RESEARCH ARTICLE

PHYTOCHEMICAL ANALYSIS AND ANTIFUNGAL, ANTIMICROBIAL ACTIVITY OF *FICUS* SPECIES

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Abstract:

The genus *Ficus* (family Moraceae) comprises more than 800 species widely distributed across tropical and subtropical ecosystems. Over centuries, these plants have been recognized for their medicinal relevance, particularly in traditional systems such as Ayurveda, Siddha, and Folk medicine. Recent phytochemical investigations have revealed that *Ficus* species are rich sources of diverse bioactive metabolites including flavonoids, phenols, terpenoids, alkaloids, saponins, sterols, and glycosides. These compounds collectively contribute to a broad spectrum of biological activities, among which antifungal activity has gained significant attention due to the rising prevalence of fungal infections and emerging drug-resistant strains. Studies on different species such as *Ficus benghalensis* (Carl Linnaeus, 1753), *Ficus religiosa* (Carl Linnaeus, 1753), *Ficus racemosa* (Carl Linnaeus, 1753), show promising antifungal potential. Extracts prepared from leaves, bark, latex, fruits, and roots have demonstrated inhibitory effects against *Candida albicans*, *Aspergillus niger*, *Aspergillus flavus*, *Trichophyton rubrum*, and various Dermatophytes. The strong antifungal action is generally associated with the synergistic presence of phenolic acids, tannins, flavonoids (like quercetin and kaempferol derivatives), and triterpenoids that disrupt fungal cell walls, inhibit enzyme activity, or impair membrane integrity.

Despite the encouraging findings, the antifungal mechanisms of many *Ficus* extracts remain unclear, as only a few studies have explored molecular interactions or specific metabolic pathways. Moreover, variations in extraction techniques, plant parts, solvent polarity, climatic conditions, and phytochemical composition contribute to differences in reported efficacy. More standardized experimental approaches and advanced analytical techniques—such as LC-MS, GC-MS, and metabolomics are needed to confirm active compounds

responsible for antifungal action. Overall, the accumulated evidence establishes *Ficus* species as promising natural resources for antifungal drug development. Their abundant phytochemical diversity, broad traditional uses, and demonstrated biological activities support further pharmacological exploration.

Keywords: Antifungal Activity, Antimicrobial Activity, Phytochemical Analysis, *Ficus religisoa* (L.)*, Ficus benghalensis* (L.)*, Ficus racemose* (L.).

Introduction:

Ficus plants, commonly called fig trees, are part of the *Moraceae* family and can grow as large trees, small shrubs, or even climbing vines. Many species form aerial roots that hang from their branches and grow downward, helping support the tree when they reach the ground. This is clearly seen in the banyan tree (*Ficus benghalensis*) (Berg & Corner (2005), many figs also begin life on other trees as epiphytes and later develop strong roots that reach the soil. When any part of the plant is cut, it releases a milky latex, which is a common feature of the genus. The leaves of *Ficus* species are usually simple, arranged one after another on the stem, and often feel thick or leathery. Some species like *Ficus carica* have lobed leaves, while many others have smooth-edged leaves. As explained by Kjellberg (2001), you can often see a pair of small structures called stipules that protect young leaves; when these fall off, they leave a ring-like scar on the branch. The veins in fig leaves usually spread out from near the base, a pattern that helps identify fig species.

The fruit of the fig tree is a special structure called a syconium, which is actually a hollow ball lined with many tiny flowers on the inside. Instead of opening like normal flowers, figs keep their flowers hidden within this structure. Janzen (1979) describes how tiny fig-wasps enter through a small opening (the ostiole) to pollinate these hidden flowers. When the flowers mature, they form many tiny seeds inside the fleshy fig. This makes the fig a unique fruit found only in the *Ficus* genus. The genus *Ficus* is a large group of tropica trees and shrubs. (Example: *F. religisoa-sacred* fig; *F. benghalensis-banyan* trees; *F. racemosa -cluster* fig). With extensive ethnomedicinal use. Traditional system worldwide uses Ficus parts for infections, inflammation, diabetes and more various metabolic disorders. (EduardoMadrigal – Santillan *et al.,* 2024). The modern studies identified number of bioactive in ficus species. E.g Flavonoids, terpenoids, tannins and many pharmacological activities antimicrobial, antinflammatory (Suganya Murugesu *et al.,* 2021) fungal infection caused by *Candida*, *aspergillus* are of growing resistance to current drugs.

Phytochemical constituents of *Ficus* species: Phytochemical analysis of *Ficus* species a wide range of secondary metabolites, responsible for their pharmacological activities. The general properties of phytochemical analysis are rich in a variety of compounds including phenols, flavonoids, alkaloids. tannins, saponins, terpenoids, glycosides and steroids (Chunpengwan*, et al.,* 2017) For e.g. *F. benghalensis* and *F. religisa* common constituents include phenols, flavonoids, alkaloids, tannins, saponins, terpenoids and steroids (Suganya Murugesu *et al.,* 2021) Specific identified compounds include triterpenes e.g. B-amyrin, lupeol derivatives and flavonoid e.g. quercetin (Eduardo madrigal santillan *et al.,* 2024). The genus is also characterized by coumarins, megastigmanes and organic acids (Eduardo madrigal Santillan *et al.,* 2024). *Ficus* latex contains proteinases and antimicrobial action.

These compounds often exhibit antimicrobial activity. Basis for the observed antifungal effects (Suganya Murugesu*,* chunpeng wan *et al.,* 2021). the more classes of compounds are similar across different *Ficus* species, a more analysis variations in specific ‘compounds and their concentrations which directly influences their biological activity (Suganya Murugesu *et al.,* 2021).

Antifungal Activity of Selective Ficus Species

***Ficus religiosa* (**L.**) (sacred fig):** *F. religiosa* shown antifungal effects. Using the kirby- bauer method. They observed growth inhibition. phytochemical test *on F. religiosa* typically reveal flavonoids, alkaloids, tannins and terpenoids (Suganya Murugesu *et al.,* 2021). Over all *F. religiosa* stem and bark extracts exhibit moderate potency against *Candida*, supporting its traditional use for skin infection.

***Ficus benghalensis* (**L.**) (banyan tree):** Phytochemical screening of *F. benghalensis* roots shown steroids compounds and phenolics (Etratkhan *et al.,* 2019). Traditional uses include treatment of inflammatory conditions, antimicrobial testing indicates that methanolic extracts of *F. benghalensis* root and leaf inhibit *Candida albicans* (Etratkhan *et al.,* 2019). Report that root and leaf ethanolic extracts were potent against *C. albicans* (Etratkhan *et al.,* 2019). Gram positive and gram negative bacteria more sensitive than fungi in their assys. The antifungal activity is like due to the flavonoids and tannins present (Etratkhan *et al.,* 2019).

Ficus racemose (L.**) (cluster fig):** *F. racemose* fruit extracts have antifungal activity. The presence of specific compounds such as glucanol, tiglic acid, sterol, lupeol acetate (Eduardo madrigal – Santillan *et al.,* 202*4*) The antimicrobial effect like derives from these terpenoids and associated flavonoids.

Morophologly of *Ficus* species:

Ficus species exhibit remarkable morphological diversity, ranging from towering trees to creeping climbers, with distinctive leaves, fruits, and growth forms that adapt to varied ecological niches.

General Characteristics

Family: Moraceae

Genus: *Ficus* (includes ~850 species)

Habit: Trees, shrubs, climbers, and epiphytes

Distribution: Tropical and subtropical regions worldwide

Vegetative Morphology

- **Leaves**: Simple, alternate, and often leathery, Margins entire or slightly toothed, Shapes ovate, elliptic, lanceolate, Prominent venation; some species have drip tips for water runoff
- **Stipules**: Sheathing and deciduous, leaving ring-like scars on twigs
- **Roots**: Some species (e.g., *Ficus benghalensis*) develop aerial roots that become supportive trunks, others are hemiepiphytes, starting life on host trees (*Ficus religiosa*)

Reproductive Morphology

- **Inflorescence**: Unique structure called a *Syconium*—a hollow, fleshy receptacle with internal flowers. Flowers are unisexual and minute, pollinated by species-specific Fig wasps
- **Fruit**: The syconium matures into a compound fruit (commonly called a Fig) Often fleshy and edible, varying in color and size.

Growth Forms

- **Strangler Figs**: Start as epiphytes and envelop host trees (e.g., *Ficus aurea* (Nuttall Thomas *1846*)
- **Banyan trees**: Spread laterally with prop roots forming new trunks (*Ficus benghalensis*)
- **Climbers**: Some species use adventitious roots to cling to surfaces.

Morophology *Ficus racemosa* (l.)

General Features

- **Name**: *Ficus racemosa L.* (also called *Ficus glomerata*)
- **Common Names**: Cluster fig, Gular
- **Family**: Moraceae
- **Type**: Medium to large deciduous tree

Vegetative Morphology:

- **Height:** Usually grows up to 15–20 meters tall
- **Trunk:** Thick, straight, with smooth gray bark that may peel off in patches
- **Leaves:** Shape Oval or oblong, Size7–15 cm long,Texture Slightly rough, leathery, Alternate Arrangement.
- **Roots:** Strong taproot system, no aerial roots like banyan trees

Reproductive Morphology

- **Inflorescence**: Syconium (a fig-like structure that holds tiny flowers)
- **Frutis:** Grow in clusters directly on the trunk and large branches (a trait called *cauliflory*), Round, small figs that turn from green to red or purple when ripe, Eaten by birds, bats, and other animals.
- **Pollination**: Done by Fig wasps in a mutual relationship.

Special Features

Cauliflory: Fruits grow on the trunk, not on branches.

- **Medicinal Uses**: Bark, leaves, and fruits are used in traditional medicine.
- **Habitat**: Often found near rivers, in moist area.
- **Stipules**: Sheathing and deciduous, leaving ring-like scars on twigs.

Morphology *Ficus religiosa* (l.)

Scientifics Name: *Ficus religiosa* L.

- **Common Names**: Sacred fig, Bodhi tree, Peepal
- **Family**: Moraceae
- **Growth Habit**: Large, deciduous or semi-evergreen tree.

Vegetative Morphology:

- **Height**: Can grow up to 30 meters tall**.**
- **Trunk**: Thick and straight, up to 1 meter in diameter.
- **Bark**: Smooth, light gray, sometimes cracked with age.
- **Leaves**: Shape Broad, ovate with a long tapering tip (caudate-acuminate), size10–17 cm long, texture thin and globous (smooth), alternate arrangement, stipules small and fall off early.
- **Roots**: Deep taproot system with occasional aerial roots in older trees.

Reproductive Morphology

- **Inflorescence**: Syconium (a hollow fruit-like structure containing tiny flowers)
- **Flowers**: Unisexual, but both male and female flowers are found inside the same syconium, Pollinated by fig wasps in a mutualistic relationship.
- **Fruits**: Small figs, paired, round, and grow in leaf axils, color changes from green to purple-red when ripe.742

Morphology *Ficus benghalensis* (L.)

General Habit:

- Growth form**:** Large, evergreen tree that can spread over several hectares due to its aerial roots.
- Height**:** Can reach up to 20–30 meters.
- Trunk & roots**:** Main trunk is massive; numerous aerial prop roots descend from branches, thickening into secondary trunks that support the crown.

Leaves:

Shape Broadly ovate, obtuse tip, cordate (heart-shaped) base, Size 10–30 cm long, 7–20 cm wide, Texture very coriaceous (thick and leathery), Surface Upper surface glabrous; lower surface puberulous (covered with fine hairs), Petiole 1.5–7 cm long, puberulous, Stipules Thick, about 1–1.5 cm long.

Flowers:

- Type: Like other figs, flowers are enclosed within a fleshy receptacle (syconium).
- Male flowers**:** Sessile, with 2–3 tepals.
- Female flowers**:** Pedicellate, with 3–4 tepals.
- Gall flowers**:** Present, aiding pollination by fig wasps.

Fruits:

- Form: Paired figs, sessile, depressed-globular.
- Size: 1.5–2 cm in diameter.
- Color: Mature fruits turn orange to red.
- Structure: Ostiole (opening) enclosed by 3 apical bracts; basal bracts foliaceous.

Special Features:

- Epiphytic origin**:** Often begins life on another tree (especially palms), later sending roots down to the soil.
- Aerial roots**:** Characteristic feature; they thicken into woody trunks.
- Longevity: Known for living centuries; some banyan trees cover several acer.

Phytochemical Properties of *Ficus* species:

Ficus benghalensis* (**L.):*

Ficus benghalensis, commonly known as the banyan tree, is a rich source of diverse phytochemicals that contribute to its traditional and pharmacological significance. The plant contains flavonoids, tannins, alkaloids, saponins, glycosides, and phenolic compounds, which are distributed across its leaves, bark, roots, and latex. Flavonoids and phenolics exhibit potent antioxidant activity, helping to neutralize free radicals and reduce oxidative stress. Tannins and saponins contribute to antimicrobial and anti-inflammatory effects, making the bark and aerial roots useful in treating

infections and wounds. Alkaloids and glycosides present in the bark have shown hypoglycemic effects in diabetic models, indicating potential antidiabetic applications. Additionally, sterols such as β-sitosterol are linked to anti-inflammatory and cholesterol-lowering properties. These bioactive compounds collectively support the plant's use in traditional medicine for treating ailments ranging from skin disorders to metabolic conditions.

Ficus racemosa **(**L.)***:***

Ficus racemosa is a plant deeply rooted in traditional medicine, and its healing potential comes from a wide array of natural compounds. The bark, leaves, fruits, and roots of this tree contain important phytochemicals such as *flavonoids, tannins, saponins, glycosides, alkaloids,* and *phenolic compounds*. These substances are known for their antioxidant, anti-inflammatory, antimicrobial, and antidiabetic effects. For instance, flavonoids and phenolics help neutralize harmful free radicals in the body, while tannins contribute to wound healing and antimicrobial activity. The presence of saponins and glycosides supports its use in managing blood sugar levels and improving heart health. Studies have confirmed that different parts of the plant exhibit significant biological activities, making *Ficus* racemosa a valuable resource in herbal medicine.

Ficus religiosa **(**L.)***:***

Ficus religiosa tree is more than just a sacred symbol—it's a natural pharmacy. Its leaves, bark, roots, and fruits are packed with bioactive compounds like flavonoids**,** tannins**,** alkaloids**,** saponins**,** glycosides**,** and phenolic acids, which give it powerful healing abilities. These phytochemicals are known to support antioxidant*,* antimicrobial*,* anti-inflammatory. and neuroprotective functions. For example, flavonoids and phenolic compounds help fight oxidative stress, while tannins and alkaloids contribute to antimicrobial and anti-diarrhoeal effects. The presence of saponins and glycosides enhances its role in managing blood sugar and protecting the heart. Research has shown that extracts from *Ficus religiosa* exhibit activities such as anti-ulcer, anti-convulsant, wound healing, and anti-acetylcholinesterase effects, making it a valuable plant in traditional and modern medicine.

Bioactives:

Ficus benghalensis **(**L.)***:***

Flavonoids and Phenolic Compounds

One of the most important groups of bioactives in *Ficus benghalensis* are flavonoids such as quercetin, rutin, and kaempferol. These compounds act as antioxidants, protecting cells from oxidative stress and reducing inflammation. Alongside flavonoids, phenolic acids like gallic acid and chlorogenic acid contribute to antimicrobial and free radical scavenging properties (Patel *et al*., 2020). Together, these compounds explain why extracts of banyan bark and leaves are often used in traditional remedies for wound healing and infections.

Tannins and Alkaloids

The bark and roots of *Ficus benghalensis* are particularly rich in tannins, which give them an astringent taste and help in wound healing. Tannins also play a role in antimicrobial activity, making them useful against bacterial and fungal infections. In addition, alkaloids present in the bark and latex are linked to analgesic and anti-inflammatory effects, supporting the tree's use in pain relief and swelling reduction (Kumar *et al*., 2019).

Sterols and Terpenoids

Another important class of bioactives are sterols and terpenoids, including β-sitosterol, lupeol, and ursolic acid. These compounds are known for their cholesterol-lowering, anticancer, and hepatoprotective properties. For example, β-sitosterol has been studied for its ability to regulate lipid metabolism, while lupeol shows promising anticancer activity in laboratory studies (Singh *et al*., 2022). These findings highlight the potential of banyan tree extracts in modern pharmacology.

Pharmacological Activities

Ficus benghalensis demonstrates multiple pharmacological activities. Extracts have shown antioxidant effects due to flavonoids, antimicrobial activity from tannins and phenolics, anti-inflammatory action from triterpenoids, and antidiabetic potential from bark and root compounds. Studies also report wound healing and immunomodulatory properties, confirming its traditional use in Indian medicine (Rao *et al*., 2023).

Ficus racemosa **(**L.)***:***

Flavonoids and Phenolic Compounds

The bark and leaves of *Ficus racemosa* are rich in flavonoids such as quercetin, rutin, and kaempferol. These compounds act as antioxidants, protecting cells from oxidative stress and reducing inflammation. Alongside flavonoids, phenolic acids like gallic acid and ellagic acid contribute to antimicrobial and free radical scavenging properties. These phytochemicals explain why extracts of the tree are often used in traditional remedies for infections and wound healing (Sharma *et al*., 2020).

Tannins and Alkaloids

The bark of *Ficus racemosa* contains significant amounts of tannins, which give it an astringent taste and help in wound healing and antimicrobial activity. In addition, alkaloids present in the bark and latex are linked to analgesic and anti-inflammatory effects. These compounds support the traditional use of the tree in treating pain, swelling, and gastrointestinal disorders (Kumar *et al*., 2021).

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Another important class of bioactives are sterols and triterpenoids, including β-sitosterol, lupeol, and ursolic acid. These compounds are known for their cholesterol-lowering, anticancer. and hepatoprotective properties. For example, lupeol has been studied for its cytotoxic effects against cancer cells, while β-sitosterol is linked to lipid regulation and cardiovascular health (Singh *et al*., 2022).

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Ficus religiosa **(**L.)***:***

Flavonoids and Phenolic Compounds

The leaves and bark of *Ficus religiosa* contain flavonoids such as quercetin, rutin, and kaempferol. These compounds act as antioxidants, protecting cells from oxidative stress and reducing inflammation. Alongside flavonoids, phenolic acids like gallic acid and ellagic acid contribute to

antimicrobial and free radical scavenging properties. These phytochemicals explain why extracts of the tree are often used in traditional remedies for infections and wound healing (Patel *et al.,* 2020).

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Results and Discussion:

Ficus trees are like living pharmacies. The banyan, peepal, and cluster fig all carry natural compounds that fight germs, reduce inflammation, heal wounds, and even help with diabetes and liver problems. Each tree has its own specialty the banyan for blood sugar control, the cluster fig for liver and digestion, and the peepal for heart and wound healing. Together, they show why *Ficus* species are so respected in traditional medicine and why modern science continues to explore them for new medicines (Mehta *et al*., 2024). *Ficus* species reveal that their bark, leaves, fruits, and latex are rich in diverse bioactive compounds. These include flavonoids, phenolic acids, tannins, sterols, triterpenoids, and alkaloids, which contribute to antioxidant, antimicrobial, anti-inflammatory, and antidiabetic activities (Sharma *et al*., 2019; Patel *et al*., 2020). show that *Ficus* species share several common morphological features, even though they grow in different environments. All species produce a milky latex, have simple leaves, and form a special fruit called a syconium. Species such as *Ficus benghalensis* and *Ficus religiosa* develop strong aerial roots that support their large crowns, while others like *Ficus carica* mainly rely on underground roots. The leaves vary in shape from heart-shaped to lobed yet most have a thick texture that helps reduce water loss. Overall, the results show that *Ficus* plants are highly adaptable and use their root systems, leaf textures, and unique fruiting structure to survive in diverse habitats.

The morphological features observed in different *Ficus* species suggest that the genus is well adapted to both tropical and semi-tropical ecosystems. The widespread presence of aerial roots in some species shows that these plants have evolved additional support mechanisms, especially where branches grow wide and heavy. According to (Berg & Corner 2005), these roots also help the plant capture moisture and minerals in humid regions. The thick and often leathery leaves found in many

species may protect the plant from sunlight and water loss, which supports the idea that these plants thrive in warm climates. The unique syconium fruit supports a specialized relationship with fig-wasps. As described by Janzen (1979), the internal flowers allow effective pollination while being protected inside the fruit. This mutual relationship may have helped *Ficus* spread into many regions, increasing its ecological success. The presence of different leaf shapes—such as lobed leaves in *Ficus carica* and long-tipped leaves in *Ficus religiosa* shows that each species has adapted to its own environment while maintaining core fig characteristics. These findings, when viewed together, suggest that *Ficus* morphology is shaped by both environmental pressures and evolutionary interactions with pollinators.

The results show that all three *Ficus* species share a common set of bioactives, particularly flavonoids and tannins, which are responsible for their strong antioxidant and antimicrobial effects. However, each species also has unique strengths. For example, *Ficus benghalensis* is especially noted for its antidiabetic potential due to compounds in its bark and roots (Rao *et al*., 2023). *Ficus racemosa* stands out for hepatoprotective and digestive health benefits, linked to phenolic acids and triterpenoids (Kumar *et al*., 2021). Meanwhile, *Ficus religiosa* shows promise in cardiovascular support and wound healing, thanks to sterols and flavonoids (Singh *et al*., 2022). Another important point is that these bioactives are not only pharmacologically active but also culturally significant. Traditional medicine systems have long recognized their healing properties, and modern science is now validating these uses with experimental evidence (Patel *et al*., 2019)

Conclusion:

The genus *Ficus*, which includes species such as *Ficus benghalensis* (banyan) *Fi* (L.), *Ficus religiosa* (peepal) (L.), and *Ficus racemosa* (Cluster fig) (L.), is a treasure house of bioactive compounds. These trees have been used for centuries in Ayurveda and Folk medicine to treat ailments ranging from diabetes and inflammation to infections and wounds. Modern phytochemical studies confirm that their bark, leaves, fruits, and latex contain flavonoids, tannins, phenolic acids, sterols, and alkaloids, which explain their wide pharmacological activities (Sharma *et al*., 2019). *Ficus* species are widely used in herbal formulations, dietary supplements, and traditional medicines. For example, bark decoctions of *Ficus benghalensis* are used for diabetes management, while *Ficus religiosa* leaves are applied in wound healing. *Ficus racemosa* fruits are consumed for digestive health. These uses are supported by both traditional knowledge and modern pharmacological studies (Kumar *et al*., 2021). *Ficus* species hold great promise for drug discovery and nutraceutical development. Their bioactives can be isolated and studied for targeted therapies against cancer, liver disorders, and metabolic diseases. Nanotechnology and modern extraction techniques may help enhance the bioavailability of these compounds, making them more effective in clinical applications (Singh *et al*., 2022).

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