INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

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Research Article

Phytochemical-Guided Formulation and Pharmacological Evaluation of Plumeria Alba Extract-Based Antimicrobial Gel

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ARTICLE INFO

Published: 6 July. 2026
Keywords:
Plumeria Alba, Herbal gel, Antifungal gel, Methanolic extract, Antioxidant etc.
DOI:
10.5281/zenodo.21218902

ABSTRACT

This study focuses on the pharmacological assessment and phytochemical-guided formulation of an antibacterial gel that contains methanolic extract of Plumeria Alba, a plant with a rich bioactive profile and traditional usage. Plumeria Alba, sometimes known as frangipani or West Indian jasmine, has strong anti-inflammatory, antibacterial, and antioxidant qualities. The study used 95% methanol to extract the active chemicals from P. Alba flowers, which were then added to a gel base made of carbomer and aloe vera gel. Three formulations with different extract amounts were made, and their physicochemical characteristics—including pH, homogeneity, spreadability, viscosity, drug content, and stability—were methodically assessed. Every formulation showed smooth texture, high homogeneity, and pH values between 4.7 and 5.7 that are suitable for skin application. Crucially, there were no indications of skin irritation, indicating the gels' safety for topical application. Strong antifungal efficacy was demonstrated by formulation F3, which showed the widest zone of inhibition (21 mm) when tested against Candida albicans. The drug content showed effective drug integration, ranging from 91.8% to 97.6%. Overall, the investigation confirms that a stable, non-irritating herbal gel with strong antibacterial action can be made using Plumeria Alba methanolic extract. This validates Plumeria Alba's historic medical use and suggests a promising application in treating skin infections.

INTRODUCTION

The antioxidant, antibacterial, and anti-inflammatory qualities of Plumeria alba, often known as West Indian jasmine or frangipani, make it a popular and ancient folklore cure.[1] Plumeria, also known as frangipani, is essentially the same blooming plant that is a member of the Pinaceae family, which includes dogbane. These are essentially small, flowering trees and shrubs that

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

are native to Central America, Mexico, the Caribbean, South America, and even Brazil. However, they may be grown in any tropical region. This 4.5-meter-tall plant is occasionally planted for decorative purposes in gardens, according to observations. The plant is undoubtedly grown mostly for its lovely, fragrant blossoms. Furthermore, it is mostly grown for aesthetic reasons.[2] The flowers are white and fragrant, and the leaves are lance-shaped. While the seeds cease bleeding, the fruit itself can be consumed. Additionally, the plant's latex helps heal wounds and skin issues. Crushed bark is applied as a plaster to hard tumours, and this plant is undoubtedly effective in lowering blood pressure, clearing the stomach, and treating cardiac issues. Additionally, the plant extract has the ability to eradicate dangerous bacteria like Pseudomonas aeruginosa and Bacillus anthracis. It also contains significant ingredients like sitosterol and iminoacetate. Frangipani flower extract has been shown to be an antibacterial agent that inhibits a variety of bacterial strains and acts as an antioxidant by stabilizing or neutralizing free radicals. It must be created for the good of humanity. The potential of frangipani flowers as antioxidants and antibacterials, as well as their use in pharmacological activities that may lead to the creation of new drugs for a number of illnesses, will be discussed in this paper.[3]

Figure No: 01[4]

- **Scientific name**: Plumeria alba.
- **Common name**: White Frangipani/caterpillar tree/pagoda tree/pigeon wood/nosegay tree/white frangipani.
- **Family:** Pinaceae.
- **Availability:** Generally available in many areas within its hardiness range.
- **Native Range:** Puerto Rico, Lesser Antilles Pharmacological Activity of Plumeria Alba
- **Zone:** 10 to 12
- **Height:** 15.00 to 25.00 feet.

Major Chemical Constituent:

Table No: 01 Major Chemical Constituent 5-7

Plant Part	Major Chemical Constituent

Flowers	Linalool, Terpineol, Plumieride, Quercetin, Kaempferol, sitosterol
Leaves	Hexadecane, Octadecane, arnesene, Phytol, Flavonoids, Terpenoids
Bark	Plumieride, Isoplumericin, Plumericin, amyrin, Lupeol, Tannins
Latex	Tannine, sitosterol, Amyrin acetate, Resins, Cardiac glycosides

Anti-Microbial Activity:

When it comes to common Ur gastrointestinal pathogens like Escherichia coli, Plumeria Alba seems to have significant antimicrobial qualities, functioning similarly to a broad-spectrum antibiotic. Since many E. coli strains are known to be harmful and frequently exhibit resistance to synthetic medications, finding efficient natural substitutes is crucial. This fragrant plant exhibits potential as a source of novel antibacterial chemicals and as a safe, non-toxic source of molecules that resemble antibiotics.

Mechanism of Action

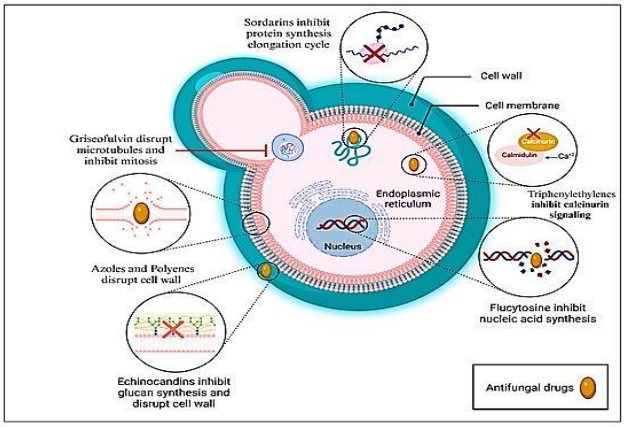

Figure No.: 02 Mechanism of Action

Table No: 02 Mechanism of Action[8-9]

Phytochemical	Class	Mechanism of Antimicrobial Action	Activity Against
Flavonoids	Polyphenols	Disrupt microbial cell membrane, inhibit enzyme activity	Bacteria, fungi
Alkaloids	Nitrogen-containing compounds	Interfere with DNA replication and protein synthesis	Bacteria
Tannins	Phenolic compounds	Precipitate proteins, damage microbial cell wall	Bacteria, fungi
Saponins	Glycosides	Increase cell membrane permeability → cell lysis	Bacteria, fungi

Terpenoids	Lipid-soluble compounds	Disrupt membrane integrity and respiration	Bacteria
Glycosides	Sugar-containing compounds	Interfere with microbial metabolism	Bacteria
Steroids	Lipid compounds	Affect membrane stability and permeability	Bacteria

Advantages of Herbal Antimicrobial Gel

- Compared to synthetic treatments, the natural and safe formulation has less negative effects.
- Strong antibacterial action against fungus and bacteria

LITERATURE REVIEW:

1. **Pharmacological, phytochemical, and traditional uses of Plumeria alba LINN. an Indian medicinal plant (Jagdish Sura, Sumeet Dwivedi, Raghvendra Dubey) et.al 2021**

   Plumeria alba (White Champa) is a tropical ornamental plant valued for its fragrant white flowers and medicinal uses. Its leaves, stem, latex, seeds, and bark contain bioactive compounds used in traditional medicine. The latex is applied for skin conditions like ulcers, herpes, and scabies, seeds have haemostatic properties, and bark is used on tumors. The plant also shows purgative, cardiotonic, diuretic, and hypotensive effects. Its therapeutic value is documented in Ayurvedic texts like the Charaka Samhita and Sushruta Samhita, reflecting the long-standing reliance on plant-based medicine.

2. **Potential antimicrobial compounds in flower extract of Plumeria alba. (Malik F. H. Ferdosia, Muhammad Kaleem Naseem a, Aroosa Afzal a, Iqra Haider Khan b, Arshad Javaid b) et.al 2021**

   The methanolic flower extract of *Plumeria alba* showed strong antimicrobial activity against various fungal (*Trichoderma* spp.) and bacterial species, with effectiveness varying by concentration and organism. Growth inhibition was significant across all tested microbes. GC–MS analysis identified 21 compounds, with benzofuran derivatives being the most abundant, likely contributing to the extract's antimicrobial effects.

3. **Potential of frangipani flower (Plumeria sp.) As a source of antimicrobial and antioxidants and its application in the pharmacological activities: a short review (Krishna Purnayan candra1,2, gisti malinda lestari1, sulistyo prabowo1, yuliani1, marwati1, maulida rachmawati1) et.al 2019**

   Frangipani (*Plumeria* spp.) is an ornamental plant with medicinal value, traditionally used for conditions like inflammation, itching, diabetes, and malaria. Its flowers show broad antimicrobial activity against various bacteria and fungi, as well as strong antioxidant properties due to phenols and flavonoids. Compounds such as saponins contribute to its antimicrobial effects, highlighting its potential for pharmaceutical use.

4. **Comparative phytochemical screening of flowers of plumeria alba and plumeria rubra (zahid zaheer, ajinkya g konale, khuman a patel, subur khan, rana. Z. Ahmed) et.al 2019**

Since ancient times, plants have served as a major source of medicine, and modern research continues to explore those mentioned in traditional systems. *Plumeria alba* and *Plumeria rubra*, belonging to the genus *Plumeria* and family Apocynaceae, are widely used for their therapeutic properties. *P. alba* is traditionally used to treat ulcers, herpes, and scabies; its seeds have haemostatic properties, and its bark is applied to hard tumors. *P. rubra* is used in the treatment of venereal diseases, as well as in indigenous medicine for rheumatism, diarrhoea, blennorrhea, and leprosy. The present study focuses on a comparative preliminary phytochemical screening of the flowers of these two species.

5. **Preparation and evaluation of different herbal gels synthesized from Chinese medicinal plants as an antimicrobial agent (Chirag Upadhyay, Vibha, Devender Pathak, Mayank Kulshreshtha) et.al 2015**

The present study aimed to formulate and evaluate herbal gels containing extracts of *Allium cepa* (Chinese onion), *Azadirachta indica* (Yin Lian Ye), and *Mentha piperita* (Chinese peppermint), and to assess their antimicrobial activity against various microorganisms. These plants are well known for their medicinal value in traditional Chinese medicine. Topical gel formulations were prepared individually and in combination using Carbopol-940 as a gelling agent along with suitable excipients. The antimicrobial activity was tested against selected microbial strains, including *Staphylococcus aureus*, *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Aspergillus tubingensis*, which are associated with acne and other skin infections.

AIM:

To assess Plumeria Alba extract's antibacterial efficacy against particular microbes when added to a gel composition.

OBJECTIVES:

- To gather and prepare the flowers, leaves, and bark of Plumeria Alba plants.
- To use an appropriate extraction technique (such as solvent extraction) to prepare the Plumeria Alba extract.
- To create a gel with the extract from Plumeria Alba.
- To assess the prepared gel's physical characteristics, including its pH, viscosity, spreadability, and appearance.
- To use techniques like agar well diffusion to assess the gel's antimicrobial effectiveness against certain bacteria and fungi.
- To assess the gel's antibacterial efficacy in comparison to a control or standard medication.
- To statistically evaluate and interpret the findings.

PLAN OF WORK:

Selection of Topic

This is the project's initial phase. Based on interest, necessity, and resource availability, an appropriate and pertinent topic is selected at this stage. The subject should be understandable, researchable, and beneficial to the study.

Literature Review

A literature review entails gathering and analysing data from books, research papers, journals, articles, and earlier studies on the subject. It aids in identifying research gaps and comprehending current knowledge.

Selection Ingredients

The materials or substances needed for formulation are chosen in this step based on their qualities, uses, compatibility, and suitability for the research or product development.

Procurements of Material

Once the ingredients have been chosen, the necessary supplies, chemicals, tools, and equipment are bought or gathered from reputable sources for the experiment.

Formulation Development

In this step, the formulation is prepared utilizing specific ingredients in various ratios and techniques. It is possible to prepare trial batches in order to achieve the necessary product attributes.

Optimization of Formulation

To find the optimal formulation among various trials, optimization is done. To determine the ideal formulation, a number of factors are assessed, including stability, efficacy, appearance, and performance.

Result

The collected experimental data are carefully interpreted and analyzed using appropriate techniques. To ascertain whether the study's goals have been met, data are compared and discussed.

Conclusion and Summary

The study's overall conclusions are summed up in the conclusion. It emphasizes the formulation's success, significant findings, and potential recommendations or future scope.

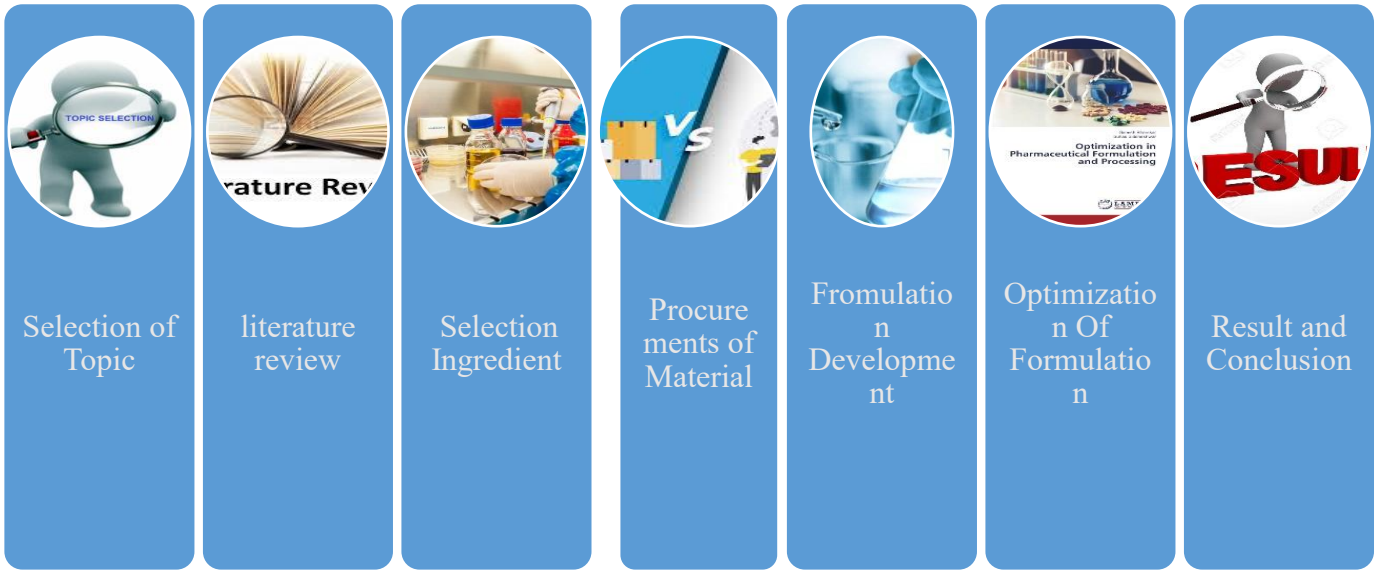

Figure No.: 03 Plan of Work

MATERIALS AND METHODS:

Extraction:

1. P. Alba flowers in good condition were gathered and placed in paper bags for transportation to the lab.
2. The petals were removed from the flowers after washing and placed in trays to allow the water to drain from their surface.
3. Flowers were completely pulverized in a pestle and mortar after being dried in the shade.

4. In a closed container, flower extract was made in 95% methanol by slowly heating it to 40 °C for 60 minutes.
5. The residual gummy substance (methanolic extract) was utilized for antimicrobial bioassays after the solvent was filtered and evaporated on a rotary evaporator at 40 °C under low pressure.

Formula

Table No: 03 Formulas

Ingredients	Formulation 1	Formulation 2	Formulation 3
Plumeria alba	2ml	4ml	6ml
Alvera Gel	1g	1g	1g
Polyethylene Glycol	3ml	3ml	3ml
Methyl Paraben	2mg	2mg	2mg
Propyl Paraben	2mg	2mg	2mg
glycerine	2ml	2ml	2ml
Carbomer	4mg	5mg	6mg
Rose water	q. s	q. s	q. s
Triethanolamine	q. s	q. s	q. s

Table No: 04 Ingredients and Use

Ingredients	Uses
Plumeria alba	Active Ingredient
Alovera Gel	Skin Conditioning
Polyethylene Glycol	Penetration
Methyl Paraben Propyl paraben	Preservative
Carbamer	Base Agent
Rose Water	Buffer

Preparation of Gel:

Preparation of gel base:

1. Carbomer and aloe vera gel were used as gelling agents in formulations made from Plumeria Alba flower extract.
2. A mechanical process was used to create the gels.

3. The necessary amount of aloe vera gel and carbomer was weighed separately, and an adequate amount of distilled water was combined in a different beaker.
4. It was then held at room temperature for 24 hours after being continually agitated by a mechanical stirrer until it was saturated in the water.[10-12]

Preparation of gel:

1. The proper amount of propyl and methyl paraben, which serve as preservatives, was added while stirring continuously.
2. To reach a neutral pH, little amounts of triethanolamine were added while being constantly stirred.
3. Lastly, Plumeria Alba flower oil was added to the gel and continuously stirred until the oil was well distributed.
4. The wide mouth bottle container was filled with the prepared gel and sealed.[13]

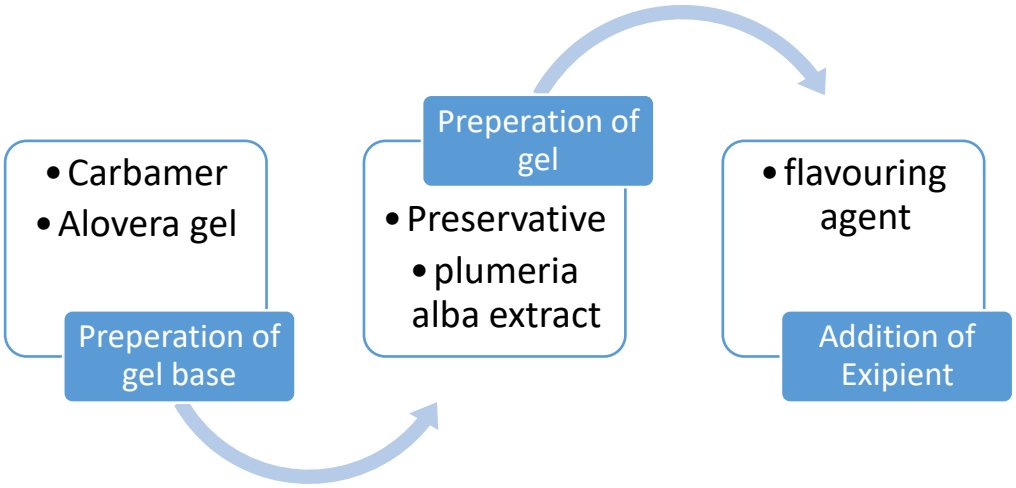

Figure No: 04 Preparation of Gel

EVALUATION PARAMETER:

A number of physicochemical characteristics, including colour, odour, consistency, homogeneity, pH, spreadability, grittiness, washability, viscosity, and drug content, were assessed for prepared formulations.

Organoleptic characteristic:

Gels are homogeneous, translucent, fluid, elastic, and plastic substances with a viscous consistency.

In vitro observations were made to determine the type of gel and its organoleptic properties.

The colour, smell, and texture of the herbal gel were assessed.

pH:

A digital pH meter was used to measure the pH of the suspension after 5 grams of the gel formulation were individually dispersed in 45 millilitres of water.

Every formulation's pH was measured three times, and the averages of the three values were recorded.

Figure No: 06 pH Determination

Homogeneity:

After the formulations were placed in the container, their homogeneity was examined visually. Their appearance and the existence of any aggregates were examined.

Drug Content:

Weigh one gram of the created gel formulation precisely, and then pour it into a beaker.

To fully dissolve the gel, add an appropriate amount of phosphate buffer (pH 6.8).

To create a homogenous mixture, the fluid was constantly swirled.

Whatman filter paper was used to filter out insoluble particles from the prepared solution.

Phosphate buffer solution was used to provide appropriate dilutions.

A UV-visible spectrophotometer set to 282 nm was used to measure the absorbance of the diluted solution.

The extract's calibration curve was used to determine the formulation's medication content.

The test was performed in triplicate and the average value was recorded.

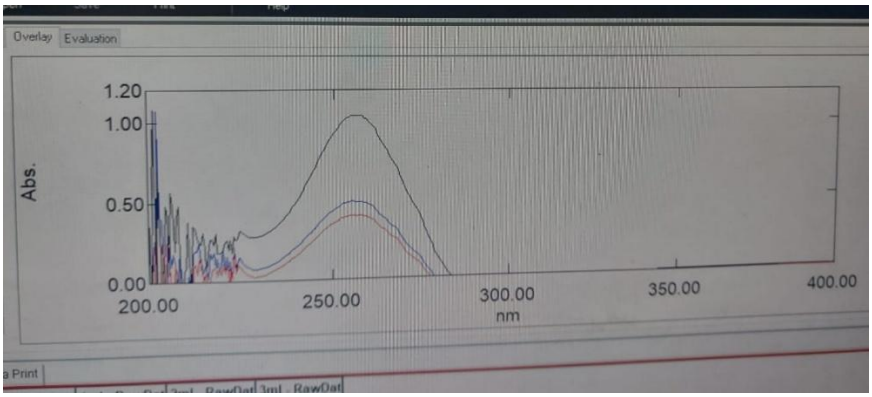

Figure No: 07 Absorbance

Viscosity:

A Brookfield viscometer DVII model with a T-Bar spindle and helipath stand was used to measure the gel's viscosity. A 100 ml beaker was filled with 50 g of gel.

The viscosity of each gel was measured using a T-bar spindle (64).

Viscosity was measured at 6 and 10 rpm as the helipath T-bar spindle was raised and lowered.

Figure No: 08 Viscosity Determinations

Skin irritation test:

The procedure applies a chemical topically for 42 minutes using the skin tissue rebuilt human epidermis model.

After applying the gel preparation to the skin, it was left for 30 minutes to check for any irritation. The skin showed no signs of redness or itching.

Spreadability test:

The gel was weighed up to 0.5 g before being put on glass-coated graph paper.

Next, we placed a second glass over the gel pile.

The diameter length of many sides was measured in order to calculate the gel diameter. Apply the formulated gel to the wound; it spreads evenly, easily, and without tiny particles.

The following formula was used to determine spreadability:

$S = M \times L / T$

Where, S = Spreadability,

M = Weight in the pan (tied to the upper slide),

L = Length moved by the glass slide and

T = Time (in sec.) taken to separate the slide completely each other.[11-14]

Figure No: 09 Spreadability Determinations

Stability Study:

The produced antifungal gel was kept at various temperatures in hermetically sealed containers.

At prearranged intervals, samples were taken out.

Color, odor, and physical characteristics were noted.

A digital pH meter was used to measure the pH.

A viscometer was used to measure viscosity.

The glass slide method was used to determine spreadability.

A UV spectrophotometer was used to measure the drug content.

Condition	Temperature
Room Temperature	25 ± 2°C
Refrigerated Temperature	4 ± 2°C
Accelerated Temperature	40 ± 2°C

Table No: 05 Storage Condition

Antifungal Activity:

The potato dextrose agar medium was correctly prepared and sterilized.

After being transferred into sterile petri dishes, the sterile medium was left to harden.

A sterile cotton swab was used to evenly distribute the Candida albicans fungal culture across the agar surface.

A sterile cork borer was used to create wells in the agar plate.

Each well was filled with the necessary amount of antifungal gel.

To allow the gel to diffuse into the medium, the plates were left at room temperature for a while.

For 24 to 48 hours, the plates were incubated at 25 to 28°C.

The zone of inhibition's diameter was measured in millimetres following incubation.

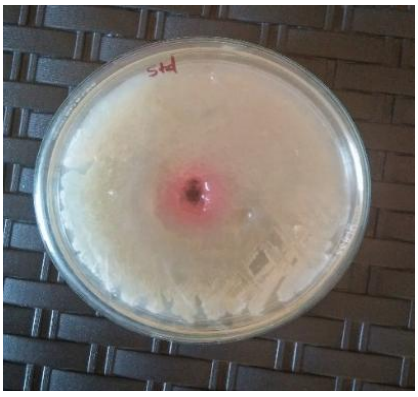

Figure No: 10

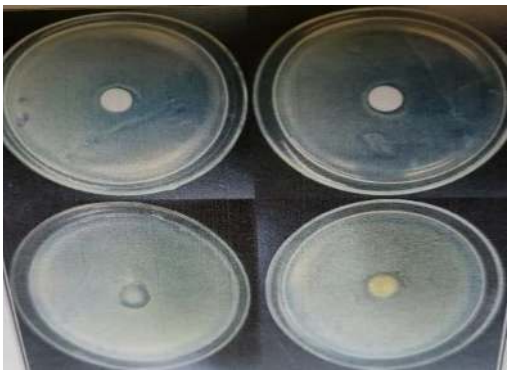

Figure No: 11

RESULT AND DISCUSSION:

Observation:

Drug Content:

Table No: 06 Observations

Sample	Absorbance
1ml	1.037
2ml	0.399
2ml	0.488

Selected absorbance: 0.488

Lambda max: 258

Standard concentration: 100ug/ml

Concentration Calculation = 0.488/0.500*100 = 97.6

Drug Content% = 97.6/100*100 = 97.6 %

Drug Content % = 97.6 %

Result Table: Table No: 07 Result

Evaluation Parameter	F1	F2	F3
Colour	Light white	Light white	white
Odour	Pleasant	Pleasant	Pleasant
Appearance	Smooth	Smooth	Smooth
Homogeneity	Good	Good	Better
pH	4.7	5.4	5.7
Spreadability	18 sec	15 sec	20 sec
Drug Content	95%	97.6%	91.8%
Skin Irritation	No irritation	No irritation	No irritation
Stability	Stable	Stable	Stable
Antifungal Activity (Zone of inhibition)	16mm	17mm	21mm

CONCLUSION:

Using methanolic extract from Plumeria Alba flowers, the study successfully created and assessed an antimicrobial gel with the goal of offering a safe and efficient substitute for traditional synthetic antibacterial agents. Flavonoids, terpenoids, tannins, and glycosides are just a few of the many bioactive substances found in Plumeria Alba that have been shown to have antibacterial and antioxidant qualities.

To improve stability, penetration, and preservation, three gel formulations (F1, F2, and F3) with increasing concentrations of Plumeria Alba extract (2 ml, 4 ml, and 6 ml, respectively) were made utilizing carbomer and aloe vera gel as bases in addition to additional excipients. The gels

showed good physicochemical properties: they were uniform, smooth, and had skin-compatible pH values (4.7 to 5.7), which reduced the possibility of discomfort. Tests for spreadability and viscosity verified the gels' uniform coverage, acceptable consistency, and ease of application.

High entrapment efficiency was demonstrated by drug content analysis, with values as high as 97.6%, indicating that the extract was properly incorporated into the gel matrix. The gels retained their chemical and physical characteristics throughout time, indicating formulation robustness, according to stability tests carried out at different temperatures. With a maximum zone of inhibition of 21 mm by the highest concentration gel (F3), antimicrobial testing against Candida albicans revealed significant antifungal activity, highlighting effective microbial growth suppression possibly due to the synergistic action of multiple phytochemicals disrupting microbial membranes and metabolism. Tests for skin irritation confirmed the gel's safety with no discernible negative effects, confirming its appropriateness for topical application.

In conclusion, the project's goals were met by creating a stable, natural, and strong antibacterial gel that may be used to treat skin infections. The study establishes the foundation for next clinical assessments and more extensive antibacterial research while validating Plumeria Alba extract as a viable phytotherapeutic agent.

FUTURE SCOPE:

- To assess advanced antibacterial activity, more research can be done.
- To verify safety and efficacy in humans, clinical trials may be conducted.
- It is possible to optimize the formulation by varying the excipients and extract concentration.
- The gel could be created for antifungal and anti-acne purposes.
- Additionally, it has anti-inflammatory and wound-healing properties.

ACKNOWLEDGEMENT:

The Authors are thankful to Guide Ms. Sameena Ibrahim Shaikh for providing the laboratory facility and her persistent creative encouragement and valuable guidance throughout the research work. Also, I would like to thank my supervisor, for all his help, guidance and assistance throughout the course of the work. It has been a great pleasure and wonderful learning experience to work under his supervision.

CONFLICTS OF INTEREST

The authors declare that they have no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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HOW TO CITE: Komal Gutte*, Sameena Shaikh, Gayatri Kale, Dipti Kanke, Apeskha Jaybhaye, Akash Jadhav., Phytochemical-Guided Formulation and Pharmacological Evaluation of Plumeria Alba Extract-Based Antimicrobial Gel, Int. J. of Pharm. Sci., 2026, Vol 4, Issue 7, 1184-1197. https://doi.org/10.5281/zenodo.21218902