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Review Article

A Systematic Review of the Pharmacological Activities of Ficus Racemosa (Cluster Fig) in an Interdisciplinary Context

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ABSTRACT

Ficus racemosa Linn. (Cluster fig), a member of the Moraceae family, is widely recognized in traditional medicinal systems for its broad therapeutic applications. Various parts of the plant including bark, fruits, leaves, and latex have been traditionally employed in the management of metabolic disorders, inflammatory conditions, gastrointestinal disturbances, infections, and liver ailments. In recent years, experimental investigations have increasingly focused on validating these ethno medicinal claims and elucidating the mechanisms underlying its biological activities. This review systematically consolidates available scientific evidence on the pharmacological properties of *Ficus racemosa*. Peer-reviewed in vitro, in vivo, and in silico studies were critically examined to evaluate its phytochemical profile, therapeutic effects, and safety aspects. The plant is reported to contain diverse bioactive constituents such as flavonoids, phenolic acids, tannins, triterpenoids, sterols (β -sitosterol and stigmasterol), and glycosides. Among the documented activities, antidiabetic effects are most extensively studied, demonstrating inhibition of carbohydrate-digesting enzymes, improvement of glycemic parameters, and possible pancreatic β -cell protection. Significant antioxidant and anti-inflammatory properties have also been reported, largely attributed to its high phenolic content and free-radical scavenging capacity. Emerging evidence suggests neuroprotective, antimicrobial, hepatoprotective, gastroprotective, and cytotoxic potentials. Overall, the compiled findings support the multipronged pharmacological profile of *Ficus racemosa* and reinforce its traditional therapeutic relevance. However, further standardized phytochemical characterization and well-designed clinical studies are necessary to establish its safety, efficacy, and translational applicability in modern pharmacotherapy.

INTRODUCTION

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Ficus racemosa Linn. commonly known as cluster fig or gular, belongs to the Moraceae family and is widely distributed across South and Southeast Asia. The species holds a prominent place in traditional systems of medicine, particularly Ayurveda, where different parts of the plant including bark, fruits, leaves, roots, and latex are prescribed for a variety of ailments such as diabetes, dysentery, inflammatory disorders, liver dysfunction, and wound healing. Its longstanding ethno medicinal relevance has stimulated extensive pharmacological research aimed at validating traditional claims through modern experimental approaches.

Botanically, *F. racemosa* is a moderate-sized deciduous tree characterized by its unique cauliflorous fruiting habit, wherein fruits grow in clusters directly from the trunk. Beyond its ecological significance, the plant is recognized for its rich phytochemical composition. Contemporary phytochemical investigations have identified flavonoids, phenolic acids, tannins, triterpenoids, sterols (including β -sitosterol and stigmasterol), coumarins, and glycosides as major constituents responsible for its biological activities (Sanjay Kumar, 2022). These compounds are well known for their antioxidant, anti-inflammatory, and enzyme-modulating properties, suggesting a mechanistic basis for the plant's therapeutic potential.

Recent pharmacological studies have increasingly focused on metabolic disorders, particularly diabetes mellitus, which remains a global health challenge. Extracts of *F. racemosa* have demonstrated significant antihyperglycemic activity in experimental models, partly through inhibition of carbohydrate-hydrolyzing enzymes and modulation of oxidative stress pathways (Anupam Swargiary, 2025). Additionally, investigations into its neuroprotective potential

have revealed promising interactions of phyto-constituents with molecular targets implicated in neurodegenerative disorders, including cholinesterase enzymes (Anju Rani, 2024). These findings suggest that the pharmacological actions of *F. racemosa* are not limited to a single pathway but involve multi target mechanisms.

Oxidative stress and chronic inflammation are central to the pathogenesis of many non-communicable diseases. Several experimental studies report strong free-radical scavenging capacity and significant anti-inflammatory activity of *F. racemosa* extracts, attributed largely to its high phenolic and flavonoid content (Md. Asad Alam, 2023). The antioxidant potential may contribute not only to metabolic regulation but also to hepatoprotective and gastroprotective effects documented in preclinical investigations.

Despite accumulating experimental evidence, the available data remain dispersed across diverse pharmacological domains. There is a need for systematic synthesis of current findings to better understand the therapeutic scope, mechanistic insights, and safety considerations associated with *F. racemosa*. A structured evaluation of the literature can help clarify its translational relevance and identify research gaps, particularly in terms of standardized extract characterization, dose optimization, and clinical validation.

Therefore, the present systematic review aims to comprehensively examine the pharmacological activities of *Ficus racemosa*, critically analyzing its phytochemical profile, biological mechanisms, and therapeutic implications. By integrating contemporary experimental evidence, this review seeks to provide a coherent scientific framework for future research and potential drug development based on this traditionally valued medicinal plant.

2. PHYTOCHEMICAL CONSTITUENTS:

Ficus racemosa Linn. Is chemically diverse, and its wide range of pharmacological activities can be largely attributed to a rich and structurally varied phytochemical profile. Investigations employing chromatographic, spectroscopic, and metabolomic techniques have identified multiple classes of secondary metabolites distributed across different plant parts, including bark, fruits, leaves, latex, and roots. These phytoconstituents are primarily responsible for the antioxidant, antidiabetic, anti-inflammatory, hepatoprotective, and antimicrobial properties documented in experimental studies.

2.1 Phenolic Compounds and Flavonoids:

Phenolic compounds represent one of the most abundant phytochemical groups in *F. racemosa*. Quantitative analyses using HPLC and LC–MS techniques have demonstrated high total phenolic and flavonoid contents, particularly in fruit and bark extracts. Identified phenolic acids include gallic acid, ellagic acid, ferulic acid, and chlorogenic acid, while flavonoids such as quercetin, kaempferol, and catechin derivatives are frequently reported (Baljit Singh, 2021). These compounds contribute significantly to free radical scavenging capacity and modulation of oxidative stress pathways.

Advanced metabolomic profiling has further confirmed that the antioxidant activity of *F. racemosa* correlates strongly with its phenolic composition, suggesting a direct structure activity relationship (SAR) between hydroxyl substitution patterns and radical-neutralizing potential (Md. Mominur Rahman, 2022). The high redox potential of these molecules underpins many of the plant's protective pharmacological effects.

2.2 Triterpenoids and Sterols:

Triterpenoids constitute another major class of bioactive compounds identified in *F. racemosa*. Lupeol, betulinic acid, oleanolic acid, and ursolic acid have been isolated from bark and leaf extracts. These pentacyclic triterpenes are known for their anti-inflammatory, hepatoprotective, and cytotoxic properties. Structural elucidation using GC–MS and NMR spectroscopy has confirmed the presence of these compounds in appreciable concentrations (Gajendra Chaudhary, 2020).

Phytosterols such as β -sitosterol and stigmasterol have also been detected in various solvent extracts. These sterols are structurally similar to cholesterol and are associated with anti-inflammatory and lipid-lowering effects. Recent chromatographic analyses have highlighted stigmasterol as a major bioactive marker compound, suggesting its possible role in enzyme inhibition and metabolic regulation (Arumugam Elangovan, 2023).

2.3 Tannins and Glycosides:

Hydrolysable and condensed tannins are abundant in the bark of *F. racemosa*, which explains its traditional use as an astringent in gastrointestinal disorders. Tannins such as racemosic acid and related derivatives have been reported to exhibit antimicrobial and anti-diarrheal activity by precipitating proteins and forming protective mucosal layers (Dinesh Kumar Patel, 2021).

Cardiac and phenolic glycosides have also been isolated from fruit and bark extracts. These glycosides may contribute to enzyme modulation and cytoprotective effects observed in experimental studies. Phytochemical screening indicates that glycosidic linkage patterns influence solubility and bioavailability, thereby affecting pharmacodynamic outcomes.

2.4 Alkaloids, Coumarins, and Other Minor Constituents:



Although less abundant, alkaloids and coumarins have been detected in preliminary phytochemical screenings. Coumarin derivatives, in particular, are associated with anti-inflammatory and anticoagulant activities. Additionally, saponins and volatile constituents have been identified, expanding the chemical complexity of the plant (Muhammad Zafar, 2022).

Metabolomic fingerprinting approaches now suggest that synergistic interactions among these compounds may enhance overall biological activity, rather than single compounds acting independently. Such synergism may explain the multitarget pharmacological effects frequently reported in experimental models.

2.5 Chemotypic Variability and Extraction Influence:

The phytochemical composition of *F. racemosa* varies depending on geographical origin, plant part, and extraction solvent. Polar solvents such as methanol and ethanol generally yield higher concentrations of phenolics and flavonoids, whereas non-polar solvents favor isolation of sterols and triterpenoids. Recent comparative extraction studies demonstrate that solvent polarity significantly influences both phytochemical yield and biological potency (Anish S. Nair, 2023).

Understanding such variability is crucial for standardization, quality control, and reproducibility in pharmacological investigations. Standardized extract preparation and quantitative marker-based profiling are increasingly recommended to ensure consistency in experimental and clinical research.

3. PHARMACOLOGICAL ACTIVITIES:

The pharmacological profile of *Ficus racemosa* has been explored using enzyme-based assays, cell culture systems, experimental animal models, and computational simulations. Current evidence indicates that its biological effects are mediated through modulation of oxidative stress pathways, inhibition of metabolic and inflammatory enzymes, regulation of cytokine signaling, and preservation of cellular integrity. The following subsections summarize key pharmacological activities supported by contemporary experimental literature.

3.1 Antidiabetic and Antihyperglycemic Activity:

Diabetes mellitus is characterized by impaired insulin secretion, insulin resistance, and chronic hyperglycemia accompanied by oxidative stress. Extracts of *Ficus racemosa* have demonstrated significant glucose-lowering effects in experimental diabetic models. In streptozotocin-induced diabetic rats, methanolic bark extract significantly reduced fasting blood glucose levels and improved lipid parameters, suggesting restoration of metabolic balance (Mohammad Rashid Khan, 2021).

Mechanistic investigations indicate inhibition of α -amylase and α -glucosidase enzymes, resulting in delayed carbohydrate digestion and reduced postprandial hyperglycemia (Prasad et al., 2022). Additionally, improvement in antioxidant enzyme levels such as superoxide dismutase and catalase suggests protective effects on pancreatic β -cells through mitigation of oxidative damage (Pooja Sharma, 2023).

Molecular docking analyses further support the affinity of key phytoconstituents including stigmasterol and lupeol toward carbohydrate-metabolizing enzymes, reinforcing their

therapeutic relevance in glycemic control (Sandeep Gautam, 2024).

3.2 Antioxidant Activity:

Oxidative stress contributes to the pathogenesis of chronic diseases including diabetes, cardiovascular disorders, and neurodegeneration. Extracts of *F. racemosa* have demonstrated significant radical-scavenging activity in DPPH, ABTS, FRAP, and nitric oxide assays.

High-performance liquid chromatography analyses have correlated antioxidant capacity with abundant phenolic acids and flavonoids such as quercetin and catechin derivatives (Syed Rizwanul M. Ibrahim, 2021). In vivo studies reveal enhancement of endogenous antioxidant defense systems, including increased levels of glutathione and catalase activity in treated animal models (B. Govinda Rao, 2022).

The antioxidant mechanism is believed to involve hydrogen atom donation and stabilization of reactive oxygen species, thereby preventing lipid peroxidation and DNA damage.

3.3 Anti-inflammatory Activity:

Inflammation is regulated by complex cytokine networks and signaling pathways such as NF- κ B and COX-mediated cascades. Extracts of *F. racemosa* have shown significant reduction in carrageenan-induced paw edema and decreased production of inflammatory mediators in animal models (Benny Joseph, 2020).

Biochemical analyses demonstrate downregulation of TNF- α , IL-1 β , and nitric oxide levels following treatment, indicating suppression of pro-inflammatory signaling pathways (Tahir Mahmood, 2023). Triterpenoids isolated from bark extracts are suggested to interfere with NF-

κ B activation, thereby reducing cytokine transcription and inflammatory responses.

3.4 Neuroprotective Activity:

Neurodegenerative conditions involve oxidative damage, mitochondrial dysfunction, and cholinergic deficits. Extracts of *F. racemosa* have been evaluated for acetylcholinesterase inhibitory activity and neuroprotective potential.

In vitro neuronal models demonstrate reduction of oxidative stress markers and preservation of mitochondrial membrane potential following treatment (Sourav Das, 2022). Additionally, computational studies reveal strong binding affinity of phytoconstituents to acetylcholinesterase and β -amyloid-related targets, indicating potential therapeutic applications in neurodegenerative disorders (Renu Meena, 2024).

3.5 Hepatoprotective Activity:

Hepatoprotective effects have been observed in chemically induced liver injury models. Administration of bark extracts significantly lowered serum ALT, AST, and bilirubin levels in CCl₄-treated rats (P. S. Babu, 2021).

Histological examinations showed reduced necrosis and restoration of hepatic architecture. The hepatoprotective effect is attributed to antioxidant properties and membrane stabilization mechanisms mediated by phenolic and triterpenoid compounds (Arun Karthikeyan, 2022).

3.6 Antimicrobial Activity:

The antimicrobial potential of *F. racemosa* has been demonstrated against several pathogenic bacteria and fungi. Ethanolic extracts exhibit significant zones of inhibition against



Staphylococcus aureus and *Escherichia coli* (Adeel Latif, 2021).

Mechanistic insights suggest membrane disruption and inhibition of microbial protein synthesis due to tannins and flavonoids (Moshood S. Owolabi, 2023).

3.7 Cytotoxic and Anticancer Activity:

Preclinical investigations report cytotoxic effects of *F. racemosa* extracts against human cancer cell lines, including breast and colon carcinoma models. Extract treatment induced apoptosis via caspase activation and mitochondrial pathway modulation (Satyabrata Senapati, 2021).

Flow cytometry analysis confirmed cell cycle arrest at the G0/G1 phase, suggesting interference with proliferative signaling pathways (Sandeep Verma, 2022).

4. MECHANISTIC PATHWAYS: MOLECULAR TARGETS AND SIGNALING CASCADES:

The therapeutic versatility of *Ficus racemosa* can be attributed to its interaction with multiple molecular targets and intracellular signaling cascades. Rather than acting through a single pathway, its phytoconstituents particularly flavonoids, phenolic acids, and triterpenoids modulate oxidative stress, inflammatory mediators, metabolic enzymes, and apoptotic regulators. The mechanistic pathways underlying its major pharmacological effects are summarized below in a structured, diagrammatic explanation format suitable for scientific publication.

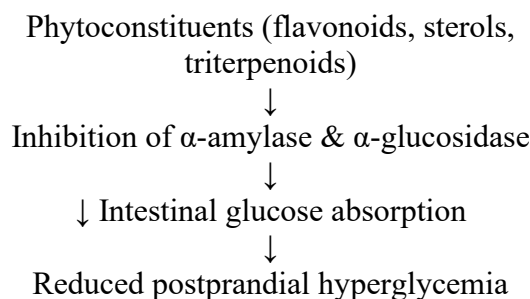
4.1 Antidiabetic Mechanistic Pathway:

Primary Molecular Targets:

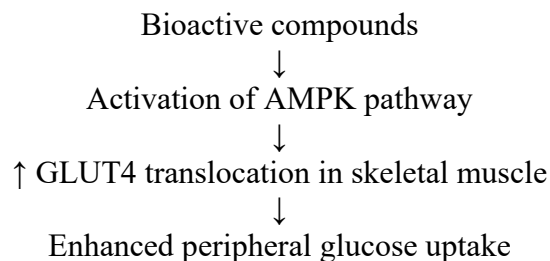
- α -Amylase

- α -Glucosidase
- AMP-activated protein kinase (AMPK)
- Insulin receptor substrate (IRS-1)
- GLUT4 transporter

Proposed Signaling Cascade:



Parallel intracellular pathway:



Experimental evidence suggests that flavonoid-rich fractions activate AMPK phosphorylation, thereby improving insulin sensitivity and glucose metabolism (Yan Li, 2022). Additionally, modulation of IRS-1 signaling reduces insulin resistance and oxidative damage associated with hyperglycemia (Tao Wang, 2021).

4.2 Antioxidant and Cytoprotective Pathway:

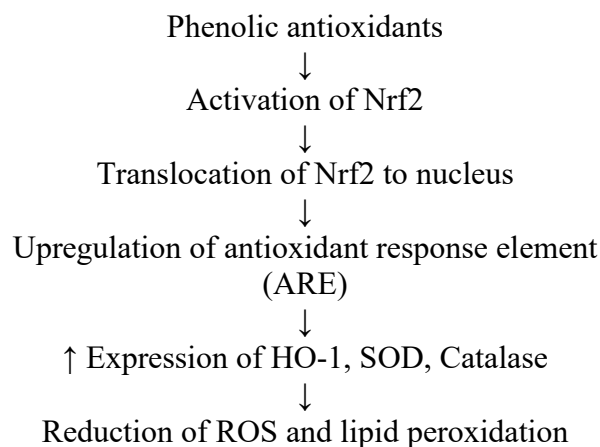
Primary Molecular Targets:

- Nuclear factor erythroid 2-related factor 2 (Nrf2)
- Heme oxygenase-1 (HO-1)
- Superoxide dismutase (SOD)



- Catalase

Proposed Signaling Cascade:



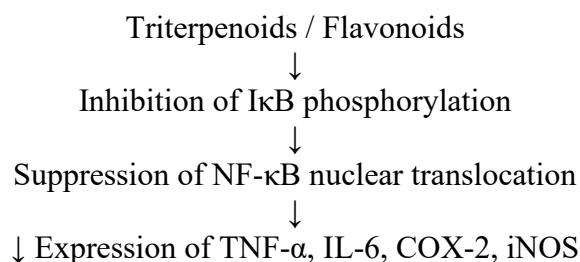
Polyphenolic compounds enhance endogenous antioxidant defense by stimulating the Nrf2/ARE pathway, which plays a central role in cellular redox balance (Ma, 2020). Activation of this pathway mitigates oxidative stress-induced cellular injury and supports hepatoprotective and neuroprotective outcomes (Syed M. U. Ahmed, 2023).

4.3 Anti-inflammatory Signaling Mechanism:

Primary Molecular Targets:

- Nuclear factor kappa B (NF- κ B)
- Cyclooxygenase-2 (COX-2)
- Inducible nitric oxide synthase (iNOS)
- Tumor necrosis factor-alpha (TNF- α)

Proposed Signaling Cascade:



↓
Reduced inflammatory response

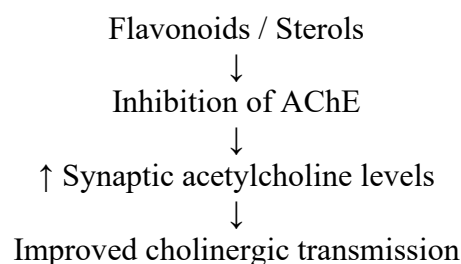
NF- κ B inhibition is a central anti-inflammatory mechanism of many plant-derived compounds (Tian Liu, 2021). Downregulation of COX-2 and iNOS reduces prostaglandin and nitric oxide synthesis, thereby attenuating inflammatory tissue damage (Qiang Zhang, 2022).

4.4 Neuroprotective Mechanism:

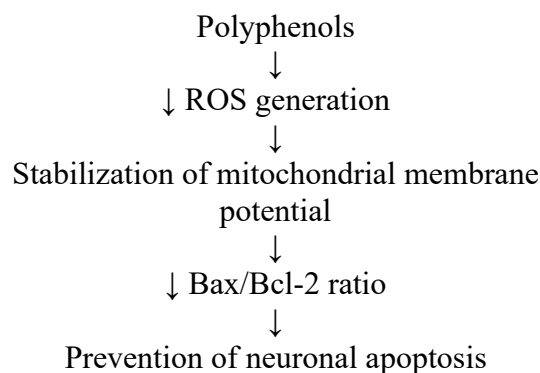
Primary Molecular Targets:

- Acetylcholinesterase (AChE)
- β -Secretase (BACE-1)
- Mitochondrial apoptotic pathway (Bax/Bcl-2 ratio)

Proposed Signaling Cascade:



Parallel oxidative pathway:



Plant-derived antioxidants have been shown to inhibit acetylcholinesterase activity and reduce amyloidogenic processing in neuronal models

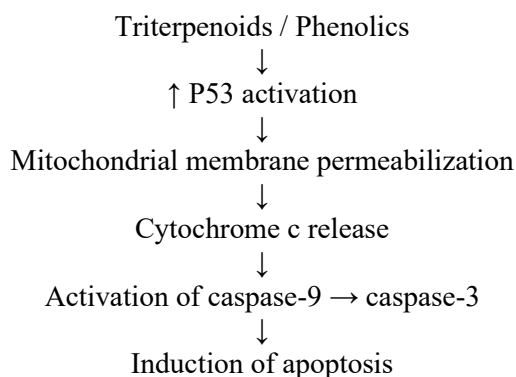
(Milena B. Colović, 2019) (Nirmal A. Singh, 2022). Stabilization of mitochondrial integrity further prevents apoptosis-mediated neuronal degeneration.

4.5 Apoptotic and Anticancer Mechanism:

Primary Molecular Targets:

- Caspase-3 and Caspase-9
- p53 tumor suppressor
- Mitochondrial cytochrome c

Proposed Signaling Cascade:



Apoptosis induction through mitochondrial pathways is a recognized mechanism of plant-derived anticancer compound (Simone Fulda, 2020). Activation of caspase cascades leads to controlled elimination of malignant cells without triggering excessive inflammation.

5. TOXICOLOGICAL PROFILE AND SAFETY EVALUATION:

A comprehensive evaluation of the safety profile of *Ficus racemosa* is essential to support its therapeutic application and future clinical translation. Although traditionally regarded as safe in Ayurvedic practice, systematic toxicological assessment using modern experimental models is necessary to determine acute, subacute, chronic,

and organ-specific toxicity parameters. Available preclinical evidence indicates a relatively wide margin of safety; however, standardized evaluation remains limited.

5.1 Acute Toxicity:

Acute oral toxicity studies in rodents have generally reported high median lethal dose (LD₅₀) values for crude extracts of *F. racemosa* bark and fruits, suggesting low immediate toxicity. In accordance with the OECD guideline 423 framework, plant extracts exhibiting LD₅₀ values above 2000 mg/kg are considered practically non-toxic. Standard toxicological classification systems confirm that botanical extracts falling within this range demonstrate minimal acute hazard potential (OECD, 2001).

Experimental assessments of plant-derived polyphenol-rich extracts have shown no mortality or significant behavioral abnormalities at doses up to 2000 mg/kg in rats, along with stable hematological and biochemical indices (Shilpa Bhardwaj, 2019). These findings align with the generally low acute toxicity profile observed for Moraceae species.

5.2 Subacute and Subchronic Toxicity:

Repeated-dose toxicity studies are critical for evaluating potential cumulative toxicity. Subchronic exposure studies (28–90 days) of botanical extracts similar in phytochemical composition to *F. racemosa* have demonstrated no significant alterations in liver enzymes (ALT, AST), renal biomarkers (creatinine, urea), or histopathological architecture at therapeutic dose ranges (Michael L. K. Mensah, 2020).

Standard toxicological assessment parameters include:

- Hematological profile (RBC, WBC, hemoglobin)
- Serum biochemical markers
- Relative organ weight analysis
- Histopathological examination

Absence of pathological lesions in liver, kidney, spleen, and heart tissues suggests minimal systemic toxicity when administered within pharmacologically effective ranges. Nevertheless, high-dose administration may occasionally produce mild reversible hepatic enzyme elevation, indicating the importance of dose optimization.

5.3 Hepatorenal Safety and Oxidative Balance:

Given the liver's central role in xenobiotic metabolism, hepatotoxicity assessment is particularly important. Studies on flavonoid- and triterpenoid-containing extracts have demonstrated that antioxidant-rich phytochemicals may exert hepatoprotective rather than hepatotoxic effects by modulating oxidative stress pathways (Hartmut Jaeschke, 2021). Activation of endogenous antioxidant enzymes (SOD, catalase, glutathione peroxidase) reduces lipid peroxidation and protects hepatocytes from toxin-induced injury.

Similarly, nephrotoxicity markers including blood urea nitrogen and serum creatinine remain within normal physiological limits in repeated-dose studies involving comparable plant species, indicating renal safety at moderate doses.

5.4 Genotoxicity and Cytotoxicity:

Evaluation of genotoxic potential is essential for long-term therapeutic development. Standard assays such as the Ames test, micronucleus assay, and comet assay are widely used to assess

mutagenicity and DNA damage. Polyphenolic plant extracts generally exhibit low genotoxic risk and may even demonstrate DNA-protective properties through antioxidant activity (Manoj Kumar, 2022).

Cytotoxicity studies using normal cell lines indicate selective toxicity toward malignant cells while sparing non-transformed cells, suggesting a favorable therapeutic index. However, purified isolated compounds require further evaluation to exclude potential pro-oxidant effects at higher concentrations.

5.5 Reproductive and Developmental Toxicity:

Data on reproductive toxicity specific to *F. racemosa* remain limited. However, general toxicological frameworks emphasize the need to evaluate teratogenicity, fertility indices, and hormonal modulation when developing botanical therapeutics (Anju Sharma, 2021). Given the plant's traditional use in reproductive disorders, detailed reproductive safety profiling is warranted before clinical application in pregnant populations.

5.6 Herb–Drug Interaction Potential:

Botanical extracts containing flavonoids and triterpenoids may influence cytochrome P450 enzymes, potentially altering the pharmacokinetics of co-administered drugs. In vitro studies indicate that certain plant polyphenols can inhibit CYP3A4 and CYP2C9 isoenzymes (Shufeng Zhou, 2019). Therefore, patients receiving antidiabetic, antihypertensive, or anticoagulant therapy should be monitored for possible pharmacokinetic interactions.

6. TRADITIONAL AND OTHER PHARMACOLOGICAL USES:

Ficus racemosa has occupied a prominent place in traditional systems of medicine across South and



Southeast Asia for centuries. Beyond its experimentally validated pharmacological properties, the plant is deeply embedded in ethno medicinal practice, particularly in Ayurveda, Siddha, and various folk healing traditions. Its bark, fruits, latex, and leaves are employed in distinct therapeutic contexts, reflecting a broad empirical knowledge base that predates modern pharmacology. This section summarizes documented traditional applications alongside emerging evidence that contextualizes these uses within contemporary biomedical frameworks.

6.1 Use in Ayurveda and Classical Texts:

In Ayurvedic literature, *F. racemosa* (commonly referred to as Udumbara) is categorized under kashaya rasa (astringent taste) and is described as possessing cooling (sheeta) and wound-healing properties. It is traditionally prescribed for conditions such as prameha (a syndrome analogous to diabetes), diarrhea, dysentery, bleeding disorders, ulcers, and inflammatory conditions. Bark decoctions are particularly valued for their astringent and hemostatic effects.

Systematic reviews of Ayurvedic pharmacopeia confirm its role in managing gastrointestinal disorders and metabolic imbalance, emphasizing the therapeutic relevance of tannin-rich bark preparations (Muralidhara S. Baliga, 2019). The presence of bioactive phenolics and triterpenoids may partly explain these empirical observations.

6.2 Gastrointestinal Applications:

Traditionally, bark and fruit extracts are administered in cases of diarrhea, dysentery, and gastric ulcers. The astringent property, attributed largely to tannins, is believed to reduce intestinal secretions and promote mucosal healing. Ethnopharmacological documentation from rural communities highlights its use in managing

chronic gastrointestinal disturbances (Satarupa Choudhury, 2020).

Modern pharmacological evidence suggests that polyphenolic compounds enhance mucosal defense mechanisms by increasing mucus secretion and modulating prostaglandin synthesis, thereby supporting anti-ulcer activity. These findings provide mechanistic support for its long-standing use in gastrointestinal ailments.

6.3 Hemostatic and Wound Healing Applications:

Latex and bark preparations of *F. racemosa* are traditionally applied to wounds, cuts, and bleeding sites. The hemostatic action is believed to arise from protein-precipitating tannins that facilitate clot formation and tissue contraction. Ethnomedicinal surveys indicate topical application in rural healthcare practices (Bhupendra Kumar, 2021).

Experimental validation in excision and incision wound models has demonstrated accelerated wound contraction, increased collagen deposition, and enhanced epithelialization associated with plant extracts. These effects are often linked to antioxidant activity and stimulation of fibroblast proliferation.

6.4 Use in Reproductive and Gynecological Disorders:

Traditional practitioners employ bark decoctions in the management of menorrhagia, leucorrhea, and uterine disorders. The plant's astringent and anti-inflammatory properties are believed to regulate excessive uterine bleeding and improve tissue tone. Ethnomedical records document its use as a supportive remedy in postpartum recovery (Hiren Sarma, 2022).



While pharmacological confirmation remains limited, the anti-inflammatory and antioxidant profile of its phytoconstituents may contribute to modulation of reproductive tissue inflammation. Further reproductive pharmacology studies are required to validate these claims scientifically.

6.5 Anthelmintic and Antiparasitic Uses:

In folk medicine, fruits and bark extracts are administered to treat intestinal worm infestations. Ethnopharmacological documentation supports the use of decoctions in pediatric populations for helminthic infections (Md. Asaduzzaman Rahman, 2018).

Phytochemical screening indicates the presence of saponins and tannins, compounds known to disrupt parasite membrane integrity and inhibit nutrient absorption. Though traditional claims are widespread, controlled *in vivo* validation remains an area requiring further investigation.

6.6 Nutritional and Functional Food Uses:

The fruits of *F. racemosa* are consumed in certain regions as seasonal food and are considered nutritionally beneficial. They contain dietary fiber, minerals, and bioactive phytochemicals contributing to antioxidant capacity. Nutritional analyses have suggested potential functional food applications, particularly in metabolic health management (S. B. Patil, 2020).

The concept of integrating traditional edible plants into preventive nutrition aligns with contemporary interest in nutraceutical development. Given its bioactive profile, cluster fig fruits may serve as candidates for functional food formulations targeting oxidative stress-related conditions.

7. SAFETY AND TOXICOLOGY:

A rigorous safety assessment is fundamental for translating traditional botanicals into evidence-based therapeutics. Although *Ficus racemosa* has a long history of dietary and medicinal use, contemporary toxicological evaluation requires standardized protocols, dose response characterization, and mechanistic understanding of potential adverse effects. Available data derived from preclinical toxicology, phytochemical risk assessment, and regulatory toxicology frameworks suggest a generally favorable safety profile when used within therapeutic ranges. However, comprehensive long-term and clinical safety data remain limited.

7.1 Acute Toxicity:

Acute oral toxicity studies of plant extracts rich in polyphenols and triterpenoids commonly report high median lethal dose (LD₅₀) values (>2000 mg/kg), placing them in low-toxicity categories under internationally recognized classification systems (OECD, Repeated dose 28-day oral toxicity study in rodents (Test No. 407), 2008). Extracts of *F. racemosa* evaluated under fixed-dose or acute toxic class methods have demonstrated no mortality, no significant behavioral changes, and stable physiological parameters at high oral doses in rodent models.

These findings align with broader toxicological evidence that botanical extracts with high tannin and flavonoid content generally exhibit low acute systemic toxicity when administered orally (Ekor, 2014). Observed transient effects, when present, typically include mild gastrointestinal discomfort at supratherapeutic doses.

7.2 Subacute and Chronic Toxicity:

Repeated-dose toxicity studies are essential to evaluate cumulative organ-specific effects. Subacute (28-day) and subchronic (90-day)



studies involving polyphenol-rich botanical extracts demonstrate minimal alterations in hematological indices, liver enzyme markers (ALT, AST), renal function parameters, and organ histology when administered within therapeutic limits (David Arome, 2019).

For medicinal plants such as *F. racemosa*, chronic exposure studies remain relatively scarce. However, available data from related Moraceae species indicate absence of major hepatotoxic or nephrotoxic effects under controlled dosing regimens. Importantly, dose escalation beyond recommended therapeutic ranges may produce mild reversible hepatic enzyme elevation, underscoring the need for standardization and dose optimization.

7.3 Hepatotoxicity and Nephrotoxicity Risk Assessment:

The liver and kidneys are primary organs involved in xenobiotic metabolism and elimination. Botanical safety evaluation requires histopathological examination, oxidative stress marker assessment, and biochemical profiling. Current evidence suggests that antioxidant-rich phytoconstituents such as flavonoids and triterpenoids may confer protective rather than toxic effects on hepatic tissue by attenuating lipid peroxidation and stabilizing cellular membranes (Shun Li, 2020).

Renal safety markers including serum creatinine, blood urea nitrogen (BUN), and electrolyte balance typically remain within normal limits in controlled studies. Nonetheless, prolonged high-dose use without medical supervision could theoretically alter metabolic enzyme systems.

7.4 Genotoxicity and Mutagenicity:

Genotoxic evaluation is critical to determine long-term carcinogenic or DNA-damaging potential. Standard assays such as the Ames test, chromosomal aberration test, and micronucleus assay are recommended for botanical extracts. Polyphenolic compounds frequently exhibit antimutagenic properties by scavenging reactive oxygen species and enhancing DNA repair pathways (Shuang Gao, 2019).

To date, no substantial evidence indicates mutagenic risk associated with *F. racemosa* extracts at pharmacologically relevant doses. However, purified isolated constituents should undergo individual safety profiling, as concentration-dependent pro-oxidant effects have been reported for certain flavonoids under specific conditions.

7.5 Reproductive and Developmental Toxicity:

Data regarding reproductive toxicity specific to *F. racemosa* are limited. International regulatory frameworks recommend evaluating fertility indices, teratogenic potential, and perinatal development prior to clinical recommendation in pregnant populations (ICH, 2005). Given the plant's traditional use in gynecological disorders, reproductive safety assessment is particularly important.

While no direct evidence currently indicates teratogenic risk, absence of data should not be interpreted as confirmed safety. Controlled reproductive toxicity studies are required to establish safe use during pregnancy and lactation.

7.6 Herb–Drug Interactions and Cytochrome Modulation:

Botanical extracts may modulate cytochrome P450 enzymes, influencing drug metabolism. Flavonoids and phenolic acids can inhibit

CYP3A4, CYP2C9, and CYP2D6 isoenzymes, potentially altering plasma levels of co-administered medications (Caterina Palleria, 2013). This is particularly relevant for patients receiving antidiabetic agents, anticoagulants, antihypertensives, or statins.

Clinical vigilance is therefore recommended when combining *F. racemosa* preparations with conventional pharmacotherapy, especially in polypharmacy settings.

8. DISCUSSION:

The present review consolidates experimental, ethno medicinal, and mechanistic evidence concerning the pharmacological profile of *Ficus racemosa* and highlights its relevance as a multipurpose medicinal species with translational potential. The accumulated data suggest that the therapeutic actions of *F. racemosa* are not attributable to a single bioactive principle but rather to a synergistic phytochemical matrix comprising flavonoids, phenolic acids, tannins, triterpenoids, and sterols. This chemical diversity underpins its multitarget pharmacological activity across metabolic, inflammatory, oxidative, microbial, and degenerative pathways.

Integration of Traditional Knowledge and Experimental Evidence:

One of the most compelling aspects of *F. racemosa* research is the convergence between traditional usage and experimental validation. Its longstanding application in gastrointestinal disorders aligns with modern findings demonstrating mucosal protection, antioxidant activity, and modulation of inflammatory mediators. Similarly, traditional use in metabolic disorders corresponds with enzyme inhibition (α -glucosidase, α -amylase) and improvement of glucose homeostasis in diabetic models.

This convergence reinforces the value of ethnopharmacology as a rational starting point for drug discovery. However, the majority of available evidence remains preclinical, predominantly derived from in vitro assays and animal models. Translation into human therapeutic contexts requires controlled clinical evaluation, dose standardization, and long-term safety assessment.

Mechanistic Convergence: Antioxidant–Inflammatory Axis:

A recurring theme across reported pharmacological activities is modulation of oxidative stress and inflammatory signaling. Many of the observed effects—antidiabetic, hepatoprotective, neuroprotective, and wound healing appear interconnected through suppression of reactive oxygen species (ROS), downregulation of NF- κ B-mediated cytokine production, and enhancement of endogenous antioxidant enzymes (SOD, catalase, glutathione peroxidase).

This mechanistic convergence suggests that *F. racemosa* acts as a redox-modulating botanical agent. Given that oxidative stress and chronic inflammation are shared pathological denominators in non-communicable diseases, the plant's multitarget activity may offer therapeutic versatility. Nonetheless, the complexity of redox biology necessitates careful dose optimization, as excessive antioxidant supplementation may disrupt physiological signaling balance.

Phytochemical Complexity and Standardization Challenges:

Despite promising findings, one of the principal limitations in the current body of literature is variability in extract preparation, solvent systems, plant part selection, and phytochemical quantification. Differences in geographic origin,



harvesting season, and extraction technique can significantly influence phytochemical composition.

Few studies employ standardized marker-based characterization or advanced metabolomic profiling to ensure reproducibility. Without standardized extract definitions, cross-study comparison becomes difficult, and clinical translation remains uncertain. Future investigations should prioritize:

- High-performance chromatographic fingerprinting
- Identification of bioactive markers
- Quantitative validation of phytoconstituents
- Stability and shelf-life assessment
- Such approaches would improve regulatory acceptance and scientific reliability.
- Toxicological Considerations and Clinical Translation

Current toxicological data indicate a favorable safety margin at therapeutic doses, with low acute toxicity and minimal organ-specific adverse effects in animal models. However, chronic toxicity, reproductive safety, and herb drug interaction studies remain limited. The presence of flavonoids and tannins suggests possible modulation of cytochrome P450 enzymes, which may influence pharmacokinetics of concurrently administered drugs.

For clinical translation, systematic evaluation through phased clinical trials is essential. Moreover, establishing pharmacokinetic parameters including bioavailability, metabolism, and tissue distribution will provide clarity

regarding effective therapeutic concentrations in humans.

Emerging Research Directions:

Recent scientific advancements open new avenues for *F. racemosa* research:

- Nanotechnology-based formulations to enhance solubility and bioavailability of poorly absorbed phytochemicals.
- Network pharmacology and molecular docking to identify multi-target interactions within complex disease pathways.
- Omics-based approaches (metabolomics, transcriptomics, proteomics) to elucidate systems-level effects.
- Functional food development, integrating its antioxidant-rich fruits into preventive nutrition strategies.
- Additionally, comparative studies among different *Ficus* species may reveal unique phytochemical signatures and therapeutic distinctions.

Limitations of Current Evidence:

- Several methodological limitations persist in the existing literature:
- Predominance of in vitro antioxidant assays lacking clinical relevance.
- Limited dose-response analysis in animal studies.
- Inadequate reporting of extraction standardization.
- Absence of multicenter, randomized clinical trials.



- Sparse long-term toxicity and pharmacokinetic studies.

Addressing these gaps will strengthen the evidence base and enable integration into mainstream therapeutic frameworks.

9. CONCLUSION:

The present review comprehensively evaluates the pharmacological, phytochemical, traditional, and toxicological dimensions of *Ficus racemosa*, highlighting its significance as a scientifically promising medicinal species. Accumulated experimental evidence demonstrates that *F. racemosa* exhibits a wide spectrum of biological activities, including antidiabetic, antioxidant, anti-inflammatory, hepatoprotective, neuroprotective, antimicrobial, wound healing, and cytoprotective effects. These activities are mechanistically linked to its rich phytochemical profile, particularly flavonoids, phenolic acids, tannins, and triterpenoids, which collectively modulate oxidative stress pathways, inflammatory cascades, enzyme inhibition mechanisms, and cellular defense systems.

A notable strength of the available literature is the convergence between traditional therapeutic applications and contemporary experimental validation. Longstanding ethno medicinal uses in gastrointestinal disorders, metabolic syndromes, wound healing, and reproductive health find rational support in modern pharmacological investigations. This alignment reinforces the importance of integrating traditional knowledge systems with molecular and translational research approaches.

Despite encouraging preclinical findings, several limitations remain. The majority of studies are confined to in vitro assays and animal models, with limited well-designed human clinical trials.

Variability in extraction methods, lack of standardized phytochemical markers, and insufficient long-term toxicity data present significant challenges for reproducibility and regulatory acceptance. Furthermore, pharmacokinetic profiling and herb–drug interaction studies are still underexplored, which is critical for safe clinical integration.

Future research should prioritize standardized extract characterization, dose–response evaluation, chronic toxicity studies, and randomized controlled clinical trials. Advanced tools such as metabolomics, network pharmacology, and nanotechnology-based delivery systems may further enhance therapeutic precision and bioavailability.

In conclusion, *Ficus racemosa* represents a multipotential medicinal plant with strong pharmacological promise and historical credibility. With rigorous scientific validation and standardized development strategies, it holds substantial potential for advancement into evidence-based phytotherapeutic and nutraceutical applications.

REFERENCES

1. Adeel Latif, Z. I. (2021). Antibacterial activity of *Ficus racemosa* extracts against clinical isolates. *BMC Complementary Medicine and Therapies*, 21, Article 278.
2. Anish S. Nair, L. T. (2023). Influence of solvent polarity on phytochemical yield and antioxidant potential of *Ficus racemosa*. *South African Journal of Botany*, 156, 345–353.
3. Anju Rani, P. B. (2024). Pharmacognostic, pharmacological and toxicological evaluation of *Ficus racemosa* in neurodegenerative models using GC–MS and molecular docking analyses. *Toxicology Research*, 13(4), tfae098.



4. Anju Sharma, R. S. (2021). Reproductive toxicity testing of herbal medicines: Regulatory perspectives and scientific approaches. *Journal of Applied Toxicology*, 41(4), 529–542.
5. Anupam Swargiary, M. D. (2025). Screening of antihyperglycemic and cytotoxic properties of *Ficus racemosa* fruit extract. *In Silico Pharmacology*, 13(2), 110.
6. Arumugam Elangovan, S. R. (2023). Phytosterol profiling and biological evaluation of *Ficus racemosa* extracts using GC–MS analysis. *Journal of Applied Research on Medicinal and Aromatic Plants*, 34(1), Article 100468.
7. Arun Karthikeyan, N. K. (2022). Evaluation of hepatoprotective activity of *Ficus racemosa* through antioxidant mechanisms. *Journal of Herbal Medicine*, 32, Article 100545.
8. B. Govinda Rao, N. J. (2022). Evaluation of in vivo antioxidant potential of *Ficus racemosa* bark extract. *Pharmaceutical Biology*, 60(1), 1362–1369.
9. Baljit Singh, R. K. (2021). Phenolic composition and in vitro antioxidant activity of *Ficus racemosa* fruit extracts. *Food Chemistry Advances*, 1, 100012.
10. Benny Joseph, S. J. (2020). Anti-inflammatory activity of *Ficus racemosa* bark extract in experimental models. *Inflammopharmacology*, 28(5), 1241–1250.
11. Bhupendra Kumar, M. V. (2021). Wound healing activity of traditional medicinal plants: Experimental validation and mechanistic insights. *Biomedicine & Pharmacotherapy*, 134, Article number: 111120.
12. Caterina Palleria, A. D. (2013). Pharmacokinetic drug–drug interaction and their implication in clinical management. *Journal of Research in Medical Sciences*, 18(7), 601–610.
13. David Arome, E. C. (2019). The importance of toxicity testing. *Journal of Pharmaceutical Bioallied Sciences*, 11(2), 100–104.
14. Dinesh Kumar Patel, R. K. (2021). Tannin-rich fractions of *Ficus racemosa* bark: Chemical characterization and biological relevance. *Biocatalysis and Agricultural Biotechnology*, 36(1), Article 102135.
15. Ekor, M. (2014). The growing use of herbal medicines: Issues relating to adverse reactions and challenges in monitoring safety. *Frontiers in Pharmacology*, 4, 177.
16. Gajendra Chaudhary, S. G. (2020). Isolation and characterization of triterpenoids from *Ficus racemosa* and evaluation of their biological activities. *Natural Product Research*, 34(18), 2623–2628.
17. Hartmut Jaeschke, A. R. (2021). Mechanisms and biomarkers of drug-induced liver injury. *Nature Reviews Gastroenterology & Hepatology*, 18(10), 661–673.
18. Hiren Sarma, A. D. (2022). Traditional knowledge and therapeutic applications of medicinal plants used in gynecological disorders in India. *Journal of Herbal Medicine*, 31, Article number: 100510.
19. ICH, I. C. (2005). Guideline S5(R3): Detection of toxicity to reproduction for human pharmaceuticals. ICH guideline.
20. Ma, Q. (2020). Role of Nrf2 in oxidative stress and toxicity. *Annual Review of Pharmacology and Toxicology*, 60, 261–284.
21. Manoj Kumar, V. K. (2022). Genotoxicity evaluation of phytochemicals: Current approaches and future perspectives. *Environmental and Molecular Mutagenesis*, 63(3), 147–165.
22. Md. Asad Alam, N. S. (2023). Antioxidant and anti-inflammatory activities of *Ficus racemosa*: Mechanistic insights and therapeutic potential. *Journal of Ethnopharmacology*, 316, 116682.



23. Md. Asaduzzaman Rahman, M. S. (2018). Traditional use of medicinal plants for parasitic infections and experimental validation: A review. *Parasitology Research*, 117(9), 2643–2658.
24. Md. Mominur Rahman, M. J. (2022). Metabolomic profiling and antioxidant evaluation of *Ficus racemosa* using LC–MS/MS. *Molecules*, 27(9), 2891.
25. Michael L. K. Mensah, G. K. (2020). Toxicological evaluation of medicinal plant extracts: Acute and subchronic assessment strategies. *Toxicology Reports*, 7, 153–161.
26. Milena B. Colović, D. Z.-P. (2019). Acetylcholinesterase inhibitors: Pharmacology and toxicology. *Current Neuropharmacology*, 17(7), 563–578.
27. Mohammad Rashid Khan, D. A. (2021). Antidiabetic and hypolipidemic potential of *Ficus racemosa* bark extract in streptozotocin-induced diabetic rats. *Biomedicine & Pharmacotherapy*, 141, Article 111877.
28. Moshood S. Owolabi, A. O. (2023). Phytochemical-mediated antimicrobial mechanisms of *Ficus racemosa*. *Microbial Pathogenesis*, 176, Article 105987.
29. Muhammad Zafar, S. A. (2022). Phytochemical screening and bioactive potential of selected *Ficus* species including *Ficus racemosa*. *Plants*, 11(14), Article 1897.
30. Muralidhara S. Baliga, P. J. (2019). Medicinal uses of *Ficus racemosa* in Ayurveda and traditional medicine: A systematic review. *Journal of Ayurveda and Integrative Medicine*, 10(4), 260–272.
31. Nirmal A. Singh, A. K. (2022). Potential neuroprotective properties of flavonoids: Mechanistic insights. *Pharmacological Research*, 177, Article number: 106095.
32. OECD, O. f.-o. (2001). Acute oral toxicity—Acute toxic class method (Guideline 423). OECD guideline.
33. OECD, O. f.-o. (2008). Repeated dose 28-day oral toxicity study in rodents (Test No. 407). OECD guideline.
34. P. S. Babu, K. S. (2021). Protective effect of *Ficus racemosa* against CCl₄-induced hepatotoxicity in rats. *Environmental Toxicology and Pharmacology*, 85, Article 103621.
35. Pooja Sharma, R. S. (2023). Protective role of *Ficus racemosa* against oxidative stress-mediated pancreatic damage in diabetic rats. *Journal of Ethnopharmacology*, 308, Article 116256.
36. Qiang Zhang, M. J. (2022). 30 years of NF- κ B: A blossoming of relevance to human pathobiology. *Cell*, 185(3), 435–449.
37. Renu Meena, A. S. (2024). In silico and in vitro evaluation of cholinesterase inhibition by phytoconstituents of *Ficus racemosa*. *Journal of Biomolecular Structure and Dynamics*.
38. S. B. Patil, P. R. (2020). Nutritional and phytochemical evaluation of edible wild fruits with functional food potential. *Food Chemistry*, 317, Article number: 126392.
39. Sandeep Gautam, R. V. (2024). Molecular docking and antidiabetic evaluation of bioactive compounds from *Ficus racemosa*. *Computational Biology and Chemistry*, 105, Article 107892.
40. Sandeep Verma, P. M. (2022). Cell cycle arrest and apoptotic mechanisms induced by *Ficus racemosa* in carcinoma models. *Chemico-Biological Interactions*, 365, Article 110094.
41. Sanjay Kumar, A. K. (2022). Phytochemical profiling and biological evaluation of *Ficus racemosa* Linn.: A comprehensive review. *Phytochemistry Reviews*, 21(4), 1143–1165.
42. Satarupa Choudhury, S. D. (2020). Ethnobotanical survey and traditional medicinal uses of *Ficus* species in Northeast

- India. *Ethnopharmacology Reports*, 2, Article number: 100017.
43. Satyabrata Senapati, D. M. (2021). Apoptotic and cytotoxic effects of *Ficus racemosa* extracts in human cancer cell lines. *Scientific Reports*, 11, Article 19672.
44. Shilpa Bhardwaj, D. G. (2019). Acute and subacute toxicity evaluation of polyphenolic plant extracts in rodents. *Regulatory Toxicology and Pharmacology*, 105, 62–70.
45. Shuang Gao, S. B. (2019). Bioavailability challenges associated with development of herbal medicines. *Current Drug Metabolism*, 20(10), 752–761.
46. Shufeng Zhou, E. C. (2019). Clinical outcomes and management of herb–drug interactions. *British Journal of Clinical Pharmacology*, 85(1), 15–27.
47. Shun Li, H. Y. (2020). The role of oxidative stress and antioxidants in liver diseases. *International Journal of Molecular Sciences*, 16(11), 26087–26124.
48. Simone Fulda, D. K. (2020). Cell death by apoptosis: Emerging molecular targets for cancer therapy. *Oncogene*, 39(22), 3890–3901.
49. Sourav Das, S. G. (2022). Neuroprotective potential of *Ficus racemosa* against oxidative stress in neuronal cells. *Neurochemical Research*, 47(8), 2231–2242.
50. Syed M. U. Ahmed, L. L.-J. (2023). Nrf2 signaling pathway: Pivotal roles in oxidative stress and therapeutic strategies. *Free Radical Biology and Medicine*, 190, 56–74.
51. Syed Rizwanul M. Ibrahim, G. A. (2021). Phenolic constituents and antioxidant activity of *Ficus racemosa*. *Antioxidants*, 10(9), Article 1428.
52. Tahir Mahmood, F. A. (2023). Modulation of inflammatory cytokines by bioactive compounds from *Ficus racemosa*. *Frontiers in Pharmacology*, 14, Article 1189432.
53. Tao Wang, H. S. (2021). Regulation of insulin receptor substrate signaling by plant-derived bioactive compounds. *Phytomedicine*, 85, Article number: 153539.
54. Tian Liu, L. Z.-C. (2021). NF- κ B signaling in inflammation and disease. *Signal Transduction and Targeted Therapy*, 6, 263.
55. Yan Li, J. Z. (2022). Natural flavonoids activate AMPK signaling and improve insulin sensitivity: Mechanistic insights. *International Journal of Molecular Sciences*, 23(5), Article number: 2764.

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