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Crossandra infundibuliformis (L.) Nees: A comprehensive review of its botanical, phytochemical, and pharmacological profile

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Abstract
Crossandra infundibuliformis (L.) Nees, belonging to the family Acanthaceae and commonly known as the firecracker flower, is a perennial tropical ornamental plant widely cultivated in South India for its aesthetic, medicinal, and pharmaceutical value. Indigenous to Southern India, Sri Lanka, and Malaysia, the plant is traditionally used in various systems of medicine to manage a wide range of ailments. Different parts of the plant—including leaves, roots, stems, flowers, and seeds—have been reported to possess diverse therapeutic properties such as antimicrobial, antibacterial, antioxidant, wound-healing, hepatoprotective, antiulcer, antidiabetic, aphrodisiac, immunomodulatory, antisolar, antitubercular, and anticancer activities. Phytochemical investigations of extracts prepared using solvents of varying polarity have revealed the presence of bioactive constituents such as alkaloids, flavonoids, tannins, saponins, steroids, glycosides, phenols, triterpenes, and reducing sugars. Several experimental studies have validated its traditional uses, demonstrating significant pharmacological potential comparable to standard drugs in certain models. In addition to its medicinal relevance, *C. infundibuliformis* is valued for its adaptability to tropical climates and its ornamental appeal, with multiple cultivars exhibiting a wide range of flower colours. This review highlights the botanical description, geographical distribution, traditional uses, phytochemical profile, and pharmacological activities of *Crossandra infundibuliformis*, emphasizing its potential as a promising source of natural therapeutic agents and supporting the need for further scientific and clinical investigations.

Keywords: *Crossandra infundibuliformis*, acanthaceae, firecracker flower, pharmacological evaluation, medicinal plant research

Introduction
Crossandra infundibuliformis, a member of the Acanthaceae family, is a well-known tropical ornamental plant commonly called the "Firecracker flower". Because of its medicinal properties, different parts of this plant are used in the treatment of various diseases [1]. *Crossandra infundibuliformis (L.)* is a perennial flowering shrub widely used for ornamental purposes, including pot cultivation, flower beds, and loose flowers, and it also has applications in the pharmaceutical field [2]. The term *Crossandra* originates from the Greek words "krossoi" meaning fringe and "aner" meaning male, referring to the plant's fringed stamens. Commercial cultivation of *crossandra* is influenced by several factors, including climatic conditions, fertilizer application, and plant spacing. It includes five cultivars—orange, yellow, red, deep orange, and bluish-flowered types—and the flowers are non-fragrant [3]. *Crossandra* is often referred to as the butterfly plant because it is a heat-loving tropical species that adds vibrant colour to gardens during the warm months [4]. It can tolerate high temperatures, enabling it to thrive even under conditions of very high humidity [5]. It is an erect, evergreen subshrub that grows up to about one metre (3 ft 3 in) tall, bearing glossy leaves with wavy margins and fan-shaped flowers that may appear throughout the year. The flowers are distinctly shaped, with three to five asymmetrical petals, and are borne on quadrangular, pedunculate spikes with tubular stalks about ¾ inch long. Flower colours range from the commonly seen orange to salmon-orange, apricot, coral, red, yellow, and even turquoise [6]. Plants have long served as a valuable source of inspiration for new drug compounds, and plant-based medicines have made significant contributions to human health and well-being [7].

Geographical distribution
The plant is indigenous to Southern India, Malaysia, and Sri Lanka [1]. In India, the primary states cultivating *crossandra* are Karnataka, Tamil Nadu, and Andhra Pradesh. In South India, it is predominantly grown in Coimbatore, Madurai, Chennai, Hyderabad, Chittoor, Chitradurga, Kolar, Mysore, Shimoga, and Belgaum [8].

Vernacular Name [9]

Hindi	Krosendra
Tamil	Kanakamparam
Telugu	Krassandra
Marathi	Aboli
Gujarati	Krossandra
Bengali	Krasandra

Taxonomical classification [4]
Kingdom – Plantae
Subkingdom - Tracheobionta (vascular plants)
Superdívision - Spermatophyta (seed plant)
Division - Magnoliophyta (Flowering plants)
Class - Magnoliopsida (Dicotyledons)
Subclass - Asteridae
Order – Scrophulariaceae
Family - Acanthaceae (Acanthus family)
Genus – CrossandraSalisb
Species - Crossandrainfundibuliformis (L.) Nees

Other species of *Crossandra infundibuliformis* [10]
Crossandra greenstock ii
The busheled *crossandra* is a compact, dwarf herb that is sometimes classified as a shrub. It features bright orange petals that spread widely around a yellow center. The flowers are borne on upright stalks arising from basal rosettes of broad, green leaves with irregular lobes.

Crossanadra pungens
It is a dense subshrub reaching about 60 cm in height. The leaves are oblong and dull green, marked with pearly veins. The flower spikes are compact, with broadly ovate bracts that have bristly to spiny margins, and the flowers are orange in color.

Crossandra flava
It is an unbranched shrub measuring about 15–20 cm in height, with an erect green stem. The leaves are glabrous, opposite, and obovate to lanceolate in shape, with a dark green color. The lower leaves are stalked, while the upper leaves are sessile. The spike is four-sided with spiny yellow-green bracts. The flowers are bright yellow, and the corolla tube is prominently exerted and jointed.

Crossandra guineensis
It is a free-flowering plant that grows to a height of about 30–60 cm. The bracts are spineless and pale lilac in color. It can be cultivated successfully in both full sun and partial shade.

Crossandra nilotica
The plants grow to about 60 cm in height and have semi-woody stems. The leaves are elliptic, dark green, and glossy. Brick-red flowers are produced in dense spikes, with the lower three petals forming a distinct lip.

Crossandra undulaefolia
It is a low, branching perennial shrub reaching about 30–90 cm in height. The leaves are 5–12 cm long, dark green, glossy, and pointed. The flower spikes are four-sided and measure about 7.5–12.5 cm in length. The flowers have prominent spiny bracts. It is commonly called the firecracker plant because the seed pods split with a cracking sound.

Traditional uses
Leaf: The plant's leaves have traditionally been used for a wide range of medicinal purposes, including as antihelmintic, antibacterial, antioxidant, antiulcer, aphrodisiac, anti-inflammatory, antimicrobial, and wound-healing agents. They have also been employed to treat conditions such as fever, headache, and pain. In addition, the plant has commonly been used as a remedy for diabetes, leprosy, ulcers, conjunctivitis, and various skin disorders.

Root: The extract was used in the treatment of infectious diseases (anti-infective).
Stem: The stem extract has demonstrated antihyperlipidemic activity.
Flower: The flower extract has exhibited antisolar properties and demonstrated effective wound-healing activity.
Seed: The seeds exhibited immunomodulatory activity [4].

Phytochemical constituents
Extracts obtained with different solvents, including ethanol, methanol, chloroform, ethyl acetate, and water, were systematically screened for phytochemicals such as alkaloids, saponins, tannins, steroids, flavonoids, anthraquinones, cardiac glycosides, and reducing sugars [11].

Pharmacological activities
Antimicrobial activity
Medicinally active compounds were isolated from the leaves of *Crossandra infundibuliformis* and identified through phytochemical screening. Powdered leaf material was extracted using aqueous and methanolic solvents. The results confirmed the presence of various bioactive constituents, including carbohydrates, alkaloids, steroids, tannins, phenols, saponins, fixed oils and fats, gums and mucilage, proteins, flavonoids, and volatile oils. Physicochemical analysis supported the evaluation of the leaf powder. Overall, *C. infundibuliformis* demonstrated notable antimicrobial potential [12].

Antibacterial activity
The leaves of *C. infundibuliformis* contain numerous phytochemical constituents that may account for their diverse pharmacological activities. The observed antibacterial activity was comparable to that of the standard drug amikacin [5].

Antioxidant activity
The study aimed to evaluate the phenolic content and antioxidant potential of *Crossandra infundibuliformis* leaves. The findings indicate that the leaves exhibit significant antioxidant activity [13].

Wound Healing Activity
Traditionally, the flower extract of *Crossandra infundibuliformis* has been employed to manage ailments such as fever, headache, loss of appetite, and pain. This review, however, is primarily centered on assessing the wound-healing potential of its ethanolic flower extract [14].

Hepatoprotective Activity
The petroleum ether extract of *Crossandra infundibuliformis* leaves demonstrates marked acute hepatoprotective activity, suggesting that continued research

on this species could facilitate the discovery of an effective therapeutic agent for the treatment of liver disorders [15].

Aphrodisiac activity

Crossandra infundibuliformis has been employed in traditional medicine for the management of male sexual disorders. This study aimed to investigate the phytochemical composition and assess the aphrodisiac potential of the petroleum ether extract derived from its leaves [7].

Tuberculosis activity

Leaf and flower extracts of *Crossandra infundibuliformis* were prepared using solvents of increasing polarity, including petroleum ether, ethyl acetate, and methanol. The extracts were assessed for anti-mycobacterial activity against Mycobacterium tuberculosis using the Alamar Blue TB assay. Phytochemical screening revealed the presence of key secondary metabolites such as phenols, glycosides, alkaloids, and tannins. Notably, the methanolic extract of the flowers and the ethyl acetate extract of the leaves demonstrated potent activity, exhibiting a minimum inhibitory concentration of 3.12 µg/ml against Mycobacterium tuberculosis. This study provides the first evidence of the anti-mycobacterial potential of *Crossandra infundibuliformis* leaf extracts [6].

Antisolar Activity

The study investigated the UV absorption potential of aqueous extracts obtained from fresh and dried leaves of *Crossandra infundibuliformis* to assess their suitability as anti-solar agents. UV–visible spectrophotometric analysis was used for evaluation. The findings revealed that the aqueous extract of fresh leaves exhibited significantly higher anti-solar activity than the extract from dried leaves. This activity is likely due to the presence of naturally occurring flavonoids and polyphenols, which are well known for their photoprotective properties. The study concludes that *C. infundibuliformis* leaf extracts may serve as a promising natural ingredient in the formulation of effective and safer sunscreen products, potentially reducing the harmful effects associated with synthetic sunscreens [16].

Antiulcer Activity

This study was conducted to evaluate the antiulcer efficacy of a methanolic flower extract in aspirin-induced gastric ulcer models in albino rats. Antiulcer activity was assessed by measuring the ulcer index and the percentage incidence of ulcers. The standard drug and the extract administered at a dose of 200 mg/kg demonstrated antiulcer effects comparable to ranitidine, whereas the extract at 400 mg/kg exhibited antiulcer activity nearly equivalent to that of ranitidine [17].

Anticancer Activity

The ethanolic leaf extract of *Crossandra infundibuliformis* has been investigated and found to contain phytoconstituents such as triterpenes, flavonoids, and tannins. These compounds exhibit physiological activity against various bacterial strains as well as several human cancer cell lines. The presence of these phytoconstituents may contribute to the anticancer potential of *Crossandra infundibuliformis* [18].

Antidiabetic Activity

The ethanolic extract of *Crossandra infundibuliformis* showed significant inhibition of α-amylase activity. These antidiabetic properties support its traditional use in Indian medicine for the treatment of various ailments [19].

Conclusion

Crossandra infundibuliformis is a multifaceted tropical plant of significant ornamental, medicinal, and pharmaceutical importance. Beyond its widespread cultivation for aesthetic purposes, the plant holds a prominent place in traditional medicine, where different parts such as leaves, roots, stems, flowers, and seeds have long been used to manage a variety of ailments. Extensive phytochemical investigations have revealed the presence of numerous bioactive compounds, including alkaloids, flavonoids, tannins, saponins, steroids, glycosides, and phenolic constituents, which collectively contribute to its diverse pharmacological activities. Scientific studies have substantiated its traditional claims by demonstrating notable antimicrobial, antibacterial, antioxidant, wound-healing, hepatoprotective, antiulcer, antidiabetic, aphrodisiac, antitubercular, antisolar, and anticancer properties. The plant's ability to exhibit biological activities comparable to standard therapeutic agents highlights its potential as a valuable source of natural drugs. However, despite promising experimental evidence, further detailed studies, including isolation of active constituents, mechanism-based investigations, toxicological evaluations, and clinical trials, are necessary to fully establish its safety, efficacy, and therapeutic applicability. Overall, *Crossandra infundibuliformis* represents a promising medicinal plant with considerable scope for future research and development in herbal and modern medicine.

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