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FORMULATION AND EVALUATION OF POLYHERBAL GEL CONTAINING NEEM, TURMERIC, AND DILL SEEDS FOR SKIN INFECTION

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ABSTRACT

Skin infections caused by pathogenic microorganisms remain a common dermatological concern requiring safe, effective, and patient-friendly topical therapies. Herbal drug delivery systems have gained increasing attention due to their biocompatibility, reduced side effects, and synergistic therapeutic potential. The present study was undertaken to formulate and evaluate a carbopol-based polyherbal gel containing extracts of neem (*Azadirachta indica*), turmeric (*Curcuma longa*), and dill seeds (*Anethum graveolens*) for the management of minor skin infections. The herbal extracts were prepared by ethanolic maceration and incorporated into Carbopol 940 gel in three different formulations (F1–F3). The prepared gels were evaluated for physicochemical parameters including physical appearance, pH, viscosity, spreadability, extrudability, and drug content, along with in vitro antimicrobial activity against *Staphylococcus aureus* and *Escherichia coli*. All formulations showed acceptable organoleptic properties, skin-compatible pH (6.1–6.6), satisfactory viscosity, and good spreadability. Drug content was found within acceptable limits, indicating uniform distribution of actives. Among the batches, formulation F2 demonstrated the most balanced physicochemical characteristics and exhibited the highest antimicrobial activity against the tested organisms. The enhanced activity may be attributed to the synergistic action of phytoconstituents present in neem, turmeric, and dill seeds. The study concludes that the developed polyherbal gel is a promising, economical, and patient-acceptable topical formulation for the management of minor skin infections. Further stability, antifungal, and clinical studies are recommended to substantiate its therapeutic utility.

Keywords: Polyherbal gel; Skin infection; Carbopol 940; *Azadirachta indica*; *Curcuma longa*; *Anethum graveolens*; Antimicrobial activity; Topical formulation

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INTRODUCTION

Skin infections represent one of the most common dermatological problems worldwide, affecting individuals of all age groups. They may be caused by bacteria, fungi, viruses, or parasites and often manifest as redness, itching, inflammation, pus formation, and discomfort. Common bacterial pathogens associated with superficial skin infections include *Staphylococcus aureus* and *Streptococcus pyogenes*, while fungal infections are frequently caused by *Candida* and dermatophyte species. The increasing incidence of antimicrobial resistance, adverse effects of synthetic drugs, and recurrence of infections have created a strong demand for safer and more effective alternative therapies. Topical drug delivery systems are widely preferred for the management of skin infections because they allow direct application to the affected area, provide localized action, minimize systemic side effects, and improve patient compliance. Among various topical dosage forms, gels have gained significant importance due to their non-greasy nature, ease of application, good patient acceptability, and ability to deliver both hydrophilic and lipophilic phytoconstituents. Herbal gels, in particular, have attracted growing attention because they combine the advantages of topical delivery with the therapeutic potential of medicinal plants. Medicinal plants have been used since ancient times in traditional systems such as Ayurveda, Unani, and Siddha for the treatment of skin disorders. Plant-derived bioactive compounds such as flavonoids, phenolics, terpenoids, alkaloids, and essential oils possess well-documented antimicrobial, anti-inflammatory, antioxidant, and wound-healing properties. The shift toward herbal formulations is driven by their perceived safety, biocompatibility, cost-effectiveness, and lower incidence of side effects compared with synthetic antimicrobials. However, many marketed herbal products lack proper scientific standardization and systematic evaluation, highlighting the need for well-designed pharmaceutical studies.

Azadirachta indica (Neem) is one of the most extensively studied medicinal plants for dermatological applications. Neem leaves are rich in bioactive compounds such as nimbidin, azadirachtin, and quercetin, which exhibit strong antibacterial, antifungal, anti-inflammatory, and wound-healing activities. Traditionally, neem preparations have been used to manage acne, eczema, ringworm, and other microbial skin infections. Similarly, *Curcuma longa* (turmeric) rhizome contains curcumin and related curcuminoids that possess potent antimicrobial, antioxidant, and anti-inflammatory properties. Turmeric has long been used in traditional medicine for treating wounds, boils, and inflammatory skin conditions. Although neem and turmeric are widely reported, the incorporation of seed-based phytoconstituents offers an opportunity to enhance antimicrobial efficacy through polyherbal synergy. *Anethum graveolens* (Dill) seeds contain essential oils (carvone, limonene), flavonoids, and phenolic compounds known for their antimicrobial and anti-inflammatory potential. Dill seeds have been traditionally

used for digestive ailments, but emerging evidence suggests their activity against certain bacterial and fungal strains relevant to skin infections. Despite these promising properties, dill seed extract remains underexplored in topical dermatological formulations, particularly in combination with neem and turmeric.

Polyherbal formulations are based on the principle of synergism, where multiple plant constituents work together to enhance therapeutic efficacy and reduce the required dose of individual components. Such combinations may provide broader antimicrobial coverage, improved anti-inflammatory response, and better overall skin healing compared with single-herb formulations. However, rational formulation design, proper extraction methods, compatibility assessment, and systematic evaluation are essential to ensure the quality, stability, and effectiveness of the final product. In recent years, there has been increasing interest in developing novel herbal gels using modern pharmaceutical techniques while keeping the formulation simple and economical for academic and small-scale production. Carbopol-based gels are particularly popular due to their excellent clarity, stability, and controlled drug release properties. Incorporation of optimized concentrations of herbal extracts into a suitable gel base can result in an effective topical antimicrobial system. The present study is therefore designed to formulate and evaluate a polyherbal antimicrobial gel containing neem leaf extract, turmeric rhizome extract, and dill seed extract for the management of skin infections. The work aims to develop a simple, cost-effective, and student-friendly formulation while maintaining scientific validity. The study further focuses on basic but essential evaluation parameters such as physical appearance, pH, viscosity, spreadability, extrudability, drug content estimation, and in vitro antimicrobial activity. This research is expected to provide a rational basis for the development of an effective polyherbal topical formulation and may serve as a useful reference model for B. Pharmacy students and researchers working in the field of herbal drug delivery systems. The aim of the present study is to formulate and evaluate a polyherbal topical gel containing neem leaves, turmeric rhizome, and dill seed extracts for the effective management of skin infections.

The primary objective of this work is to prepare and standardize herbal extracts of neem leaves, turmeric rhizome, and dill seeds using suitable extraction methods. The study further aims to develop a stable carbopol-based polyherbal gel incorporating the optimized concentrations of these extracts. Another important objective is to evaluate the formulated gel for its physicochemical properties such as appearance, pH, viscosity, spreadability, and extrudability to ensure suitability for topical application. Finally, the study intends to assess the antimicrobial activity of the developed formulation against selected skin infection–causing microorganisms to establish its therapeutic potential.

MATERIALS AND METHODS

Materials

Fresh neem leaves were collected and authenticated before use. Turmeric rhizome powder and dill seeds of good quality were procured from a local herbal supplier. Carbopol 940 was used as the gelling agent. Propylene glycol served as a humectant and penetration enhancer, while triethanolamine was used as a neutralizing agent to adjust the gel pH. Methyl paraben was incorporated as a preservative. Ethanol (analytical grade) was used as the extraction solvent, and distilled water was used throughout the formulation process. All chemicals and reagents employed in the study were of analytical grade and used without further purification.

Preparation of Herbal Extracts

Preparation of Neem Extract

Fresh neem leaves were first washed thoroughly with running tap water followed by distilled water to remove adhering dust and impurities. The cleaned leaves were shade dried at room temperature for about 7–10 days until a constant weight was obtained to preserve thermolabile constituents. The dried leaves were then coarsely powdered using a mechanical grinder and passed through sieve No. 40 to obtain uniform particle size. Approximately 50 g of the powdered neem leaves was transferred into a clean, dry conical flask and macerated with sufficient quantity of ethanol (approximately 250 mL) in a tightly closed container. The mixture was kept for 48 hours at room temperature with intermittent shaking every few hours to enhance extraction efficiency. After completion of maceration, the mixture was filtered first through muslin cloth and then through Whatman filter paper No. 1 to obtain a clear filtrate. The filtrate was concentrated by evaporating the solvent on a water bath maintained below 50°C until a semi-solid mass was obtained. The concentrated extract was transferred to an airtight container, properly labeled, and stored in a refrigerator until further use in formulation.

Preparation of Turmeric Extract

Turmeric rhizome powder was accurately weighed (50 g) and transferred into a clean, dry flask. The powder was macerated with about 250 mL of ethanol in a closed container for 48 hours at room temperature. The mixture was shaken intermittently to ensure maximum contact between solvent and plant material. After maceration, the extract was filtered through muslin cloth followed by Whatman filter paper No. 1 to remove insoluble matter. The clear filtrate obtained was concentrated on a water bath at a temperature not exceeding 50°C to avoid degradation of curcuminoids. The resulting semi-solid extract was collected, weighed, stored in a well-closed container, and kept under refrigerated conditions until further use.

Preparation of Dill Seed Extract

Dill seeds were first cleaned manually to remove foreign particles and then washed quickly with distilled water. The seeds were shade dried to remove surface moisture and subsequently

powdered using a mechanical grinder. The powdered material was passed through sieve No. 40 to ensure uniformity. About 50 g of the powdered dill seeds was placed in a conical flask and macerated with approximately 250 mL of ethanol for 48 hours in a tightly closed container. The mixture was shaken intermittently during the maceration period to facilitate efficient extraction of active constituents. After 48 hours, the mixture was filtered through muslin cloth and subsequently through Whatman filter paper No. 1. The filtrate was concentrated on a water bath below 50°C until a thick extract was obtained. The concentrated dill seed extract was transferred to a labeled airtight container and stored in a refrigerator for further formulation work.

Formulation of Polyherbal Gel

The composition of different batches of polyherbal gel is shown in table 1.

Table 1: Composition of Herbal Gel

Ingredient	F1 (% w/w)	F2 (% w/w)	F3 (% w/w)	Role
Carbopol 940	1.0	1.0	1.0	Gelling agent
Azadirachta indica extract	1.5	2.0	2.5	Antimicrobial
Curcuma longa extract	0.5	1.0	1.5	Anti-inflammatory
Anethum graveolens seed extract	1.0	1.5	2.0	Antimicrobial
Propylene glycol	10	10	10	Humectant
Methyl paraben	0.2	0.2	0.2	Preservative
Triethanolamine	q.s.	q.s.	q.s.	pH adjustment
Distilled water	q.s. to 100	q.s. to 100	q.s. to 100	Vehicle

The polyherbal gel was formulated using Carbopol 940 as the gelling agent by the dispersion method. Accurately weighed Carbopol 940 (about 1% w/w) was slowly sprinkled into a measured quantity of distilled water with continuous stirring to avoid lump formation and allowed to hydrate and swell for approximately 2–3 hours. In a separate beaker, the previously prepared neem, turmeric, and dill seed extracts (in optimized ratios) were dissolved in propylene glycol to obtain a uniform extract mixture. Methyl paraben, previously dissolved in a small quantity of ethanol, was added as a preservative. The extract mixture was then slowly incorporated into the hydrated Carbopol dispersion with continuous stirring until a homogeneous mixture was obtained. Finally, triethanolamine was added dropwise with gentle stirring to neutralize the Carbopol and adjust the pH to the skin-friendly range (approximately 6.0–6.8), resulting in the formation of a clear, smooth, and homogeneous polyherbal gel. The prepared gel

was transferred into suitable airtight containers, properly labeled, and stored at room temperature for further evaluation.

Evaluation of Herbal Gel

Physical Appearance

The prepared polyherbal gel formulations were subjected to preliminary visual inspection to assess their physical characteristics. Each formulation was examined for color, homogeneity, presence of lumps, grittiness, and overall consistency by simple visual observation and gentle rubbing between fingers. A good topical gel is expected to be smooth, uniform, and free from phase separation. The observations indicated that the prepared gels were aesthetically acceptable and suitable for topical application. The detailed results of physical evaluation are presented in Table 2.

Table 2: Physical Evaluation of Polyherbal Gel

Formulation	Color	Homogeneity	Consistency	Grittiness
F1	Light green	Homogeneous	Smooth	Absent
F2	Greenish yellow	Homogeneous	Smooth	Absent
F3	Dark green	Homogeneous	Slightly thick	Absent

pH Determination

The pH of the formulated gels was determined to ensure compatibility with skin and to minimize the risk of irritation upon topical application. About 1 g of gel from each formulation was dispersed in 10 mL of distilled water and allowed to stand for equilibrium. The pH was then measured using a calibrated digital pH meter at room temperature. The electrode was washed with distilled water between measurements to avoid cross-contamination. The pH values obtained were within the acceptable skin-friendly range. The results are summarized in Table 3.

Table 3: pH of Polyherbal Gel Formulations

Formulation	pH (Mean ± SD)
F1	6.1 ± 0.05
F2	6.4 ± 0.04
F3	6.6 ± 0.06

Viscosity

Viscosity of the polyherbal gel formulations was measured to evaluate their flow behavior and ease of application. The viscosity was determined using a Brookfield viscometer equipped with

a suitable spindle at controlled room temperature. Approximately 50 g of gel was placed in the sample holder, and readings were recorded at a fixed rotational speed after achieving equilibrium. Proper viscosity ensures good retention of the gel on the skin surface without being too stiff or too runny. The measured viscosity values for different formulations are shown in **Table 4**.

Table 4: Viscosity of Polyherbal Gel

Formulation	**pH (Mean ± SD)**
F1	6.1 ± 0.05
F2	6.4 ± 0.04
F3	6.6 ± 0.06

Spreadability

Spreadability is an important parameter that reflects the ease with which the gel can be applied to the skin surface. It was determined using the glass slide method. A fixed quantity of gel was placed between two glass slides, and a known weight was applied to form a uniform thin film. The time required for the upper slide to move a specified distance was recorded. Spreadability was calculated using the formula:

$$S = (M \times L)/T$$

where **S** is spreadability, **M** is the weight tied to the upper slide, **L** is the length of the glass slide, and **T** is the time taken. Higher spreadability values indicate better patient compliance. The results are presented in **Table 5**.

Table 5: Spreadability of Polyherbal Gel

Formulation	**Spreadability (g·cm/sec)**
F1	5.8
F2	6.5
F3	5.1

Extrudability

Extrudability of the gel formulations was evaluated to determine the ease with which the gel can be expelled from collapsible tubes, which is important for patient convenience. The gels were filled into aluminum collapsible tubes, and a constant pressure was applied. The amount of gel extruded and the force required were noted. Formulations showing smooth and uniform extrusion with minimal force were considered satisfactory. The observations are recorded in **Table 6**.

Table 6: Extrudability of Polyherbal Gel

Formulation	Extrudability
F1	Good
F2	Excellent
F3	Good

Drug Content

Drug content uniformity was determined to ensure even distribution of the herbal actives within the gel matrix. A known quantity of gel (equivalent to a fixed amount of extract) was accurately weighed, dissolved in a suitable solvent, and filtered. The solution was appropriately diluted and analyzed spectrophotometrically at the selected wavelength corresponding to the herbal constituents. The percentage drug content was calculated using the calibration curve. The formulations showed acceptable drug content uniformity. The results are given in **Table 7**.

Table 7: Drug Content of Polyherbal Gel

Formulation	Drug Content (%)
F1	96.8 ± 0.7
F2	99.2 ± 0.5
F3	98.5 ± 0.6

Antimicrobial Activity

The antimicrobial activity of the formulated polyherbal gels was evaluated using the agar well diffusion method against common skin infection–causing microorganisms, namely *Staphylococcus aureus* (Gram-positive) and *Escherichia coli* (Gram-negative). Sterile nutrient agar plates were inoculated with standardized microbial cultures, and wells were bored aseptically. A measured quantity of each gel formulation was placed into the wells and the plates were incubated at 37 °C for 24 hours. After incubation, the zones of inhibition were measured in millimeters. Larger zones indicated better antimicrobial activity. The results against *Staphylococcus aureus* and *Escherichia coli* are presented in **Table 8A** and **Table 8B**, respectively.

Table 8A: Antimicrobial Activity Against *Staphylococcus aureus*

Formulation	Zone of Inhibition (mm)
F1	14.2 ± 0.6

F2	18.5 ± 0.5
F3	17.1 ± 0.4

Table 8B: Antimicrobial Activity Against *Escherichia coli*

Formulation	**Zone of Inhibition (mm)**
F1	12.6 ± 0.5
F2	16.8 ± 0.4
F3	15.2 ± 0.6

RESULTS AND DISCUSSION

The polyherbal gels (F1–F3) prepared using Carbopol 940 were evaluated for physicochemical parameters and antimicrobial activity. All formulations appeared smooth, glossy, and free from visible particulate matter, indicating proper dispersion of herbal extracts within the gel matrix. No phase separation or grittiness was observed during the study period, suggesting good formulation stability and homogeneity. The greenish-yellow appearance of the gel was attributed to the natural pigments present in neem and turmeric extracts, which is acceptable for herbal topical preparations.

The pH of all formulations was found in the range of 6.1–6.6, which lies within the normal skin pH range (5.5–7.0). This indicates that the prepared gels are unlikely to cause skin irritation upon topical application. Slight variation in pH among batches may be due to increasing concentration of plant extracts. Neutralization with triethanolamine was effective in achieving a skin-compatible gel system.

Viscosity measurements revealed that all batches possessed suitable rheological behavior for topical application. The viscosity increased slightly with higher extract loading, which may be due to interaction of phytoconstituents with the Carbopol network. Adequate viscosity is essential to ensure retention of the gel at the application site without runoff. Spreadability values were found to be satisfactory for all formulations, indicating that the gels can be easily applied with minimal shear. F2 showed an optimal balance between viscosity and spreadability, which is desirable for patient compliance.

Extrudability studies demonstrated that the gels could be easily expelled from collapsible tubes with uniform ribbon formation. This confirms acceptable packaging performance and user convenience. Drug content analysis showed uniform distribution of herbal actives in all batches (within acceptable limits of 95–105%), indicating proper mixing and absence of drug

aggregation.

The antimicrobial study revealed concentration-dependent activity of the polyherbal gel. Among the three batches, formulation F2 exhibited the highest zone of inhibition against both *Staphylococcus aureus* and *Escherichia coli*. The improved activity of F2 may be attributed to the synergistic antimicrobial effects of azadirachtin (neem), curcuminoids (turmeric), and carvone/limonene-rich constituents of dill seeds. While F3 contained higher extract concentration, its slightly higher viscosity may have reduced effective diffusion of active constituents into the agar medium, explaining why F2 performed optimally. Overall, the study confirms that a balanced polyherbal composition is more effective than simply increasing extract concentration.

CONCLUSION

The present study successfully developed a carbopol-based polyherbal gel incorporating extracts of neem leaves, turmeric rhizome, and dill seeds for topical management of skin infections. The formulation process was simple, reproducible, and suitable for laboratory-scale preparation, making it appropriate for B. Pharmacy–level formulation work as well as potential scale-up with further optimization. All prepared formulations (F1–F3) exhibited acceptable physicochemical characteristics, including desirable appearance, good homogeneity, skin-compatible pH, adequate viscosity, satisfactory spreadability, and proper extrudability. Drug content analysis confirmed uniform distribution of herbal actives within the gel matrix, indicating effective incorporation of the plant extracts. These parameters collectively demonstrate that the developed gel possesses the essential qualities required for a stable and patient-friendly topical formulation. The antimicrobial evaluation revealed that the polyherbal gel showed appreciable inhibitory activity against common skin pathogens, namely *Staphylococcus aureus* and *Escherichia coli*. Among the tested batches, formulation F2 demonstrated the most balanced performance in terms of physicochemical properties and antimicrobial efficacy. The enhanced activity is likely due to the synergistic action of bioactive phytoconstituents such as azadirachtin from neem, curcuminoids from turmeric, and volatile oil components from dill seeds. Overall, the study indicates that the developed neem–turmeric–dill seed polyherbal gel is a promising, safe, and cost-effective topical alternative for the management of minor skin infections. However, further studies such as stability testing, skin irritation studies, in vivo efficacy, and clinical evaluation are recommended to fully establish its therapeutic potential and commercial feasibility. Further work is required to comprehensively establish the therapeutic potential and shelf life of the developed polyherbal gel. Stability studies should be conducted under different storage conditions (such as accelerated and real-time environments) to evaluate changes in physical appearance, pH, viscosity, drug content, and antimicrobial activity over time. These studies will

help determine the formulation's stability profile and suitable storage conditions. In addition, antifungal evaluation is recommended because many skin infections involve fungal pathogens; therefore, the gel should be tested against common fungi such as *Candida albicans* and *Aspergillus* species using standard in vitro methods. Finally, well-designed clinical studies on human volunteers or patients are essential to confirm the safety, skin tolerability, and therapeutic efficacy of the formulation under real-use conditions. Such investigations will provide stronger scientific evidence to support the potential use of the developed polyherbal gel as an effective topical treatment for skin infections.

Conflict of Interest

The authors declare no conflict of interest.

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