International Journal for Research in Biology & Pharmacy
(ISSN: 2208- 2093)
Vol. 12, Issue 02, February 2026
DOI: 10.69980/bp.v12i1.2476

PREPARATION AND CHARACTERIZATION OF ANTIMICROBIAL POLYHERBAL GEL BY UTILIZING PLANT EXTRACTS OF NEEM, TURMERIC AND PIPAL: A REVIEW

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Received:28/11/2025 Revised:16/01/2026 Acceptance:10/02/2026 Published:25/02/2026

ABSTRACT:

Polyherbal gels have emerged as an effective form of topical formulation due to their synergistic effects from multiple plant extracts, enhancing therapeutic efficacy. This review focuses on the preparation, characterization, and antimicrobial activity of polyherbal gels using neem (Azadirachta indica), turmeric (Curcuma longa), and pipal (Ficus religiosa) as the primary active ingredients. These plants are well-known for their antimicrobial, anti-inflammatory, and healing properties. The review discusses various methods of formulating the gel, including extraction of plant components, gel base preparation, and the combination of these extracts to formulate a stable and effective antimicrobial gel. It also includes the characterization techniques, phytochemical screening, and in vitro testing methods for antimicrobial activity. Furthermore, the review explores the benefits of polyherbal gels, their potential application in skin infections, along with their future prospects in pharmaceutical and cosmetic industries.

Keywords: Polyherbal gel, antimicrobial activity, neem, turmeric, pipal, gel formulation,characterization, in vitro testing, plant extracts.

1. Introduction

Polyherbal gel is a semi-solid formulation containing a blend of two or more herbal extracts, dissolved in a suitable gelling agent, and optionally supplemented with preservatives, moisturizers, and other excipients. Herbal extracts, particularly Neem (Azadirachta indica), Turmeric (Curcuma longa), and Pipal (Ficus religiosa), possess inherent antimicrobial properties. This study aims to develop and evaluate an antimicrobial polyherbal gel formulation combining these herbs for topical applications.

Polyherbal gels are formulations derived from the combination of extracts of different medicinal plants, which are believed to work synergistically to enhance their therapeutic effects. In recent years, polyherbal gels have gained significant attention in pharmaceutical, cosmetic, and therapeutic applications due to their ability to provide multiple benefits over single-plant formulations. These gels are particularly known for their bioavailability, easy application, and ability to deliver active ingredients directly to the target site, especially for localized treatment.

The primary advantages of polyherbal gels include enhanced antimicrobial, anti-inflammatory, antioxidant, and healing properties, all contributing to effective treatment of skin conditions, wounds, and infections. Moreover, they offer a natural alternative to synthetic antimicrobial agents, reducing the risk of side effects and antibiotic resistance. The use of polyherbal gels as topical formulations provides controlled drug release and higher patient compliance. Here is the detailed information of Neem, Turmeric, and Pipal-

1.1 Neem (Azadirachta indica):

Neem is a tropical evergreen tree known for its antimicrobial, anti-inflammatory, and antioxidant properties. Its leaves, bark, and oil contain bioactive compounds such as flavonoids, alkaloids, and terpenoids. Neem has been proven to exhibit antimicrobial activity against a broad spectrum of bacteria, fungi, and viruses, making it an ideal candidate for inclusion in polyherbal gels. It is particularly beneficial in treating skin infections, acne, and wounds.

1.2 Turmeric (Curcuma longa):

Turmeric is a widely used spice and medicinal plant that contains the active compound curcumin, which has potent antimicrobial, anti-inflammatory, and antioxidant properties. Curcumin has been shown to inhibit the growth of various pathogenic microorganisms and enhance wound healing. Its inclusion in polyherbal gels can help in managing skin infections, inflammation, and oxidative stress.

1.3 Pipal (Ficus religiosa):

Pipal, also known as the peepal tree, is considered sacred in many cultures and is rich in bioactive compounds such as tannins, flavonoids, and alkaloids. The antimicrobial activity of pipal has been demonstrated against a range of bacteria, fungi, and viruses. It is also known for its anti-inflammatory, wound-healing, and antioxidant effects, making it an excellent choice for inclusion in polyherbal gels for skin applications.

1.4 Advantages of Polyherbal Gels:-

- **Synergistic Effects:** The combined antimicrobial, anti-inflammatory, and antioxidant properties of neem, turmeric, and pipal.
- **Enhanced Therapeutic Efficacy:** Potential for increased effectiveness over single herb formulations.
- **Biocompatibility and Safety:** Reduced side effects and better tolerance compared to synthetic drugs.

- **Sustainability:** Natural and eco-friendly ingredients in polyherbal gels.
- **Cost-Effectiveness:** Accessibility and affordability compared to pharmaceutical alternatives.

1.5 Challenges in Formulating Polyherbal Gels:-

- Standardization of Herbal Extracts: Variability in bioactive compounds and their concentrations.
- Stability and Shelf-Life: Maintaining the efficacy of the gel over time, especially the preservation of active compounds.
- Interactions between Herbs: Potential incompatibility between neem, turmeric, and pipal in formulations.
- Optimization of Gel Consistency: Achieving the right texture, viscosity, and spreadability while maintaining stability.
- Regulatory Hurdles: Challenges in the approval of herbal formulations and standardization practices.

2. Methods of Formulation of Polyherbal Gel: - The preparation of a polyherbal gel involves several steps:

2.1 Extraction of Plant Materials:

- **Neem:** Leaves and bark are usually subjected to solvent extraction (ethanol, methanol, or water) to obtain neem extract, which is rich in bioactive compounds.
- **Turmeric:** Curcumin can be extracted from turmeric rhizomes using solvents like ethanol or methanol.
- **Pipal:** The leaves or bark of pipal are extracted using solvents like ethanol or aqueous extraction methods.

2.2 Preparation of Gel Base:

The gel base can be prepared using natural gelling agent (carbopol 940). The base is usually mixed with the plant extracts in appropriate proportions to achieve a homogenous formulation.

2.3 Incorporation of Plant Extracts:

Once the extracts are obtained, they are combined with the gel base. The active components from neem, turmeric, and pipal are added carefully to avoid degradation of bioactive molecules. Stabilizing agents and preservatives are included to ensure the gel's longevity and efficacy.

3. Methods of Testing in Vitro Antimicrobial Activity of Polyherbal Gel:-To evaluate the antimicrobial efficacy of the formulated polyherbal gel, various in vitro methods can be used such as Disk Diffusion Method, Broth Dilution Method, and Agar Well Diffusion.

3.1 Agar well diffusion method: -The agar well diffusion method, also known as the agar disk diffusion method or Kirby-Bauer method, is a widely use technique in microbiology for assessing the antimicrobial activity of various substances, such as antibiotics, plant extracts, or synthetic compounds. Here is an overview of the procedure:

3.2 Materials and Reagents-

- Agar plates: Prepared with a suitable growth medium (e.g., Mueller-Hinton agar for bacteria).
- Microorganisms: Test strains of bacteria or fungi.
- Sterile swabs or inoculating loops.
- Antimicrobial agent: This could be a plant extract
- Sterile forceps.
- Sterile cork borer or pipette tip: Used to create wells in the agar. Incubator.

Procedure-

- Prepare agar plates by pouring the sterile agar medium into Petri dishes and allowing it to solidify.
- Streak the surface of the agar plates with standardized inoculums of the test microorganism using a sterile swab or inoculating loop. Ensure even distribution of the inoculums.
- Allow the inoculums to dry on the agar surface for a few minutes to prevent excess moisture.
- Using sterile forceps, place the antimicrobial agent onto the surface of the inoculated agar plates.

This could be in the form of antibiotic disks or small volumes of liquid solutions (e.g., plant extracts).

- If using a cork borer or pipette tip, create wells in the agar around the antimicrobial agent. Wells should be evenly spaced and sufficiently away from the edge of the plate to prevent overlap of Inhibition zones.
- Incubate the plates inverted (agar side up) in an incubator at the appropriate temperature for the test microorganism. Incubation time and temperature vary depending on the microorganism being tested (e.g., 37 °C for bacteria, 25-30 °C for fungi).
- After the incubation period, examine the plates for zones of inhibition around the wells containing the antimicrobial agent. Measure the diameter of the zones using a ruler or caliper.
- Interpret the results based on the diameter of the inhibition zones and compare them with established standards or breakpoints for the specific microorganism and antimicrobial agent being tested.

The agar well diffusion method provides a qualitative assessment of the antimicrobial activity of the test agent against the target microorganism. It is important to note that factors such as inoculums density, incubation conditions, and the diffusion rate of the antimicrobial agent can influence the results and should be standardized for accurate interpretation.

4. Characterization Techniques:-

1. **PH:** Measures the acidity or alkalinity of the gel. Use a pH meter (e.g., digital pH meter) to measure the pH of the gel. Dip the pH electrode into the gel and record the pH value.
2. **Viscosity:** Measures the thickness and flow ability of the gel. Use a viscometer (e.g., Brookfield viscometer) to measure the viscosity.
3. **Color:** Evaluate the color of the gel using a colorimeter.
4. **Texture:** Evaluate the texture of the gel using a texture analyzer.
5. **Clarity:** Evaluate the clarity of the gel using a turbidity meter.
6. **Spreadability:** Measures the ease of spreading the gel on a surface. Place a fixed amount of gel on the glass plate, start the stopwatch, and measure the time taken for the gel to spread to a predetermined distance.
7. **Stability:** Evaluate the stability of the gel over time using techniques like centrifugation, freeze-thaw cycles, or storage at different temperatures.

- **Centrifugation Test:** Evaluates the physical stability of the gel. Centrifuge the gel at 3000 rpm for 30 minutes. Check for phase separation, sedimentation, or changes in texture.
- **Freeze-Thaw Cycles:** Evaluates the stability of the gel under temperature fluctuations. Store the gel at -20°C for 24 hours, then thaw at room temperature (25°C). Repeat for 3-5 cycles. Check for changes in texture, consistency, or appearance.
- **Storage at Different Temperatures:** Evaluates the stability of the gel under various storage conditions. Store the gel at 4°C, 25°C, and 40°C for 30 days. Check for changes in pH, viscosity, texture, or appearance.

Phytochemical Screening of Neem, Turmeric, and Pipal:-

- **Neem (Azadirachta indica):** Key bioactive compounds (e.g., azadirachtin, nimbin) and their antimicrobial properties.
- **Turmeric (Curcuma longa):** Active compounds (curcumin, Curcuminoids) and their pharmacological effects.
- **Pipal (Ficus religiosa):** Phytochemicals (flavonoids, tannins, alkaloids) and their antibacterial, antifungal, and antiviral actions.

Factors Influencing Polyherbal Gel Characteristics:-

- **Selection of Gelling Agents:** Influence of natural and synthetic gelling agent (carbopol940) on gel formation and consistency.
- **Herbal Extract Concentration:** Effects of varying concentrations of neem, turmeric, and pipal on the antimicrobial efficacy and stability of the gel.
- **PH, Viscosity, and Texture:** How the pH, viscosity, and texture impact the release of active compounds and the gel's usability.
- **Formulation Factors:** Interactions between gel base, active herbal ingredients, and excipients.

- **Effect of Storage Conditions:** Temperature, humidity, and light exposure on the stability of herbal gels.

Recent Advancements in Polyherbal Gel Development:-

- **Nanoencapsulation:** Use of nanotechnology for controlled release and enhanced bioavailability of bioactive compounds.
- **Advanced Delivery Systems:** Development of transdermal and targeted delivery methods for improved therapeutic effects.
- **Sustainability and Natural Preservatives:** Use of natural preservatives and packaging to extend the shelf life and maintain efficacy.
- **Microencapsulation:** Techniques to preserve the integrity of sensitive bioactive compounds during gel formation.

Future Prospects of Polyherbal Gels:-

- **Chronic Wound Healing:** The potential for polyherbal gels in treating chronic wounds, burns, and ulcers, particularly with antimicrobial properties.
- **Skin Care and Dermatological Applications:** The use of antimicrobial polyherbal gels in treating skin conditions like acne, eczema, and psoriasis.
- **Biotechnology and Herbal Engineering:** Potential for biotechnology innovations in improving the extraction and formulation of herbal compounds for more effective gels.
- **Personalized Medicine:** Customizing polyherbal gel formulations based on individual skin needs or medical conditions.
- **Global Market Expansion:** Opportunities for polyherbal gels in emerging markets due to their affordability, safety, and natural appeal.
- **Regulatory and Ethical Considerations:** Addressing regulatory concerns and achieving standardization in herbal product manufacturing.

Conclusion:-

Polyherbal gels incorporating neem, turmeric, and pipal extracts offer a promising approach to antimicrobial therapy, combining the benefits of natural plant compounds with the convenience and efficacy of topical gel formulations. The gel aims to exhibit broad-spectrum antimicrobial activity, anti-inflammatory effects, and enhanced wound healing properties. Their natural composition reduces the risks associated with synthetic drugs, making them a safer alternative for treating skin infections and other ailments. The future prospects of these gels in the pharmaceutical and cosmetic industries are promising, especially with increasing demand for natural and sustainable products. Further research into optimizing formulations, improving stability, and expanding their therapeutic applications could enhance the impact of these polyherbal gels. The future of polyherbal gels is bright, especially as the global shift toward natural products continues. Further studies on the synergistic effects of various plant extracts and the optimization of gel formulations could open new doors in treating chronic infections, skin conditions, and even for use in cosmetic applications. Advances in nanotechnology and drug delivery systems may enhance the efficacy of polyherbal gels in the future.

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