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# Formulation and Evaluation of Quercetin and Gallic Acid Anti-Acne Emulgel

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## Editorial

**Aim:** To formulate and evaluate antiacne emulgel containing quercetin and gallic acid.

**Objectives:** Quercetin and Gallic acid are effective against acne causing micro-organisms. The main aim of the present work is to develop anti-acne emulgel of Quercetin and Gallic acid for the treatment and management of acne.

**Methodology:** Quercetin and Gallic acid were calibrated using UV-Visible Spectrophotometer. The anti-acne emulgel of Quercetin and Gallic acid were prepared by mixing gel base and emulsion to form emulgel was formed using carbopol-940. The prepared anti-acne emulgel formulations were evaluated for in- vitro drug release, drug content, pH, spreadability, extrudability, viscosity & evaluated for microbial inhibition by disc diffusion.

**Results:** Anti-acne emulgel comprising of Quercetin and Gallic acid were successfully developed. The emulgel formulations exhibited improved in-vitro drug release, with cumulative drug content ranging from 94.39 – 97.53%(Quercetin), 97.1- 99.5% (Gallic acid). pH ranging from 5.32 -5.45, Extrudability 90.2- 96.6%. Viscosity 583.1-594.5. Vesicle size 1713 -1957.5µm, Zone of inhibition was 12 – 13mm for S. epidermis & 8- 12mm P.acne.

**Conclusion:** The formulated emulgel containing quercetin and gallic acid demonstrated outstanding effectiveness in inhibiting the growth of acne-causing microorganisms.

**Key words:** Quercetin; Gallic acid; Emulgel; Anti-acne activity; Antimicrobial activity

## Introduction

Acne is a long-term inflammatory condition that affects the pilosebaceous unit, which includes hair follicles and sebaceous glands [1]. It is mainly caused by the effect of androgens, which increase sebum production, and is also linked to the presence of the bacterium Propionibacterium acnes. Other microorganisms that can contribute to acne include Staphylococcus epidermis, Escherichia coli, Staphylococcus aureus, and Pseudomonas aeruginosa [2]. An emulgel is a type of formulation that is created by gelling an emulsion with the help of a gelling agent. It can be of two types, either water-in-oil (w/o) or oil-in-water (o/w). Emulgels are effective in delivering medicines in both water-soluble and oil-based forms. They offer numerous benefits such as easy application, lack of greasiness, thixotropy (ability to change consistency when subjected to stress), long shelf life, being odourless, and having an appealing appearance [3]. Quercetin is considered a promising treatment for acne due to its strong anti-

inflammatory and antibacterial properties. It helps to reduce inflammation by preventing the production of tumor necrosis factor alpha (TNF-α), which plays a key role in chronic inflammatory conditions, and it also inhibits the production of other inflammatory substances [4]. Gallic acid is a crystalline substance that is either slightly colourless or has a slight yellow tinge. It has various health benefits, including antibacterial, anti-tumour, anti-diabetic, anti-obesity, anti-microbial, and anti-anginal properties [5].

## Materials and Methods

### Materials

Gallic acid, Quercetin, and Carbopol 940 were obtained from Loba Chemical Pvt Ltd, Mumbai. Liquid paraffin and Tween 20 were purchased from SDFCL Fine Chemical Ltd, Mumbai. Propylene glycol was sourced from Thermo Fisher Scientific India Pvt Ltd, Mumbai. Methyl paraben was acquired from NR CHEM Mumbai, and Propyl paraben was obtained from Genuine Chemical Co., Bombay.

### Methodology

#### Preparation of gel base

Carbopol 940 was soaked in distilled water for 24 hours until it swelled and formed a gel base.

#### Preparation of Anti- Acne emulgel

An oil phase was made by mixing Quercetin, Liquid Paraffin, Propylene glycol, Propyl paraben, and a water phase was prepared using Gallic acid, Tween 20, Methyl paraben, and distilled water. Both phases were blended and homogenized to form an emulsion. The emulsion was then mixed with the Carbopol 940 gel base to produce the final emulgel [6] (Table 1).

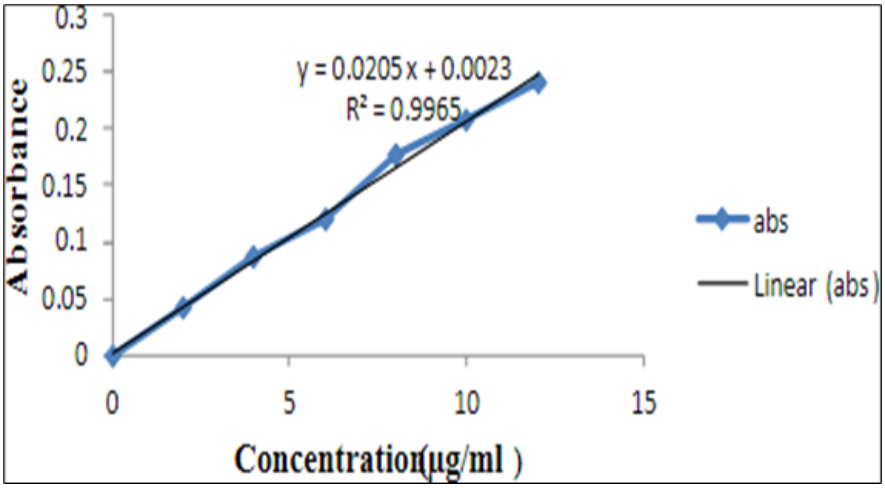



***Figure 1:*** *Standard Calibration Curve.*

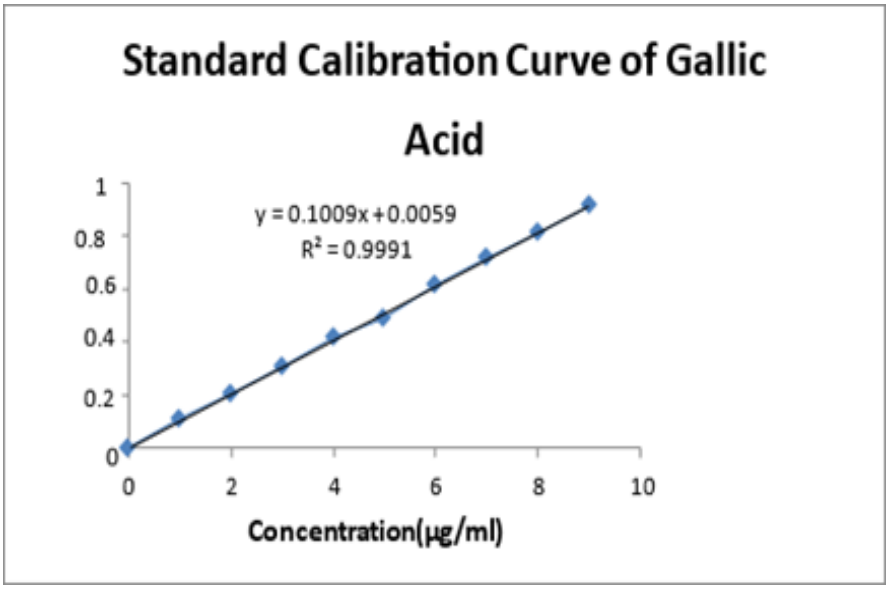



***Figure 2:*** *Standard Calibration Curve of Gallic Acid.*

***Figure 3:*** *Evaluation of Spreading Coefficient.*


***Figure 4:*** *Evaluation of viscosity.*

***Figure 5:*** *Evaluation of Extrudability.*

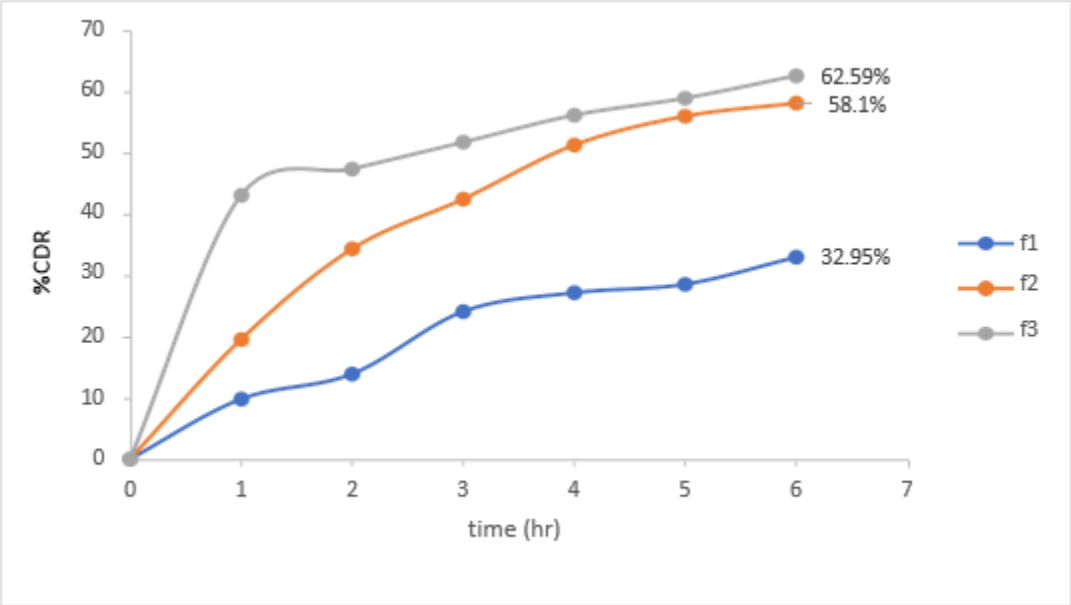



***Figure 6:*** *In vitro Drug Release of Quercetin.*

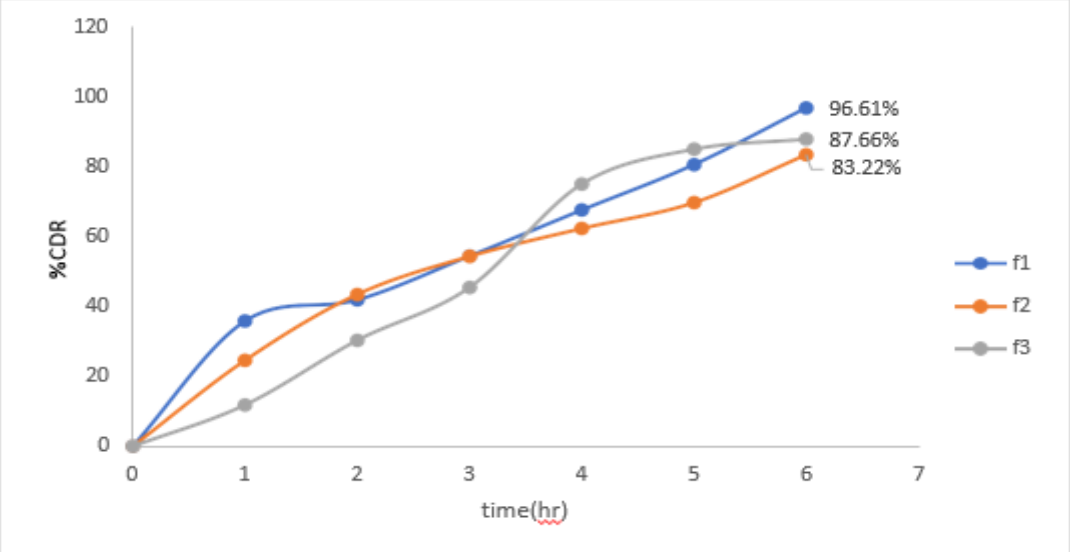
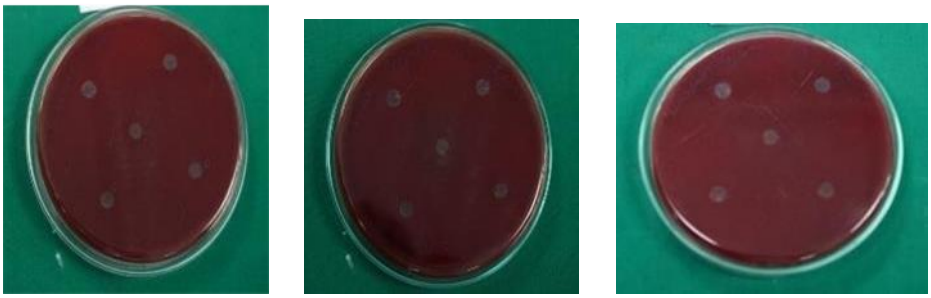



***Figure 7:*** *In vitro Drug Release of Gallic acid.*

*[a]* *[b]* *[c]*

***Figure 8:*** *[a, b & c] Anti-microbial activity of S. epidermidis.*



*F1=10mm* *F2=12mm* *F3=8mm*

***Figure 9:*** *[a, b & c] Anti-microbial activity of P. acne.*

***Table 1:*** *Composition of Anti- Acne emulgel.*

| SLNO. | INGREDIENTS (100 gm) | F1 | F2 | F3 |
|---|---|---|---|---|
| 1. | Gallic Acid | 0.2 | 0.4 | 0.6 |
| 2. | Quercetin | 0.05 | 0.075 | 0.1 |
| 3. | Carbopol 940 | 2 | 2 | 2 |
| 4. | Liquid Paraffin | 7.48 | 7.48 | 7.48 |
| 5. | Tween20 | 1.4 | 1.4 | 1.4 |
| 6. | Propylene glycol | 5 | 5 | 5 |
| 7. | Methyl paraben | 0.03 | 0.03 | 0.03 |
| 8. | Propyl paraben | 0.02 | 0.02 | 0.02 |
| 9. | Distilled water | q.s | q.s | q.s |
| 10. | Lavender oil | q.s | q.s | q.s |

***Table 2:*** *Evaluation results of Physical Appearance.*

| | |
|---|---|
| Colour | Creamish White |
| Texture | Smooth, Uniform |
| Odour | Pleasant |

***Table 3:*** *Absorbance data of standard calibration of Quercetin.*

| S.No | Conc(µg/ml) | Abs |
|---|---|---|
| 1 | 0 | 0 |
| 2 | 2 | 0.043±0.038 |
| 3 | 4 | 0.086±0.041 |
| 4 | 6 | 0.121±0.023 |
| 5 | 8 | 0.176±0.018 |
| 6 | 10 | 0.209±0.052 |
| 7 | 12 | 0.242±0.033 |

***Table 4:*** *Absorbance data of Standard Calibration of Gallic acid.*

| S.No | Conc(µg/ml) | Abs |
|---|---|---|
| 1 | 0 | 0 |
| 2 | 1 | 0.113±0.01 |
| 3 | 2 | 0.209±0.26 |
| 4 | 3 | 0.313±0.035 |
| 5 | 4 | 0.416±0.063 |

| | | |
|---|---|---|
| 6 | 5 | 0.487±0.047 |
| 7 | 6 | 0.615±0.039 |
| 8 | 7 | 0.718±0.055 |
| 9 | 8 | 0.815±0.068 |
| 10 | 9 | 0.912±0.081 |

***Table 5:*** *Vesicle Size of Emulgel.*

| S.No | Formulation | Vesicle Size(µm) |
|---|---|---|
| 1 | F1 | 1957 |
| 2 | F2 | 1713 |
| 3 | F3 | 1719 |

***Table 6:*** *Evaluation Results of pH.*

| S.NO. | Formulations | pH |
|---|---|---|
| 1 | F1 | 5.45±0.832 |
| 2 | F2 | 5.32±0.763 |
| 3 | F3 | 5.39±0.986 |

***Table 7:*** *Evaluation Results Spreading Coefficient.*

| S.NO | Formulations | Time (sec.) | Spreading Coefficient (gm.cm/sec) |
|---|---|---|---|
| 1 | F1 | 2.25 | 66.66±0.782 |
| 2 | F2 | 2.07 | 72.46±0.896 |
| 3 | F3 | 2.64 | 56.81±0.989 |

***Table 8:*** *Evaluation Results of viscosity.*

| S.NO | Formulations | Centipoise |
|---|---|---|
| 1 | F1 | 583.1±0.643 |
| 2 | F2 | 590.3±0.732 |
| 3 | F3 | 594.5±0.767 |

***Table 9:*** *Evaluation Results of Extrudability.*

| Sl.NO | Formulations | Amt. of Emulgel (gm) | Extruded Emulgel (gm) | % of Drug Extrudability |
|---|---|---|---|---|
| 1 | F1 | 5 | 4.51 | 90.2±0.132 |
| 2 | F2 | 5 | 4.83 | 96.6±0.248 |
| 3 | F3 | 5 | 4.64 | 92.8±0.371 |

***Table 10:*** *Evaluation Results of Drug content.*

| Sl. No | Formulations | Drug Content (%) | |
|---|---|---|---|
| | | Quercetin | Gallic acid |
| 1 | F1 | 95.23 | 98.12 |
| 2 | F2 | 97.53 | 99.5 |
| 3 | F3 | 94.39 | 97.2 |

## Evaluation of Anti Acne Emulgel

### Physical Characterization

The color, odor, and texture of the prepared emulgels were visually examined to assess their physical properties [7].

### Calibration

Calibration curves for quercetin and gallic acid were developed using the UV-Visible spectrophotometric method. Standard solutions were prepared by dissolving known amounts of quercetin and gallic acid in methanol to create stock solutions of known concentration (e.g., 100 µg/mL). Appropriate dilutions were made to prepare solutions in the range of 2–20 µg/mL for quercetin and 5–30 µg/mL for gallic acid. Absorbance was measured at 372 nm and 256 nm, respectively [8,9].

### Vesicle size

The calibration of the eyepiece micrometer was done using a stage micrometer. The emulgel was spread on a slide, and 500 vesicles were counted. Using the calibration factor, the average size of the vesicles was calculated [10].

### pH

The pH of the prepared emulgel was measured using a digital pH meter. The glass electrode was dipped into the emulgel for one minute, and the pH was recorded. Each formulation was tested in triplicate, and the mean value was calculated [11].

### Spreading coefficient

The spreading coefficient was determined using a house developed apparatus. It consisted of a wooden block attached to a pulley. The emulgel was placed on a ground glass slide, which was fixed on the block. A second glass slide was placed on top, and a weight of 20gram was placed on the two slides for 5 minutes to expel air and create a uniform film of the emulgel. A known weight was placed on the pulley, and the time required for the top slide to travel 5 cm was measured. A shorter time indicated better spreading [12].

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

Where S = Spreadability
M = Weight in the Pan (tied to the upper slide) in gm
L = Length moved by the glass slide in cm

### Viscosity

The viscosity of the prepared gel was measured using a Brookfield Viscometer. The gels were rotated at 50 rpm using spindle number 64, and the dial reading was recorded [13].

### Extrudability

About 5 grams of the emulgel was filled into a clean, lacquered aluminium collapsible tube. A clamp was applied to prevent the product from flowing back. The cap was removed, and the emulgel was extruded through the tip. The extruded emulgel was collected and weighed. The percentage of extrudability was calculated by dividing the amount of emulgel extruded by the total amount in the tube and multiplying by 100 [14].

Percentage extrudability = Amount of gel extruded from tube/ Total amount of gel in tube
X 100
(>90% Extrudability: Excellent)
(>80% extrudability: good)

### Drug Content

The drug content in the emulgel was determined using a spectrophotometer. A known quantity of emulgel was dissolved in a suitable solvent using sonication. The absorbance was measured after appropriate dilution in a UV/VIS spectrophotometer. Gallic acid was measured in water at 256 nm, and quercetin was measured in methanol at 372 nm [15].

### In Vitro drug release studies

The in vitro drug release behavior of the anti-acne emulgel formulations was evaluated using a locally built setup. It included a donor compartment and a receptor compartment with an effective diffusion area of 3 $cm^2$ and a length of 10 cm. A certain volume of emulgel was placed in the donor compartment, while 50 mL of PBS (pH 6.8) was placed in the receptor compartment. The setup was maintained at 37 ± 0.5°C with continuous stirring at 50 rpm. 1ml sample withdrawn from the sampling port at 1, 2. 3, 4. 5, and 6 hours. The withdrawn sample is immediately replaced with a fresh buffer to attain a fixed volume. The samples were subjected to spectrophotometric examination at 372 & 256 nm for Quercetin and Gallic acid respectively, using PBS (pH 6.8) as a blank. After carrying out the in vitro release experiments in triplicate, the results were analyzed to determine the drug release kinetics from the different formulations [16].

### Anti-Microbial Test

Procedures: Disc Diffusion Test
01) Media used: - Brain Heart Infusion agar
02) Temperature: - Bring agar plates to room temperature before use.

## Discussion

### Appearance

All the prepared gel formulations were visually analyzed they were found to be clear and there was no aggregation found and free from presence of particles (Figures 1-7) (Table 2).

### Visual appearance and Homogeneity

The prepared anti-acne emulgel formulations were transferred into clean, transparent containers and subjected to visual inspection to evaluate their physical appearance, color, and homogeneity. This evaluation is an essential preliminary step in assessing the overall quality and acceptability of topical formulations. All formulations exhibited a uniform and smooth appearance with consistent color

throughout, indicating proper mixing and uniform dispersion of both the aqueous and oily phases. No visible signs of phase separation, creaming, cracking, or sedimentation were observed during the inspection period, suggesting that the emulsification process was effective and the formulations were physically stable.

**pH Determination**

The pH of all formulated anti-acne emulgels was determined using a calibrated digital pH meter to ensure accuracy and reliability of the measurements. Prior to analysis, the pH meter was standardized using appropriate buffer solutions, and the measurements were performed at room temperature. The pH values of the developed formulations were found to range between 5.32 ± 0.02 and 5.45 ± 0.03, indicating minimal variation among the different emulgel batches. This pH range closely corresponds to the normal physiological pH of human skin, which is typically mildly acidic in nature (Table 6). The observed pH values suggest that the emulgels are unlikely to cause discomfort or adverse skin reactions upon application.

**Extrudability**

Extrudability is a critical evaluation parameter for topical semisolid formulations, as it indicates the ease with which the product can be expelled from a collapsible tube or container under the application of gentle pressure. This property is closely related to the viscosity, consistency, and gel strength of the formulation, all of which influence patient convenience and compliance. In the present study, the extrudability of all prepared anti-acne emulgel formulations was assessed, and the results demonstrated that each formulation possessed satisfactory extrudability, reflecting an appropriate balance between firmness and flowability.

Among the evaluated formulations, F2 exhibited superior extrudability when compared to F1 and F3. This observation suggests that formulation F2 achieved an optimal viscosity and gel structure, allowing it to be smoothly and uniformly extruded without requiring excessive force. In contrast, slightly lower extrudability observed in the other formulations may be attributed to higher viscosity or increased gel strength. Adequate extrudability is essential to ensure ease of application, accurate dosing, and uniform spreading of the formulation over the skin surface. Therefore, the favourable extrudability characteristics of the developed emulgels, particularly formulation F2, indicate their suitability for topical anti-acne therapy and enhance their potential for effective and user-friendly application (Figure 5 & Table 9).

**Viscosity**

Viscosity is a key rheological parameter that significantly influences the performance, stability, and patient acceptability of topical semisolid formulations. In the present study, viscosity measurements were carried out for all formulated anti-acne emulgels to evaluate their flow behaviour and suitability for topical administration. The results indicated that all formulations possessed adequate viscosity, demonstrating appropriate consistency for application onto the skin. The observed viscosity values suggest that the emulgels can maintain their structure and remaining at the site of application for a prolonged period, which is essential for sustained contact with the skin and improved therapeutic efficacy of the active ingredients.

Comparative evaluation revealed that formulation F3 exhibited relatively higher viscosity than the other formulations, which may be attributed to a higher concentration of gelling agent or increased intermolecular interactions within the gel matrix. While higher viscosity can enhance residence time at the application site, excessively viscous formulations may hinder spreadability. In contrast, formulations F1 and F2 displayed moderate viscosity, offering a favorable balance between consistency and ease of spreading. This moderate viscosity is advantageous as it allows uniform application with minimal effort, thereby improving patient comfort and compliance (Figure 4) (Table 8). Overall, the viscosity characteristics of the developed emulgels indicate their suitability for topical anti-acne therapy, with each formulation exhibiting desirable rheological properties tailored for effective skin application.

**Spreadability**

Spreadability studies indicated that the anti-acne emulgels spread easily upon application of minimal shear. Formulations with relatively lower viscosity demonstrated higher spreadability. The observed spreadability values confirm that the emulgels can be uniformly applied over the skin surface with minimal effort. This property enhances patient comfort and ensures better drug distribution at the application site.

The spreadability of the anti-acne emulgel formulations was evaluated to assess their ease of application and ability to uniformly distribute over the skin surface. Among the tested formulations, F2 exhibited the highest spreading coefficient (72.46 ± 0.896 gm·cm/sec) and the shortest spreading time (2.07 sec), indicating superior spreadability compared to the other formulations. This suggests that formulation F2 possessed optimal viscosity and consistency, allowing it to spread easily with minimal applied force. Formulation F1 showed moderate spreadability with a spreading coefficient of 66.66 ± 0.782 gm·cm/sec and a spreading time of 2.25 sec, reflecting acceptable spreading characteristics. In contrast, formulation F3 demonstrated the lowest spreading coefficient (56.81 ± 0.989 gm·cm/sec) and the longest spreading time (2.64 sec) (Figure 3) (Table 7), which may be attributed to its comparatively higher viscosity.

**Vesicle size**

The vesicle size of the formulated anti-acne emulgels was determined using an optical microscopic method. Formulations F2 and F3 exhibited nearly similar vesicle sizes when compared to F1. The results indicate that a reduction in vesicle size enhances the surface area available for drug release, thereby potentially improving drug permeation and therapeutic efficacy (Table 5). The optimized vesicle size also contributes to formulation stability and controlled drug release.

**Antimicrobial activity**

The formulated anti-acne emulgel formulations were subjected to antimicrobial activity on *S. epidermidis and P. acne organisms*. On antimicrobial studies by disc diffusion method, it was found that F2 was having greater diameter of zone of inhibition as compared to F1 and F3 formulation (Figure 8 & 9).

## Conclusion

The present investigation successfully developed and evaluated a topical emulgel formulation. The prepared emulgels were systematically examined for key physicochemical parameters such as pH, viscosity, spreadability, extrudability, vesicle size, drug content, in-vitro drug release, and antimicrobial activity. All measured parameters were found to fall within acceptable limits, confirming the suitability of the formulation for topical drug delivery. Among the different batches, the optimized formulation exhibited appropriate viscosity and excellent spreadability, allowing smooth application and uniform distribution over the skin with minimal shear stress. The extrudability findings further indicated that the formulation could be conveniently dispensed from the container, thereby improving patient compliance and ease of use.

In-vitro drug release studies demonstrated that the emulgels provided satisfactory and controlled drug release profiles. Notably, formulations F2 and F3 showed comparatively higher drug release than the other batches, indicating efficient diffusion of the drug from the emulgel matrix. Antimicrobial evaluation using the disc diffusion method revealed that formulation F2 produced the largest zone of inhibition, signifying superior antimicrobial activity. This enhanced efficacy may be attributed to improved drug release and greater interaction between the drug and microbial cell membranes. Overall, the findings suggest that the optimized emulgel formulation possesses favorable physicochemical characteristics, controlled drug release behavior, and significant antimicrobial effectiveness. Therefore, it can be considered a promising topical drug delivery system for the effective treatment of microbial skin infections.

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