



CHAPTER 10

***Ficus tinctoria*: analysis of bioactive compounds and their pharmacological potential with smattering of ecological factors**

A. Maajitha Begam¹, Agamani Pattanayak², Sanjeet Kumar³, and Sugimani Marndi³

¹Department Of Botany, Hajee Karutha Rowther Howdia College (Autonomous), Uthamapalayam, Theni, Tamil Nadu, India

²Plant Taxonomy and Ecophysiology laboratory, Department of Botany, Research Centre, Midnapore college (Autonomous), Affiliated to Vidyasagar University, West Bengal, India

³Ambika Prasad Research Foundation, Odisha, India

*Email-Id: sugimani2marndi@gmail.com



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Abstract: *Ficus tinctoria*, is a hemiepiphytic tree a species within the Moraceae family. This chapter provides a comprehensive analysis of the bioactive compounds present in bark of *F. tinctoria* and evaluates their pharmacological potential. A review of existing literature and present study reveals a diverse phytochemical profile, including tannins, saponins, alkaloids, reducing sugars and terpenoids, which are responsible for its reported therapeutic properties. The chapter incorporates a discussion on the ecological factors influencing the plant's growth and secondary metabolite production. This integrated approach highlights the intricate link between the plant's biochemistry, its ecological context, and its medicinal value, offering a holistic perspective for future research and sustainable exploitation of this valuable resource.

Keywords: Ethnomedicinal, ecological, pharmacological, phytochemical



INTRODUCTION

The genus *Ficus*, a salient of the Moraceae family, is a remarkably diverse and ecologically significant group of plants comprising over 880 species. Found across tropical and subtropical regions, many *Ficus* species are basis resources, providing sustenance for countless animals and shaping forest ecosystems (POWO, 2025). It has countless benefits in terms of medicinal, ecological, food value and economical values. According to literature review it concluded that different *Ficus* species contain sesquiterpenes, monoterpenes, triterpenoids, alkaloids, furanocoumarins, organic acids, volatile components and phenylpropanoids. These bioactive compounds occur in latex, leaves, fruit, stem and roots show a significant role in pharmacological activities such as analgesic, antimicrobial, antiarthritic, anticancer, and antidiabetic (Salehi et al., 2020; Singh and Sharma, 2023).

Among these, *Ficus tinctoria*, commonly known as the humped fig, dyeing fig or hairy figs. It is hemi-epiphytic tree and also known as an intricate growth form because its successional rate depends on many factors, such as the species' ability, the size of the host tree, and the position in the canopy in terms of access to light. It is also one of the species known as strangler fig. It is commonly found in deciduous and semi-evergreen forests. It usually grows on the other *Ficus* trees (Nayak and Kumar, 2023). Flowering and fruiting period on December -May. It is distributed throughout the Bhutan, China, Indonesia, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam. In India, it is found in Bihar, Kerala, Madhya Pradesh, Meghalaya, Odisha, Tamil Nadu, Uttar Pradesh and Andhra Pradesh (Reddy et al., 2020). According to IUCN Red list it is least concern. It has two types of recognized varieties or sub-species such as *Ficus tinctoria* var *tinctoria* and *F. tinctoria* var *gibbosa* (POWO, 2025). Through tentative literature survey it concluded that *F. tinctoria* has many varieties for its morphological factors. Such as multi-scaled intraspecific variation and co-variation in trait-based strategies on *F. tinctoria* are reported (Chen et al., 2020; Li et al., 2024).

Mostly all *Ficus* species has various indigenous traditional knowledge where its leaves, bark, and roots have been used to treat a wide array of ailments, including skin infections, inflammation, and gastrointestinal issues. Unfortunately, *F. tinctoria* has less documentation on its ethnomedicinal as well as pharmacological activities. Despite its less traditional use, a



comprehensive scientific analysis of the bioactive compounds responsible for these therapeutic effects has been a relatively recent endeavor. This chapter aims to bridge this gap by providing an exploration of the phytochemical profile of *F. tinctoria* bark and a critical evaluation of its pharmacological potential. We will first delve into the plant's diverse secondary metabolites, examining key classes such as tannins, saponins, terpenoids, reducing sugars and alkaloids, and the specific compounds that have been isolated and identified. We will then connect these phytochemicals to the plant's documented pharmacological activities, including its potent antioxidant, anti-inflammatory, antimicrobial, and cytotoxic properties, offering a scientific basis for its traditional applications. Furthermore, a complete understanding of *F. tinctoria* is impossible without considering the ecological factors that govern its life and, by extension, its biochemistry. The production of secondary metabolites is not merely a random process but is often a direct response to environmental pressures and ecological interactions. This chapter will therefore also incorporate a discussion on the ecological context of *F. tinctoria*. We will touch upon its unique obligate mutualism with species-specific fig wasps (*Platyscapa* sp.), which are essential for its reproduction, and its role as a crucial resource for frugivorous fauna (Ma et al., 2009). Additionally, by integrating a deep analysis of its phytochemistry and pharmacology with a consideration of its ecological drivers, this chapter offers a holistic perspective on *F. tinctoria*, which has less documentation in medicinal, and pharmacological activities.

MORPHOLOGY

It is deciduous or evergreen climbing bushy shrub or standing hemi-epiphytic tree up to 10m high. Bark greenish- yellow or grey, smooth. Leaves are alternate, variable, rhomboid-sub rhomboid or elliptic-ovate, 3-15 x2.8-8 cm. Base oblique, entire, apex acute, gibbose, scabrous, hispidulous, sparsely puberulous on both surfaces, dark green and shiny above, pale green and tuberculate beneath, petiole up to 2 cm long. Figs in axillary, solitary or umbellate fascicles, pedunculate, up to 1 cm long; receptacles 1.2 cm diam. Globose-sub-globose, depressed globose, pubescent, papillose, turning yellow-orange or red when ripe (Saxenna and Brahmam, 1995; Figure 1-4).



Figure 1: Leaves of *F. tinctoria*



Figure 2: Fruits of *F. tinctoria*



Figure 3: Bark of *F. tinctoria*



Figure 4: Syconium of *F. tinctoria*



METHODOLOGY

The bark of *F. tinctoria* was collected from the State Botanical Garden, Odisha, India. The plant species was identified by the authors. The Soxhlet extraction method was adopted using three solvents (N-hexane, ethanolic, and methanolic) for phytochemical analysis. Detection of nine secondary metabolites was conducted using standard methods (Kumar et al., 2013; Marndi et al., 2024; Figure 5-8). Literature data was also gathered from Scopus, Web of Science, PubMed, Google Scholar, MDPI, Science Direct, SciFinder, Scirus, and Scientific Electronic Library Online (SciELO) from 2020-2025.

Qualitative phytochemical analysis (Marndi et al., 2024)

Test for tannin: About 1 ml of the bark extract was taken. Three to five drops of 10% lead acetate solution were added. The gelatinous precipitate formation confirmed the presence of tannin.

Test for saponin: About 1 ml of the bark extract was taken and 1 ml of distilled water was added and shaken well. The formation of persistent froth was observed confirming the presence of saponin.

Test for flavonoids: About 1 ml of the bark extract was taken. Two ml of 2% NaOH solution and 3 to 4 drops of dilute HCl were added. The colour initially turned to an intense yellow colour with NaOH solution and later became colourless. This colour changes in appearance confirmed the presence of flavonoids.

Test for terpenoids: About 1 ml of the bark extract was added with 5-6 drops of chloroform and placed in the water bath for a few minutes. Then 5-6 drops of concentrated sulphuric acid were added. The reddish-brown interface confirmed the presence of terpenoids.

Test for phenolic groups: About 1 ml of the bark extract was taken. A few drops of 5% ferric chloride solution were added. The dark bluish-black appearance confirmed the presence of phenolic compounds.

Test for reducing sugars: About 1 ml of the bark extract was taken and 2 drops of Fehling's solution A followed by Fehling's solution B were added and kept in the water bath for some time. The presence of red-orange precipitate confirmed the presence of reducing sugar.



Test for steroids: About 1 ml of the bark extract was taken. 1 ml of chloroform and 1 ml of concentrated sulphuric acid was added to it. The appearance of upper red and lower yellow color with green fluorescence provided the presence of steroids.

Test for alkaloids: About 1 ml of the bark extract was taken and 3 to 4 drops of Dragendroff's reagent were added. The formation of a reddish-brown precipitate confirmed the presence of alkaloids.

Test for carbonyl compounds: About 1 ml of the bark extract was taken and 3 to 4 drops of 2,4- Dinitrophenylhydrazine (DNPH) reagent was added. The formation of yellow crystals confirmed the presence of carbonyl compounds.



Figure 5: Bark sample for *F. tinctoria*

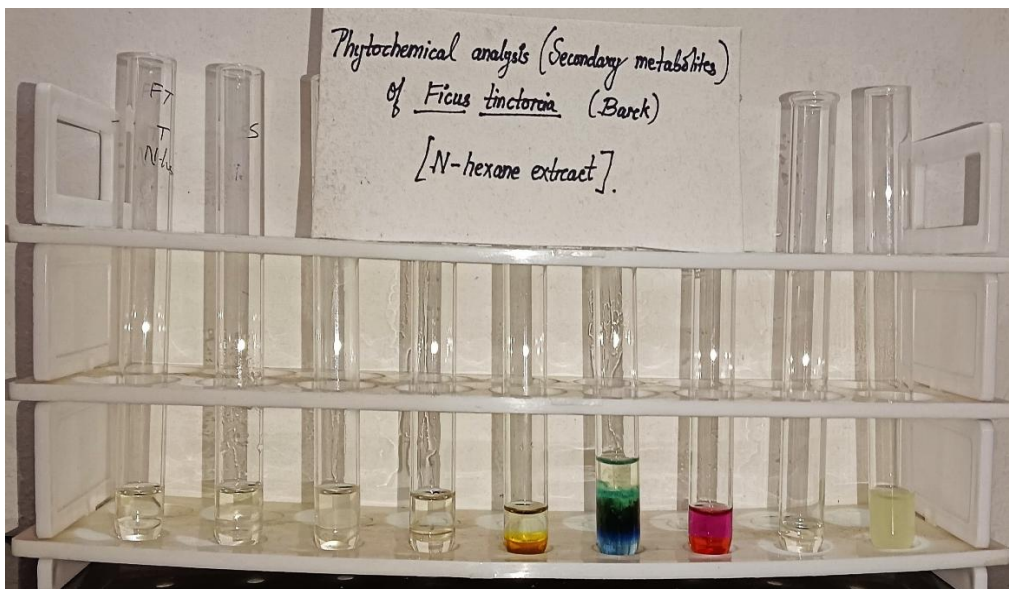


Figure 6: Phytochemical analysis (Secondary metabolites) of *F. tinctoria* (Bark) of n-hexane extract

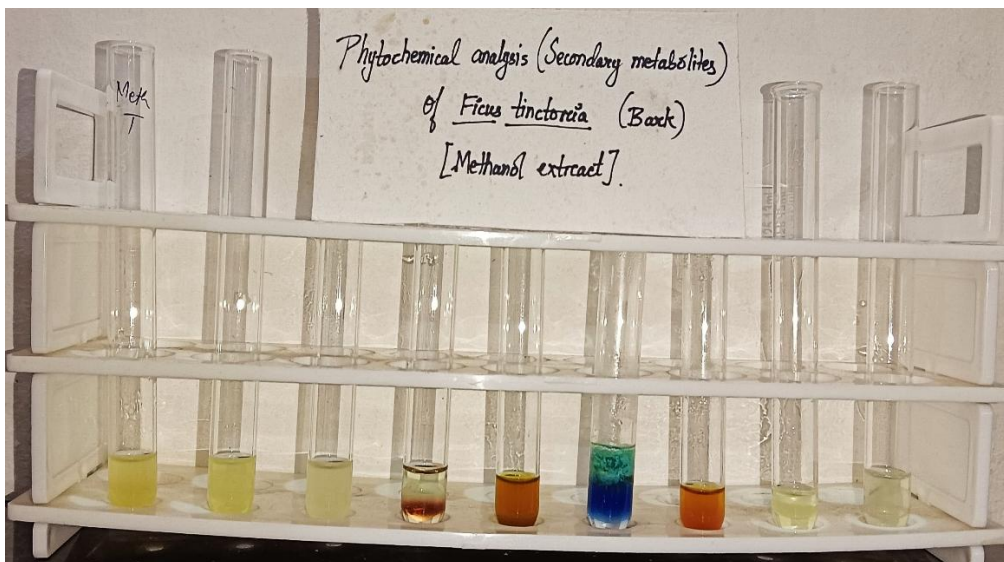


Figure 7: Phytochemical analysis (Secondary metabolites) of *F. tinctoria* (Bark) of methanolic extract

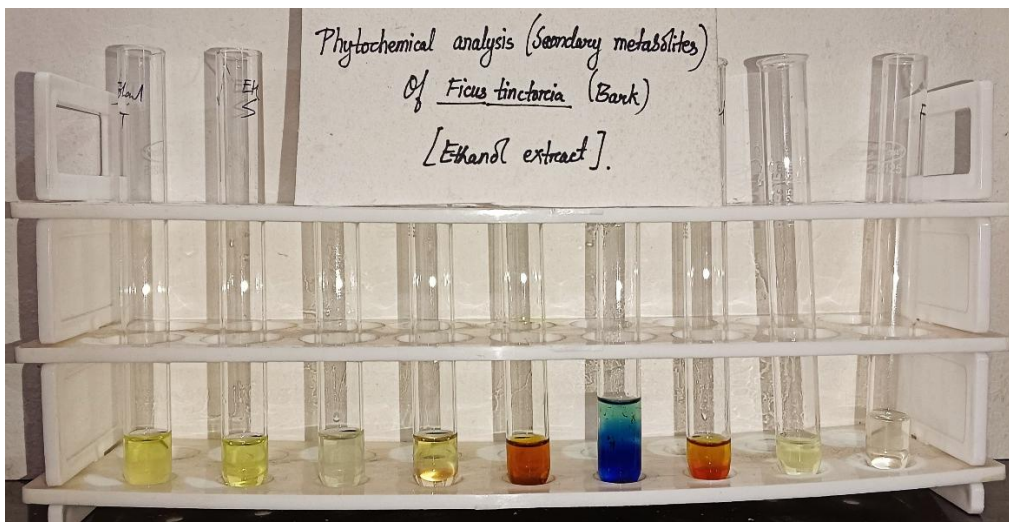


Figure 8: Phytochemical analysis (Secondary metabolites) of *F. tinctoria* (Bark) of ethanolic extract

RESULTS AND DISCUSSION

Through a tentative literature survey, it concluded that less work carried out in phytochemical analysis on *Ficus tinctoria*. According to the phytochemical analysis on the bark shows a range of active compounds such as tannins, saponin, flavonoids, terpenoids, reducing sugars, and alkaloids. Majorly three extract was taken as N-hexane, methanol and ethanol. Tannins, saponins, flavonoids, and alkaloids are present in Methanolic and ethanolic extract. Terpenoids is present in methanolic extract. Reducing sugars are present in all three extracts (**Table 1**).

Table 1: Phytochemical analysis using different extracts of *F. tinctoria* bark

Bioactive compounds	N- hexane extract	Methanolic extract	Ethanolic extract
Tannin	-	+	+
Saponin	-	+	+
Flavonoids	-	+	+



Terpenoids	-	+	-
Phenolic compounds	-	-	-
Reducing sugars	+	+	+
Steroids	-	-	-
Alkaloids	-	+	+
Carbonyl compounds	-	-	-

(+: Presence; -: Absence)

Relatively limited number of reported studies on the ethnomedicinal uses of *Ficus tinctoria*, reflecting a combination of factors related to its geography, cultural context, and the broader challenges of ethnomedicinal research. Researchers often gravitate towards these (*F. religiosa*, *F. benghalensis* and *F. carica*) more widely recognised and commercially promising species, leaving less attention for others like *F. tinctoria*. In **Table 2**, it concluded that handful of ethnomedicinal uses are available. According to the **table 2**, fruits, leaves, bark and root are used for indigestion, fever, broken bones and diarrhoea. Mode of uses mostly decoction, maceration, raw and juice form.

Table 2: Ethnomedicinal uses of *F. tinctoria*

Plant parts	Mode of uses	Disease	Sources
Bark and root	Decoction	Diarrhoea	Nayak and Kumar, (2023)
Fruit	Raw	Fever	Salehi et al., (2020)
Fruits	Maceration	Indigestion	Devi et al., (2022)



Leaves	Juice	Broken bones	Nayak and Kumar, (2023)
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As mentioned previously, the traditional knowledge of *F. tinctoria* is a scarcity of reported pharmacological activity studies is a multifaced issue, stemming from a combination of scientific, economic, and logistical challenges. According to the present phytochemical analysis on the bark carried out in **Table 1**, on that basis their probable utilization is listed in **Table 3**.

Table 3: Some bioactive compounds from the *F. tinctoria* (Bark) and their probable utilization

Bioactive compounds	Pharmacological values	Sources
Alkaloids	Antibacterial, antifungal, antiviral	Patel and Vdhrodiya, (2022)
Flavonoids	Antioxidant, antidepressant, anticonvulsant, antihypertensive, and antidiabetic	Sangeetha et al., (2016); Ullah et al., (2020)
Reducing sugars	Antioxidant	Kaur et al., (2020)
Saponin	Anti-hypercholesterolemic, anti-inflammatory, antiallergic, and antitumor	Barbosa, (2014); Juang and Liang, (2020)
Tannins	Antioxidant, antimicrobial, antiviral, anti-mutagenic, anti-carcinogen, and anthelmintic	Hossain et al., (2021); Pizzi, (2021); Maugeri et al., (2022)
Terpenoids	Antitumor, anti-inflammation, antibacterial, antiviral, antimalarial	Yang et al., (2020)



There is a limited documentation on the ethnomedicinal and pharmacological activities of *F. tinctoria* is not a reflection of its lack of medicinal value, but rather the result of several intertwined factors. The geographically dispersed nature of its traditional uses, coupled with the erosion of oral knowledge in the face of modernization, has made systematic ethnobotanical documentation a significant challenge. Furthermore, the immense size and popularity of other *Ficus* species, which often draw more research funding and attention, have left *F. tinctoria* relatively overlooked. This gap in the literature is compounded by the inherent complexities of phytochemical research and the high costs associated with rigorous pharmacological validation. Bridging this knowledge gap requires a concerted, interdisciplinary effort that combines dedicated ethnobotanical surveys, advanced phytochemical analysis, and targeted pharmacological studies, ultimately paving the way for the sustainable and responsible use of this valuable plant resource.

ECOLOGICAL SIGNIFICANCE

The *Ficus tinctoria* is a mainspring of tropical forest ecosystems, playing a vital role in maintaining stability by providing a consistent food source for a wide variety of frugivores. Figs are exceptionally prolific, capable of producing a large number of fruits, and most species bear fruit year-round. This makes them a crucial resource for frugivores, especially during periods of scarcity. The consumption of figs by these animals directly contributes to the wider distribution of their seeds. This process, known as zoochory, occurs through several mechanisms. Endo-zoochory: Seeds are dispersed after being ingested and passed through the digestive tract of the frugivore. Dys-zoochory: Seeds are dispersed when the fruit is eaten and the seeds are spit out. Exo-zoochory: Seeds are dispersed by attaching to the external body parts of the animal. The physical characteristics of fig fruits have evolved to attract specific dispersers. Fruits with large size, pale colors (often green when ripe), and those that grow directly from the trunk or large branches (cauliflorous/ramiflorous) or on long, trailing stems (flagelliflorous) are commonly preferred by volant mammals, such as bats. In contrast, fruits with bright colors that contrast with the foliage and are located on the leaf axils or at the tips of branches are typically more attractive to birds (**Wijaya and Defiani, 2021**). Fig wasp community associated with male figs of *Ficus tinctoria* in Xishuangbanna, China. The community comprised one pollinator



species *Liporrhopalum gibbosae* and six non-pollinating wasp species: *Sycoscapter* sp., *Philotrypesis ravii*, *Philotrypesis* sp., *Neosycophila omeomorpha* (*Epichrysomallinae*), *Sycophila* sp. (*Eurytomidae*), and *Walkerella* sp. (Ma et al., 2009).

CONCLUSION

Ficus tinctoria is a plant of significant, yet underexplored, potential, embodying a fascinating convergence of ethnomedicinal heritage, and intricate ecological relationships. This analysis has demonstrated that the plant's traditional uses across diverse cultures are underpinned by a complex array of bioactive compounds, including flavonoids, alkaloids, terpenoids, and tannins. The documented bioactive compounds from the *F. tinctoria* (Bark) and their probable utilization of pharmacological activities—spanning antioxidant, anti-inflammatory, antimicrobial, and cytotoxic effects—provide a compelling scientific validation for its historical applications. The presence of these compounds and their associated biological activities strongly positions *F. tinctoria* as a promising candidate for further research and the potential development of novel therapeutic agents. The obligate mutualism with its pollinator fig wasp, its role as a basis resource. Future research should therefore move beyond simple phytochemical screening and incorporate ecological variables to understand how to sustainably cultivate and harvest the plant to maximize the yield of its desired compounds. This integrated perspective, which connects the plant's biochemistry to its environmental drivers, is essential for unlocking its full therapeutic potential while also ensuring the long-term conservation of this ecologically vital species. Therefore, *Ficus tinctoria* represents a prime example of a gap between documentation of traditional knowledge into scientific validation.

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