapeutic properties or contribute positively to human health are referred to as medicinal plants. Such plants naturally synthesize and accumulate various bioactive compounds, including alkaloids, glycosides, tannins, volatile oils, along with essential minerals and nutrients, which play a significant role in disease prevention and healing processes.

In traditional Ayurvedic medicine, Calotropis gigantea is known as “Sweta Arka”, while Calotropis procera is referred to as “Raktha Arka.” The present study primarily focuses on Calotropis gigantea. This species is a flowering plant belonging to the family Asclepiadaceae and is commonly known by several vernacular names such as Akada, Aak, Mandar, and Aakh. It is widely regarded as a hardy weed that thrives in arid and semi-arid regions and is commonly called giant milkweed.

Calotropis gigantea is indigenous to many Asian countries, including India, Bangladesh, Myanmar, China, Indonesia, Malaysia, Pakistan, the Philippines, Thailand, and Sri Lanka. The plant is characterized by its oval-shaped, pale green leaves, a milky

latex-containing stem, and clusters of thick, waxy flowers that are typically white or light purple in color. In India, this plant is abundantly available and has been extensively used in traditional medicinal practices. In recent years, it has attracted scientific attention due to its wide range of medicinal potential.

Figure 1. Calotropis gigantea

Studies have reported that the flowers of C. gigantea exhibit analgesic and antimicrobial properties, along with cytotoxic effects on certain cell types. The leaves and other aerial parts have been found to possess antidiarrheal,

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antifungal, antibacterial, and antioxidant activities. Research has shown that the roots demonstrate antipyretic, cytotoxic, antimicrobial, insecticidal, wound-healing, central nervous system–modulating, and enzyme-inhibitory properties. The latex of the plant is reported to have laxative effects, promote blood coagulation, enhance wound healing, and exhibit antimicrobial activity. However, studies have also indicated that the stem may exert hepatotoxic effects.

This review aims to present a comprehensive overview of the medicinal and biomolecular properties of Calotropis gigantea and to highlight potential directions for future research in the development of effective therapeutic compounds. The flowers have been found to have painrelieving and antimicrobial properties, as well as being toxic to some cells.

The leaves and other parts of the plant have been reported for their ability to treat diarrhea, fight fungal infections, kill bacteria, and act as antioxidants. The roots have been found to have fever-reducing effects, celltoxicity, antimicrobial effects, insect-killing properties, wound-healing abilities, effects on the central nervous system, and the ability to block certain chemicals. The plant's latex has been reported to have laxative effects, help in blood clotting, aid in wound healing, and kill microbes. The stem has been found to have harmful effects on the liver.

This review aims to provide a general overview of the medicine and biomolecular properties of C. gigantea and tohighlight future research opportunities for developing effective therapeutic compound Keywords

Common Names

English: Calotropis, calotrope, giant milkweed Hindi: Akada, Madar, Aak, Akdo

French: Algodón de seda, Pomme de Sodome, Arbre à soie du Sénégal, Arbre à soie, Cotonsoie

Botanical Description Taxonomical Classification

Table 1. Taxonomical classification of Calotropis gigantea Linn. Morphology

Root and Stem

The plant possesses a simple to branched growth habit, with a woody base covered by fissured, corky bark. The branches are moderately thick and densely coated with fine white tomentose hairs in the mature stage, which gradually disappear as the tissues age, resulting in a smooth and glossy surface. Upon incision or injury, all parts of the plant exude a characteristic white, viscous latex.

Leaves

Leaves are opposite in arrangement and decussate in orientation. They are sessile or nearly sessile, lacking distinct petioles and stipules. The lamina is ovate to broadly ovate, measuring approximately 5–30 cm in length and 2.5–15.5 cm in width. The apex is acute to acuminate with a small pointed tip, while the base is cordate. Leaf margins are entire. In young leaves, the surface is soft and densely covered with white pubescent hairs, which later diminish, giving the leaves a smooth and glossy appearance upon maturation.

Fruit

The fruit is a solitary, fleshy, inflated follicle that is nearly spherical to ovoid in shape and may attain a length of up to 10 cm or more.

Figure 2. Fruits of Calotropis gigantea are ellipsoid to ovoid in form and contain approximately 350–500 seeds, each equipped with tufts of white, silky hairs (pappus).

Seeds

Seeds are numerous, small, flat, and ovate, measuring approximately 6 × 5 mm. They are closely packed within the fruit and bear long, silky white, hair-like appendages (pappus) that are at least 3 cm in length, facilitating wind dispersal.

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Flowers

The flowers are large, conspicuous, and bisexual, bearing both male and female reproductive organs. They are complete and pentamerous, with five floral parts. Leaf-like bracts are present, and the gynoecium is positioned inferiorly. Flowers are pedicellate, with pedicels measuring approximately 1–3 cm in length.

Calyx

The calyx consists of five distinct sepals that are basally united, five-lobed, and arranged in a quincuncial pattern. The sepals are initially pubescent and become glabrous upon maturation.

Androecium

The androecium comprises five stamens that are adnate and fused, forming a unified structure. The anthers are bilocular and fertile.

Inflorescence

The inflorescence is a dense, many-flowered umbellate cyme borne on a peduncle. It arises either from the axils of leaves or terminally from the main stem.

Gynoecium

The gynoecium consists of two free carpels with styles that unite at the apex, forming a broad, flattened stigmatic head characterized by five longitudinal adhesive surfaces. The anthers are attached to the base of the carpels, collectively forming a specialized structure known as the gynostegium.

Macroscopical Characteristics

The macroscopic features of various parts of Calotropis gigantea are described below.

Root

The root system is well developed and complete. The bark readily separates from the woody portion and has a thickness ranging from 0.5 to 2.0 cm. Numerous rootlets are present, measuring approximately 0.2–0.5 cm in diameter. Externally, the root surface is pale grey and exhibits longitudinal wrinkles when fresh. On incision or injury, copious amounts of white latex are exuded. The fracture is uneven and incomplete.

Leaf

Leaves are simple, opposite in arrangement, and subsessile. They are thick, fleshy, and coriaceous in texture, measuring about 10–15 cm in length and 4.5–6.5 cm in width. The lamina is broad at the base, slightly cordate, and tapers to an acute apex. The abaxial surface near the point of attachment bears short, simple trichomes. Young leaves are covered with a greyish bloom, while mature leaves become glabrous or nearly glabrous and appear light green in color.

Flower

The flowers are actinomorphic, bisexual, and display a range of colors including lilac, pale pink, purple, or light greenish yellow. They emit a faint characteristic odor. Flowers are arranged in simple, and occasionally compound, cymose inflorescences borne on peduncles arising alternately from the stem. Each inflorescence is enclosed by small, pointed, scale-like bracts that are deciduous. Flower buds are ovoid in shape.

Calyx

The calyx consists of five broad, ovate lobes, each bearing small, fleshy glands at the base.

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Corolla

The corolla is regular and sympetalous, exhibiting pale pink to lilac coloration. It is campanulate with a short tube and five broad, ovate to lanceolate lobes that spread outward.

Stamens

The androecium comprises five stamens that are adnate to the base of the corolla. The filaments are fused to form a central column. This column bears five prominent, radially arranged, crown-like appendages that are completely adnate but slightly shorter than the column. These structures are fleshy and pale purple to yellowish white in color. They are laterally flattened, with a curved, hollow spur at the base and two short, curved, obtuse appendages near the apex, just below the tip. The anthers are short and broad, possessing wide, triangular, membranous extensions that curve over the sides of the stigma.

Root Bark

The primary roots are rounded at the apex, with the remaining portion exhibiting a spiral form. These rigid roots are greyish white in appearance and exude latex upon cutting. In older roots, the bark is fissured at several locations. The outer bark is yellowish grey, while the inner surface is yellowish white. The external layer is spongy and rough, whereas the inner layer is smooth and sticky. Upon drying, the bark develops a distinctly bitter taste.

Geographical Distribution

Calotropis gigantea Linn belongs to the family Asclepiadaceae, which comprises approximately 180 genera and nearly 2,200 species. Members of this family are predominantly distributed in tropical and subtropical regions across the globe. C. gigantea is believed to have originated in the Afro-Asiatic monsoon belt and subsequently spread through the Arabian Peninsula to northwestern Africa, including regions such as Mauritania and Senegal.

The plant is widely distributed in the Indian subcontinent, occurring abundantly in the sub-Himalayan tracts and extending from the Deccan Plateau to Kanyakumari. It is also commonly found in Bangladesh, Myanmar, and Pakistan. Beyond Asia, C. gigantea has been reported in subtropical regions of the Americas, the Mascarene Islands, and arid to semi-arid areas of Australia. The species thrives naturally from coastal plains to inland regions and adapts well to dry and disturbed habitats.

Traditional Uses

Ayurvedic Uses

In Ayurvedic medicine, various parts of Calotropis gigantea—including fresh or dried leaves, roots, root bark, and flowers—are utilized for therapeutic purposes. Powdered leaves are traditionally employed for rapid wound healing, as a purgative, and in the treatment of indigestion. They are also prescribed for dermatological disorders and hepatic ailments.

Dried leaves are believed to enhance sexual vitality and are used in the management of sexual dysfunction, particularly erectile disorders, and are considered to possess aphrodisiac properties. Hot poultices prepared from the leaves are applied externally to relieve abdominal pain, headaches, sprains, and inflammatory swelling.

The flowers are commonly administered in milk-based preparations to treat respiratory and gastrointestinal conditions such as cough, cold, asthma, indigestion, and cholera.

Flowers collected between September and February are also prepared as a paste for the treatment of piles.

Folk Medicine

In traditional folk practices, C. gigantea has been widely used as an antifungal, antipyretic, and analgesic agent. Dried leaves act as expectorants and exhibit

anti-inflammatory activity, providing relief in paralysis and rheumatic disorders. The dried latex and roots are traditionally administered as antidotes for snake bites. The plant is also used as an abortifacient, in the treatment of

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piles, and for the elimination of intestinal worms. Tender leaves are applied for the relief of migraine headaches, while powdered root bark, administered in capsule form, is reported to be effective in managing diarrhea and asthma.

Siddha Uses

In the Siddha system of medicine, the leaves of C. gigantea are used to treat ulcers, intestinal parasitic infections, vatha disorders, intermittent fevers, and venomous snake bites. The roots are crushed and vigorously applied to the site of snake envenomation. The latex is utilized in the treatment of dental ailments, rat bites, inflammatory swellings, gonococcal arthritis, and other rheumatic conditions. The flowers are traditionally used in the management of bronchial disorders.

Phytochemistry

Phytochemical investigations of Calotropis gigantea have revealed a diverse array of bioactive compounds distributed throughout different parts of the plant. Benzoylisolone and benzoylisolinelone have been identified in the root bark, while proceragenin and cardioid compounds are present in the plant tissues. The leaves and stem contain cardiac glycosides such as calotropin and calotropagenin. Floral constituents include calotropenyl acetate, multiflavenol, uzarigenin, and various terpenol esters.

Chemical analyses have further identified triterpenoids such as calotropursenyl acetate and calopfriedelenyl, norditerpenyl esters including calotropternyl ester, oleanane-type triterpenes such as calotropoleanyl ester, procerleanol A and B, and several cardiac glycosides, including calotogenin, calotropin, uscharin, calotoxin, and calactin.

Additionally, the presence of cardenolides and anthocyanins in the plant has been extensively documented.

Detailed phytochemical examination of Calotropis procera roots has revealed known compounds such as N-dotriacont-6-ene, glyceryl mono-oleolyl-2-phosphate, methyl myristate, methyl behenate, and glyceryl-1,2-dicapriate-3-phosphate. Two novel phytoconstituents—procerursenyl acetate and proceranol—have also been isolated. Structural elucidation based on spectral data and chemical reactions identified these compounds as urs-18α-11-12,20(30)-diene-3β-yl acetate and n-triacontan-10β-ol.

Furthermore, α-amyrin, β-amyrin, lupeol, β-sitosterol, and flavanols such as quercetin-3-rutinoside have been detected in the root bark. The principal active

constituent of the leaves is mudarine, which is also present in the resin, along with a bitter yellow acidic compound and three potent cardiac glycosides—calotoxin, uscharin, and calotropin.

Pharmacological Activities Antidiarrhoeal Activity

The antidiarrhoeal potential of a hydroalcoholic (50:50) extract prepared from the aerial parts of Calotropis gigantea was evaluated using the castor oil–induced diarrhoea model in rats. Gastrointestinal motility was assessed by calculating the percentage of the maximum distance travelled by a charcoal meal relative to the total length of the small intestine. In addition, enteropooling studies were conducted to measure the volume and weight of intestinal contents induced by castor oil administration.

Antipyretic Activity

The roots of Calotropis gigantea have been traditionally employed in Indian medicine for the treatment of leprosy, eczema, syphilis, elephantiasis, ulcerative conditions, and cough. In the present investigation, the antipyretic activity of the plant was evaluated using typhoid (TAB) vaccine–induced pyrexia models in rats and rabbits. Significant reductions in elevated body temperature and restoration to normal levels were observed in both

yeast-induced and TAB vaccine–induced fever models following intraperitoneal administration of the extract at doses of 200 and 400 mg/kg.

Central Nervous System (CNS) Activity

The central nervous system effects of an alcoholic extract of peeled roots of Calotropis gigantea were assessed in albino rats following oral administration at doses of 250 and 500 mg/kg. The extract exhibited pronounced analgesic activity

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in both Eddy's hot plate test and the acetic acid–induced writhing assay, as evidenced by a significant delay in paw-licking response and a marked reduction in the number of writhing movements.
Furthermore, the extract demonstrated anticonvulsant activity by delaying the onset and reducing the severity of pentylenetetrazole-induced seizures. Anxiolytic activity was also observed, as extract-treated animals spent a significantly longer duration in the open arms of the elevated plus maze (EPM), indicating reduced anxiety-like behavior.

Analgesic Activity
The analgesic potential of the alcoholic extract of Calotropis gigantea flowers was evaluated in mice using both chemical and thermal nociception models. In the acetic acid–induced writhing test, the extract produced a 20.97% and 43.0% inhibition in writhing responses at doses of 250 and 500 mg/kg, respectively. In the hot plate assay, a significant prolongation in paw-licking latency was recorded. The analgesic effect became evident within 30 minutes of administration and reached its maximum intensity at approximately 90 minutes.

Anti-inflammatory Activity
The anti-inflammatory properties of Calotropis gigantea extracts were investigated using carrageenan- and kaolin-induced rat paw oedema models to assess acute inflammation, as well as cotton pellet–induced granuloma and adjuvant-induced arthritis models to evaluate chronic inflammatory responses.
Antipyretic activity was further examined using the yeast-induced pyrexia method, while analgesic effects were assessed by the phenylquinone-induced writhing test in mice. The tested compounds exhibited varying degrees of anti-inflammatory activity, with peak effects observed approximately two hours after administration. Notably, the alkaloid fraction demonstrated comparatively higher initial anti-inflammatory activity. The sustained residual anti-inflammatory effect of the alkaloid fraction suggests a possible mechanism involving inhibition of the malic enzyme of the filarial parasite Setaria digitata.

Hepatoprotective Activity
The methanolic extract of Calotropis gigantea leaves demonstrated significant hepatoprotective effects in a dose-dependent manner against carbon tetrachloride (CCl_4)–induced hepatotoxicity in experimental rat models.

Antitussive Activity
The leaf extract of Calotropis gigantea exhibited notable antitussive (cough-suppressant) activity, which has been attributed to the presence of bioactive alkaloids and glycosides.

Herbal Soap Preparation Collection of Plant Material
Fresh leaves or flowers of Calotropis gigantea were collected and thoroughly washed to remove dirt and contaminants.
Preparation of Plant Extract
The collected plant materials were crushed and boiled in distilled water for 10–15 minutes. After boiling, the decoction was filtered, and the filtrate was preserved for further use.

Preparation of Soap Base
A sodium hydroxide (NaOH) solution was prepared by dissolving NaOH in distilled water and allowed to cool to room temperature. Coconut oil and castor oil were used as the lipid base for soap formulation.

Mixing Process
The cooled NaOH solution was slowly added to the oil mixture with continuous stirring to ensure proper saponification. Subsequently, the Calotropis gigantea extract was incorporated, along with optional fragrance or coloring agents if required.

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Molding and Curing

The final mixture was poured into suitable molds and allowed to solidify for 24–48 hours. After demolding, the soap bars were left to cure for approximately 10–15 days to complete the saponification process.

Methods

Fresh, mature leaves of Calotropis procera were collected and thoroughly washed under running tap water followed by rinsing with distilled water. The cleaned leaves were dried in a hot air oven at 40 °C until a constant weight was achieved. The dried material was then pulverized into a fine powder using a mechanical grinder.

The powdered leaf material was extracted with distilled water using a Soxhlet extraction apparatus. The obtained extract was concentrated at 40 °C under reduced pressure (72 mbar) using a rotary evaporator and subsequently lyophilized to obtain a dry extract. The dried extract was stored in an airtight container at 4 °C for future experimental use.

Extraction

Fresh leaves and stems of Calotropis gigantea were initially washed thoroughly with tap water to eliminate dust and extraneous materials. The cleaned plant materials were shade-dried and subsequently ground into a fine powder, which was stored in clean, airtight zip-lock plastic bags for future use.

Phytochemical extraction was carried out using the percolation method, specifically employing the Soxhlet extraction technique. The powdered samples were placed into two separate thimbles within the Soxhlet apparatus. A round-bottom flask was filled to two-thirds capacity with hexane and connected to the extractor. The solvent was heated to approximately 40 °C, and extraction was allowed to proceed for about one hour.

Following extraction, the solvent containing the dissolved phytoconstituents was concentrated using a rotary evaporator at 40 °C. The resulting hexane extract was dried using a controlled heat source and stored appropriately for subsequent analyses.

A methanolic extract was prepared using the same procedure, with the extraction solvent heated to approximately 70 °C.

Traditional Uses Ayurvedic System

In Ayurveda, the leaves of Calotropis gigantea are traditionally used in the treatment of paralysis, inflammatory swellings, and intermittent fevers. The flowers are employed to manage asthma, catarrhal conditions, anorexia, helminthic infections, inflammation, and febrile disorders. The root bark is used in the treatment of skin diseases, intestinal parasitic infections, cough, and ascites. Powdered roots are administered for asthma, bronchitis, and digestive disorders and are known to stimulate gastric secretions.

Siddha System

In the Siddha system of medicine, the leaves of C. gigantea are used for treating snake bites, recurrent fevers, vatha-related disorders, intestinal worm infestations, and ulcers. The roots are crushed and applied vigorously to the site of snake envenomation. The latex is used in the management of dental ailments, rat bites, inflammatory swellings, gonococcal arthritis, and various rheumatic conditions. The flowers are commonly prescribed for bronchial asthma.

II. RESULTS AND DISCUSSION

Extractive Value of Calotropis gigantea by Soxhlet Method

Sequential extraction of Calotropis gigantea was performed using solvents of increasing polarity, namely hexane, chloroform, ethyl acetate, and ethanol. The percentage yield of each extract was determined, and the results are presented in Table 2.

Table 2. Percentage yield of different extracts of Calotropis gigantea Sr. No.

Extract

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Extractive Value (%) 1
Hexane 12% 2
Chloroform 14% 3
Ethyl acetate 10% 4
Ethanol 16%

III. CONCLUSION

In recent years, ethnomedicinal research has received considerable attention due to its ability to reveal numerous lesser-known and unexplored therapeutic properties of medicinal plants. Extensive studies on Calotropis gigantea have demonstrated its significant medicinal potential, establishing it as a valuable plant with a broad spectrum of pharmacological activities. The diverse bioactive constituents present in this plant contribute to its effectiveness in the management of various diseases. As the search for novel therapeutics from natural sources continues to expand, the development of modern medicinal formulations derived from C. gigantea holds promise for future healthcare applications. Therefore, comprehensive research and systematic development are essential not only to validate its therapeutic efficacy but also to ensure conservation of the plant and to enhance its economic and medicinal value.

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