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Review Article

Ecological and Medicinal Importance of *Ficus microcarpa*: Unveiling the Diversity of a Versatile Plant

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ABSTRACT

The genus *Ficus*, belonging to the *Moraceae* family, encompasses a diverse group of trees, shrubs and vines, including notable species such as *Ficus microcarpa, F. carica* (common fig) and *F. lyrata* (fiddle-leaf fig). Known for their ecological and economic importance, *Ficus* species play critical roles in their ecosystems, providing habitats for various fauna and contributing to biodiversity. They are characterized by their unique growth habits, intricate leaf structures and distinctive fruiting patterns. Phytochemical analyses have revealed a wealth of bioactive compounds, including flavonoids, terpenoids and phenolic acids, which exhibit a range of pharmacological activities such as antioxidant, anti-inflammatory, antimicrobial and anticancer effects. *Ficus microcarpa* has shown promise in traditional wound healing practices, attributed to its ability to accelerate tissue regeneration. These findings suggest that the plant has significant therapeutic potential, warranting further research to explore its applications in modern medicine. Additionally, its ecological significance and role in urban landscaping make it a valuable species for both environmental and health-related studies.

Keywords: *Ficus*, *Moraceae*, Ecological significance, *Ficus microcarpa*, Fruiting patterns.

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INTRODUCTION

The majority of tropical and subtropical woods are home to the more than 800 species and 2000 kinds of figs that make up the biggest genera of angiosperms, Ficus.[1] Figs are significant in both history and religion.[2] Fig trees draw in creatures and birds that eat fruit[3,4] and are revered as spiritual homes.[2] Numerous *Ficus* species were brought in as attractive plants; today, they are widespread in cities and are considered a significant part of the past.[5] In Nepal, the foliage is collected and fed to cattle.[6] In South China, fruits and leaves of the plant species are a major source of both food and healing.[7] *Ficus* species have a number of important therapeutic characteristics, such as antitumor, anticancer, anti-diabetic, anti-inflammatory, antiulcer, hypoglycemic, hypocholesterolaemic, gastroprotective and hepatoprotective effects. Every *Ficus* species has latex-like substance in their veins that helps them defend against physical harm and mend themselves.[8,9]

Botany, Habitat and Traditional Uses

For generations, people have grown *Ficus microcarpa* (*Moraceae*), often known as Chinese or Malayan banyan, as a shade tree. A broad word for *Ficus* trees, "banyan" refers to tree species that have aerial adventitious roots.[10] With a flattened or rounded crown, it is a fast-growing, usually evergreen tree that can reach heights of 15 to 25 m under the right circumstances.[11] The plant has simple, alternating, leathery-textured leaves. Usually averaging 5-10 cm in length and 2-5 cm in breadth, they have an ovate to elliptical form.

The apex of leaves is frequently pointed, while the edges are smooth. The leaves have a glossy, dark green upper surface and a paler below surface.[11] Its glossy green foliage has slightly meaty or leathery leaves that dangle aerial roots which grow into columnar stems.[12,13] The circular structure known as the synconium, or fig, is where the unisexual small flowers are developed. The little fruits are pink when mature and turn purple. The plant produces figs, also called syconiums, which are small, globose to pear-shaped fruits.[14] The fruit of the plant, known as a fig or syconium, is a small, globose to pear-shaped structure. The figs are usually borne in pairs in the leaf axils. They measure around 0.5-1 cm in diameter and turn from green to purple or black as they ripen.[15] Its habits vary; as it ages, it is frequently an epiphytic, subscandent shrub. As it matures, it becomes a spreading evergreen tree with many branches and many aerial roots that hang from the trunk and branches and occasionally penetrate the ground to form pillar-like roots.[16] These roots occasionally have the potential to grow thick and woody, creating auxiliary trunks that give the tree more support.[17]

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Ficus microcarpa

Its natural habitats range from sea level to 1,200 m in elevation and include lowland rainforests, riverbanks, tidal flood plains, coastal vegetation, especially susceptible rocky shores, on cliffs and tidal freshwater swamp forests and other swamps.[18,11] This specie is a common decorative plant that can be cultivated as topiary in gardens or potted as a bonsai. *Nasalis larvatus*, a proboscis monkey, has been seen to favor young leaves of *F. microcarpa* over other food sources in Malaysia.[19]

Folk remedies for fever, pain relief and temperature control have been practiced in Japan using the bark, dried leaves and aerial roots of *F. microcarpa*.[20] It has been used to cure rheumatism, tonsillitis, acute enteritis, influenza, malaria and bronchitis in China, where *F. microcarpa* is frequently grown as a shade tree.[21] The wood ash of the plant produces excellent noodles. The herb has been used traditionally in South Asian medicine to treat type-2 diabetes (Figure 2).[22]

Microscopy of *Ficus microcarpa*

Below is a description of the microscopic features.

Leaf Microscopy

Epidermis

The leaves of *F. microcarpa* have a single-layered epidermis on both the adaxial (upper) and abaxial (lower) surfaces.[23] The cells are polygonal and relatively large. The cuticle covering the epidermal cells is thick and waxy, which contributes to the plant's water retention and resistance to environmental stress (Figure 1).

Stomata

The plant has paracytic stomata (stomata with two subsidiary cells parallel to the guard cells) on the abaxial surface of the leaves. The stomata are numerous and evenly distributed, primarily regulating gas exchange.

Palisade and Spongy Parenchyma

Beneath the upper epidermis, there is a well-developed palisade parenchyma, consisting of elongated cells arranged in one or two layers. This is followed by the spongy parenchyma, which is loosely packed with intercellular spaces to facilitate gas exchange.

Stem Microscopy

Epidermis

The outermost layer of the stem consists of a single-layered epidermis with polygonal, thick-walled cells covered by a waxy cuticle.[24]

Cortex

Beneath the epidermis, there is a multi-layered cortex composed of collenchyma and parenchyma cells. The collenchyma cells are primarily located near the epidermis, providing mechanical support.

Vascular Bundles

The stem exhibits collateral vascular bundles (xylem and phloem in the same bundle), with the xylem facing inward and the phloem facing outward. The xylem is composed of tracheids, vessels and fibers, while the phloem consists of sieve tubes, companion cells and phloem parenchyma.

Pith

The central part of the stem is occupied by the pith, composed of large parenchyma cells with prominent intercellular spaces.

Root Microscopy

Epidermis

The outer layer of the root, known as the epidermis or piliferous layer, is thin and consists of rectangular cells. In younger roots, root hairs are also present, aiding in the absorption of water and nutrients.[25]

Cortex

Beneath the epidermis, the cortex is composed of thin-walled parenchyma cells that store starch. The cortical cells are loosely packed, allowing for the passage of water and nutrients toward the vascular tissues.

Endodermis and Pericycle

The cortex is followed by the endodermis, a layer of cells with thickened cell walls (Casparian strips), which regulate the flow of water into the vascular tissues. The pericycle lies just beneath the endodermis and is involved in the formation of lateral roots.

Vascular Tissues

The root has a typical dicot vascular arrangement, with xylem and phloem arranged radially. The xylem consists of vessels and fibers, while the phloem contains sieve tubes and companion cells.

Latex Microscopy

F. microcarpa produces latex, which is secreted by specialized cells called laticifers. These cells are scattered throughout the plant tissues, including the bark, leaves and roots.[26] Laticifers are long, branching cells that contain latex, a milky fluid rich in proteins, alkaloids and enzymes. The latex serves as a protective mechanism against herbivores and pathogens.

Characteristics and Anatomical Structure of Aerial Roots

Table 1 shows the characteristeristic features along with section (Figure 3) of new and mature aerial roots.

Section of Aerial Roots

The new aerial root tip, in section (Figure 3), shows one layer of exodermis cells covering a broad cortex, consisting of 9-12 layers of parenchyma cells, arranged closely. The endodermis is not well defined. The roots have 4-5 xylem groups. A broad parenchymatous pith occupies the centre. The mature flexible aerial root, in section (Figure 3), shows many xylem vessels. Medullary rays cross the xylem. The broad cortex has been sloughed off and the parenchymatous pith has become lignified.[27]

Phytochemistry

Phytochemical studies have identified several bioactive compounds in *F. microcarpa*, including flavonoids, phenolics, triterpenoids, coumarins and polysaccharides. These compounds have been found to exhibit a range of pharmacological activities such as antioxidant, anti-inflammatory, anticancer and immunomodulatory effects.

Flavonoids are a group of polyphenolic compounds that have potent antioxidant and anti-inflammatory activities. Studies have shown that the leaves of the plant contain several flavonoids, including quercetin, kaempferol and isorhamnetin. These flavonoids have been shown to scavenge free radicals and reduce oxidative stress, which can contribute to the prevention and management of various chronic diseases.[35]

Phenolic compounds are another group of polyphenolic compounds that have been identified in *Ficus microcarpa*. These compounds have potent antioxidant and anti-inflammatory activities and have been shown to inhibit the growth of cancer cells. Studies have shown that the methanol extract of the bark contains several phenolic compounds, including gallic acid, caffeic acid and protocatechuic acid.[36]

Triterpenoids are a group of compounds that have been found to exhibit anticancer, anti-inflammatory and antioxidant activities. Several triterpenoids have been identified in the plant, including betulinic acid and ursolic acid. These compounds have been found to inhibit the growth of cancer cells and to reduce inflammation by inhibiting the production of pro-inflammatory cytokines.[37] It also includes friedelin and taraxasterol.

Coumarins are a group of compounds that have been shown to exhibit anticoagulant, anti-inflammatory and antimicrobial activities. Several coumarins have been identified, including scopoletin, umbelliferone and fraxetin. These compounds have been found to inhibit the growth of bacteria and to reduce inflammation by inhibiting the production of pro-inflammatory cytokines.[38]

Polysaccharides are a group of complex carbohydrates that have been found to exhibit immunomodulatory activities. Several polysaccharides have been isolated from leaves of the plant, including FMP-1, FMP-2 and FMP-3. These polysaccharides have been found to stimulate the production of cytokines, such as Interleukin-1beta (IL-1β), Interleukin-6 (IL-6) and Tumor Necrosis Factor-alpha (TNF-α), which play a key role in the immune response.[39]

Along with these, it also contains alkaloids (ficustannin), saponins and essential oils.[40]

Pharmacological Activities

Modern research has revealed that the plant possesses several pharmacological activities, including antioxidant, anti-inflammatory, anticancer, antimicrobial and immuno-modulatory effects.

Antioxidant activity

F. microcarpa extracts, particularly from leaves and bark, exhibit significant antioxidant activity. This is attributed to the presence of phenolic compounds and flavonoids, which help scavenge free radicals, thereby reducing oxidative stress and preventing cellular damage.[35]

Table 1: Aerial root characteristics of *F. macrocarpa*.

Characteristeristic features	New Aerial Roots	Mature Aerial Roots
Color	Light brown to reddish-brown.	Dark brown to black.[27,1]
Texture	Smooth, soft	Rough, woody, hard.[28,29]
Diameter	Thin, around 1-3 mm	Thick, more than 5 mm.[30,31]
Water Absorption	High, primarily for support in early stages.	Decreased, primarily structural.[32,33]
Branching	Minimal, usually unbranched or sparsely branched.	Highly branched, supporting complex structures.[33]
Lignification	Low, non-lignified, flexible	High, lignified, stiff.[34,1]
Growth Rate	Fast, particularly in humid conditions.	Slow, as growth shifts to structural reinforcement.[29]
Function	Primarily for nutrient and water uptake.	Structural support, water conduction.[27,31]

Anti-inflammatory activity: Studies indicate that the plant has potential anti-inflammatory effects, likely due to its flavonoids, triterpenoids and saponins. These compounds inhibit pro-inflammatory mediators like prostaglandins and cytokines, which are involved in the inflammatory response.[37]

Anticancer activity

Preliminary studies indicate that certain phytochemicals found in *F. microcarpa* (like flavonoids and triterpenoids) may have cytotoxic effects against cancer cells. However, more research is needed to fully understand its potential in cancer therapy.[37]

Antimicrobial activity

Extracts from the plant have been shown to possess antimicrobial properties, effective against various bacterial and fungal strains. This makes it a potential candidate for use in treating infections, including skin and respiratory infections.[38]

Immunomodulatory activity

It has the ability to modulate immunity since polysaccharides are present. These substances improve the immune response and promote cytokine production. According to a study, polysaccharides taken from the leaves significantly affected mice's immune systems.[39]

Antidiabetic activity

Some studies suggest that *F. microcarpa* may exhibit antidiabetic activity, likely by enhancing insulin sensitivity or regulating glucose metabolism. This effect is primarily observed in animal models, but its exact mechanism is still being explored.[41]

Hepatoprotective Activity

There is evidence suggesting that it's extracts may offer protection to the liver against damage caused by toxins. This is attributed to its antioxidant and anti-inflammatory properties, which help in maintaining liver health.[41]

Antipyretic and Analgesic Activity

The plant's extracts have been traditionally used for their pain-relieving and fever-reducing effects. These properties are believed to be due to the inhibition of prostaglandin synthesis, which is involved in the body's pain and fever responses.[42]

Antihypertensive Activity

The plant may also have antihypertensive effects, helping to reduce high blood pressure. The underlying mechanism is thought to involve the modulation of nitric oxide pathways or the relaxation of smooth muscles in blood vessels.[43]

Neuroprotective Activity

The antioxidant and anti-inflammatory compounds in the plant are thought to provide neuroprotective effects, protecting the brain from oxidative damage and inflammation, which may be useful in neurodegenerative diseases like Alzheimer's and Parkinson's disease.[44]

Here's a structured Table 2, summarizing key aspects of *F. microcarpa*, including its characteristics, medicinal uses.

Clinical Applications of *Ficus microcarpa*

While it is well-known for its pharmacological properties, its direct clinical applications in modern medicine are limited due to the need for more comprehensive clinical trials. However, its traditional medicinal uses and some preclinical studies suggest

Figure 1: *Ficus macrocarpa.*

potential therapeutic benefits in several areas. Below is clinical or therapeutic application based on existing evidence:

Wound Healing

The plant extracts have been used traditionally for treating wounds, cuts and skin infections. The plant's antimicrobial, anti-inflammatory and antioxidant properties aid in the healing process. This has led to the development of topical formulations for wound healing and skin care.[49]

Table 2: Key aspects of *F. macrocarpa*.

Aspect	Details
Common Names	Chinese banyan, Indian laurel, curtain fig.[45]
Family	*Moraceae*.[46]
Phytochemical Constituents	Flavonoids (quercetin, kaempferol), triterpenoids (friedelin, taraxasterol), phenolic acids (gallic acid, caffeic acid), alkaloids, saponins.[47]
Medicinal Uses	Antioxidant, anti-inflammatory, antimicrobial, anticancer, wound healing.[48]
Biological Activities	Potent antioxidant activity, inhibition of inflammatory mediators, antimicrobial efficacy against various pathogens, potential anticancer effects.[40]
Traditional Uses	Used in traditional medicine for wound healing and treating various ailments.[46]
Ecological Importance	Plays a crucial role in urban landscaping and provides habitat for various species, contributing to biodiversity.[45]

Antioxidant Properties

Ficus microcarpa is rich in bioactive compounds like polyphenols and flavonoids, which exhibit potent antioxidant properties. This makes it beneficial for preventing oxidative stress-related disorders, including cardiovascular diseases and certain cancers. Antioxidants from this plant have been used to neutralize free radicals, reducing cellular damage.[50]

Diabetes Management

Preliminary studies suggest that *F. microcarpa* may have anti-diabetic properties, mainly through its ability to reduce

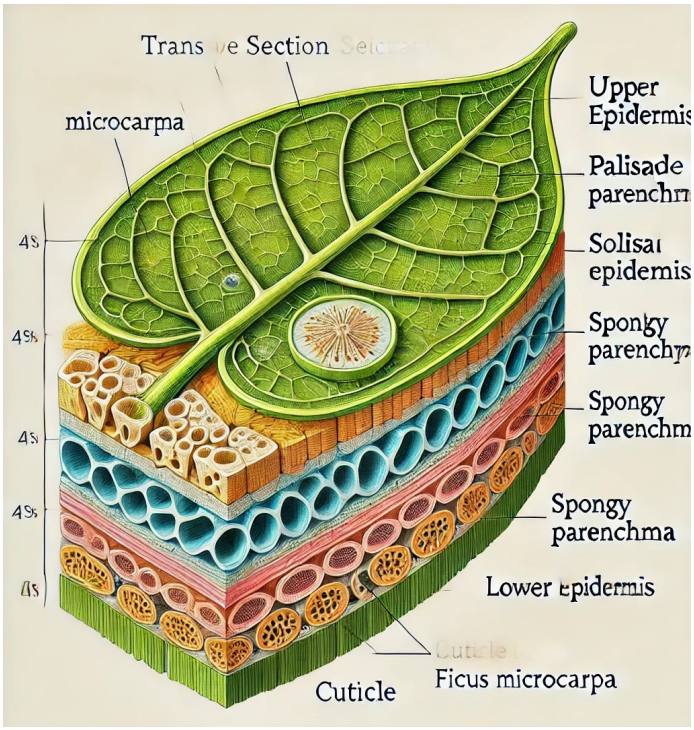

Figure 2: Leaf Microscopy of *Ficus microcarpa*.

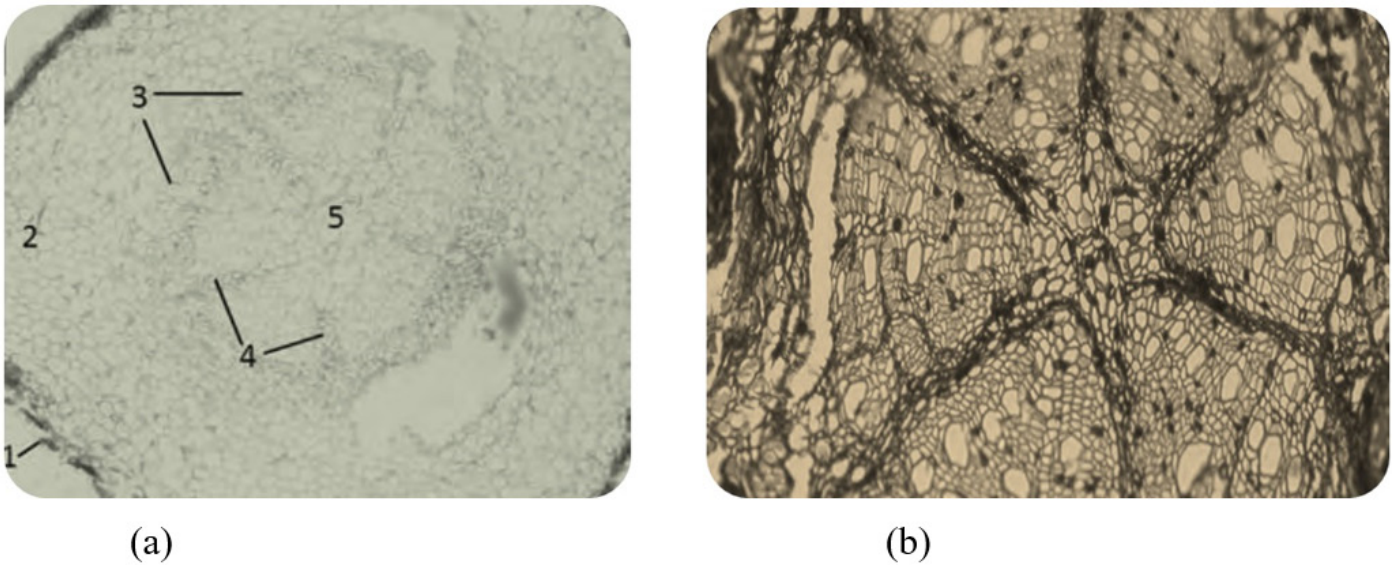

Figure 3: Section of flexible aerial (a: new; b: mature) root of *Ficus macrocarpa*.

blood glucose levels. It has been used in traditional treatments for managing symptoms of diabetes, though more clinical trials are necessary to substantiate its efficacy.[51]

Liver Protective Effects

Certain studies have suggested that extracts from *Ficus microcarpa* can help protect the liver from damage caused by toxins, likely due to its antioxidant properties. It has been investigated for its potential role in treating liver disorders such as hepatitis.[52]

Antimicrobial Activity

The extracts from different parts of *Ficus microcarpa* (leaves, bark and roots) have shown significant antimicrobial properties against a variety of pathogens. Studies indicate its effectiveness against bacteria like *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa*. The antimicrobial activity is attributed to the presence of phytochemicals such as flavonoids, tannins and phenols.[53]

CONCLUSION

Ficus microcarpa is a remarkable species with significant ecological, cultural and medicinal value. Its unique morphological characteristics, such as aerial roots and broad foliage, contribute not only to its ornamental appeal but also to its adaptability in diverse environments. The rich phytochemical profile of *F. microcarpa* includes various bioactive compounds, which have demonstrated potent antioxidant, anti-inflammatory, antimicrobial and anti-cancer properties in preclinical studies. Traditional uses in herbal medicine highlight its therapeutic potential, reinforcing its significance in both traditional and modern healthcare practices. Given its versatility, further research into the pharmacological applications of the plant is warranted to fully elucidate its health benefits and contribute to the development of natural remedies. Additionally, its role in promoting biodiversity and enhancing urban landscapes underscores the importance of conserving this species for ecological sustainability.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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