

BIOACTIVE CONSTITUENTS AND THERAPEUTIC POTENTIAL OF *CAPPARIS ZEYLANICA LINN*

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ABSTRACT

Background: *Capparis zeylanica* Linn. is an important medicinal climber extensively used in traditional medicine for treating inflammatory disorders, infections, diabetes, gastrointestinal ailments, and other diseases. **Objective:** This review summarizes the phytochemical constituents, traditional uses, pharmacological activities, and therapeutic potential of *C. zeylanica* while highlighting future research opportunities. **Methods:** Published literature was collected from scientific databases including PubMed, Scopus, Google Scholar, ScienceDirect, and Web of Science using keywords related to *Capparis zeylanica*, phytochemistry, pharmacology, and ethnomedicine. **Results:** The plant contains flavonoids, alkaloids, phenolic acids, sterols, glycosides, terpenoids, and spermidine alkaloids. These phytoconstituents are responsible for experimentally validated antioxidant, anti-inflammatory, antimicrobial, immunomodulatory, antidiabetic, antipyretic, hepatoprotective, anti-ulcer, and anticancer activities. **Conclusion:** Current evidence supports the therapeutic potential of *C. zeylanica*; however, comprehensive phytochemical characterization, toxicity evaluation, pharmacokinetic investigations, and well-designed clinical studies are required before clinical application. "This review demonstrates that flavonoids, spermidine alkaloids, phenolic acids, and sterols are the principal bioactive constituents responsible for multiple experimentally validated pharmacological activities."

KEYWORDS: *Capparis zeylanica*, phytochemicals, ethnopharmacology, medicinal plants, antioxidant activity, anti-inflammatory activity, anticancer activity.

Capparis zeylanica Linn. acts as tough, slim, as well as heavily climbing shrub with branches that increases well inside wet places. It is common in China, India, Bangladesh, Nepal, Malaysia, Sri Lanka, as well as little parts in the Pakistan. It is very common in India, especially in places like Mumbai, Delhi, Dehradun, the southern Himalayas, and the Andaman Islands.

The plant usually grows between 2 and 3 meters tall and has curved thorns that are 3 to 6 mm long. It is a climbing shrub with reddish-brown, short-lived hair on its young parts. The stems are rough and woody, and the younger parts are green and smell good. The foliage is oval to rectangular and 3-10 cm large. The petiole appears 10 to 15 mm long, rounded at the base, and ends in a small point. Most of the time, flowers are in pairs, but they can also be alone or in threes. They are 2 to 4 cm wide and have pedicels that are approximately 4 cm in length. The sepals appear hairy as well as almost the same size. The petals are white or slightly yellowish, approximately 18 mm in length, as well as have hair on outside. A large number of stamens are present that are twice as long as the petals and have purple tips. The fruit is round as well as having a diameter of 3-4 cm. It is packed with white pulp.^[12,18,19] The plant is known by various names across different languages and regions.

Literature Search Methodology

The literature included in this review was retrieved from PubMed, Scopus, Web of Science, Google Scholar, ScienceDirect, and SpringerLink up to June 2026 using the keywords *Capparis zeylanica*, phytochemistry, pharmacology, ethnomedicine, medicinal plants, antioxidant, anti-inflammatory, antimicrobial, and anticancer. Only peer-reviewed articles published in English were included. Reference lists of selected articles were also screened to identify additional relevant studies.

Botanical Authentication

The accepted botanical name is *Capparis zeylanica* Linn. (Family: Capparaceae). Botanical nomenclature follows Plants of the World Online (Kew Science). Future pharmacological studies should authenticate plant material through a qualified taxonomist, and voucher specimens should be deposited in a recognized herbarium to ensure reproducibility.

Phytochemical Composition

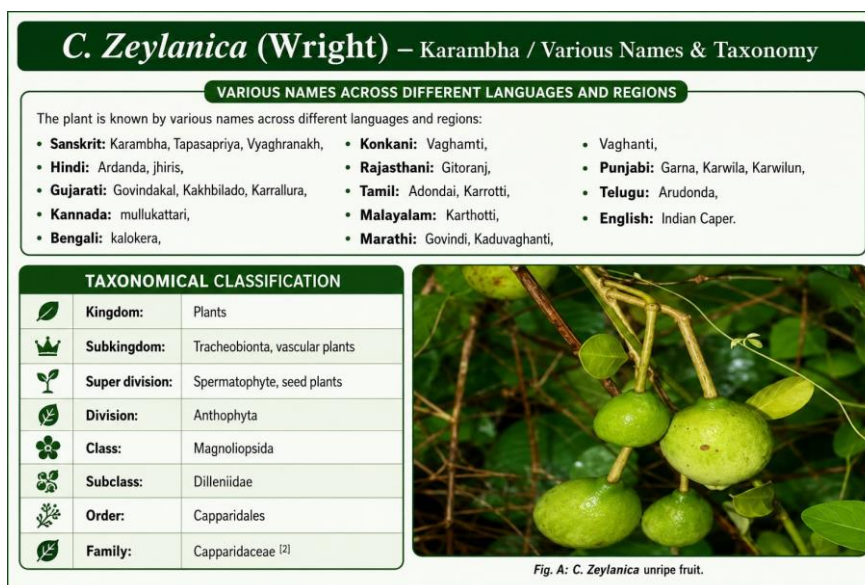


Figure 1: Unripe fruits of *Capparis zeylanica* Linn.

It has been determined that *Capparis zeylanica* contains a wide variety of chemical components. Saponins, syringic acid, p-hydroxybenzoic acid, ferulic acid, vanillic acid, as well as p-coumaric acids are present throughout the entire plant. Glycocappain, thioglycosides, β -carotene, α -amyrin, n-triacontane as well as secured oils are abundant in the seeds.^[33,35,37] Additionally, *Capparis zeylanica* fruits have shown anti-gout, anti-allergic, astringent, and anti-diabetic qualities. The fruits as well as seeds have the potential to be anthelmintic, or anti-parasitic.^[28,29,30]

Understanding the biological, nutritional, and therapeutic properties of certain plant species requires analysing the qualitative and quantitative composition of phytochemicals. Therefore, evaluating food and medicinal plants' biochemical composition and bioactive components is crucial to investigating their possible application in pharmaceutical formulations and nutraceuticals. *Capparis* species have been investigated as important sources of bioactive and valuable phytochemicals. An outline of the main bioactive categories found in different *Capparis* species is given in the following sections.^[2,9]

Numerous alkaloids and phytosterols, including spermidine alkaloids like isocodonocarpine, capparisine, capparine, capparinine, and capparidisine has been found in the base of caper plants. Notable alkaloids such as spermidine, isocodonocarpine, capparine, codonocarpine, capparisine, capparipine-26-O- β -D-glucoside, as well as cadabacine-26-O- β -D-glucoside have been obtained from the dried root cortex of *Capparis decidua*. Cadabacine-26-O- β -D-glucoside as well as capparispine-26-O- β -D-glucoside are examples of spermidine-based alkaloids found in the roots of *Capparis spinosa*. The root cortex of *C. decidua* also further alkaloids, like N-acetylated spermidine derivatives such as 14-N-acetylisocodonocarpine as well as 15-N-acetylcapparisine.^[2,12]

These results demonstrate the high concentration of spermidine-type alkaloids in *Capparis* roots, suggesting their potential as a natural source for the extraction of such polyamines for therapeutic purposes. A multipurpose polyamine, spermidine is present in a number of microorganisms and animals as well as some plants, including cabbage, spinach, and wheat. Poultry liver, fermented soy, aged cheese, mushrooms, legumes, maize, as well as entire grains are rich dietary sources; wheat germ endosperm can contain up to 243 mg/kg.^[10]

Because of these natural polyamines' wide range of biological functions and potential therapeutic benefits, scientific interest in them has increased recently. Mammalian cell growth, development, and proliferation are greatly aided by spermidine and spermine. These substances also prevent the glycation process and have antiallergy and antioxidant properties. Additionally, due to their anti-inflammatory properties as well as cell-regenerating characteristics, they are linked to avoiding arteriosclerosis and encouraging hair growth.^[11]

Guanosine, β -sitosterol, isocodonocarpine, capparine A, and capparine B are additional bioactives that have recently been identified from *C. spinosa* fruits. Among these, β -sitosterol is a well-known plant sterol that can be found in vegetables, grains, and plant oils. It has demonstrated antibacterial activity by inhibiting the cyclooxygenase and 5-lipoxygenase enzyme pathways.^[12]

Flavonoids and Phenolic Acids

Flavonoids and phenolic acids, which include groupings like flavonoids, tannins, and other phenolic acids, are important secondary metabolites in plants. With almost 6,500 varieties found in the kingdom of plants, flavonoids are among the most prevalent phytochemicals in the human diet. They serve as a defense against environmental stressors

and are mainly kept in the vacuoles of plant cells found in leaves, flowers, and fruits. Depending on how saturated and hydroxylated their flavin ring structure is, these substances can be divided into flavones, flavanols, and anthocyanins.^[13]

It is known that *Capparis* genera include are abundant into flavonoids, including flavones and flavanols. For example, apigenin and kaempferol are present in the fruits, but quercetin 3-O-gentiobioside has been isolated from the embryo fluid of *C. spinosa*. Additionally, chemicals like kaempferol-3-O-rutinoside, quercetin-3-O-rutinoside, as well as sakuranetin have been found in *C. spinosa* fruits, along with novel flavonoids such as isoginkgetin, ginkgetin, and sakuranetin. Flavonoids, such as kaempferol, quercetin, as well as isorhamnetin has also been shown to be abundant in *C. spinosa* leaves. Kaempferol-3-O-rutinoside, isorhamnetin-3-O-rutinoside, as well as rutin are the main polyphenols found into this species. The leaves of *C. spinosa* have a considerable concentration of rutin as well as quercetin, which emphasizes their potential as affordable sources of these beneficial phytochemicals.^[14]

Phytochemical–Pharmacological Correlation

Capparis zeylanica contains a diverse array of bioactive phytochemicals, including flavonoids, phenolic acids, alkaloids, sterols, terpenoids, glycosides, and saponins, which collectively contribute to its broad spectrum of pharmacological activities. Flavonoids such as quercetin, kaempferol, and rutin possess potent antioxidant properties by scavenging reactive oxygen species (ROS), inhibiting lipid peroxidation, and enhancing endogenous antioxidant enzymes. These compounds also suppress inflammatory mediators, including cyclooxygenase (COX), lipoxygenase (LOX), nuclear factor-kappa B (NF-κB), and pro-inflammatory cytokines, thereby contributing to the plant's anti-inflammatory and analgesic effects.

Spermidine alkaloids, a characteristic class of compounds found in *Capparis* species, have demonstrated cytoprotective, immunomodulatory, and antiproliferative properties. Experimental studies suggest that these alkaloids may induce apoptosis, arrest the cell cycle, and regulate oxidative stress, supporting the reported anticancer potential of the plant. Phenolic acids, including ferulic acid, syringic acid, vanillic acid, and *p*-coumaric acid, exhibit strong antioxidant and antimicrobial activities through free radical neutralization and disruption of microbial cell integrity. These compounds may also contribute to hepatoprotective and antiulcer effects by reducing oxidative damage and preserving cellular homeostasis.

Plant sterols such as β -sitosterol possess anti-inflammatory, antimicrobial, and lipid-lowering properties by modulating inflammatory pathways and stabilizing cellular membranes. Saponins and triterpenoids further enhance the therapeutic profile of *C. zeylanica* through immunomodulatory, antimicrobial, and gastroprotective activities. The combined action of these phytoconstituents is likely responsible for the experimentally reported antioxidant, antimicrobial, antidiabetic, anti-inflammatory, antiulcer, immunomodulatory, hepatoprotective, and anticancer activities of *C. zeylanica*. Nevertheless, the precise molecular mechanisms, synergistic interactions among phytochemicals, pharmacokinetic behaviour, and clinical efficacy remain inadequately explored and warrant further investigation as shown in **Table 01**.

Table 1: Correlation of major phytochemical constituents of *Capparis zeylanica* with their proposed mechanisms of action and reported pharmacological activities.

Phytochemical Class	Major Constituents	Proposed Mechanism of Action	Reported Pharmacological Activity
Flavonoids	<i>Quercetin, Kaempferol, Rutin</i>	ROS scavenging, COX/LOX inhibition, NF- κ B suppression	Antioxidant, anti-inflammatory, analgesic
Phenolic acids	<i>Ferulic acid, Syringic acid, Vanillic acid, p-Coumaric acid</i>	Free radical scavenging, membrane protection	Antioxidant, antimicrobial, hepatoprotective
Spermidine alkaloids	<i>Capparisine, Capparine, Isocodonocarpine</i>	Apoptosis induction, cell cycle arrest, oxidative stress modulation	Anticancer, immunomodulatory
Phytosterols	<i>β-Sitosterol</i>	Anti-inflammatory pathway modulation	Anti-inflammatory, antimicrobial
Saponins	<i>Glycosidic saponins</i>	Membrane interaction, immune stimulation	Immunomodulatory, antimicrobial
Triterpenoids	<i>α-Amyrin</i>	COX inhibition, antioxidant activity	Anti-inflammatory, antiulcer

Medicinal and Traditional Uses

Capparis zeylanica has a lengthy history of being used in conventional ways, starting with its use as a vegetable.¹⁶ People used to take the leaf extract with black pepper powder twice a day to help with dysentery.^[18] People also drink the juice from its leaves mixed with fresh goat milk to help with coughs and colds.^[19] To treat diabetes, the ripe fruits are eaten twice in two weeks, and the bark of the stem extract is used three times daily.^[20]

This plant is also used as a digestive stimulant or appetizer. It is often made into a paste with black pepper, tamarind, and garlic.^[21] A traditional treatment for convulsive seizures consists of a blend of fresh roots, onions, and jaggery, ground into a paste and shaped into a bolus.

The bark from the roots of *C. zeylanica* is valued for its cooling properties and is recognized as a cholagogue as well as bitter tonic. It has been used for a long time as a stomachic, sedative, and antiperspirant, as well as to cholera, neuralgia, hemiplegia, and rheumatism. Seeds as well as the fruits are utilized are used to treat dysentery and urinary tract infections that cause pus to come out. In the northern part of India, the foliage was utilized as a rubefacient and topical irritant on the skin as well as a poultice on seethe, swelling, as well as hemorrhoids.^[17] People have always thought of the fruit as a cure for snake bites.^[24,50] Other ethnomedicinal uses include treating testicular swelling, smallpox, boils, cholera, abdominal pain, paralysis, nerve pain, skin sores, pneumonia, and pleurisy.^[26,27]

People also use the root bark to treat smallpox and inflammation of the testicles. People drink a decoction made by grinding the root bark with water and boiling it to help with indigestion. Traditional medicine uses the stem and leaves to relieve spasms. Root bark preparations are also recommended for their soothing effects.^[28,44,46] In folk medicine, leaf juice is well-known for helping with diarrhea. People have traditionally used unripe *C. zeylanica* fruits to treat bad headaches, coughs, colds, nasal congestion, throat infections, and snake bites.^[6]

In Siddha medicine, the plant is called "Aathondai," and unripe fruits are used because they are calming, good for the stomach, and bitter. People think that they help balance the body's three doshas, and the bitterness in particular helps calm the Kapha and Vata doshas.^[3]

Pharmacological Properties

Ethyl alcohol as well as methanol concentrate from the rhizoidal structure of *Capparis zeylanica* have exhibited significant antioxidant activity in vitro. free radical scavenging of DPPH (1,1-diphenyl-2-picrylhydrazyl) assays as well as reducing ability tests showed this. Extracts from raw floral buds obtained using methanol has demonstrated antioxidant properties into multiple in vitro models, indicating their capability to utilities in the management of oxidative stress-related disorders. The root powder extract also had strong antioxidant effects.^[29,45]

Researchers found that the leaves of *C. zeylanica* had immunostimulatory properties. When given to mice by mouth at doses of 150 mg/kg as well as 300 mg/kg, aqueous as well as ethanolic extracts significantly increased the delayed hypersensitivity response caused by through sheep RBC's dependent on the dose way. Moreover, these extracts aided in the prevention of myelosuppression induced by cyclophosphamide therapy.^[1,30,49] Also, rude plant extracts were found to make the central nervous system (CNS) less active. Steam-distilled volatile oils derived from flowers and seeds exhibited significant antimicrobial properties. A 50% hydroalcoholic extract from the aerial parts exhibited spasmolytic (muscle-relaxant) characteristics.^[31,34]

In the tail-immersion test, ethanolic and aqueous concentrate of *C. zeylanica* leaves similarly shown dose-dependent analgesic effects. In both stages of the formalin-induced pain paradigm, both extracts successfully decreased discomfort and markedly suppressed writhing responses. In animal studies, the water extracts significantly reduced yeast-induced fever.^[32,35] Polyherbal preparations for liver problems frequently contain aqueous extracts from the complete aerial portions, which have demonstrated antifungal, anti-inflammatory, antidiabetic, and lipid-lowering properties.^[33]

Both Gram-negative as well as gram-positive bacterial strains existed as susceptible as antibacterial activity of root concentrate which made with chloroform, ethanol, and water. Petroleum ether extracts showed promise as antibacterial agents against specific strains. Furthermore, the cytotoxic potential of the separated fatty acids and crude extracts has been investigated.^[36,37,43]

The antioxidant, anti-cancer, anti-ulcer, anti-inflammatory, and antibacterial properties of *C. zeylanica* are attributed to flavonoid molecules. With qualitative efficacy comparable to diazepam, the ethanolic root extract demonstrated significant anti-aggressive qualities. The plant's methanolic extracts have also shown strong antipyretic (fever-lowering) effects.

- 1. Antirheumatic Activity:** In animal studies, the plant's ethanolic and methanolic extracts have demonstrated analgesic and anti-inflammatory properties. In rats given drugs like formalin or carrageenan, which are common models for researching anti-inflammatory and anti-arthritic properties, these extracts dramatically decreased paw edema. Inflammatory indicators such prostaglandins and cytokines have been shown to decrease, suggesting the possibility of modifying immune responses related to rheumatoid arthritis.^[11]
- 2. Anti-inflammatory Activity:** Research on animals utilizing models like rats with claw induced by carrageenan edema has exhibited remarkable anti-inflammatory benefits following treatment with *C. zeylanica* extracts (particularly ethanolic or methanolic extracts of the leaves or roots). Depending on the study, the decrease in paw swelling was comparable to that seen with was comparable to that seen with common anti-edematous medications such NSAID's or diclofenac sodium.^[27]
- 3. Antibacterial Activity:** In studies using agar well diffusion and disc diffusion assays, the plant extract produced measurable zones of inhibition, with effectiveness sometimes comparable to standard antibiotics like ampicillin or

ciprofloxacin. Contingent on the kind of bacterial strain as well as extract, the minimum inhibitory concentration (MIC) values varied, but they frequently showed moderate to strong antibacterial activity.^[4]

4. **Antioxidant Activity:** *C. zeylanica* extracts have shown high the ability to scavenge free radicals in in-vitro antioxidant assays such as nitric oxide scavenging, DPPH (2,2 diphenyl-1-picrylhydrazyl) as well as FRAP (ferric reducing antioxidant power) radical scavenging. In majority of the tests, the methanolic as well as ethyl alcohol concentrates of the foliage, roots, as well as stems exhibited the strongest antioxidant activity. There appears to be a dose-dependent association between the antioxidant activity and extract concentration. According to certain research, the activity was similar to that of typical antioxidants as BHT (butylated hydroxytoluene) or ascorbic acid.^[42]
5. **Anti-Cancer Activity:** Extracts of *C. zeylanica* have shown cytotoxic action against a range of human cancer cell lines, such as MCF -7 (breast tumor) HeLa (cervical tumor) HepG2(Liver tumor)

The MITT assay is commonly used to assess cell viability and *C. zeylanica* extracts have shown significant reduction in cell proliferation that is dose-dependent.

Mechanism

- Apoptosis induction by mitochondrial pathways.
 - Arrest of the cell cycle at various phases (G0/G1 or G2/M), Preventing uncontrolled cell division.
 - Oxidative stress modulation, in which the extract's production of reactive oxygen species (ROS) aids in the specific killing of tumor cells.
 - Damage to DNA or prevention of DNA replication in cancer cells.
6. **Anti-Ulcer Activity:** Research employing animal models, including pylorus ligation, ethanol-induced, and aspirin-induced stomach ulcer models in rats, has demonstrated that extracts from *Capparis zeylanica* considerably lessen:
 - Ulcer index
 - Gastric volume
 - Free as well as total acidity
 - Pepsin activity
 - Mucosal damage
 - Promoted mucosal protection.^[41,48]
 7. **Antimicrobial Activity:** Research has shown that ethanolic, methanolic, as well as aqueous concentrate of *C. zeylanica* foliage, roots, and stems prevent both Gram-positive and Gram-negative bacteria from growing, including:^[40,41]
 - *Escherichia coli*
 - *Bacillus subtilis*
 - *Pseudomonas aeruginosa*
 - *Staphylococcus aureus*
 - *Klebsiella pneumoniae*Disc diffusion experiments reveal a zone of inhibition that suggests moderate to strong antibacterial potential, frequently on par with common antibiotics like ciprofloxacin or ampicillin.^[39,40,47]

- 8 **Antipyretic Activity:** Research employing animal models has demonstrated that *Capparis zeylanica* extracts, particularly ethanolic and aqueous leaf or root extract, have notable antipyretic properties. These effects frequently resemble those of common antipyretic medications like paracetamol. In these investigations, the fever is often produced by yeast or lipopolysaccharide (LPS), and it has been demonstrated that the plant extracts considerably lower the increased body temperature.^[43]

CONCLUSION

Capparis zeylanica Linn. is a medicinally important plant with a long history of use in traditional medicine for the management of inflammatory disorders, microbial infections, diabetes, gastrointestinal ailments, and various other health conditions. The plant is a rich source of diverse bioactive phytoconstituents, including flavonoids, phenolic acids, spermidine alkaloids, phytosterols, saponins, and triterpenoids, which are responsible for its broad spectrum of pharmacological activities. Experimental studies have demonstrated significant antioxidant, anti-inflammatory, antimicrobial, immunomodulatory, antidiabetic, analgesic, antipyretic, antiulcer, hepatoprotective, and anticancer properties, highlighting its considerable therapeutic potential.

Despite these promising findings, the available evidence is predominantly derived from **in vitro** and animal studies, while well-designed clinical investigations remain limited. Furthermore, variations in extraction methods, phytochemical composition, and experimental protocols make direct comparisons among studies challenging. Future research should therefore focus on the isolation and characterization of active constituents, elucidation of molecular mechanisms, standardization of plant extracts, pharmacokinetic and toxicological evaluations, and well-controlled clinical trials to establish the efficacy and safety of *C. zeylanica* in humans. In addition, preserving traditional ethnomedicinal knowledge and conserving the biodiversity of this valuable medicinal species are essential for promoting its sustainable utilization and facilitating the development of novel plant-derived therapeutic agents. Overall, this review provides a comprehensive overview of the phytochemistry, ethnomedicinal significance, and pharmacological potential of *Capparis zeylanica* while identifying important knowledge gaps that should guide future pharmaceutical and clinical research.

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