IJARSCT
ISSN: 2581-9429
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Volume 6, Issue 13, May 2026
Impact Factor: 8.2

Formulation and Evaluation of Harbal Nanogel Containing Albizia Saman Extract for Antifungal Activity

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Abstract: *Nanogels play a crucial role in drug delivery systems due to their high drug loading capacity and favorable biocompatibility and biodegradability. This article reviews advancements in nanogel drug delivery, focusing on aspects like drug loading, swelling behavior, and biological applications. It evaluates various types of nanogels, manufacturing methods, and drug release mechanisms. The study also examines the physicochemical and Pharmacognostic properties of the rain tree (Samanea saman), including its leaf morphology and bioactive compounds. Furthermore, a herbal nanogel using Albizia saman extract was formulated to assess its antifungal properties against fungi, particularly Trichophyton rubrum. Through physicochemical evaluations, including pH and viscosity, the optimized formulation demonstrated significant antifungal efficacy compared to the plain extract, highlighting its potential as a topical treatment for fungal infections.*

Keywords: Drug delivery systems, herbal Nanogel, Albizia saman, Antifungal Activity

I. INTRODUCTION

Medicinal plants have been vital to healthcare for over 2,000 years, identified with nearly 6,000 species having medicinal properties. Approximately 80% of the global population relies on traditional remedies, with a growing commercial and research interest in these plants. The Himalayan region, rich in diverse plant species, exemplifies the importance of herbal treatments for various illnesses. Despite the affordable options, many in developing countries still depend on these traditional medicines due to the high cost of synthetic drugs. The World Health Organization has historically advocated for recognizing traditional medicine, emphasizing its potential in developing new drug compounds and improving public health globally through natural remedies.

Samanea saman, or the rain tree, is a medicinal tree in the Fabaceae family, prevalent in tropical regions like Brazil and India. Its notable characteristics include a large canopy, rapid growth, and adaptability. Traditionally, various tree parts have been used to treat ailments such as diarrhea and arthritis. With issues related to conventional antifungal treatments, research is exploring herbal alternatives like S. saman, known for its nutritional benefits and nitrogen fixation. The study focuses on its bioactive compounds, which exhibit antioxidant, antibacterial, anti-diabetic, analgesic, anti-ulcer, insecticidal, antifungal, and cytotoxic properties.

❖ **Feature of Nanogel**

- Targeting Delivery: Nanogels can be focused on specific sites via surface binding or passive retention in physiological spaces.
- Low Level of Toxicity: They must be biocompatible, non-toxic, and degrade into non-toxic by-products for rapid elimination from the body.
- Controlled and Sustained Medication Delivery**: Efficient drug delivery at target locations aims for high drug loading with reduced side effects.

- High Encapsulation Stability: Drug molecules must remain contained in nanogels to maximize therapeutic effectiveness and minimize toxicity.
- Size Control: The size and surface features of nanogels are modified using physicochemical methods to enhance targeting and reduce clearance by somatic cells, facilitating passage through capillaries and tissues.

❖ **Constituents:**

Chemical constituents in plants are critical for antifungal activity, with key bioactive compounds including flavonoids (quercetin, kaempferol), tannins, and saponins, which disrupt fungal membranes. Alkaloids and phenolic compounds also provide antimicrobial and antioxidant effects. Different plant parts offer varying constituents: leaves contain flavonoids, tannins, and saponins; bark holds triterpenes and alkaloids; seeds have proteins and glycosides; pods are rich in sugars and phenolic compounds. The antifungal efficacy of Albizia saman is largely due to these constituents damaging fungal cell walls and inhibiting growth, thereby mitigating microbial infections.

❖ **Properties:**

- Albizia saman extract-containing nanogel has antifungal, antioxidant, and anti-inflammatory properties.
- Enhances bioavailability and patient compliance compared to traditional topical therapies via improve skin penetration and controlled drug release.
- Effectiveness relies on phytoconstituents like tannins and flavonoids.
- Common gelling agents such as HPMC and Carbopol 940 provide appropriate viscosity and stability.
- Suitable for topical use due to good spreadability, extrudability, homogeneity, texture, and pH.
- Quality is ensured through particle size analysis and in-vitro drug release assessment.

❖ **Future Scenarios in Herbal Medicines**

Nanogel-based antifungal therapy has significant potential but faces challenges for clinical application. Safety concerns arise from residual chemicals in synthesis, which may cause cytotoxic effects; thus, optimized purification and biocompatible polymers are needed. Stability and scalability issues, such as aggregation during storage, require robust synthesis and standardized production protocols. The regulatory landscape is lacking, hindering the approval of new therapies; collaboration between stakeholders is essential to establish effective guidelines. Additionally, targeted drug delivery is hampered by low specificity, necessitating strategies like surface functionalization and stimuli-responsive mechanisms. Future systems should focus on combination therapies to enhance treatment efficacy and combat drug resistance due to the complex nature of fungal infections.

II. INTRODUCTION TO ALBIZIA SEMAN (SAMANEA SAMAN)

- **Botanical name:** Samanea Saman (Jacq.) Merr,
- **Synonym:** Albizia saman, Pithecellobium samen Enterolobium saman, Inga saman, Pithecellobium saman, and Mimosa saman.
- **Family:** Fabaceae (Leguminosae)

➢ **Morphology:**

The rain tree (Albizia saman) is a large deciduous tree in the Fabaceae family, reaching heights of 15 to 25 meters with an umbrella-like canopy. Its strong tap root system and nitrogen-fixing nodules enhance soil fertility. The bark is thick and dark brown to grayish, while its small pinkish to reddish flowers appears in dense clusters. The tree's bipinnately complex leaves fold at night and during rain. The fruit is a flat, blackish-brown pod containing hard seeds and is valued for its canopy, blooms, and medicinal properties.

Figure no. 01 ALBIZIA SEMAN (SAMANEA SAMAN)

- **Bark:**

The mature tree's bark is hard, grey, and divided into long plates. The inner bark is bitter and pale in color. Younger trees have smoother bark that ranges in color from pale gray to brownish

- **Leaves:**

S. saman has alternating leaves measuring 2-4 cm long and 1-2 cm wide, featuring a bulge at the petiole base. The leaves include yarn-like stipules and two to six pairs of pinnae, with each pinna consisting of six to sixteen diamond-shaped leaflets. They are pinnately complex and shiny green on the top, with a somewhat dry appearance on the undersides. In humid climates, S. saman appears evergreen despite being semi-deciduous, as it sheds leaves in the summer but quickly regrows them in moist conditions.

- **Flower:**

The S. saman tree yields 12–25 small flowers per head, each having a white interior and a pinkish-red outside. Each flower head is 4 cm tall and 5–6 cm wide, resembling a feather duster in its fluffy appearance. The tree is covered in pinkish blossoms at the same time by thousands of these heads during flowering.

- **Growth Habit:**

Large deciduous tree with a broad, umbrella-shaped canopy, growing quickly to heights of 15 to 25 meters. It thrives in tropical and subtropical regions and features symmetric branches and deep roots. The leaves fold at night and during rainfall, making it a popular choice for shade and decorative purposes

- **Medical Uses:**

Tamarind tree (S. saman) is associated with various folk remedies for headaches, colds, diarrhea, stomach aches, and stomach cancer. Its boiled bark serves as a constipation bandage, and a decoction of its inner bark and leaves aids diarrhea. In Venezuela, roots are used in hot baths for stomach cancer, while in the West Indies, seeds alleviate sore throats. The plant exhibits antimicrobial properties against pathogens and fungi, as well as antioxidant, anti-plasmodial, and cytotoxic effects. Leaf extracts inhibit Mycobacterium tuberculosis, and alkaloids influence the nervous systems. Leaf infusions act as laxatives, and fruit decoctions serve as sedatives. Research continues on the protective qualities of its leaves and bark.

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➢ **Research Needs:**

- The therapeutic qualities of Samanea saman include antifungal, antibacterial, antioxidant, and anti-inflammatory actions.
- There is little scientific proof of its conventional applications, which calls for more investigation.
- The active phytochemical components of the plant must be identified and separated.
- There are currently few investigations on its pharmaceutical formulations (such as creams, nanogels, and herbal drug delivery systems).
- It is essential to look at its toxicity, safety, and clinical efficacy.
- The creation of affordable herbal remedies from natural sources could be aided by research.
- Investigating its antibacterial properties might help with problems related to drug resistance

Kingdom	Plantae
Sub Kingdom	Tracheobionta
Division	Magnoliophyta
Class	Magnoliopsida
Order	Fabales
Family	Fabaceae (Leguminosae)
Sub family	Mimosoideae
Botanical Name	Samanea saman (Jacq.) Merr.
Genus	Samanea
Species	Albizia saman /Samanea saman

Table No 1. Classification of plant

➢ **MEDICAL PROPERTIES**

Samanea saman is a medicinal plant known for its therapeutic properties in traditional medicine. Its leaves, bark, seeds, and pods are rich in bioactive phytochemicals like flavonoids, tannins, alkaloids, and saponins, which contribute to its antifungal, antibacterial, antioxidant, anti-inflammatory, and wound healing effects. The plant's extract is effective against various fungal species and shows significant antibacterial activity against both Gram-positive and Gram-negative bacteria.

Antifungal Activity: This extract has proven effective against various fungal species, making it a viable treatment for fungal infection

III. MATERIALS AND METHODS

METHODS

• PLANT COLLECTION AND AUTHENTICATION

The aerial part of the plant Samanea saman (Albizia saman) was collected from Kasegoan, Sangli District and authenticated in Department of Padmabhushan Vasantraodada Patil Mahavidyalaya, Kavathemahankal-416405.Soon after collection, the leaves were cleaned and shade dried. After drying, these leaves were crushed to a coarse powder, stored in air tight plastic containers for further use.

Figure no. 2: Albizia Saman Leaves Powder

- **EXTRACTION OF THE PLANT MATERIAL**

S. Saman 50 g leaves kept under the shade for drying and from powdered of leaves into mortal pistel, After Soxhlet apparatus was used in the extraction process, and 200ml ethanol was first used to extract coarse powdered leaves. Ethanol was used in a second extraction of the defatted substance. To create a viscous mass, the resultant extracts were concentrated using a rotary evaporator and then dried at room temperature.

Figure no.3: Leaf soxhlet extraction Albizia saman

IV. QUALITATIVE PHYTOCHEMICAL ANALYSIS

- **Preparation for test samples**

The Nanogel containing Albizia saman extract was dissolved in distilled water and filtered for qualitative phytochemical analysis. Various reagents were used for screening phytochemicals: Shinoda for flavonoids, Wagner for alkaloids, TCM, and others for terpenoids/sterols, ferric chloride for phenols, and various tests for saponins, tannins, amino acids, carbohydrates, glycosides, phlobatannins, quinones, and oxalates, following established protocols.

Flavonoids: 2mL of S. saman plant extract was treated with 5 mL of pure water as the solvent. A volume of 2 mL of filtrate was combined with pure hydrochloric acid, followed by the addition of 1mg of Mg powder (Shinoda reagent). The appearance of a light pink coloration occurred after some time.

Alkaloids: 2mL of diluted hydrochloric acid solution was transferred to the 5 mL methanol filtrate. Following the application of warmth to the mixture using a water bath, a few droplets of Wagner's reagent were then introduced. The detection of alkaloids has been achieved by observing the development of a reddish-coloured residue.

Terpenoids: 2 mL of S. saman leaf extract was poured with 5mL of trichloromethane (TCM), 3 mL of acetic anhydride, and pure H2SO4. This made for clear layers. The occurrence of terpenoids was confirmed by observing a heavy, dark red colouration of the junction.

Steroids: Several droplets of acetic anhydride were poured into 2 mL of S. saman extract, which was then heated and chilled. After that, 2 mL of pure H2SO4 is poured along the walls of the glass beaker to dilute the solution. The appearance of a brownish-coloured ring at the intersection of the two layers, as well as the Colour change of the top layer, confirmed the existence of steroids.

Phenol: 1 mL of a 5% fresh FeCl 3 solution was mixed with 2mL of S. saman extract. The mixture can be noticed by having indigo or dark greenish colouration.

Sterol: 2 mL of S. saman extract poured into 2 ml of TCM, 2ml of acetic anhydride, and one drop of concentrated H2SO4. The appearance of sterol is confirmed by the development of a violet Colour.

Saponins: 1 g of S. saman was finely powdered, and 10 mL of pure water was rapidly mixed. The resultant solution was then inspected for the presence of a firm and continuous foam. The foam was combined with a small quantity of oil and agitated briskly, following which it was examined for the occurrence of emulsification.

Tannins:2 mL volume of S. saman extract was mixed with 2mL of a 5% fresh ferric chloride solution, and the resulting mixture was examined for the occurrence of a pale-brown or golden-brown deposit, which confirmed the presence of tannins.

Amino acid: 2 mL of S. saman extract was treated with several droplets of 2% alcoholic Ninhydrin solution and warmed in a water bath. A deep blue or violet precipitate was formed, which indicates the presence of amino acids (proteins).

Carbohydrates: In 2 mL of S. saman extract, Molisch reagent (alcoholic α-naphthol) was added.

Method of preparation of nanogel

Preparation of carbopol dispersion: - To prepare the carbopol dispersion, mix 15 ml of pure water in a 100 mL beaker while stirring at 400 to 500 rpm. Gradually add carbopol and stir for 15 minutes, then stop stirring and cover the beaker to let it hydrate for two hours. Afterward, gently stir for 5 to 10 minutes to achieve uniformity. For the HPMC solution, combine 5–7 ml of filtered water with of HPMC, stirring for 15 minutes before allowing it to hydrate for 30 to 45 minutes. Stir again briefly before blending. Combine the carbopol dispersion with the hydrated HPMC solution and stir for 20 minutes at 500 rpm to ensure a homogenous mix without lumps.

Alcoholic phase: To prepare the mixture, take ethanol and add 2 propylene glycols, mixing thoroughly. When adding the alcoholic phase, reduce the stirring speed to 400 rpm and slowly incorporate it into the polymer mixture, stirring for 20-30 minutes while avoiding high RPM.

ISSN: 2581-9429
Volume 6, Issue 13, May 2026
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Neutralization phase: Neutralization involves adding Triethanolamine dropwise while stirring gently at 300-400 rpm. Monitor the increase in viscosity, check the pH, and adjust it to a range of 5.5 to 6.5. Finally, make the total volume 50 ml, stir for 10 minutes, and let it stand for 30-60 minutes.

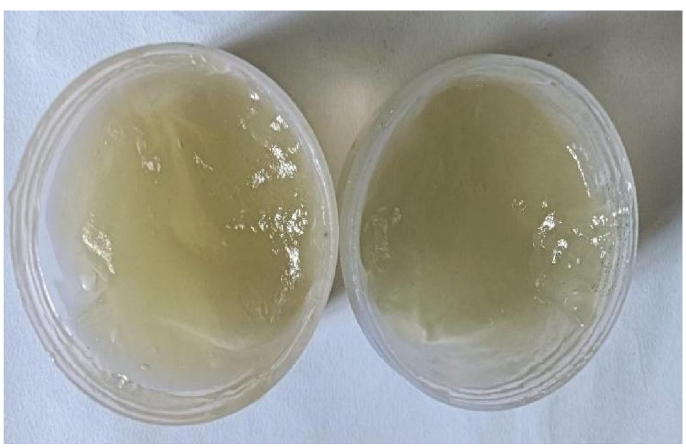
Figure : Preparation of Nanogel

Formulation table

Table no.4: formulation table

Sr.no	Ingredient	F1	F2	Function
1	Plant extract	5	6.25	API [Active pharmaceutical ingredient]
2	Carbopol 940	0.75	1.00	Gelling Agent
3	HPMC [Hydroxy propyl methylcellulose]	0.75	1.00	Thickening Agent
4	Propylene Glycol	1.25	1.50	Penetration Enhancer
5	Triethanolamine	q. s	q. s	PH adjustment
6	Methyl paraben	0.050	0.062	Preservative
7	Propyl paraben	0.005	0.006	Preservative
8	Distilled water	q.s to 25g	q.s to 25g	Solvant

Figure no. 5 Formulation of Nanogel



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V. SUMMARY AND CONCLUSION

• Organoleptic Properties

Physical	F1	F2
Colour	Green	Light green
Texture	Slightly Thick	Smooth
Homogeneity	No lumps	No lumps
Odour	Characteristic herbal odour	Characteristic herbal odour
Appearance	Smooth gel	Smooth gel
Clarity	Clear	Slightly clear
Consistency	Semi-solid	Semi-solid
Spreadability	Moderate	Good

Table no. 5 organoleptic properties table

➢ **PH Test :** The pH of the formulated herbal nanogel containing Albizia saman extract was found within the acceptable range of 5.5–7.0, indicating suitability for topical application

1. Method for pH Determination
2. Take 1 g of nanogel.
3. Disperse in 25 mL distilled water.
4. Allow you to stand for 2 hours.
5. Measure pH using a calibrated digital pH meter at room temperature

F1 batch	5.56
F2batch	6.13

Spreadability Test

- Two clean glass slides
- Place amount of nanogel (0.5–1 g) one slide
- Second slide on top
- Sandwich method
- Apply std weight (500 g)
- For uniform spreading
- Time taken for the upper slide to move a fixed distance

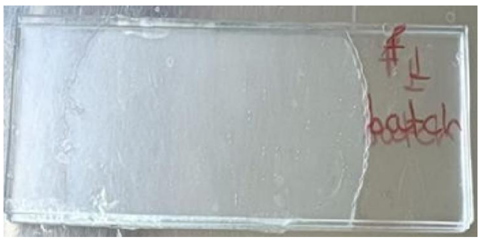
S= weight × Distances / time

Where, M = weight tied to upper slide (g)

L = length moved by slide (cm)

T = time (sec)

Batch	Gel amount	Weight (g)	Distance	Time (sec)	Spreadability
F1	0.5 g	11g	5	7	7.87
F2	0.5 g	11g	5.5	6	10.08



Viscosity

Viscosity is an important evaluation parameter of herbal nanogel formulations. It indicates the thickness and flow behavior of the gel, which affects spreadability, drug release, stability, and patient acceptability

- **Procedure**

Transfer the prepared nanogel into a clean beaker.

Place the spindle of the viscometer into the gel without trapping air bubbles. Rotate the spindle 4 at selected speed (e.g., 12 rpm).

Record the viscosity reading in centipoise (cP)

Batch	RPM	Viscosity	Observation
F1	12	11419	Slightly thin
F2	12	18447	Good Consistency

Table viscosity table

Skin Irritation

The skin irritation test is performed to evaluate the safety and compatibility of the herbal nanogel for topical application

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Figure no. 9 Evaluation test of Skin irritation

- **In vitro test**

Activity: Antifungal activity by well diffusion method

Media: Sabouraud Dextrose agar (Hi Media)

- The inoculum of the microorganism was prepared from the fungal cultures. 15ml of Sabouraud Dextrose agar (Hi media) medium was poured in clean sterilized Petri plates and allowed to cool and solidify.
- 100 µl of broth of fungal strain was pipetted out and spread over the medium evenly with a spreading rod till it dried properly.
- Wells of 6mm in diameter were boring using a sterile corn borer. Solutions of the compounds (100µl/ml) were prepared in DMSO and 100µl of prepared test solutions and standard was added to the wells. The petri plates incubated at 370C for 24 h.
- Miconazole (1mg/ml) was prepared as a positive control and DMSO was taken as negative control.
- Antifungal activity was evaluated by measuring the diameters of the zone of inhibitions (ZI)

VI. RESULTS

Anti-fungal Activity of test samples against T. rubrum

SR.NO	SAMPLES	ZONE IN DIAMETER (mm)
1	Control	00
2	Standard (Miconazole)	12 8
3	NaNogel	07

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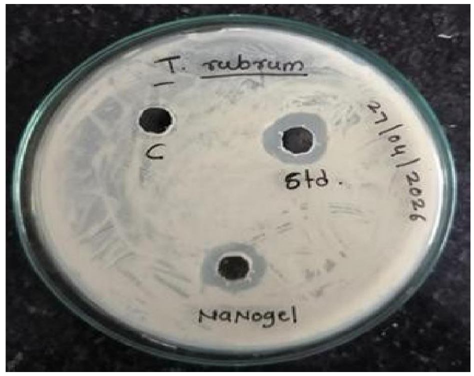

Figure no. 10 Antifungal Activity

Image Activity:

- **Conclusion of the study:**

The antifungal activity of the Nanogel was evaluated against T. rubrum using the well diffusion method. The Nanogel exhibited a measurable zone of inhibition (7 mm), indicating moderate antifungal activity. While its efficacy was lower than the standard drug Miconazole (12 mm), it still demonstrated potential antifungal properties compared to the control, which showed no activity. These results suggest that Nanogel possesses promising antifungal potential and may be considered for further optimization and detailed studies

VII. CONCLUSION

The research developed an herbal nanogel with Albizia saman extract to enhance antifungal activity. Recognized for their therapeutic advantages and minimal side effects, herbal drug delivery systems are gaining prominence. This study successfully encoded the extract into a nanogel using suitable polymers, which was evaluated for physicochemical properties like stability, pH, viscosity, and spreadability, all indicating its topical suitability. Phytochemical analysis revealed bioactive compounds such as flavonoids and tannins that contribute to its antimicrobial properties. Antifungal tests showed significant inhibition of fungal growth, particularly against Trichophyton rubrum, attributed to improved penetration and controlled release of the herbal extract. The study concludes that the Albizia saman nanogel presents a promising alternative for topical antifungal treatments, merging herbal medicine with nanotechnology for enhanced therapeutic benefits, while advocating for further pharmacological and clinical validation

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International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429

Volume 6, Issue 13, May 2026

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DOI: 10.48175/568