

Original Article



Preparation of Emulgel and Antimicrobial Activity of Polyherbal Formulation

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Abstract:

This research focuses on the formulation, evaluation, and antimicrobial assessment of a polyherbal emulgel incorporating Eucalyptus and Lemongrass essential oils. Herbal medicines have long been celebrated for their therapeutic properties, particularly their antimicrobial, anti-inflammatory, and antioxidant effects. However, their topical delivery often faces challenges related to stability, penetration, and patient compliance. Emulgels, which combine the advantages of emulsions and gels, offer a promising solution by improving drug solubility, skin absorption, and controlled release. In this study, essential oils were extracted and subjected to phytochemical screening, followed by formulation of an emulgel using Carbopol 934 as the gelling agent and emulsifiers such as Span 80 and Tween 80. The prepared formulation was evaluated for physicochemical parameters (pH, viscosity, spreadability, extrudability), stability over three months, and antimicrobial efficacy against common skin pathogens including *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Bacillus subtilis*, *Salmonella abony*, *Candida albicans*, and *Aspergillus niger* using the agar well diffusion method. Results showed the emulgel had stable physicochemical properties and exhibited significant antimicrobial activity comparable to standard antibiotics and antifungal agents, with the strongest effects observed against Gram-positive bacteria and fungal strains. This work underscores the potential of polyherbal emulgels as natural, effective alternatives to synthetic antimicrobial products, paving the way for further clinical development.

Keywords: Emulgel, Polyherbal, Eucalyptus, Lemongrass, Antimicrobial, Stability, Rheology, Topical Drug Delivery

1. Introduction

Herbal medicines have long played a vital role in treating skin infections and microbial ailments in traditional systems like Ayurveda and Unani. With growing concerns over antibiotic resistance and synthetic drug side effects, interest in plant-based therapies has surged¹. Emulgels—a hybrid of emulsions and gels—have emerged as an advanced topical delivery system, offering enhanced drug penetration, stability, and patient compliance. This study explores the formulation of an emulgel incorporating *Eucalyptus* and *Lemongrass* essential oils, known for their strong antimicrobial and anti-inflammatory properties²⁻⁶.

By leveraging the synergistic potential of these oils, the research aims to develop a more effective and user-friendly treatment for topical infections⁷.

1. Materials and Methods

Materials

The following materials were used in this study: Eucalyptus oil (*Eucalyptus globulus*) and Lemongrass oil (*Cymbopogon citratus*) were sourced from certified botanical suppliers and served as the primary plant-based active ingredients. Carbopol 934 (Lubrizol, USA) was employed as the gelling agent to provide

consistency and texture to the emulgel formulation. Span 80 (sorbitan monooleate)⁸⁻⁹ and Tween 80 (polysorbate 80) were used as emulsifiers to stabilize the emulsion system, while propylene glycol (analytical grade) functioned as a co-surfactant to enhance solubility and spreadability. Methylparaben and propylparaben were included as preservatives to ensure microbial stability. Sodium hydroxide (NaOH) solution was used as a neutralizer to adjust the pH of the final formulation. Distilled water and ethanol were used as solvents. Microbial strains including *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Candida albicans* were obtained from the microbiology laboratory culture collection for antimicrobial testing¹⁰.

Eucalyptus and Lemongrass essential oils were extracted through hydro-distillation, where fresh plant materials were chopped, placed in a distillation unit, and heated for 3–4 hours; the collected oils were filtered and stored in amber-colored bottles at 4°C. The extracted oils were then subjected to standard qualitative phytochemical screening to detect the presence of key bioactive compounds such as alkaloids (Wagner's test), flavonoids (Shinoda test), phenolics (Ferric chloride test), saponins (Foam test), and glycosides (Keller-Killiani test), indicating their therapeutic potential¹¹⁻¹².

Preparation of Polyherbal Emulgel

The polyherbal emulgel was formulated through a two-step process involving emulsion and gel preparation. In the first step, the oil phase containing Eucalyptus oil, Lemongrass oil, Span 80, and liquid paraffin, and the aqueous phase comprising Tween 80, methylparaben, propylparaben, and distilled water were each heated to 70°C and then combined under continuous stirring to form a stable emulsion. In the second step, Carbopol 934 was dispersed in water, allowed to swell overnight, and neutralized with sodium hydroxide to form a smooth gel. The emulsion was then gradually blended into the gel base under homogenization to yield the final polyherbal emulgel formulation¹³⁻¹⁵.

Physicochemical Evaluation

The formulated emulgel was subjected to a series of physicochemical evaluations to assess its quality and performance. The pH was measured using a calibrated digital pH meter to ensure skin

compatibility, while viscosity was determined using a Brookfield viscometer to assess consistency¹⁶⁻¹⁷. Spreadability was evaluated by the glass slide method, measuring the area spread under a standard weight. Extrudability was tested by quantifying the amount of emulgel extruded from a collapsible tube under uniform pressure. Grittiness was examined both visually and tactilely to ensure smooth texture, and clarity and overall appearance were observed under adequate lighting to confirm homogeneity, appropriate color, and the absence of particulate matter¹⁸.

Antimicrobial Activity Evaluation

The antimicrobial potential of the polyherbal emulgel containing Eucalyptus and Lemongrass oils was evaluated using the agar well diffusion method to determine its efficacy against bacterial and fungal pathogens commonly implicated in skin infections. The test organisms included *Staphylococcus aureus*, *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella abony*,¹⁹ and *Candida albicans*, selected for their clinical relevance. Specific agar media were prepared and poured into sterile Petri dishes: Mannitol Salt Agar for *S. aureus*, Soybean Casein Digest Agar for *B. subtilis*, MacConkey Agar for *E. coli*, Cetrimide Agar for *P. aeruginosa*, Xylose Lysine Deoxycholate Agar for *Salmonella*, and Sabouraud Dextrose Agar (SDA) for *C. albicans*. After solidification²⁰⁻²¹, microbial suspensions standardized to 0.5 McFarland turbidity were spread on the agar surfaces. Wells of 6 mm diameter were punched aseptically and filled with 100 µL of the polyherbal emulgel, Ciprofloxacin (10 µg/mL) for bacteria, Fluconazole (10 µg/mL) for fungi as positive controls, and sterile water as negative control²²⁻²³. Plates were incubated at 37°C for 24 hours for bacterial strains and 28°C for 48 hours for fungal strains. Zones of inhibition (ZOI) were measured using a digital caliper, and the results, recorded in millimeters, demonstrated significant antimicrobial activity of the emulgel,²⁴ highlighting the synergistic effects of the essential oils in inhibiting a broad spectrum of pathogens²⁵.

3. Results and Discussion

The formulated polyherbal emulgel demonstrated notable antimicrobial activity against all tested strains, with the highest zone of inhibition (ZOI) observed against *Bacillus subtilis* (21.5 mm),

followed by *Candida albicans* (20.1 mm) and *Staphylococcus aureus* (18.5 mm). Moderate ZOI were recorded against *Escherichia coli* and *Pseudomonas aeruginosa*, which is attributed to their outer membrane-based resistance mechanisms. These findings confirm the synergistic antimicrobial effects of the essential oils—eucalyptol from *Eucalyptus globulus* and citral from *Cymbopogon citratus*. Compared to standard antibiotics (Ciprofloxacin) and antifungals (Fluconazole), the emulgel exhibited slightly lower but comparable activity, supporting its potential as a natural topical antimicrobial. The plain gel base used as a negative control showed negligible inhibition, validating the bioactivity of the herbal components. Physicochemical

evaluations of five formulations (EG1–EG5) revealed that all maintained a skin-compatible pH (6.6–6.9), smooth consistency, and uniform white appearance with herbal scent. Among these, EG3 emerged as the most promising, showing optimal spreadability (13.31 g·cm/s), maximum extrudability (90.72%), and favorable viscosity (5,000 cP), indicating ease of application and good patient compliance. No signs of irritation were observed during preliminary dermal testing. Overall, EG3 displayed the best balance of physical properties and antimicrobial efficacy, establishing it as a lead formulation for further development as a safe and effective natural topical agent for bacterial and fungal skin infections.

Table 1: Physicochemical Properties of Polyherbal Emulgel

S. No	Parameter	Formulation				
		EG1	EG2	EG3	EG4	EG5
1	pH	6.8	6.7	6.9	6.8	6.6
2	Physical Appearance	Semisolid	Semisolid	Semisolid	Semisolid	Semisolid
3	Spreadability	10.01	10.12	13.31	9.9	10.11
4	Extrudibility	89.91	85.16	90.72	88.99	84.13
5	Viscosity	32000	99000	5000	31000	27000
6	Color	Whitish	Whitish	Whitish	Whitish	Whitish
7	Odor	Characteristic	Characteristic	Characteristic	Characteristic	Characteristic
8	Irritability	Nil	Nil	Nil	Nil	Nil

Table 2 : Results – Zone of Inhibition (ZOI) in mm (Batch No. EG 3)

Microorganism	Polyherbal Emulgel	Positive Control	Negative Control
Bacillus subtilis	21.5	24.0	6.0
Escherichia coli	19.8	22.5	6.2
Salmonella abony	17.3	20.8	5.8
Pseudomonas aeruginosa	20.1	23.2	6.1
Staphylococcus aureus	18.5	21.6	5.9
Candida albicans	16.1	22.0	5.7

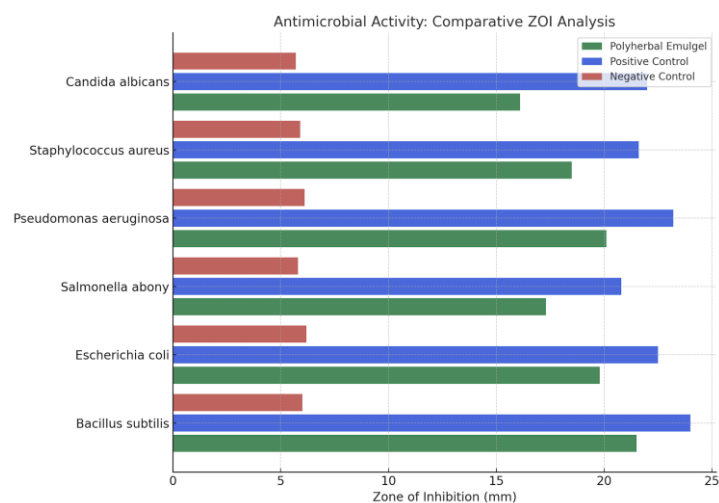


Figure 1: Comparative Zone of Inhibition (ZOI) for Polyherbal Emulgel, Positive Control, and Negative Control against various microbial strains.

The antimicrobial activity of the polyherbal emulgel (Batch EG3) was evaluated against six microbial strains and compared with standard pharmaceutical controls. EG3 exhibited strong antibacterial effects, notably against *Bacillus subtilis* (21.5 mm zone of inhibition) and *Pseudomonas aeruginosa* (20.1 mm), both of which are commonly implicated in acne and wound infections. It also demonstrated significant antifungal activity against *Candida albicans* (16.1 mm). Although standard antibiotics and antifungals produced slightly larger inhibition zones (e.g., 24.0 mm for *Bacillus subtilis*), the emulgel's performance was comparable, suggesting strong therapeutic potential. The plain emulgel base (negative control) showed minimal inhibition (5.7–6.2 mm), confirming that the observed activity was due to the herbal actives. These findings, supported by comparative graphical data, highlight the polyherbal emulgel's efficacy and its promise as a natural alternative to conventional antimicrobial treatments.

4. Discussion

The polyherbal emulgel developed using Eucalyptus and Lemongrass essential oils demonstrated promising antimicrobial and physicochemical properties, making it a strong candidate for topical use. The formulation, particularly batch EG3, exhibited optimal pH, viscosity, spreadability, and extrudibility, along with significant inhibition zones against a broad range of bacterial and fungal pathogens, nearly matching the efficacy of standard antibiotics and

antifungals. These effects are attributed to the synergistic actions of eucalyptol and citral, the active constituents of the oils. Its non-irritant profile and user-friendly texture further enhance its appeal as a natural alternative to chemical-based treatments. Overall, the findings support its potential in managing skin infections and suggest further *in vivo* and clinical studies to validate its therapeutic and commercial viability.

5. Conclusion

This study developed and evaluated a polyherbal emulgel combining Eucalyptus and Lemongrass oils, which showed excellent physicochemical characteristics and strong antimicrobial activity. Among the tested batches, EG3 demonstrated optimal viscosity, spreadability, extrudibility, and broad-spectrum antimicrobial efficacy, comparable to standard drugs. The formulation was non-irritant and aesthetically acceptable, suggesting its potential as a natural and effective topical treatment for bacterial and fungal skin infections. Future studies should focus on *in vivo* validation, scale-up, and clinical trials to support its therapeutic and commercial use.

6. References

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