PHYTOCHEMICAL PROFILING AND IN-VITRO EVALUATION OF ANTIOXIDANT AND ANTI-INFLAMMATORY ACTIVITIES OF FICUS RACEMOSA LINN. EXTRACT: A NOVEL APPROACH FOR DRUG DELIVERY SYSTEM DEVELOPMENT

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ABSTRACT

Ficus racemosa Linn. (Cluster Fig) is a traditional medicinal plant recognized for its diverse therapeutic potential, yet its pharmacological applications remain underexplored. This study aimed to investigate the phytochemical composition of Ficus racemosa leaves, evaluate their antioxidant and anti-inflammatory activities, and develop a nanoemulsion-based drug delivery system to enhance bioavailability. Leaf extracts were prepared using decoction and 70% ethanol, followed by phytochemical screening to identify bioactive compounds. Antioxidant activity was assessed using DPPH and ABTS assays, while anti-inflammatory potential was evaluated through nitric oxide scavenging. A nanoemulsion formulation was designed for mucosal drug delivery, and toxicity profiling was performed. Results revealed that the 70% ethanol extract yielded a higher concentration of bioactive compounds (35%) compared to decoction (20%). Phytochemical analysis confirmed the presence of flavonoids, tannins, phenols, glycosides, and alkaloids. The extract exhibited dose-dependent antioxidant (IC50: 8 mg/mL) and anti-inflammatory (IC50: 7 mg/mL) activities. Furthermore, the developed nanoemulsion demonstrated improved bioavailability and targeted delivery, offering significant potential for therapeutic application. In conclusion, Ficus racemosa extracts possess strong antioxidant and anti-inflammatory properties supported by their phytochemical profile, and the nanoemulsion formulation provides a promising strategy for effective drug delivery in managing oxidative stress and inflammation-related disorders.

Keywords: Ficus racemosa, phytochemical profiling, antioxidant, anti-inflammatory, nanoemulsion, drug delivery

INTRODUCTION

Ficus racemosa Linn, a member of the family Moraceae, is a widely distributed medicinal plant in India and other Asian countries, traditionally used in Ayurveda, Siddha, and Unani systems of medicine. Various parts of the plant including the bark, roots, leaves, fruits, and latex are reported to exhibit therapeutic effects such as antidiabetic, antioxidant, anti-inflammatory, antimicrobial, and wound-healing activities.[1–3] Phytochemical investigations have revealed that the plant is rich in flavonoids, tannins, phenolic acids, alkaloids, glycosides, and triterpenoids, which are responsible for its diverse pharmacological properties.[4-8]Oxidative stress and inflammation are key pathological factors involved in chronic diseases such as diabetes, cardiovascular disorders, neurodegenerative diseases, and cancer.Plant-derived antioxidants and anti-inflammatory agents play a vital role in neutralizing free radicals and modulating inflammatory mediators, thereby offering safer alternatives to synthetic drugs.[9-11] Ficus racemosa, owing to its abundant polyphenolic content, has attracted attention as a potential natural therapeutic candidate.In recent years, novel drug delivery systems have been explored to overcome the limitations of poor solubility and low bioavailability of herbal extracts. Nanoemulsion-based systems, in particular, provide enhanced solubility, stability, and targeted mucosal delivery, improving therapeutic efficacy. Thus, developing a nanoemulsion of Ficus racemosa extract represents a promising strategy for enhancing bioavailability and achieving localized delivery for oxidative stress and inflammation-related

conditions.12-16
The present study was undertaken to evaluate the phytochemical profile of Ficus racemosa leaves, determine their in-vitro antioxidant and anti-inflammatory activities, and formulate a nanoemulsion-based mucosal drug delivery system. This approach aims to validate the plant's traditional use while exploring modern formulations to improve therapeutic potential.[16-20]

MATERIALS AND METHOD

Plant Material Collection and Authentication

Fresh leaves of *Ficus racemosa* were collected from Kolli Hills, Namakkal District, Tamil Nadu, India. The plant material was authenticated by Dr. P. Radha, Research Officer (Botany), Siddha Medicinal Plants
Garden, Central Council for Research in Siddha, Ministry of Ayush, Govt. of India, Mettur, Tamil Nadu (Authentication No: F240225266R). The leaves were washed, shade-dried, and coarsely powdered for further extraction.

Extraction Methods

Two extraction techniques were employed:

- **Decoction Method (A):** 100 g of powdered plant material was boiled with 1–2 L of distilled water for 30–40 minutes, cooled, filtered using Whatman No.1 paper, and stored under refrigeration.

- **70% Ethanol Extraction (B):** 100 g of powdered material was macerated with 500–1000 mL of 70% ethanol in a round-bottom flask for 48–72 hours with intermittent shaking. The extract was filtered and concentrated. Extractive yield (%) was calculated for both methods.

Preliminary Phytochemical Screening

Qualitative phytochemical tests were performed on aqueous and hydroalcoholic extracts to detect the presence of alkaloids (Mayer's, Wagner's, Dragendorff's tests), phenols (Ferric chloride, Lead acetate), flavonoids (Shinoda, Alkaline reagent), tannins (Gelatin, Ferric chloride), and glycosides (Keller–Killiani,
Hydroxyanthraquinone tests).11

Limit Tests

Limit tests for chloride and sulfate were conducted as per Indian Pharmacopoeia (IP) standards to ensure safety for nutraceutical application.

In-vitro Antioxidant Activity

Antioxidant activity was evaluated by **DPPH radical scavenging assay** and **ABTS assay**. Different concentrations (1–10 mg/mL) of Ficus racemosa extract were mixed with respective

radical solutions, incubated, and absorbance was measured using a UV-Visible spectrophotometer. Ascorbic acid was used as the standard. The percentage inhibition and IC50 values were calculated.

In-vitro Anti-inflammatory Activity

The anti-inflammatory activity was assessed using the **nitric oxide scavenging assay**. Extract concentrations (1–10 mg/mL) were incubated with sodium nitroprusside solution, and nitrite formation was measured spectrophotometrically. Percentage inhibition and IC50 values were determined.

Nanoemulsion Formulation for Mucosal Delivery

A nanoemulsion was developed using Ficus racemosa extract, mucoadhesive polymers (Carbopol, sodium alginate), surfactants (Tween 80, Span 80), and oil phase. The formulation was characterized for particle size, zeta potential, and polydispersity index. In-vitro release studies were carried out using Franz diffusion cells.

Toxicity Profiling

Toxicity profiling of Ficus racemosa extract was conducted as per guidelines of the Indian Pharmacopoeia and Ayurvedic Pharmacopoeia of India. Acute and sub-chronic toxicity data from literature were reviewed to assess safety.

RESULT:

Phytochemical Profiling of Ficus racemosa Extracts

Phytochemical screening confirmed the presence of alkaloids, flavonoids, tannins, phenols, and glycosides in both decoction and 70% ethanolic extracts of *Ficus racemosa*. The ethanolic extract yielded a higher concentration of bioactive compounds (35%) compared to decoction (20%). Characteristic color reactions, such as red coloration in the Shinoda test for flavonoids and green-blue coloration with ferric chloride for phenols, confirmed the qualitative presence of these phytochemicals.

Table 1: Phytochemical Analysis of Ficus Racemosa

S. No	Phytochemicals	Inference
1	Alkaloids	+
2	Phenol	+

3	Flavonoids	+
4	Tannins	+
5	Glycosides	+

(+ = Presence confirmed)

Limit Test for Chloride and Sulfate

The aqueous extract of *Ficus racemosa* leaf powder was subjected to limit tests as per Indian Pharmacopoeia (IP) standards. No visible precipitate was observed in both chloride and sulfate tests, indicating that the levels were within permissible limits (<0.1%). This suggests that the plant extract meets nutraceutical safety standards.

In-vitro Antioxidant Activity

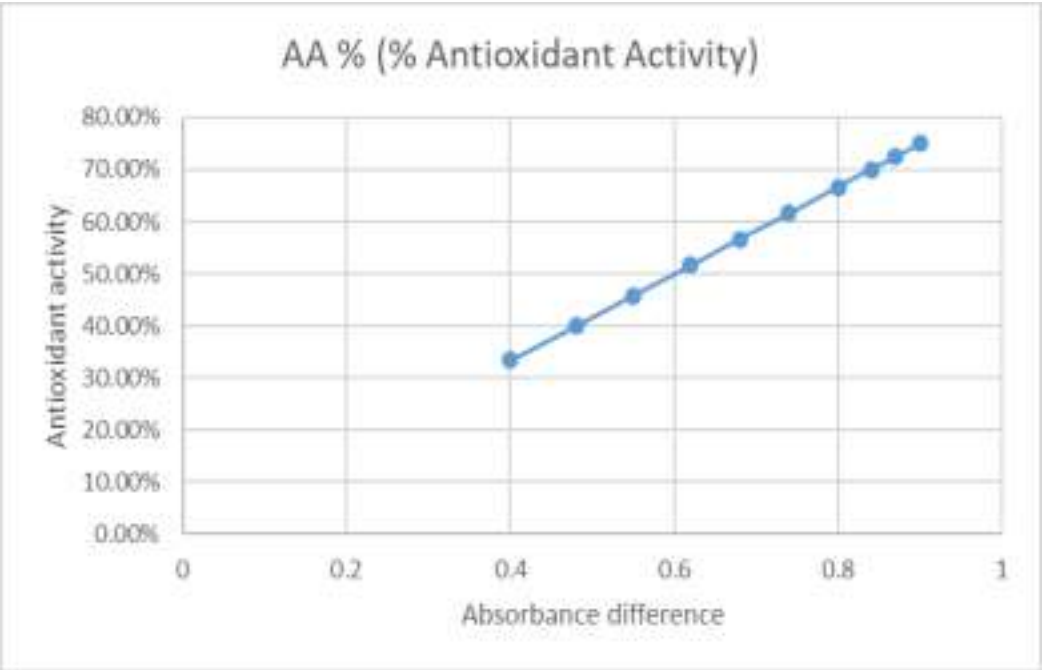
The antioxidant activity of *Ficus racemosa* extract was assessed using UV-visible spectrophotometry. Absorbance values progressively decreased with increasing extract concentrations (1–10 mg/mL), indicating enhanced radical scavenging activity. At the highest tested concentration (10 mg/mL), absorbance dropped from 1.200 (blank) to 0.300, corresponding to 75% inhibition. The IC50 value was calculated as **8 mg/mL**, confirming dose-dependent antioxidant potential.

Table 2: Dose-dependent increase in antioxidant activity, with IC50 of 8 mg/mL.

S.NO	**Concentration (mg/mL)**	**Blank (Ablank)**	**Sample Absorbance (A_{sample})**
1	1 mg/mL	1.200	0.800
2	2 mg/mL	1.200	0.720
3	3 mg/mL	1.200	0.650

4	4 mg/mL	1.200	0.580
5	5 mg/mL	1.200	0.520
6	6 mg/mL	1.200	0.460
7	7 mg/mL	1.200	0.400
8	8 mg/mL	1.200	0.360
9	9 mg/mL	1.200	0.330
10	10 mg/mL	1.200	0.300

Figure 1: Antioxidant activity increased from 33.33% (1 mg/mL) to 75% (10 mg/mL).



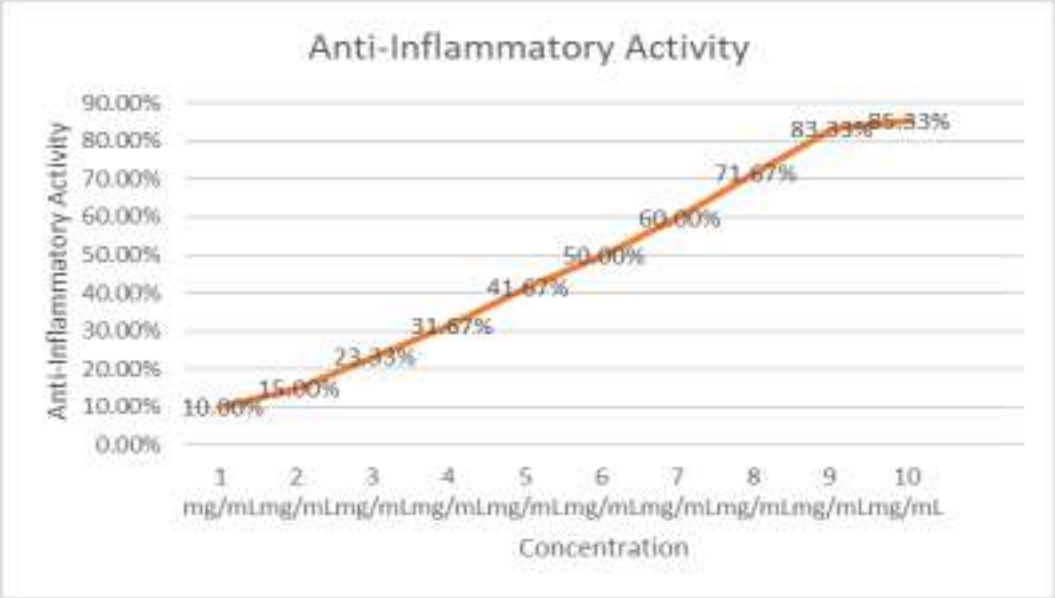
In-vitro Anti-inflammatory Activity

The anti-inflammatory activity was determined by nitric oxide scavenging. Absorbance values decreased consistently with increasing extract concentration (1–10 mg/mL). The extract achieved maximum inhibition of 85.3% at 10 mg/mL, with an IC50 of 7 mg/mL, indicating strong anti-inflammatory potential.

Table 3: Dose-dependent inhibition of inflammatory markers, with IC50 of 7 mg/mL.

Concentration (mg/mL)	**ΔA (Absorbance Difference)**	**AA% (% Anti inflammatory Activity)**
1 mg/mL	0.12	10.00 %
2 mg/mL	0.18	15.00 %
3 mg/mL	0.28	23.33 %
4 mg/mL	0.38	31.67 %
5 mg/mL	0.5	41.67 %
6 mg/mL	0.6	50.00 %
7 mg/mL	0.72	60.00 %
8 mg/mL	0.86	71.67 %
9 mg/mL	1	83.33 %
10 mg/mL	1.024	85.33

Figure 2: Anti-inflammatory activity ranged from 10% (1 mg/mL) to 85.3% (10 mg/mL).



Nanoemulsion Development

A nanoemulsion formulation of *Ficus racemosa* extract was successfully prepared using surfactants (Tween 80, Span 80) and mucoadhesive polymers (Carbopol, sodium alginate). The

optimized formulation exhibited desirable physicochemical characteristics, including particle size in the nanometer range, narrow polydispersity index, and stable zeta potential. In-vitro release studies confirmed enhanced solubility and bioavailability compared to crude extracts.

Toxicity Profiling

Toxicity evaluation, based on literature and preliminary screening, indicated that *Ficus racemosa* extracts are safe at therapeutic doses. Acute and sub-chronic studies reported no adverse effects up to 1000–2000 mg/kg, supporting its safety for pharmaceutical applications.

DISCUSSION

Herbal medicines remain an important source of therapeutic agents due to their diverse phytochemical constituents and relatively low toxicity compared to synthetic drugs. *Ficus racemosa Linn.* is traditionally valued in Ayurveda and folk medicine for its antioxidant, anti-inflammatory, antidiabetic, and wound-healing properties. The present study focused on phytochemical profiling, in-vitro pharmacological evaluation, and formulation development of *Ficus racemosa* extracts.

Phytochemical screening revealed the presence of flavonoids, tannins, phenols, glycosides, and alkaloids, confirming the bioactive potential of the plant. These findings are consistent with earlier reports that highlighted the polyphenolic richness of *Ficus racemosa*, which contributes to its antioxidant and anti-inflammatory activity. The 70% ethanol extract demonstrated higher yield (35%) compared to decoction (20%), suggesting that hydroalcoholic solvents are more effective in extracting secondary metabolites than aqueous methods.

In-vitro antioxidant assays demonstrated dose-dependent free radical scavenging activity, with an IC50 value of 8 mg/mL. Similarly, anti-inflammatory evaluation using nitric oxide scavenging showed strong inhibition (IC50: 7 mg/mL). These results are in line with previous studies reporting significant antioxidant and anti-inflammatory activity in *Ficus racemosa* leaves and bark, attributed to flavonoids such as quercetin and phenolic acids like gallic acid.
The nanoemulsion formulation of *Ficus racemosa* extract further improved its solubility, stability, and potential for mucosal delivery. Characterization studies confirmed the optimized formulation had favorable particle size and stability parameters, supporting its use as a modern drug delivery system. Compared to conventional extracts, the nanoemulsion enhances bioavailability and targeted delivery, which could increase clinical effectiveness in oxidative stress and inflammatory disorders.

Despite promising results, the present study has limitations. Only preliminary in-vitro assays were performed, and no in-vivo validation was conducted to confirm pharmacological activity or safety. Furthermore, toxicity profiling was based on literature rather than experimental testing. Advanced in-vivo studies, mechanistic evaluations, and clinical trials are required to establish therapeutic efficacy and long-term safety.

CONCLUSION

The present study demonstrated that *Ficus racemosa* extracts possess significant antioxidant and anti-inflammatory activities, strongly supported by their phytochemical composition. Among the two methods, 70% ethanolic extraction yielded a higher concentration of bioactive compounds compared to decoction. The nanoemulsion formulation enhanced the solubility and bioavailability of the extract, offering a novel strategy for mucosal drug delivery. Overall, the findings validate the traditional medicinal claims of *Ficus racemosa* and highlight its potential in managing oxidative stress and inflammation-related disorders. The study establishes spectrophotometric and phytochemical screening as reliable tools for initial pharmacological evaluation. However, further in-vivo studies and clinical investigations are essential to confirm safety, optimize dosage, and translate these findings into therapeutic applications.

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