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# Natural neuroprotective agent: A review on *Clerodendrum serratum* and its phytoconstituents

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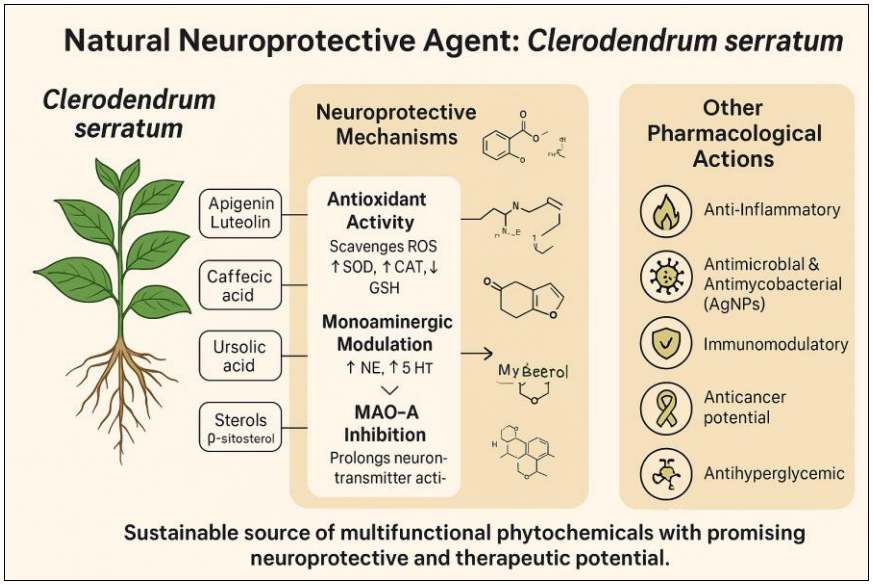
**Abstract**
*Clerodendrum serratum* (L.) Moon, also referred to as Bharangi in Ayurveda, is a *Lamiaceae* family medicinal plant that is prized for its neuroprotective qualities and variety of pharmacological characteristics. Rich in secondary metabolites, including phytosterols, phenolics, terpenoids, and flavonoids, C. serratum has strong immunomodulatory, antimicrobial, anti-inflammatory, and antioxidant properties.
Traditional texts in the *Brihat Trayi* extol its therapeutic use in respiratory and inflammatory disorders. At the same time, modern studies have demonstrated its efficacy in managing stress-induced neuropsychiatric conditions, partly through modulation of monoaminergic transmission and inhibition of monoamine oxidase-A. Ethanolic extracts of its leaves have shown antidepressant-like effects in acute restraint stress models without affecting locomotor activity, suggesting a specific neuromodulatory role. Moreover, green-synthesized silver nanoparticles derived from C. serratum possess potent antimycobacterial and biofilm-disrupting properties. The plant's pharmacological actions are attributed to the synergistic activities of its bioactive compounds, which act through the reduction of oxidative stress, stabilization of mast cells, and inhibition of enzymes. This review consolidates the botanical, phytochemical, and pharmacological insights into C. serratum, emphasizing its potential as a natural neuroprotective and therapeutic agent, and advocating further in-depth studies for drug development purposes.

**Keywords:** *Clerodendrum serratum*, Bharangi, neuroprotection, antioxidant, anti-inflammatory, phytochemicals, monoamine oxidase inhibition, green synthesis, silver nanoparticles

## Introduction
Plants have always been essential to human life. In addition to being a key source of food and shelter, plants are also used to make medicines that treat illnesses. Antiseptic, antioxidant, antifungal, anticarcinogenic, analgesic, and insecticidal qualities have been shown by chemicals isolated from several plants. Secondary metabolites are typically defined as chemical substances that have medicinal properties (Siddik et al., 2021) [14].
Since ancient times, naturally sourced therapies have been integral in managing and preventing illnesses. Bioactive compounds obtained from prehistoric life forms, microbes, vegetation, and animal species have consistently intrigued researchers for their potential health-promoting properties.
At first, these components were frequently mixed with aspects of mysticism or witchcraft. But over time, the effectiveness of these therapies became clear, and early herbal medicine was documented and developed as a result. The evolution of Ayurveda and the use of plant-based remedies are deeply ingrained in India's cultural heritage. The World Health Organization (WHO) estimates that nearly 80% of people in developing nations get their basic medical care from traditional medicine.
Nearly every traditional medical system in these areas is based on medicinal herbs. The Indian Materia Medica consists of over 2000 natural remedies derived from various traditional systems and customs. Nowadays, inflammatory disorders that frequently lead to tissue inflammation are becoming more and more common among people all over the world. Thus, there is a lot of interest in how plant-based medications might help control inflammation. Drug therapies are frequently necessary for inflammatory disorders such as cancer, IBD, arthritis, and the prevention of organ transplant rejection; occasionally, these medications must be taken in combination for maximum effectiveness.

However, the development of synthetic medications to treat inflammation can be costly and result in unfavorable side effects.




Plant-based medications, on the other hand, are thought to be natural, safe, easily available, affordable, and free of side effects. There is hope for finding bioactive molecules with anti-inflammatory qualities in herbal medications, considering the undesirable side effects of synthetic pharmaceuticals (Laware, S., & Shirole, N., 2023) [7]

For many years, new therapeutically useful chemicals, scaffolds, and pharmacophores have been derived from herbal plants. According to the World Health Organization, approximately 65–80% of the population in developing countries relies on medicinal plants for healthcare, as they serve as rich sources of diverse bioactive compounds. Despite an estimated 300,000 plant species existing globally, the pharmacological properties of only about 15% have been explored, marking them as invaluable natural resources that warrant extensive investigation for drug discovery and development.

*Clerodendrum*, a genus in the *Lamiaceae* family that Linnaeus originally defined in 1753, is one such target. With over 580 species of trees, shrubs, and plants spread across the biosphere's tropical and subtropical zones, the genus is varied (Patel, R. R. et al, 2024) [13].

In Ayurveda, the plant is known as Bharangi in Sanskrit and Blue Glory in English. Traditionally, its roots have been employed in herbal medicine for the treatment of numerous ailments, including rheumatism, allergies, body pain, respiratory disorders, infectious diseases, dropsy, ocular problems, fever, inflammation, malaria, ophthalmia, snake envenomation, tuberculosis, ulcers, and wounds. Phytochemical investigations The plant contains several bioactive constituents known by various names, including Wulzen factor, stigmasta-5,22-dien-3β-ol, DEHP, dioctyl phthalate, 4′,6-dimethoxy-5,7-dihydroxyflavone, verbascoside, myricetin-3-O-β-D-glucopyranoside, prunol, 3β-hydroxy-urs-12-en-28-oic acid, 22,23-dihydrostigmasterol, spinasterol-3-O-β-D-glucoside, along with unique compounds such as serratumin A and serratumoside-A.. (Tiwari, R. K.et al., 2021) [15].

Ayurvedic medicine places a great deal of importance on Bharangi (*Clerodendrum serratum*), which is mentioned extensively in the Brihat Trayi, a compilation of classical literature that comprises the Ashtanga Samhita, Sushruta Samhita, and Charaka Samhita (Yadav, M. D., & Kadam, M. B., 2024) [17].

The majority of C. serratum's therapeutic properties are found in its roots, which include sapogenins, stigmasterol, and D-mannitol, as well as in its leaves, which are rich in flavonoids and phenolic acids. The uncontrolled collection of this extremely important and endangered medicinal plant from the wild has put the already fragile species under extreme exploitation strain. An alarming decline in natural plant populations can also be attributed to habitat degradation, deforestation, and poor seed germination. Understanding an endangered plant species' distribution of genetic diversity, population genetic structure, and differentiating is crucial for effective conservative measures and proper genetic management.

A species' genetic diversity greatly influences its capacity to adapt to its shifting environment for both immediate and long-term survival and evolution.

Determining the genetic diversity within and between populations may serve as a gauge of how a species has responded to evolutionary processes at work in its current and historical surroundings (Apana, N. et al, 2021)

Like many other genera within the *Lamiaceae* family such as *Coleus* Lour., *Hyptis* Jacq., *Plectranthus* L'Hér., *Salvia* L., *Scutellaria* L., *Stachys* L., *Teucrium* L., *Thymus* L., and *Vitex* L., *Clerodendrum* possesses notable economic value due to its widely cultivated ornamental varieties, which include *C. bungei* Steud., *C. nutans* Wall. ex Jack, *C. laevifolium* Blume, *C. paniculatum* L., and *C. trichotomum* Thunb. Numerous beneficial phytochemicals have been identified in a number of *Clerodendrum* species, including phenolic compounds, terpenes, flavonoids, and steroids (Satthaphorn, J. *et al*., 2024) [13].

## 2. Botanical profile of *Clerodendrum serratum*

### 2.1 Taxonomy of *Clerodendrum serratum*

**Taxonomic Classification**

- **Kingdom:** Plantae
- **Division:** Angiosperms (flowering plants)
- **Class:** Magnoliopsida (dicotyledons)
- **Subclass:** Lamiidae
- **Order:** Lamiales

- **Family:** Verbenaceae
- **Genus:** *Clerodendrum*
- **Species:** *C. serratum*

### 2.2 Vernacular Names

- **Sanskrit:** Angaravalli, Padma, Brahmanayashtika, Barbura
- **English:** Blue glory, Beetle killer
- **Telugu:** Ganttubrarangee
- **Bengali:** Bamunhatee, Bamanhatee, Bhuijam
- **Punjabi:** Bhadangee
- **Hindi:** Bharangi
- **Marathi:** Bharangee, Bharang
- **Malayalam:** Cheruthekku
- **Urdu:** Bharangi, Baharangi
- **Gujarati:** Bharangee
- **Tamil:** Cheruteku
- **Kannada:** Gantubarangee
- **Oriya:** Chinds

**Synonyms & Meanings (Dongare, G.et al., 2020) [2]**

| Synonym | Meaning / Significance |
|---|---|
| Padma | The flowers bear resemblance to lotus blossoms. |
| Bharangi | Known for its ability to destroy diseases; considered to have power comparable to the sun. |
| Kasagni | Effective in alleviating *kasa* (cough). |
| Vatari | Beneficial in managing *Vata* disorders, according to the Ayurvedic concept of body energies. |

**Habitat:** Almost everywhere in India, *Clerodendrum serratum* Linn. may be found in woods up to 1500 meters high. In Gujarat, it is said to be uncommon and endangered.

### Habit

The perennial shrub *Clerodendrum serratum* Linn. grows to a height of 0.9 to 2.4 meters. Stem: bluntly quadrangular, sparsely woody, with few branches, and typically glabrous juvenile sections. The leaves run upward into bracts and are opposite or occasionally ternate, and they are sessile or almost so. Measurements: 12.52-15 by 5.7-6.3 cm, with occasional lengths of up to 28 cm; glabrous; Leaves narrowly obovate–oblong or sub-elliptic, with an acute base, acuminate apex, and coarsely serrated margins severely serrated edges. In the axil of large leafing bracts, there are numerous flowers in lax pubescent dichotomous cymes, each branching having two acute bracts and a flower in the fork. They combine to form a long, lax terminal penicle that is 15–25 cm long and typically pyramidal. Often, the large lower corolla is formed by twisting pedicels. Bracts are often colored, 1.3 to 3.8 cm long, obovate to lanceolate, and hairy. When mature, the fruit is a dark purple, somewhat succulent, roughly oblong drupe that is 6 cm long.

### Phytochemical Composition

### Chemical Constituents in the Root

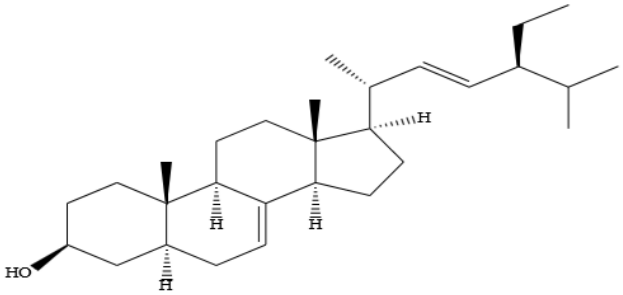
| Compound Name | Type / Note |
|---|---|
| Saponins | Phytochemical |
| D-mannitol | Sugar alcohol |
| Stigmasterol | Phytosterol |
| Oleanic acid- | Triterpenoid |
| hydroxylated oleanolic acid | Triterpenoid |
| *3β-hydroxy-Δ12-oleane-28,29-dioic acid* | Triterpenoid |
| Stigmast-5-en-3β-ol | Phytosterol |
| (3β,24S)-Stigmasta-5 | 5,25-Stimastadien-3β-o sterol |
| Lupan-12-one | 3β-Hydroxyl-lupan-12-one |
| 24-ethylcholestrol | Plant sterol |
| Clerodol | Triterpenoid |
| steroidoside | Glycoside-based steroid |
| Plant sterols | General category of plant-derived sterols |
| Ferulic acid | Phenolic compound |
| Arabinose | Sugar |
| Scutellarcin | Flavonoid-related |
| Baicalein | Flavonoid |
| Serratin | Likely a flavonoid or related compound |
| Ursolic acid | Triterpenoid |

### 3.2 Chemical Constituents in the Leaf

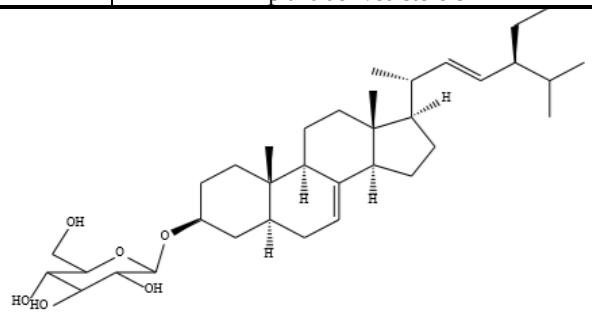
| Compound Name | Type / Note |
|---|---|
| Catchin | Flavonoid |
| α-Spinosterol | Phytosterol |
| Luteoline | Flavonoid |
| Polyphonolics | Phenolic compounds group |
| Diterpin – Clerodin | Diterpenoid specific to *Clerodendrum* |
| Ethycholesta-5,24,25-trine-3β-o | Steroidal compound |
| Hispidulin | Flavonoid |
| 7-o-Gluconoids of Hispidulin | Glycosylated flavonoid |
| Cruteuarein | Phenolic/flavonoid compound |

### 3.3 Chemical Constituents in *Clerodendrum* Genus (Kumar & Nishteswar, 2013, and Patel et al., 2014) [6, 10]

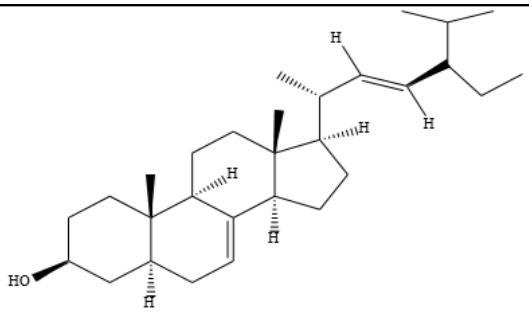
| Group | Examples / Subtypes | Biological Activities / Notes |
|---|---|---|
| Carbohydrates | D-mannitol | Found in roots; common sugar alcohol |
| Flavonoids | Catechins, Flavanols, Flavones, Flavanones, Flavanonols, Isoflavones, Anthocyanidins, Leucoanthocyanidins, Chalcones, Aurones, Hispidulin, Apigenin, Cleroflavone, Scutellarein, 7-Hydroxy Flavanone, And Pectolinarigenin. | Possess anti-oxidants, anti-microbial, anti-asthmatic, anti-tumor, and CNS-binding activities |
| Phenolics | Serratagenic acid, Acteoside, Indolizino, Verbascoside | Occur free or bound to sugars; show antioxidant, antimicrobial, antiproliferative, antihypertensive, anti-cancer activity |
| Terpenoids | Oleanolic acid, betulin, betulinic acid, clerodermic acid, friedelin, and monomelittoside. | Typically, β-D glucosidic form; have molluscicidal, fungitoxic and mild CNS activities |
| Steroids | β-Sitosterol, γ-sitosterol, campesterol, cholestanol, clerosterol, and 24-ethyl cholesterol. | Based on cyclopentane perhydrophenanthrene ring; plant-derived sterols |



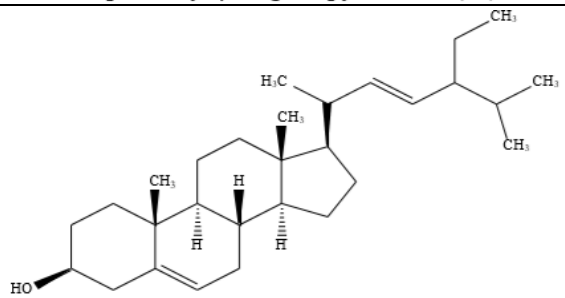
Spinasterol (9)



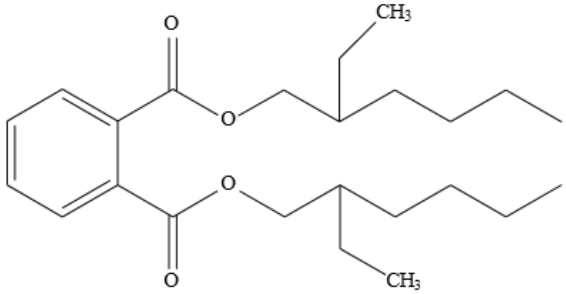
Spinasteryl-β-D-glucopyranoside (10)



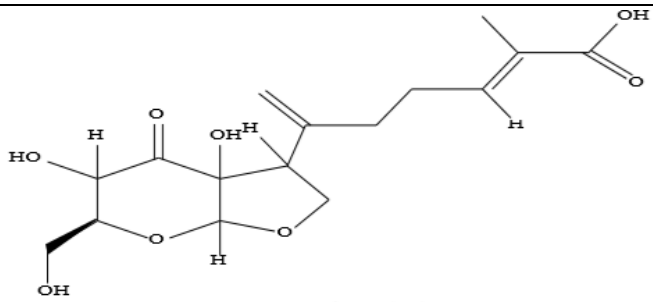
α-Spinasterol (11)



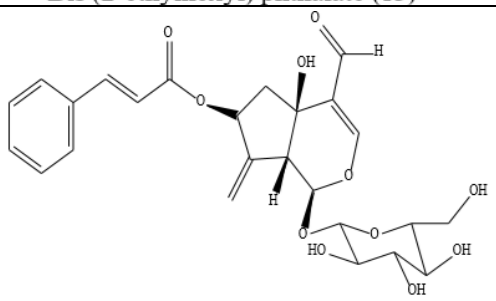
Stigmasterol (12)



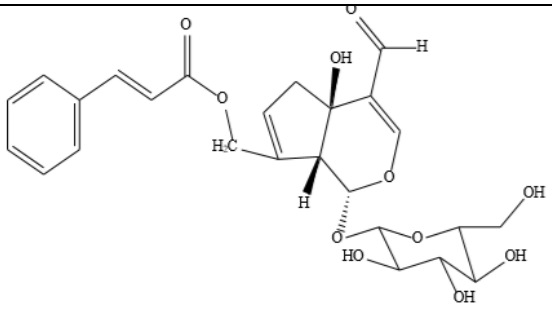
Bis (2-ethylhexyl) phthalate (13)



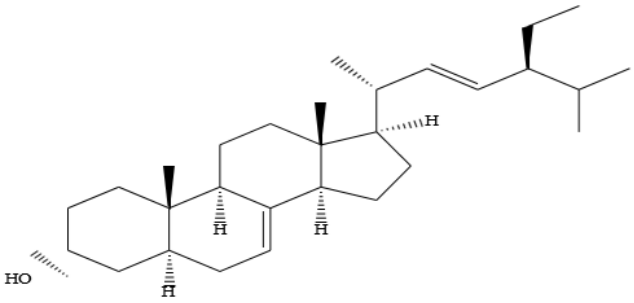
Serratumin A (14)



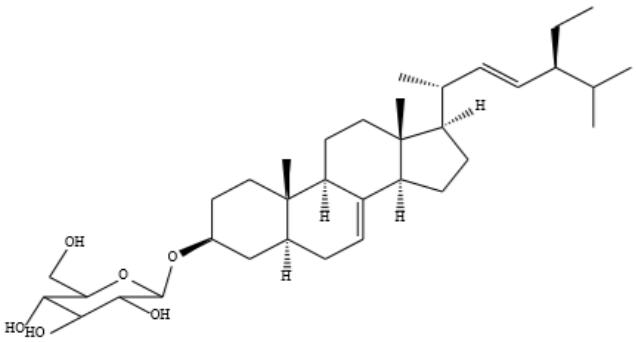
Serratoside A (15)



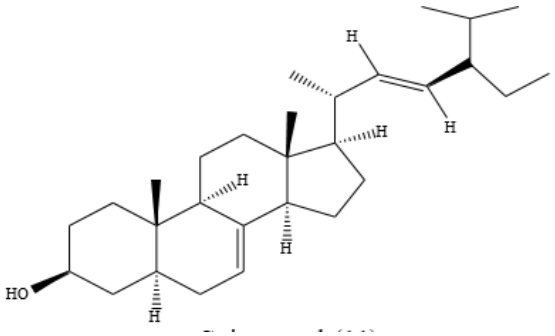
Serratoside B (16)

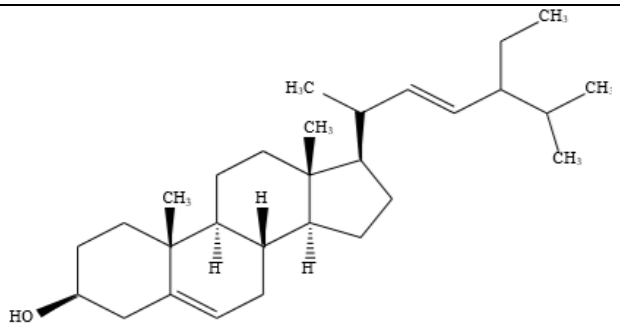


Spinasterol (9)

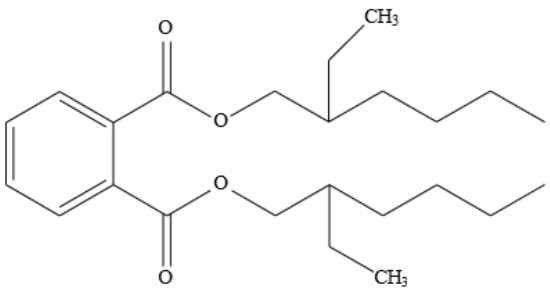


Spinasteryl-β-D-glucopyranoside (10)

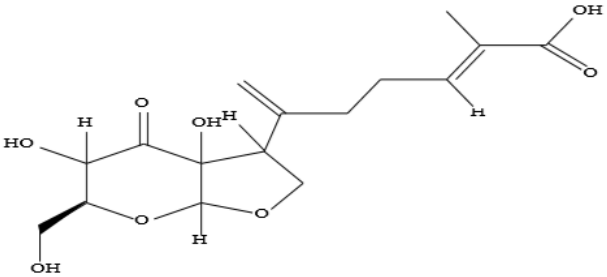




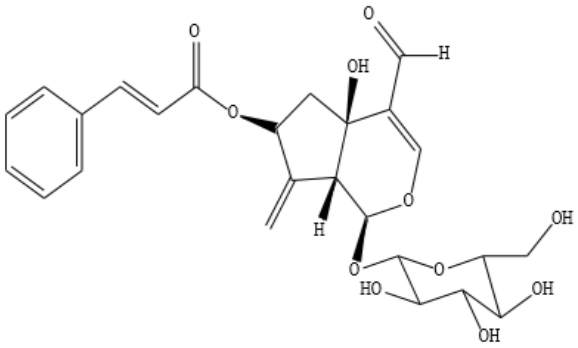
Stigmasterol (12)



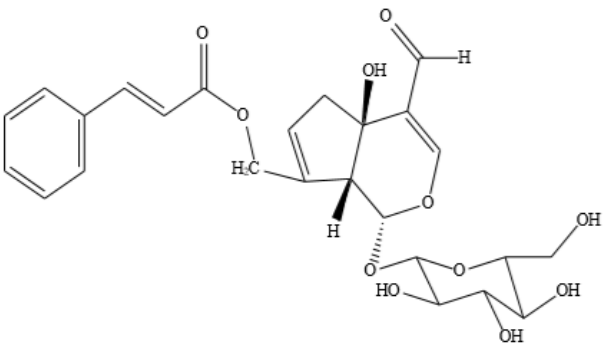
Bis (2-ethylhexyl) phthalate (13)



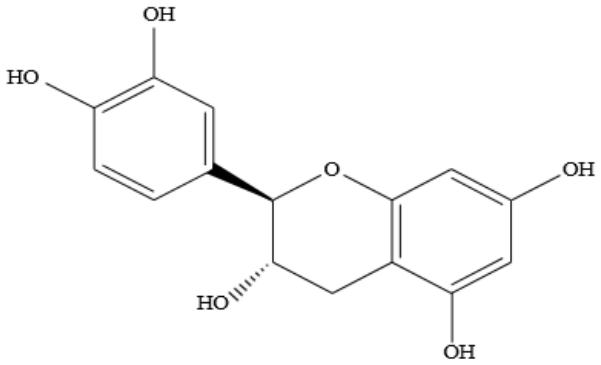
Serratumin A (14)



Serratoside A (15)

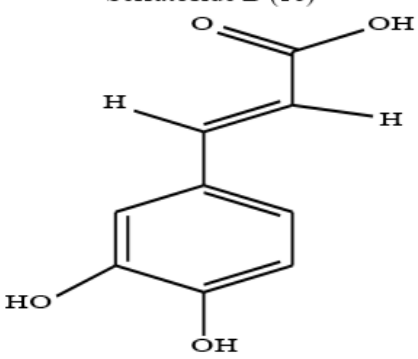


Serratoside B (16)

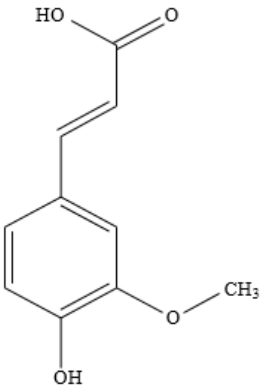


(+)-catechin (17)

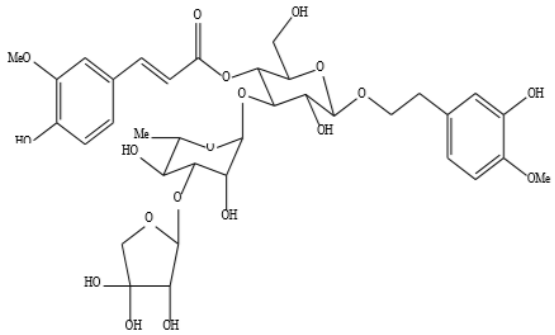
Serratoside B (16)



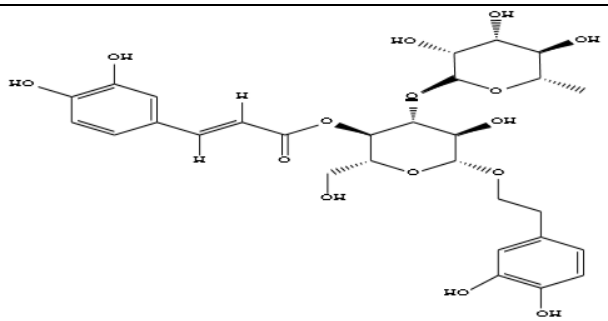
Caffeic acid (18)



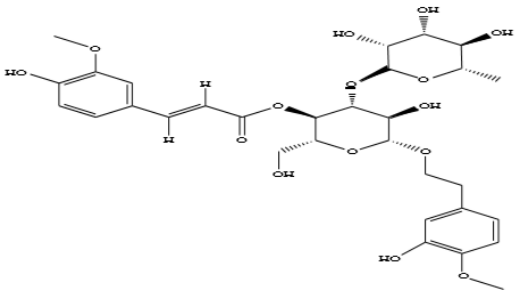

Ferulic acid (19)



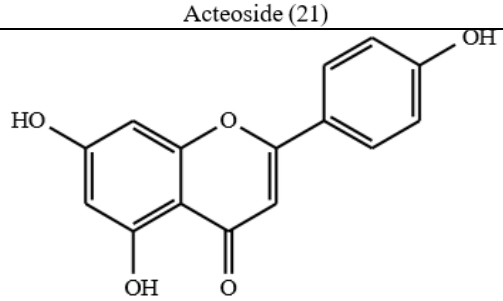

Serratumoside-A (20)



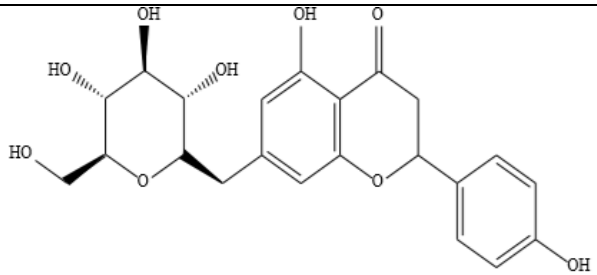
Acteoside (21)



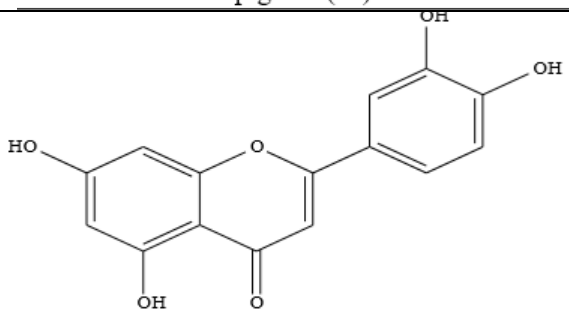
Martynoside (22)



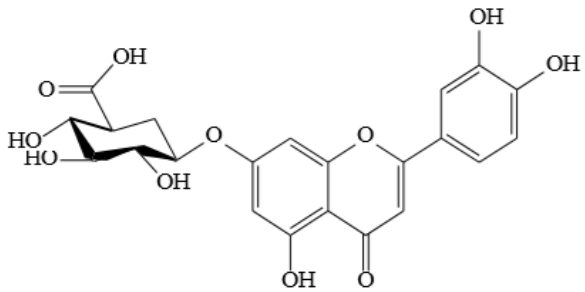

Apigenin (23)



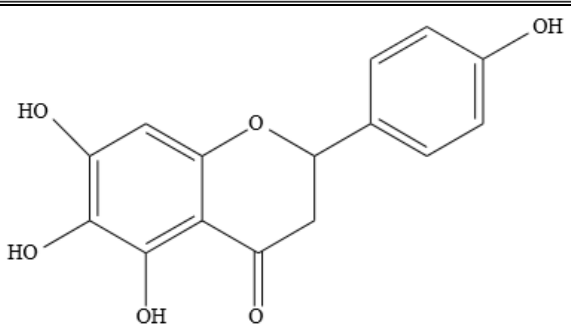

Apigenin-7-glucoside (24)



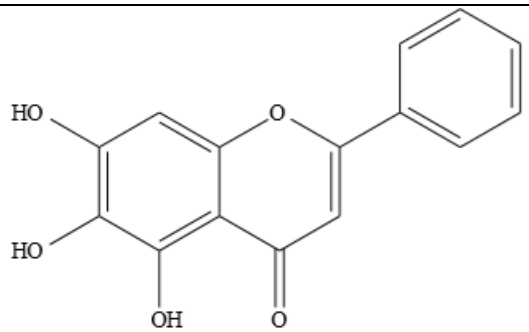

Luteolin (25)



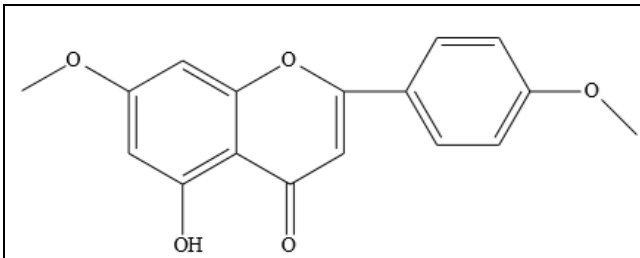

Luteoline 7–O-β-D-glucuronide (26)



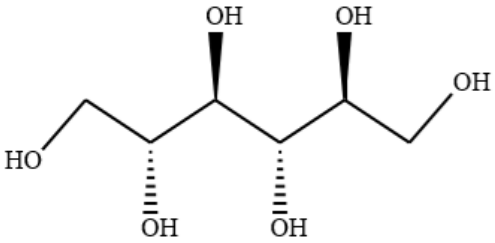

Scutellarein (27)




Baicalein (28)



5-hydroxy-7,4-dimethoxy flavone (29)



D-mannitol (30)

**Mechanisms of neuroprotection by *Clerodendrum serratum* leaf extract:** A complex process including antioxidant activity, neurotransmitter level modulation, and possible monoamine oxidase (MAO) inhibition accounts for the neuroprotective properties of Ethanol-derived preparation of *Clerodendrum serratum* (EECS) tested for its effects on acute restraint stress (ARS)-triggered depressive-like responses in murine models. The antioxidant capacity of EECS is one of the main mechanisms, mainly because of the presence of flavonoids like luteolin (LUT) and apigenin (API), which were detected by RP-HPLC. Due to its high lipid content and metabolic rate, under stressful conditions, the brain is highly susceptible to oxidative injury caused by ROS. Acute restraint stress (ARS) leads to a decline in oxidative balance markers, including lipid peroxidation (LPO), superoxide dismutase (SOD) activity, as well as catalase (CAT) and glutathione (GSH) levels. EECS treatment significantly normalized these parameters, suggesting that its neuroprotection stems from effective free radical scavenging and restoration of endogenous antioxidant defense systems.

Furthermore, by raising norepinephrine (NE) and 5-hydroxytryptamine (5-HT) levels, which are both vital for mood regulation, EECS altered central monoaminergic neurotransmission.

ARS-induced depletion of these neurotransmitters was reversed by EECS, indicating its antidepressant-like effect. This effect may be partly mediated through inhibition of MAO-A, an enzyme responsible for the breakdown of NE and 5-HT. Flavonoids like API have been previously reported to selectively inhibit MAO-A, leading to enhanced monoamine availability at synaptic sites.

Importantly, EECS did not affect locomotor activity, ruling out false-positive antidepressant outcomes due to increased motor activity. Overall, the neuroprotective mechanism of *C. serratum* is likely a synergistic outcome of its antioxidative and monoaminergic modulation properties, supporting its traditional use in managing stress-related neuropsychiatric disorders (Vazhayil, Rajagopal, Thangavelu, Swaminathan, & Rajagounder, 2017) [16].

**Pharmacological studies**

Serratum *Clerodendrum* (L.) Ayurvedic medicine values moon, also called bharagi, as a medicinal plant, and contemporary pharmacological research supports its many therapeutic uses. A variety of secondary metabolites, such as flavonoids, terpenoids, sterols, phenolic acids, and glycosides, are responsible for its activity.

**Free Radical Scavenging Potential**

The remarkable free radical neutralizing ability of *Clerodendrum serratum* extracts has been demonstrated through a range of *in vitro* assays, including DPPH, ABTS, hydrogen peroxide scavenging, hydroxyl radical quenching, and nitric oxide scavenging tests, and reducing power tests. (Siddik et al., 2021) [14]. This effect is linked to the high concentration of phenolic compounds (ferulic acid, caffeic acid, acteoside) and flavonoids (apigenin, luteolin, hispidulin, baicalein). Mechanistically, these compounds neutralize reactive oxygen species (ROS), chelate pro-oxidant metal ions, and prevent lipid peroxidation, thereby protecting biomolecules from oxidative damage. In related *Clerodendrum* species, isoacteoside enhanced antioxidant enzyme expression, indicating that similar pathways might be active in C. serratum.

**Anti-inflammatory and Anti-arthritic Effects**

Standardized extracts have shown significant inhibition of heat-induced protein denaturation, a model for anti-arthritic action, with results comparable to diclofenac sodium (Tiwari et al., 2021) [15]. Its conventional application in asthma and bronchitis is explained by the documented stabilization of mast cells, which lowers the production of histamines and inflammatory mediators.

The presence of sterols (β-sitosterol, stigmasterol) and triterpenoids (ursolic acid, oleanolic acid) supports the anti-inflammatory qualities by inhibiting inflammatory pathways like lipoxygenase (LOX) and cyclooxygenase (COX).

**Neuroprotective and Antidepressant-like Effects**

Ethanolic leaf extract (EECS) demonstrated efficacy in acute restraint stress (ARS) mouse models by reversing stress-induced depletion of serotonin (5-HT) and norepinephrine (NE) in the brain (Patel et al., 2024) [12]. This suggests modulation of monoaminergic transmission, possibly through inhibition of monoamine oxidase-A (MAO-A), which prolongs the activity of monoamines at synaptic clefts.

Flavonoids like apigenin are reported as selective MAO-A inhibitors, reducing oxidative stress in neurons and supporting neurogenesis. Importantly, EECS showed no sedative or locomotor effect, pointing to a targeted antidepressant action.

**Immunomodulatory Potential**

Immunomodulation by C. serratum is evidenced by mast cell-stabilizing effects and regulation of immune responses (Tiwari et al., 2021) [15]. Reducing mast cell degranulation diminishes allergic and asthmatic pathology. Bioactive terpenoids and flavonoids may also modulate pro-inflammatory cytokines, contributing to systemic immune regulation.

**Antimicrobial and Antimycobacterial Effects**

Green-synthesized silver nanoparticles (AgNPs) derived from C. serratum extracts exhibited potent bactericidal

activity against Mycobacterium species, disrupting cell walls and inducing lysis (Patel et al., 2024) [12]. These nanoparticles were effective against microbial biofilms, addressing a key limitation of conventional antibiotics. PEGylated formulations enhanced stability and bioavailability, making them promising candidates for anti-TB research.

**Antihyperglycemic Potential**

Preliminary *in vitro* findings suggest that C. serratum or related *Clerodendrum* species could reduce hyperglycemia by enhancing glucose uptake and inhibiting carbohydrate-digesting enzymes (Kumar & Nishteswar, 2013) [6]. While not yet validated in clinical trials, the presence of polyphenols and triterpenoids supports this potential.

**Table 1:** Pharmacological Action of *Clerodendrum serratum* (L.) Moon

| Pharmacological Action | Mechanistic Insight | Major Compounds Involved | Key References |
|---|---|---|---|
| Antioxidant | Scavenges ROS, inhibits lipid peroxidation, chelates metals; increases endogenous antioxidant enzymes | Ferulic acid, caffeic acid, acteoside, apigenin, luteolin | Siddik et al., 2021 [14] |
| Anti-inflammatory | Inhibits protein denaturation, stabilizes mast cells, suppresses COX & LOX pathways | Ursolic acid, oleanolic acid, β-sitosterol, stigmasterol | Tiwari et al., 2021 [15] |
| Anti-arthritic | Protein stabilization prevents structural deformation in arthritis | Phytosterols, triterpenoids, flavonoids | Tiwari et al., 2021[15] |
| Neuroprotective | MAO-A inhibition, restores NE & 5-HT levels, antioxidant neuroprotection | Apigenin, hispidulin, luteolin | Patel et al., 2024 [12] |
| Immunomodulatory | Modulates cytokine balance; stabilizes mast cells | Flavonoids, terpenoids | Tiwari et al., 2021 [15] |
| Antimicrobial | Silver nanoparticles cause bacterial lysis and disrupt biofilms | AgNPs, polyphenolic capping agents | Patel et al., 2024 [12] |
| Antihyperglycemic | Possible α-amylase/α-glucosidase inhibition; improves glucose control | Polyphenols, triterpenoids | Kumar & Nishteswar, 2013 [6] |

**Toxicity and safety profile**

The safety and toxicity profile of *Clerodendrum serratum* seed extract was evaluated in a preclinical study using a paracetamol-induced hepatotoxicity model in Wistar albino rats. Acute oral toxicity testing, conducted according to OECD guidelines, demonstrated no mortality or adverse behavioral changes at doses up to 2000 mg/kg, indicating a wide safety margin. The study further assessed the protective effects of ethyl acetate and ethanolic extracts against paracetamol-induced liver damage. Paracetamol administration significantly altered hepatic biomarkers, including elevated levels of AST, ALT, ALP, and total bilirubin, alongside reduced antioxidant enzyme activity (SOD, CAT) and increased malondialdehyde (MDA) levels, indicating oxidative stress and hepatocellular injury. Treatment with *C. serratum* seed extracts, particularly the ethanolic extract at 200 mg/kg, significantly mitigated these effects and restored biochemical parameters toward normal values. These findings not only confirmed the non-toxic nature of the extracts at therapeutic doses but also highlighted their antioxidant-mediated hepatoprotective potential, supporting the plant's traditional usage and suggesting its suitability for safe inclusion in herbal hepatoprotective formulations (Nayak, J.et al., 2025) [9].

**Clinical trials and case study**

PEGylated Silver Nanoparticles Made from Leaf Extract of *Clerodendrum serratum* Have Antimycobacterial and Antibiofilm Properties

The pharmacological potential of PEGylated silver nanoparticles made with *Clerodendrum serratum* leaf extracts was examined by researchers. Silver nanoparticles were created by reducing silver nitrate using phytoconstituents that were first extracted from the plant leaves. To increase these nanoparticles' physicochemical stability and biocompatibility, they underwent additional PEGylation. Several analytical methods were used to characterize the produced PEG-AgNPs, including FTIR-ATR, HR-TEM, UV-Visible spectroscopy, Zetasizer, XRD, and HPLC, which confirmed their successful formation, uniform morphology, and appropriate size distribution.

Pharmacological evaluations demonstrated that the PEGylated silver nanoparticles possessed significant antimycobacterial activity. Researchers found that these nanoparticles induced effective lysis of *Mycobacterium* species, indicating strong bactericidal effects. Additionally, the nanoparticles were capable of degrading bacterial biofilms, suggesting their potential to disrupt microbial communities often resistant to conventional antibiotics. These findings indicated that PEG-AgNPs derived from *Clerodendrum serratum* could serve as a promising therapeutic tool for treating mycobacterial infections and biofilm-associated diseases (Patel, R. R.et al., 2025)

***Clerodendrum serratum* Linn anti-asthmatic properties. Inhalation Treatment in Model of Ovalbumin-Induced Asthma**

Researchers investigated the anti-asthmatic potential of a novel inhalable formulation prepared from hydroalcoholic root extract of *Clerodendrum serratum* Linn. in a well-established ovalbumin-induced asthma model in Wistar rats. The extract was formulated using a lactose carrier to optimize aerosolization and ensure effective pulmonary delivery. The study aimed to validate the plant's traditional use in Ayurveda for treating respiratory disorders, particularly asthma.

The inhaled formulation considerably decreased the typical symptoms of allergic asthma, according to the researchers' findings.

It markedly lowered serum leukocyte and eosinophil counts, which are indicators of systemic and airway inflammation. The formulation also stabilized mast cells in the bronchoalveolar lavage fluid (BALF), preventing their degranulation and subsequent release of inflammatory mediators.

Further, the researchers observed a significant reduction in total tissue protein content in lung homogenates, indicating decreased tissue injury and oxidative stress. Histopathological examinations revealed that the treated groups exhibited minimal airway remodeling and inflammation compared to the disease control, supporting the formulation's protective effects on lung architecture. Moreover, levels of Th2 cytokines Tumor Necrosis Factor-α (TNF-α) and Interleukin-4 (IL-4) were significantly reduced in BALF, indicating potent immunomodulatory activity.

According to the results, C. serratum exhibited pharmacological effects via immunomodulatory, antioxidant, mast cell stabilizing, and anti-inflammatory mechanisms. This study demonstrated *Clerodendrum serratum*'s potential for development as an alternate inhalation therapy for asthma and offered strong preclinical evidence in favor of its traditional therapeutic use in respiratory conditions. (Patel, L.et al., 2023) [11]

**Antioxidant Properties of *Clerodendrum* Species**

The antioxidant capacity of several Northeast Indian native *Clerodendrum* species was thoroughly reviewed by researchers, who also noted the ethnopharmacological significance of these species. With over 580 species, the genus *Clerodendrum* (Verbenaceae) has long been used to treat a wide range of conditions, such as skin conditions, rheumatism, diabetes, hypertension, and asthma. According to the researchers, bioactive phytochemicals like polyphenols and flavonoids found in various parts of *Clerodendrum* spp., particularly the roots and leaves, demonstrated strong antioxidant properties.

Ethanolic and methanolic extracts from species such as *C. serratum*, *C. infortunatum*, *C. phlomidis*, *C. viscosum*, and *C. inerme* showed significant free radical scavenging activity in various *in vitro* assays including DPPH, ABTS, hydrogen peroxide, hydroxyl and nitric oxide scavenging, and reducing power assays. Extracts demonstrated IC50 values comparable to standard antioxidants like BHT and vitamin C. Particularly, *C. phlomidis* roots and *C. inerme* shoots showed pronounced antioxidant efficacy, linked to high levels of total phenolic and flavonoid content.

Compounds such as isoacteoside isolated from *C. trichotomum* were shown to inhibit lipid peroxidation and enhance intracellular antioxidant enzyme levels. The study also emphasized the role of phenolic hydroxyl groups in redox reactions and the chelation of pro-oxidant metal ions, contributing to the observed antioxidant effects. Researchers concluded that while *Clerodendrum* species exhibit strong antioxidant properties, further phytochemical isolation and *in vivo* investigations are necessary to validate their pharmacological applications as natural antioxidant agents (Siddik, A.et al., 2021) [14].

**Antihyperglycemic Activity *In vitro***

The researchers used α-amylase and α-glucosidase inhibition assays to test the methanolic leaf extract of *Clerodendrum* species *in vitro* and found that it had significant antihyperglycemic activity. One of the most important ways to regulate postprandial blood glucose levels is to inhibit these enzymes, which are involved in the digestion of carbohydrates.

The extract showed a dose-dependent inhibitory effect on both enzymes, with efficacy comparable to the standard drug acarbose. This suggested that the extract could effectively reduce glucose absorption and modulate blood sugar spikes following meals. Based on these findings, the researchers concluded that *C. speciosum* possessed significant antihyperglycemic potential through enzyme inhibitory mechanisms.

**Antiarthritic Activity *In vitro***

The researchers reported that the antiarthritic potential of *Clerodendrum speciosum* was demonstrated through the inhibition of protein denaturation *in vitro*, using the heat-induced albumin denaturation assay. This model reflects an inflammatory response relevant to rheumatoid arthritis. Protein denaturation was significantly inhibited by the methanolic extract in a concentration-dependent manner; the results were similar to those of the common anti-inflammatory medication diclofenac sodium.

The researchers suggested that the extract's ability to stabilize proteins and prevent denaturation could contribute to its anti-inflammatory and antiarthritic effects. These findings bolstered C. speciosum's therapeutic value in treating inflammatory diseases like arthritis. (Elhady, S. S. et al., 2025) [4].

**Anti-Corrosive Activity**

In a 0.5 M sulfuric acid medium, the researchers found that *Clerodendrum serratum* extract demonstrated strong anti-corrosive potential against mild steel corrosion. To assess the inhibition efficiency at different concentrations, the study used potentiodynamic polarization (PDP), electrochemical impedance spectroscopy (EIS), and weight loss analysis.

The phytochemical-rich extract, containing compounds such as apigenin, hispidulin, oleanolic acid, ursolic acid, β-sitosterol, and serratin, was found to enhance corrosion resistance, likely due to the presence of multiple bonds and heteroatoms facilitating strong surface adsorption. The inhibition efficiency increased with higher concentrations of the extract, reaching 88.6% at 3000 mg/L in the absence of KCl and peaking at 93.05% in its presence, indicating a synergistic effect. UV spectroscopy supported the identification of molecular interactions contributing to the protective layer formation. The researchers concluded that *C. serratum* extract offers a highly effective and eco-friendly alternative to synthetic corrosion inhibitors, with promising applications in industrial metal protection (Dutta, A., Kaur, J., & Saxena, A., 2024) [3].

**Antibacterial Activity**

*Clerodendrum serratum* methanolic extract showed strong antibacterial activity, according to the researchers, especially against Staphylococcus aureus, a gram-positive bacterium linked to a variety of infections, including skin and respiratory conditions. Strong antibacterial efficacy was suggested by the noticeable 19 mm zone of inhibition. The presence of secondary metabolites, including flavonoids, terpenoids, and phenolic compounds, which probably compromised the integrity of the bacterial cell wall or inhibited important microbial enzymes, was the reason

given by the researchers for this activity. This finding indicated that C. serratum may be a viable option for the development of plant-based antibacterial medications and validated its historical use in the treatment of infections.

**Antifungal Activity**

*Clerodendrum serratum* methanolic extract showed significant antifungal activity against Candida albicans, a common opportunistic fungal pathogen that causes candidiasis, according to the researchers' findings from the same study. The extract successfully suppressed fungal growth, as evidenced by the 16 mm zone of inhibition it produced. Since sterols, alkaloids, and tannins are known to impair the integrity of fungal cell membranes and prevent the synthesis of ergosterol, it was believed that they were the bioactive substances responsible for the antifungal action. This discovery supported the plant's traditional use in ethnomedicine to treat fungal infections and skin conditions.

**Antiviral Activity**

Additionally, the extract demonstrated antiviral activity against the Herpes Simplex Virus (HSV), according to the researchers, as evidenced by a reduction in virus-induced cytopathic effects during *in vitro* testing. Although quantitative viral inhibition data were not detailed, the qualitative suppression of HSV cytotoxicity pointed to a potential inhibitory effect on viral replication or host cell protection. The antiviral action was presumed to involve polyphenolic and flavonoid compounds capable of blocking viral entry, inhibiting nucleic acid synthesis, or enhancing host immune responses. These results suggested a promising scope for *C. serratum* in developing phytotherapeutic antiviral agents, especially against resistant HSV strains.

**Anthelmintic Activity**

The researchers also reported that *Clerodendrum serratum* possessed strong anthelmintic activity when tested on *Pheretima posthuma* (earthworm model). The extract demonstrated a swift and powerful effect at a concentration of 50 mg/mL, causing paralysis in 8.4 minutes and death in 13.2 minutes. The presence of tannins, saponins, and other bioactive compounds that harm the worm's cuticle and hinder energy metabolism was thought to be the cause of this anthelmintic effect.

The findings supported the plant's traditional usage in expelling intestinal parasites and highlighted its potential as a natural source for developing alternative anthelmintic therapies with reduced resistance risk (Joshi, B. et al., 2020) [5].

***In-vitro* Anti-cancer Evaluation of *Clerodendrum serratum* L. Root Extract via Transferosomal Drug Delivery System**

The researchers reported that roots of *Clerodendrum serratum* L. were extracted using a hydroalcoholic solvent system to isolate phytochemicals with potential anticancer properties. To enhance their therapeutic efficacy and stability, the extract was formulated into transferosomes ultra-deformable vesicles designed for improved drug penetration. Using the thin film hydration method, the extract was entrapped within a lipid bilayer composed of phosphatidylcholine, along with edge activators to increase vesicle flexibility and facilitate transdermal or intracellular delivery.

The formulation was lyophilized and subjected to comprehensive characterization, including UV and IR spectroscopy to assess chemical integrity, particle size and zeta potential analysis for colloidal stability, X-ray diffraction (XRD) and thermal analysis to understand crystalline behavior and thermal properties, and morphological studies using electron microscopy to confirm nanoscale spherical vesicles.

*In vitro* pharmacological evaluation was performed using B16F10 murine melanoma skin cancer cells, where the transferosomal formulation was tested via the MTT assay. The researchers observed a significant decrease in cell viability, attributed to disrupted mitochondrial reductase activity, confirming dose-dependent cytotoxic and antiproliferative effects of the encapsulated extract. These results suggested that the bioactive compounds from *C. serratum* roots retained their pharmacological potency when delivered through nanocarriers, and the transferosomal system markedly enhanced their cellular uptake and anticancer efficacy.

Overall, the study highlighted the synergistic advantage of integrating traditional medicinal plants with nanotechnology for targeted cancer therapy (Bhinge, S. D. et al., 2025) [1].

**Future Perspectives on *Clerodendrum serratum* Research and Applications**

*Clerodendrum serratum* (Bharangi) has a long-standing history of use in Ayurveda, corroborated by emerging experimental evidence demonstrating its antioxidant, anti-inflammatory, neuroprotective, antimicrobial, and immunomodulatory effects. Despite these promising findings, several critical areas demand targeted research to translate preclinical potential into practical therapeutics.

**Standardization of Extracts and Dosage Forms**

Most studies employ crude ethanolic or methanolic extracts, but there is limited information on standardized phytochemical profiles. Future research should focus on:

- Defining marker compounds (e.g., apigenin, acteoside, ursolic acid, β-sitosterol) for quality control.
- Developing validated analytical protocols (HPLC, LC–MS/MS) for batch-to-batch consistency.
- Determining optimal dose ranges and safety margins through acute and chronic toxicity studies.

**Mechanistic Elucidation through Molecular Studies**

While antioxidant and monoaminergic pathways have been implicated in neuroprotection, detailed molecular targets remain underexplored. Advanced omics technologies metabolomics, transcriptomics, proteomics could:

- Identify gene expression changes following treatment.
- Map signalling pathways involved in anti-inflammatory and immunomodulatory actions.
- Clarify interactions with MAO-A, COX, LOX, and other enzyme systems.

***In Vivo* and Clinical Translation**

Most efficacy data are limited to *in vitro* or small-scale animal studies. The next research stage must include:

- *In vivo* pharmacokinetic and pharmacodynamic profiling to assess bioavailability and metabolism.

- Randomized controlled trials in humans to validate safety, efficacy, and possible herb–drug interactions.
- Evaluation of delivery routes for targeted therapeutic applications, such as inhalational formulations for asthma.

**Development of Novel Formulations**

Recent successes with green-synthesized silver nanoparticles suggest nanoparticle-based delivery could improve drug stability, targeting, and antimicrobial efficacy. Future work may include:

- PEGylated or ligand-modified nanoparticles for brain-targeted neuroprotective therapy.
- Encapsulation in liposomes, phytosomes, or polymeric nanoparticles to enhance oral bioavailability.
- Combination therapies with standard drugs for synergistic effects in infections, inflammation, or depression.

**Exploration of Understudied Pharmacological Effects**

Although anti-inflammatory, antimicrobial, and neuroprotective roles are well documented, other areas remain promising but underexplored:

- Metabolic disorders: Preliminary antihyperglycemic effects warrant detailed mechanistic and clinical evaluation.
- Anticancer properties: Flavonoids and terpenoids present in *C. serratum* have shown cytotoxicity in related *Clerodendrum* species; targeted screening against cancer cell lines could reveal new leads.
- Immuno-oncology: Combining immunomodulation with antioxidant activity may help attenuate cancer-related oxidative stress.

**Conservation and Sustainable Utilization**

Given rising interest in *C. serratum*, sustainable harvesting and conservation of wild populations are critical. Strategies could include:

- Tissue culture and micropropagation for large-scale cultivation.
- Genetic diversity mapping (as initiated by Apana et al., 2021) to select resilient, phytochemically rich strains.
- Integration into community-based cultivation programs to reduce pressure on wild resources.

**Integration with Traditional Knowledge Systems**

The *Brihat Trayi* offers unexplored combinational therapies where *C. serratum* is used in polyherbal formulations. Scientific validation of these classical preparations could:

- Reveal novel synergistic interactions.
- Provide culturally acceptable, evidence-based interventions.

**Conclusion**

A strong phytochemical repertoire and the variety of pharmacological activities found in C. serratum make this species a promising option for the creation of respiratory treatments, antimicrobial formulations, and natural neuroprotective agents.

However, achieving translational success will require multidisciplinary efforts combining ethnopharmacology, phytochemistry, nanomedicine, and clinical research while ensuring sustainable utilization and conservation of this valuable medicinal resource.

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