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"FORMULATION AND EVALUATION OF ANTIMICROBIAL GEL USING GRAPEFRUIT OIL FOR THE TREATMENT OF FOLLICULITIS"

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ABSTRACT

Folliculitis is inflammation of hair follicles, arises from infections or trauma. This study focuses on formulating an antimicrobial gel for folliculitis treatment, incorporating grapefruit oil. Carbopol 943 or 940 is dispersed into water with methyl and propyl paraben preservatives. Allowing the Carbopol-water solution to stand overnight ensures complete hydration, forming a consistent gel matrix. Simultaneously, an oil-based extract is dissolved in propylene glycol for integration. This extract-oil and propylene glycol solution is carefully introduced into the Carbopol solution, stirred for 10 minutes to achieve uniform dispersion. Triethanolamine is gradually added for pH adjustment to 6.4, crucial for stability. High-speed mixing for 10 minutes ensures thorough blending. The gel exhibits a lime-yellow colour, citrus Odor, translucent appearance, and a smooth texture. pH measurements range from 6.45 to 6.81, indicating skin-friendly acidity. Homogeneity assessments confirm uniform dispersion. Spreadability tests show variations, with formulations F3, F5, and F6 having higher spreadability indices, suggesting improved application. Antimicrobial activity testing against Escherichia Coli and Streptococcus aureus shows promising efficacy comparable to streptomycin sulphate. In conclusion, the formulated gels exhibited favorable physical characteristics, with a lime-yellow color, a fragrant citrus odor, translucent appearance, smooth texture and found to be effective in treatment of Folliculitis.

KEYWORDS

Folliculitis, Grapefruit Oil, Herbal Gel, Antimicrobial Activity, Anti-bacterial gel

INTRODUCTION

Grapefruit, a member of the citrus family Rutaceae, originated in Jamaica in the 18th century. Its bitter taste distinguishes it among citrus fruits. Widely cultivated globally, it holds significant value in human diet, alongside other citrus varieties like kinnow and sweet orange. It has yellow-orange skin and varies in diameter from 10-15 cm. The flesh of grapefruit is segmented and acidic, varying in colour depending on the cultivars including white, pink and red pulp of different sweetness[1].

The objective is to develop and assess the efficacy of an antimicrobial gel utilizing grapefruit oil for treating folliculitis. This study aims to investigate the potential of grapefruit oil's antimicrobial properties in combating the infection and inflammation associated with folliculitis, offering a novel therapeutic approach for this common skin condition. Folliculitis is a common skin condition characterized by inflammation of hair follicles, often caused by bacterial or fungal infection. Symptoms include redness, itching, and pustules around hair follicles. Treatment typically involves topical or oral antibiotics, antifungals, or medicated shampoos, depending on the cause. – The most common form of folliculitis, this particular condition is usually caused by the bacteria *Staphylococcus aureus*[2,3]. It should be noted that both the methicillin-sensitive and methicillin-resistant forms of this bacteria can cause folliculitis. Folliculitis can also arise from certain skin conditions like acne or dermatitis, or from prolonged exposure to hot tubs or pools contaminated with bacteria. Treatment options vary depending on the severity and cause of folliculitis, ranging from self-care measures such as warm compresses and gentle exfoliation to topical or oral medications prescribed by a healthcare professional. In severe cases or when the infection spreads beyond the hair follicle, medical intervention may be necessary to prevent complications such as cellulitis or abscess formation[4]. Preventive measures such as practicing good hygiene, avoiding tight clothing, and using clean razors can help reduce the risk of folliculitis recurrence. Folliculitis, inflammation of hair follicles, stems from various infections or noninfectious causes like trauma or occlusion. Eosinophilic folliculitis, however, likely results from autoimmune activity targeting sebocytes or sebum components. The acneiform eruption linked to epidermal growth factor receptor inhibitors is poorly understood but may involve inhibited follicular epidermal differentiation, leading to obstruction and inflammation[5,6]. Acute bacterial folliculitis typically exhibits neutrophil infiltration, either superficially in the infundibulum or deeply in the follicle and surrounding dermis. Understanding these etiologies helps tailor treatments for folliculitis, which range from addressing underlying infections to managing inflammatory responses.

Grapefruit oil contains key compounds like limonene and citronellal, known for their antimicrobial properties. These constituents offer potential benefits in folliculitis treatment by combating microbial infections responsible for inflammation. Limonene exhibits antifungal activity, while citronellal contributes to antimicrobial effects[7]. When incorporated into topical formulations, grapefruit oil may help alleviate symptoms of folliculitis by targeting the underlying microbial causes. Additionally, its antioxidant properties can support skin health and reduce inflammation. However, further research is warranted to determine the

optimal concentration and formulation for maximizing its efficacy while minimizing potential side effects. Traditional treatments often involve antibiotics or antifungal agents, but the emergence of antimicrobial resistance underscores the need for novel therapeutic approaches. Essential oils, such as grapefruit oil, have garnered attention for their antimicrobial properties and potential in dermatological formulations[8,9]. This study aims to formulate and evaluate an antimicrobial gel utilizing grapefruit oil as a natural remedy for folliculitis treatment. The gel's efficacy, safety, and potential as an alternative or adjunct therapy will be explored, offering insights into the development of innovative treatments for this prevalent skin condition. Grapefruit oil, with its antifungal and antimicrobial properties, offers skin health benefits and a refreshing aroma. As a natural alternative, it may reduce side effects and provide broad-spectrum activity in antifungal gels. However, caution is advised due to potential allergies and the need for proper dilution[10].

MATERIALS AND METHODS

Ingredients used for the formulation of Grapefruit Oil Gel are : Grapefruit Oil (obtained from Naturoman Grapefruit Pure & Natural Essential Oil Brand naturoman from site TATA 1mg) , Carbopol 934 and Carbopol 940 (from Ultra Pure Lab Chem Industries LPP, Mumbai) Propylene Glycol (BRM Chemicals), Methyl paraben, Propyl paraben (HiMedia Laboratories, Thane), Glycerin (Chemall International Private Limited), Triethanolamine (Rakem laboratories), Distilled water. Instruments used are Microscope, pH meter, Magnetic Stirrer etc.

Preparation of gel[11,12]

The formulation process begins by dispersing Carbopol 934 or 940, a cross-linked polyacrylic acid polymer, into water containing methyl paraben (0.18%) and propyl paraben (0.02%) as preservatives. Glycerin, a humectant, is added to create a stable base for the formulation. Allowing the Carbopol-water solution to stand overnight facilitates complete hydration and dispersion of Carbopol 940, ensuring a consistent gel matrix. Simultaneously, the targeted extract is dissolved in propylene glycol, a hydrophilic solvent, to ensure proper integration. This oil-based component is dissolved in a specified ratio to ensure solubility within the solvent medium. The extract-oil and propylene glycol solution are then carefully introduced into the Carbopol solution, followed by stirring for 10 minutes to achieve uniform dispersion. Triethanolamine (TEA) is added drop by drop as a neutralizing agent until the desired pH of 6.4 is reached, ensuring stability and compatibility. To finalize the formulation, high-speed mixing at 300 rpm for 10 minutes is employed to blend all constituents thoroughly. This process ensures homogeneity and complete incorporation of all components, resulting in a well-defined gel suitable for further evaluation and testing in the treatment of folliculitis.

pH measurement : For pH measurement, approx. 1 gram of sample in a beaker containing 10 ml of distilled water and then the pH glass electrode was dipped in the beaker. This method was done for all of the formulations. Before using pH meter, the instrument was cleaned and calibrated[13].

Homogeneity : An optical microscope was used to assess the homogeneity of the formulations. A pea sized amount of the gel was taken for the test, which was then put on a glass slide and then it was pressed with a mounting glass by applying uniform pressure. This method was used for all the formulations[14].

Spreadability : Spreadability was measured by weighing and placing a fixed amount of gel between two glass slides. A specific weight is then applied for a set duration. The gel was spread with the another glass slide. The time of spreading and the area to which gel spread was measured. The spreadability index was calculated using the below mentioned formula[15].

Spreadability Index = (M · L)/ T

Where, M = mass/weight of sample taken, L = Length moved on glass slide, T = time taken

Antimicrobial Activity : The antibacterial activity of formulated gel and grapefruit oil was studied in microbiology by using Agar disk diffusion method. Escherichia Coli and Streptococcus aureus are the two bacteria used for evaluation in nutrient agar. Streptomycin sulphate is used as the reference standard for comparison. Zone of inhibition was measured after inoculation for 24 hours[16,17].

Formulation Table [18]

Ingredients /Formulations	F1	F2	F3	F4	F5	F6
Carbopol 934	0.3gm	-	0.4gm	-	0.5gm	-
Carbopol 940	-	0.3gm	-	0.4gm	-	0.5gm
Grapefruit oil	1ml	1ml	1ml	1ml	1ml	1ml
Propylene glycol	4ml	4ml	4ml	4ml	4ml	4ml
Glycerin	0.1ml	0.1ml	0.1ml	0.1ml	0.1ml	0.1ml
Methyl paraben	0.03gm	0.03gm	0.03gm	0.03gm	0.03gm	0.03gm
Propyl paraben	0.004gm	0.004gm	0.004gm	0.004gm	0.004gm	0.004gm

Tab. 1 : Grapefruit oil gel formulation table

RESULT AND DISCUSSION

1. Physical Appearance : The gel exhibits a vibrant lime yellow colour, emanating a fragrant, citrusy odour characteristic of grapefruit oil. Its transparency is translucent, allowing light to pass through, while the texture is smooth to the touch. Overall, the gel presents an inviting appearance, visually appealing with its vibrant hue and refreshing citrus scent, and its smooth texture promises ease of application onto the skin.

Fig. 1 : Grapefruit oil gel formulations

2. Formulation pH : The pH of the gel formulations ranged from 6.45 to 6.81. Formulation F3 exhibited the lowest pH at 6.45, while F6 had the highest at 6.81. The pH values remained within a narrow range, indicating good formulation consistency. All formulation pH values are skin friendly.

Formulations	F1	F2	**F3**	F4	F5	F6
pH range	6.62±0.11	6.73±0.13	**6.45±0.12**	6.75±0.10	6.71±0.14	6.81±0.13

Tab. 2 : pH result of formulations

Fig. 2 : F3 pH result

3. Homogeneity

All the six formulations were found to be homogenous, with equal dispersion of water and oil particle droplets. An optical microscope was used to assess the homogeneity of the formulations. Water molecules and oil globules in the gel were homogenously dispersed when observed under microscope.

Fig. 3 : Microscopic examination of F3 formulation

4. Spreadability : The gel formulations Spreadability ranged from 5.5 to 8.5. Formulations F3, F5, and F6 exhibited the highest spreadability indices, indicating their ability to spread over a larger area with less force. Conversely, F2 showed the lowest spreadability index. Optimizing spreadability is crucial for topical formulations, impacting ease of application and coverage. The development of topical products with improved user experience and therapeutic efficacy.

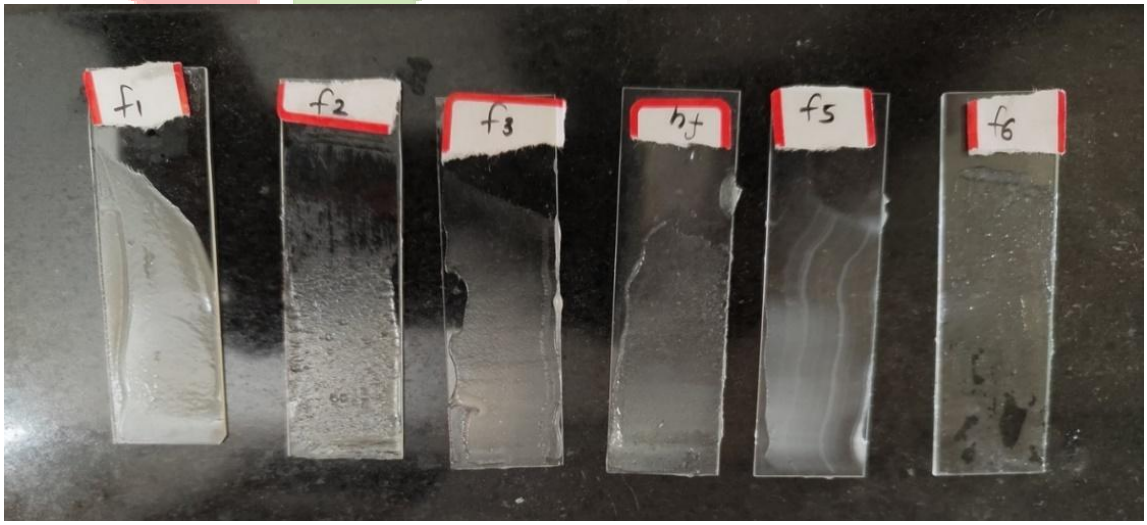


Fig. 4 : Spreadability of the formulations

Formulations	Spreadability Index {(M·L)/T}
F1	7.5
F2	5.5
F3	**8.4**
F4	6.1
F5	8.4
F6	8.5

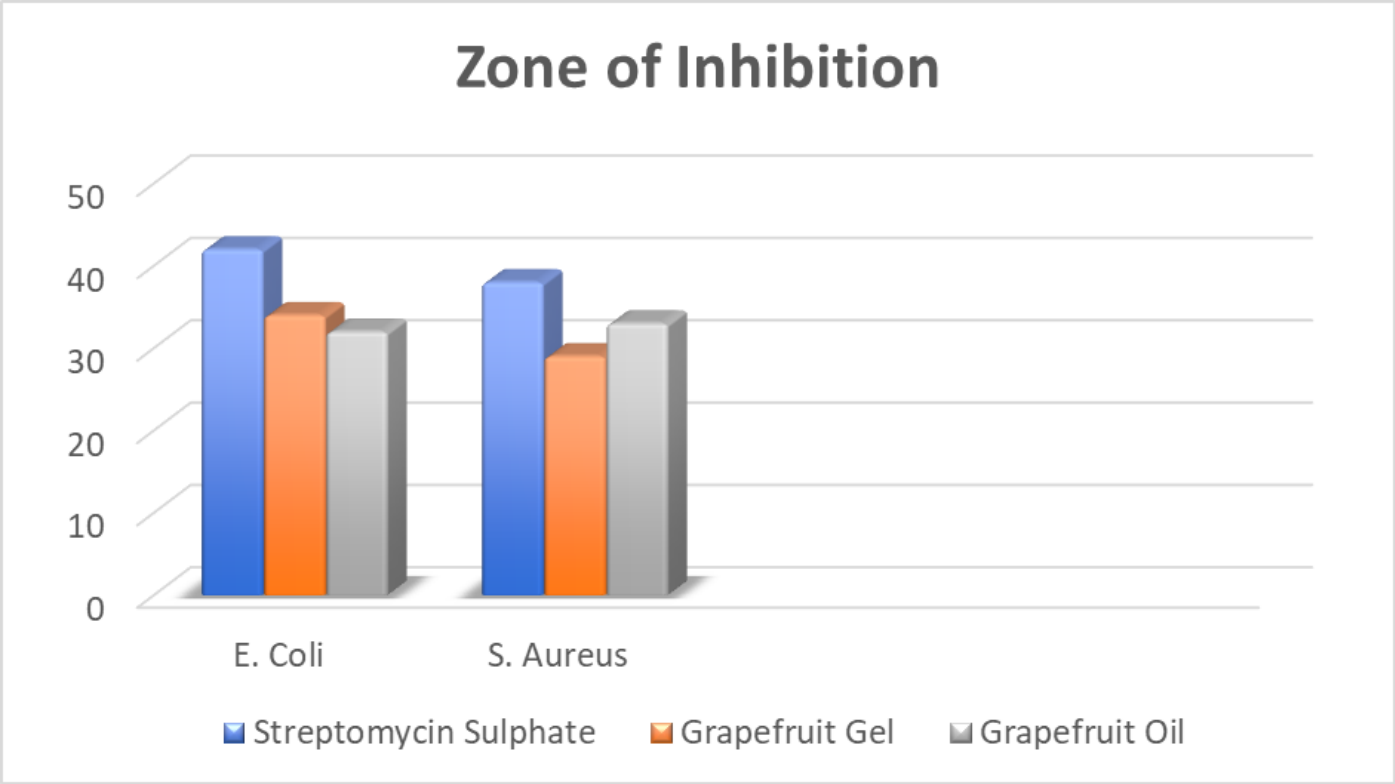
Tab. 3 : Spreadability result of formulations

5. Antimicrobial Activity : The antimicrobial activity results demonstrate that both the Grapefruit Gel and Grapefruit Oil exhibit effective inhibition zones against Escherichia coli (E. coli) and Staphylococcus aureus (S. aureus) compared to the standard. The Grapefruit Gel shows slightly higher inhibition against E. coli (34 mm) than S. aureus (29 mm), whereas the Grapefruit Oil displays slightly stronger activity against S. aureus (33 mm) than E. coli (32 mm).

	E. Coli	S. Aureus
Standard	42	38
Grapefruit Gel	34	29
Grapefruit Oil	32	33

Tab. 4 : Antimicrobial Activity: Zone of inhibition

Fig. 5 : Antimicrobial activity result



Grp. 1 : Antimicrobial Activity graphical

CONCLUSION

The development and evaluation of an antifungal gel utilizing grapefruit oil for the treatment of folliculitis hold significant promise in the realm of dermatological care. The inclusion of grapefruit oil, known for its antimicrobial properties attributed to compounds like limonene and citronellal, has exhibited noteworthy efficacy against the fungal infections associated with folliculitis. Grapefruit oil has stuff in it that fights the fungus causing folliculitis. The gel seems stable and good over time, and it's safe on the skin based on early checks. Still, we need more tests, especially on a larger group of people, to be sure it's safe in the long run. The formulated gel is created by dispersing Carbopol polymer in a water solution with preservatives and glycerin. Allowing overnight standing ensures polymer hydration, forming a consistent gel matrix. An oil-based extract, dissolved in propylene glycol, is integrated, and pH adjusted using triethanolamine. High-speed mixing ensures homogeneity. This systematic process yields a stable, homogenous gel with therapeutic potential, pending further evaluation for safety and efficacy in its intended application.

In conclusion, the formulated gels exhibited favourable physical characteristics, with a lime-yellow colour, a fragrant citrus odour, translucent appearance, and smooth texture. The pH levels across formulations F1 to F6 fell within a narrow range close to neutral (6.45 to 6.81), indicating skin-friendly acidity. Homogeneity assessments revealed uniform dispersion of water and oil particles in all formulations, ensuring consistent product quality. Optical microscope examination confirmed the homogeneous nature of each gel.

Spreadability tests demonstrated variations, with formulations F3, F5, and F6 exhibiting higher spreadability indices, suggesting improved ease of application. Carbopol 934 is present in F1, F3, and F5, while Carbopol 940 is present in F2, F4, and F6. Formulation 3 **F3** was found to be optimized formulation. the formulation and evaluation of an antimicrobial gel utilizing grapefruit oil show promising potential for the treatment of folliculitis. The antimicrobial properties of grapefruit oil offer a natural and effective solution for combating bacterial or fungal infections associated with this condition[19]. Further research and clinical trials are warranted to assess its efficacy, safety, and potential as a therapeutic option for managing folliculitis. With continued exploration and development, this grapefruit oil-based gel may emerge as a valuable addition to the armamentarium of treatments available for individuals suffering from folliculitis.

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Authors contribution

All authors have contributed equally to the research. This includes data collection, literature review, methodology design, data analysis and interpretation, supervision of the research project. All aspects of the research were conducted collaboratively and supported by all authors. Research manuscript was prepared and drafted by Vicky Chaurasiya.

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Conflict of Interest

The authors declare no conflict of interest.

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