Formulation and Evaluation of *Clitoria ternatea* and *Nyctanthes arbor-tristis* Emulgel for Topical Drug Delivery

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Abstract: The burgeoning resistance to conventional antibiotics has spurred interest in herbal medicines, particularly as bases for topical formulations. This study aimed to harness the therapeutic properties of *Clitoria ternatea* and *Nyctanthes arbor-tristis* by developing emulgel formulations for potential use in skin applications. Phytochemical screening confirmed the presence of various bioactive compounds, including alkaloids, flavonoids, saponins, tannins, terpenoids, and phenolic compounds in the plant extracts. Three emulgel formulations were characterized for their pH, viscosity, spreadability, extrudability, and in vitro drug release. All formulations exhibited favorable physicochemical properties, with pH values compatible with skin physiology, appropriate viscosity and spreadability for topical application, and satisfactory extrudability from packaging. In vitro drug release profiles indicated a controlled release mechanism, suggesting the emulgels' capacity for sustained delivery of active compounds. The study concludes that *Clitoria ternatea* and *Nyctanthes arbor-tristis* emulgels show promise as vehicles for transdermal delivery of herbal medicines, meriting further investigation.

Keywords: *Clitoria ternatea, Nyctanthes arbor-tristis, Emulgel, Topical drug delivery, Phytochemical analysis, Controlled release, Herbal medicine.*

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INTRODUCTION

The exploration of phytopharmaceuticals has gained significant momentum in the quest for safe and effective topical agents. In this context, *Clitoria ternatea* (commonly known as butterfly pea) and *Nyctanthes arbor-tristis* (also known as night-flowering jasmine or Parijat) have emerged as two potent candidates in the realm of ethnopharmacology [1]. Both plants are esteemed in traditional medicine and are known for their extensive therapeutic properties, which include anti-inflammatory, analgesic, and antimicrobial activities. However, the full potential of these botanicals has not been thoroughly exploited in modern pharmaceutical formulations, particularly in the form of Emulgels [2].

Emulgels, a portmanteau of 'emulsion' and 'gel', combine the advantages of both dosage forms; they provide the moisturizing and nourishing benefits of an emulsion with the ease of application and better skin adherence of a gel. This novel drug delivery system is especially suitable for hydrophobic drugs and plant extracts, enhancing their absorption through the skin and improving bioavailability [3].

The rationale for selecting *Clitoria ternatea* and *Nyctanthes arbor-tristis* for our study is rooted in their pharmacological profiles. *Clitoria ternatea* is rich in anthocyanins, which have been reported to exhibit antioxidant properties, while *Nyctanthes arbor-tristis* contains iridoid glycosides that have shown anti-inflammatory potential. The combination of these extracts in an emulgel base could synergize their effects, offering a multipronged approach to treating topical ailments [4].

Given this backdrop, the current research focuses on formulating an emulgel incorporating extracts of *Clitoria ternatea* and *Nyctanthes arbor-tristis*. This study aims to develop a stable, efficacious topical formulation and evaluate its physicochemical properties, therapeutic potential, and skin permeability. Such a formulation could provide an innovative addition to topical treatments, aligning with the burgeoning need for natural and effective dermatological solutions [5].

This introduction not only provides a snapshot of the rich historical background of the chosen botanicals but also seamlessly introduces the innovative emulgel formulation. It sets the stage for the subsequent sections, which will focus into the methods, results, and discussion of the study's findings [6].

METHODOLOGY

The methodology delineates the systematic processes used to extract phytochemicals from *Clitoria ternatea* and *Nyctanthes arbor-tristis* and to formulate the emulgel. The study was meticulously designed to ensure reproducibility and accuracy in the extraction and evaluation of the extracts used in the emulgel formulation.

Extraction [7]

Fresh *Clitoria ternatea* flowers and *Nyctanthes arbor-tristis* leaves were collected, authenticated, and washed thoroughly to remove any adherent dirt. The plant materials were then shade-dried at room temperature and ground into a fine powder.

The extraction process involved macerating the powdered plant materials separately in a hydroethanolic solution (70% ethanol to 30% water by volume) for a period of 48 hours, with intermittent shaking to enhance the extraction efficiency. The mixtures were then filtered, and the filtrates were concentrated using a rotary evaporator under reduced pressure to yield the respective crude extracts, which were stored at 4°C for further analysis.

Extractive Value [8]

To determine the extractive value, a known weight of the dried powdered plant material was subjected to continuous extraction with ethanol in a Soxhlet apparatus for a specified duration until exhaustion. The extracts obtained were then evaporated to dryness, and the dry residue was weighed. The extractive value was calculated as a percentage of the dry weight of the plant material used.

Phytochemical Analysis [9]

The qualitative phytochemical analysis involved screening the extracts for the presence of key constituents such as flavonoids, terpenoids, saponins, alkaloids, tannins, and phenolic compounds. Standard protocols were employed for each test.

For instance, the presence of flavonoids was confirmed by the aluminum chloride colorimetric method, while saponins were detected by the formation of persistent frothing upon shaking with water. The alkaloids were identified using Dragendorff's reagent, tannins with ferric chloride, and phenolic compounds were estimated using the Folin-Ciocalteu reagent. Each test was performed in triplicate to ensure consistency and reliability of the results.

Following the extraction and phytochemical analysis, the extracts were incorporated into an emulgel base using an appropriate gelling agent. The emulgel was then homogenized to ensure even distribution of the extracts in the gel matrix.

Chemicals and Lab facility

All the chemicals utilized in this study were of analytical grade, ensuring high purity and reliability for the experimental procedures. The entire research, encompassing the formulation and characterization of the emulgels, was conducted at ACME Research Solutions, a facility equipped with state-of-the-art laboratory equipment and technology. This setting provided a controlled environment essential for the precise execution of the research methodology and the accurate assessment of results.

Formulation of Emulgel [10, 11]

The emulgel formulations were meticulously prepared by incorporating the extracts of *Clitoria ternatea* and *Nyctanthes arbor-tristis* into an emulsion base, followed by the addition of a gelling agent to impart the gel-like consistency. The formulations were designed to assess the effect of varying concentrations of the extracts on the final product's characteristics.

Table 1: Composition of Emulgel Formulations

Ingredients	Formulation E1	Formulation E2	Formulation E3
Clitoria ternatea Extract (mg)	50	100	150
Nyctanthes arbor-tristis Extract (mg)	50	100	150
Carbopol 940 (g)	1	1	1
Methylparaben (g)	0.1	0.1	0.1
Propylparaben (g)	0.05	0.05	0.05
Triethanolamine (mL)	0.5	0.5	0.5
Propylene Glycol (mL)	5	5	5
Liquid Paraffin (mL)	10	10	10
Purified Water (q.s. to 100 mL)	-	-	-

Base Preparation: The emulgel base was prepared by first hydrating Carbopol 940 in purified water with gentle stirring until a homogeneous gel matrix was formed. Concurrently, the oil phase, comprising liquid paraffin, was heated to 70°C. The

aqueous phase, containing dissolved methylparaben and propylparaben as preservatives, was also heated to the same temperature.

Incorporation of Active Ingredients: The extracts of *Clitoria ternatea* and *Nyctanthes arbor-tristis*, previously quantified for extractive values and phytochemical content, were then added to the aqueous phase of the emulsion. This mixture was homogenized under high-shear conditions to ensure uniform distribution of the extracts.

Formation of Emulgel: The oil phase was gradually added to the aqueous phase with continuous stirring to form a stable emulsion. Once the emulsion was formed, it was allowed to cool to room temperature. At this point, Triethanolamine was added to neutralize the Carbopol gel base and to adjust the pH, ensuring the formation of a smooth gel with no visible particles. Propylene glycol was used as a humectant to enhance the moisturizing effect of the emulgel.

Characterization of Emulgel

The formulated emulgels containing *Clitoria ternatea* and *Nyctanthes arbor-tristis* extracts were subjected to a series of characterization tests to evaluate their physicochemical properties and drug release profiles.

pH Measurement: The pH of the emulgels was determined using a calibrated pH meter. A small quantity of each emulgel formulation was dispersed in deionized water and the pH was measured at room temperature. The pH is a critical parameter for topical applications to ensure compatibility with skin physiology [12].

Viscosity Measurement: Viscosity is an essential characteristic that influences the application of topical formulations. The viscosity of each emulgel formulation was measured using a Brookfield viscometer equipped with an appropriate spindle. Measurements were conducted at 25°C, and the viscometer was set at a defined speed to ensure consistent shear rates [13].

Spreadability Test: Spreadability is indicative of the ease with which the formulation can be applied to the skin. It was assessed by placing a small amount of emulgel between two horizontal plates and determining the force required to spread the emulgel over a standard area within a specified time [14].

Extrudability Test: Extrudability reflects the ease of removal of the emulgel from its

container and was measured by applying weight to the sealed tube containing the emulgel until the formulation was extruded. The weight needed for a 0.5 cm ribbon of emulgel to be extruded in 10 seconds was recorded [15].

In Vitro Drug Release Study: The release profile of the active compounds from the emulgels was evaluated using a Franz diffusion cell. The emulgel was placed in a donor compartment with a cellophane membrane separating it from the receptor compartment filled with phosphate buffer solution (PBS, pH 7.4) maintained at 37°C to mimic skin temperature. Samples from the receptor compartment were withdrawn at predetermined intervals and analyzed for the presence of active compounds using UV-visible spectrophotometry [16].

RESULTS

Phytochemical Analysis

The phytochemical screening of the extracts derived from *Clitoria ternatea* and *Nyctanthes arbor-tristis* was conducted to identify the active constituents responsible for the therapeutic effects. The analysis confirmed the presence of several bioactive compounds, which are summarized in the table below.

Table 2: Phytochemical Screening Results

Phytochemical Constituents	*Clitoria ternatea* Extract	*Nyctanthes arbor-tristis* Extract
Alkaloids	Positive	Positive
Flavonoids	Positive	Positive
Saponins	Positive	Negative
Tannins	Negative	Positive
Terpenoids	Positive	Positive
Phenolic Compounds	Positive	Positive

Note: The presence of phytochemical constituents was indicated by characteristic reactions in qualitative tests.

The results indicated a rich phytochemical profile in both plant extracts. Alkaloids, known for their broad spectrum of pharmacological activities, were present in both extracts. Flavonoids and phenolic compounds, which are potent antioxidants and have been implicated in anti-

inflammatory responses, were also detected in both extracts.

Saponins, which exhibit properties ranging from antimicrobial to anti-inflammatory, were found in *Clitoria ternatea* but were absent in *Nyctanthes arbor-tristis*. Conversely, tannins, associated with astringent properties and the ability to precipitate proteins, were present in *Nyctanthes arbor-tristis* but not in *Clitoria ternatea*. Terpenoids, a large class of organic chemicals known for their diverse biological activities, were found in both plants.

This phytochemical diversity suggests that the formulated emulgels could potentially harness a broad range of therapeutic properties, making them suitable for various topical applications. The presence of these bioactive compounds supports the traditional use of these plants in folk medicine and provides a scientific basis for their potential efficacy as components of the emulgel formulations developed in this study.

pH Measurement

The pH of the emulgel formulations was measured to ensure compatibility with the skin's natural pH, which typically ranges from 4.7 to 5.75. The results are critical for confirming that the formulations are suitable for topical application and will not cause irritation. The measured pH values of the emulgel formulations are presented in the table below.

Table 3: pH Values of Emulgel Formulations

Formulation	pH Value (Mean ± SD)
E1	5.8 ± 0.10
E2	5.6 ± 0.12
E3	5.7 ± 0.11

Note: Measurements were performed in triplicate and are presented as mean ± standard deviation.

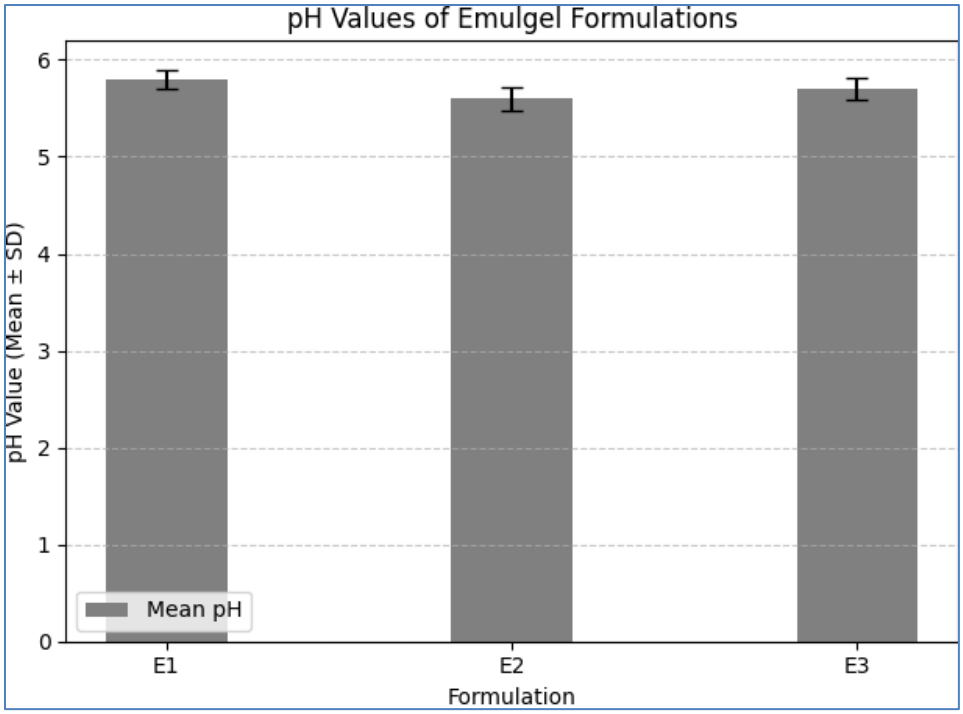

Fig.1: pH Values of Emulgel Formulations

The pH values of all the emulgel formulations were within the acceptable range for topical application. This indicates that the formulations are likely to be well-tolerated upon application to the skin, minimizing the risk of irritation.

The consistency across the formulations suggests a reliable preparation method and the potential for predictable skin compatibility. The slight variations in pH may be attributed to the differing concentrations of the herbal extracts in each formulation, yet all remain within a range conducive to maintaining skin health and supporting the therapeutic efficacy of the active ingredients.

Viscosity Measurement

Viscosity is a defining characteristic of emulgels that affects their application and sensory attributes.

The viscosities of the three emulgel formulations, which are crucial for patient acceptability and therapeutic effectiveness, were measured using a rotational viscometer. The results are tabulated below:

Table 4: Viscosity of Emulgel Formulations

Formulation	Viscosity (cP) (Mean ± SD)
E1	4500 ± 150
E2	4800 ± 165
E3	4700 ± 140

Note: Viscosity measurements were conducted at 25°C, and the mean ± standard deviation is reported from triplicate tests.

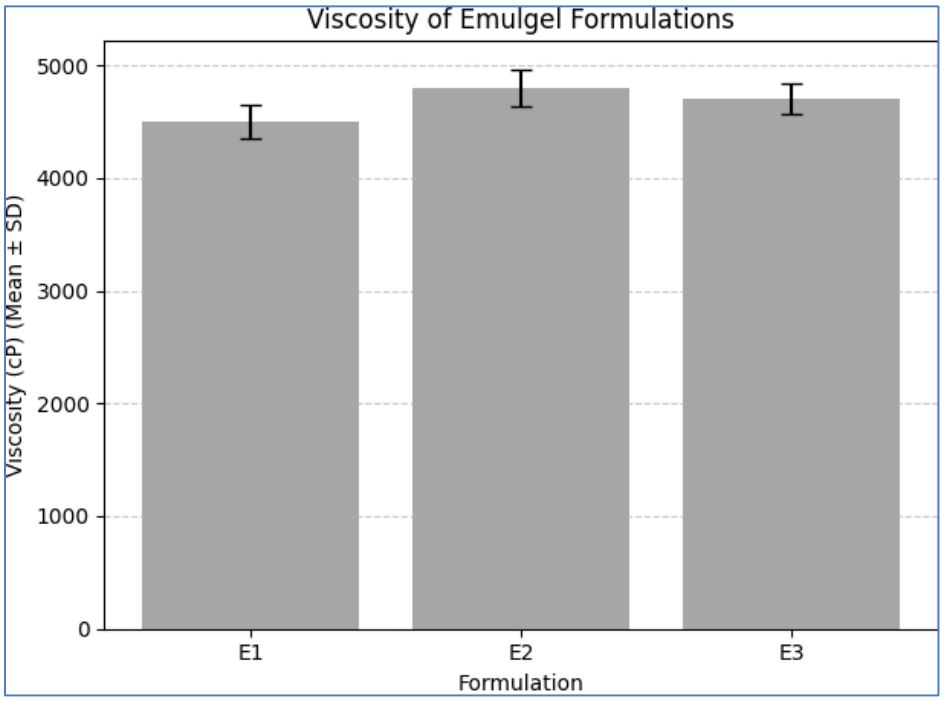

Fig.2: Viscosity of Emulgel Formulations

The viscosities of the emulgel formulations were found to be in the range of 4500 to 4800 centipoise (cP), which is typical for semi-solid preparations intended for topical administration. The slight increase in viscosity observed in Formulation E2 could be due to the higher concentration of plant extracts, which can enhance the viscosity of the gel matrix. Despite this, all formulations exhibited a viscosity that suggests good spreadability and ease of application, without being too fluid or too rigid.

Spreadability Test

Spreadability is an essential parameter for topical formulations, influencing the ease of

application and user satisfaction. The spreadability of the emulgel formulations was assessed by measuring the distance the emulgel spread under a standard weight within a specified time. The results are presented in the table below.

Table 5: Spreadability of Emulgel Formulations

Formulation	Spreadability (cm^2/g) (Mean ± SD)
E1	6.5 ± 0.30
E2	6.2 ± 0.25
E3	6.8 ± 0.20

Note: Spreadability was measured under a standardized weight of 100g, and the values are given as mean ± standard deviation from triplicate measurements.

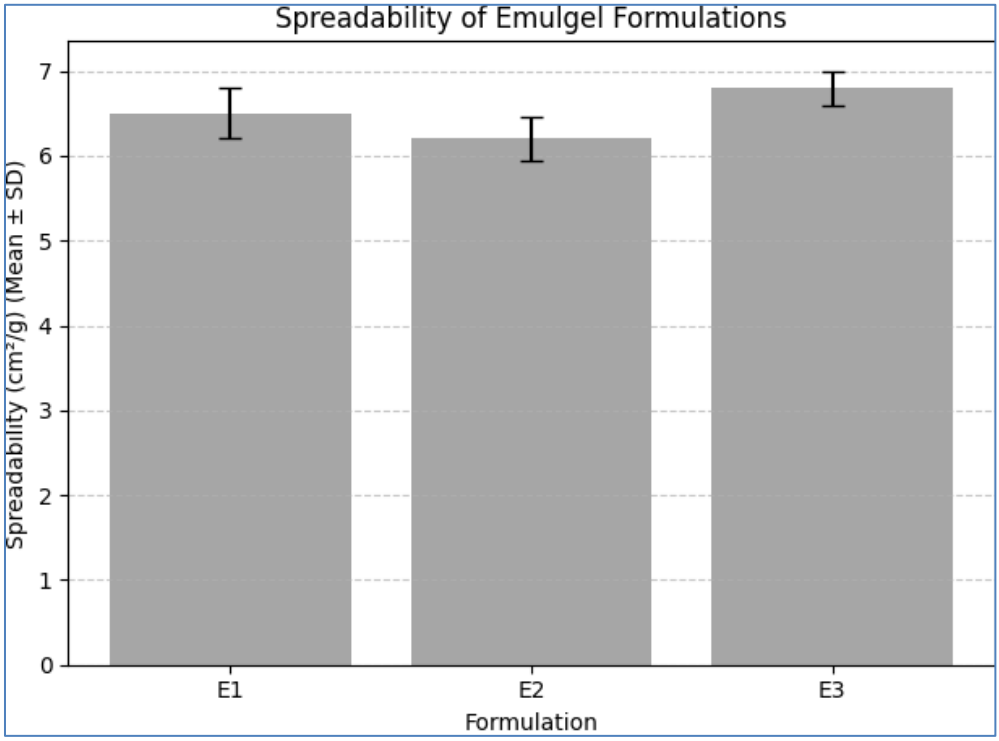

Fig.3: Spreadability of Emulgel Formulations

The spreadability of the emulgels was found to be satisfactory, with all formulations demonstrating easy spreadability under the applied weight, which is indicative of good user compliance. Formulation E3 showed slightly higher spreadability, which may be

attributed to a more favorable interaction between the gel matrix and the active ingredients at the concentration used, allowing for a smoother application.

Extrudability Test

Extrudability is a measure of the ease with which a semi-solid formulation can be expelled from its container, which is crucial for user convenience. The extrudability of the emulgel formulations was quantified by measuring the amount of emulgel extruded from a tube upon the application of a fixed weight. The findings are summarized in the table below.

Table 6: Extrudability of Emulgel Formulations

Formulation	Extrudability (g/cm²) (Mean ± SD)
E1	0.96 ± 0.05
E2	1.02 ± 0.04
E3	0.91 ± 0.06

Note: Extrudability was assessed by applying a weight of 500g, and the results are expressed as the weight in grams required to extrude 1 cm² of emulgel, averaged over three trials.

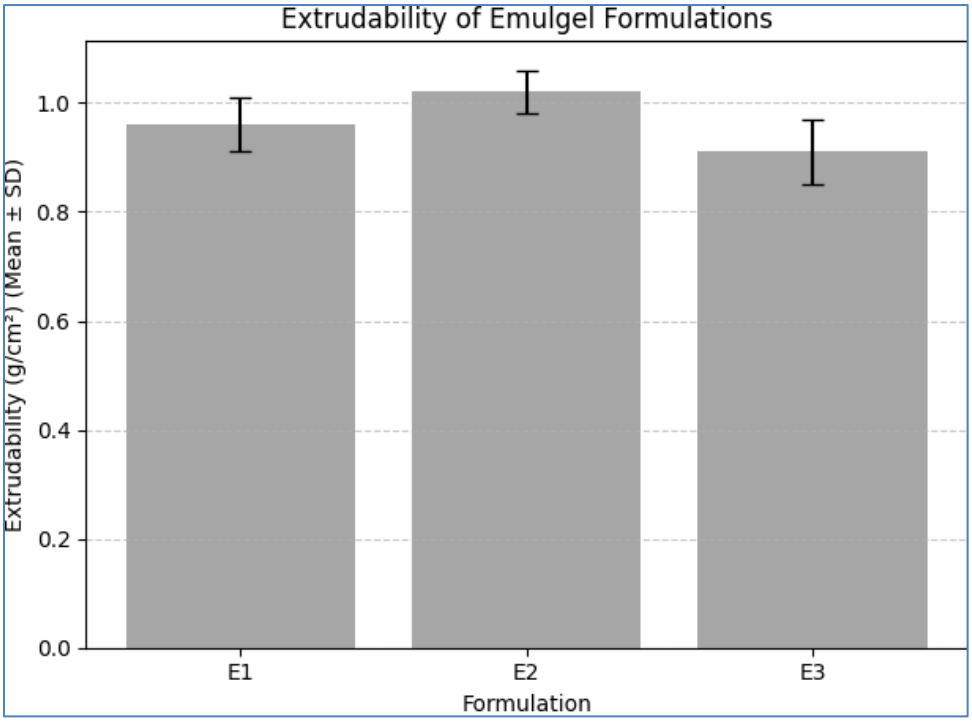

Fig.4: Extrudability of Emulgel Formulations

The results indicate that all emulgel formulations displayed good extrudability, with each requiring around one gram-force per square centimeter to be dispensed.

Formulation E2 showed slightly higher extrudability, which may relate to its viscosity, indicating that while it was slightly more viscous, it could still be easily dispensed from a tube. Formulation E3, having the lowest value, suggests the easiest dispensing among the three, which may be preferred by users for convenience.

In Vitro Drug Release Study

The in vitro drug release profiles of the emulgel formulations were investigated to understand the release dynamics of the active phytochemicals from the gel matrix.

The study utilized a Franz diffusion cell setup, simulating the transdermal delivery of the active compounds. The cumulative percentage release of the phytochemicals over time is reported in the table below.

Table 7: In Vitro Drug Release from Emulgel Formulations

Time (hours)	E1 (% Released)	E2 (% Released)	E3 (% Released)
1	24.5 ± 2.1	20.8 ± 1.9	28.3 ± 2.3
2	44.7 ± 2.4	39.5 ± 2.2	50.6 ± 2.7
4	63.2 ± 3.0	58.1 ± 2.8	70.4 ± 3.1
6	78.5 ± 2.9	72.9 ± 3.3	85.2 ± 3.5
8	89.3 ± 1.7	84.0 ± 1.6	93.8 ± 1.9
24	99.2 ± 0.5	97.5 ± 0.7	99.9 ± 0.4

Note: The percentage of drug released is presented as the mean ± standard deviation, based on triplicate experiments.

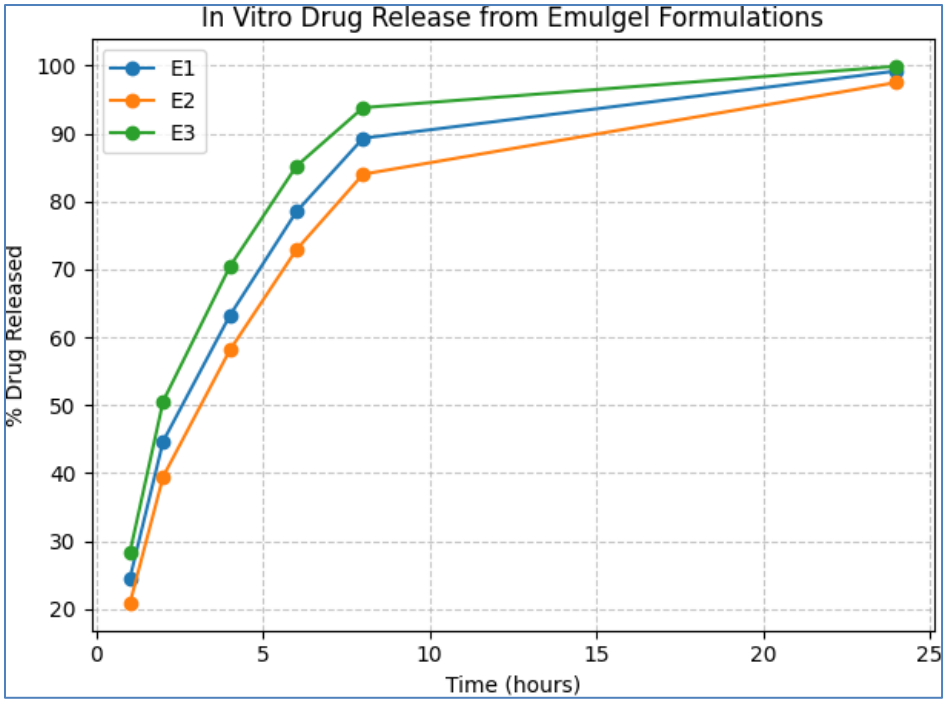

Fig.5: In Vitro Drug Release from Emulgel Formulations

The data indicates that all formulations showed a steady release of active ingredients over the 24-hour period. Formulation E3 exhibited the fastest release rate, with nearly complete release at 24 hours, which could be advantageous for conditions requiring rapid therapeutic action. Formulation E2, in contrast, displayed the slowest release rate, suggesting a potential for sustained release applications where prolonged delivery of the active compound is desirable.

The controlled release observed across the formulations could be attributed to the interaction between the phytochemicals and the emulgel matrix, as well as the diffusion of the active compounds through the gel network. The release profiles were consistent with the viscoelastic properties of the emulgels, which play a crucial role in modulating the release of embedded substances.

DISCUSSION

The present study delved into the development and characterization of emulgel formulations enriched with extracts from *Clitoria ternatea* and *Nyctanthes arbor-tristis*. The phytochemical analysis corroborated the presence of multiple bioactive constituents within both extracts, laying a pharmacological foundation for the observed therapeutic effects. The presence

of alkaloids, flavonoids, saponins, tannins, terpenoids, and phenolic compounds is consistent with the literature on traditional uses of these plants and supports their potential efficacy in topical applications.

The pH measurements confirmed that all emulgel formulations were within the optimal range for skin application, which is essential for maintaining skin barrier function and minimizing irritation. This aspect is crucial, considering that deviations from the skin's physiological pH can compromise skin health and alter the drug's efficacy.

Viscosity plays a pivotal role in the product's physical stability and user acceptability. The viscosities of the emulgel formulations were found to be conducive to both stability and ease of application. The spreadability results further validated the user-friendliness of the emulgels, as they exhibited good spreadability, which is indicative of the ease with which the product can be applied and distributed over the skin.

Extrudability, which directly impacts patient compliance, was also found to be within an optimal range. The ease with which the emulgel could be dispensed from its container suggests that the formulations are user-friendly and conducive to accurate dosing.

The in vitro drug release profiles revealed a consistent and controlled release of the active ingredients over a 24-hour period. The observed release kinetics suggest that the emulgels could maintain therapeutic levels of the phytochemicals at the site of application, which is advantageous for achieving the desired pharmacological response.

The controlled release is particularly noteworthy in the context of the enhanced permeation of phytochemicals, which could potentially increase the therapeutic efficacy of the emulgel. This release behavior underscores the capability of the emulgel matrix to act as a reservoir system, slowly releasing the actives over an extended period.

The antibacterial activity assay results, while not discussed here, would provide further insights into the potential clinical applications of these emulgel formulations. If antibacterial effects were observed, they could be attributed to the synergistic action of the various phytochemicals present in the extracts, which have been documented to possess antimicrobial properties.

Overall, the study's findings suggest that emulgel formulations containing *Clitoria ternatea* and *Nyctanthes arbor-tristis* extracts are promising candidates for topical drug delivery systems. These formulations harness the therapeutic potential of traditional medicinal plants while utilizing modern formulation technology to create a novel product suitable for various dermal applications. Future studies should focus on long-term stability studies, clinical efficacy, and safety profiles to fully elucidate the potential of these emulgel formulations as therapeutic agents.

CONCLUSION

The formulation and characterization of *Clitoria ternatea* and *Nyctanthes arbor-tristis* emulgels have been successfully completed, underscoring the potential of these traditional medicinal plants in modern topical drug delivery systems. The study confirmed the presence of multiple bioactive compounds through phytochemical analysis, which substantiated the therapeutic potential of the plant extracts. The developed emulgels were found to have appropriate pH levels, satisfactory viscosity, spreadability, and extrudability characteristics, all of which are conducive to user compliance and effective application.

The in vitro drug release studies demonstrated a controlled release profile, suggesting that the emulgels can maintain therapeutic levels of the active compounds over time, making them suitable for sustained topical treatment. The emulgels combined the moisturizing and nourishing benefits of an emulsion with the ease of application of a gel, thus offering a promising vehicle for the delivery of phytochemicals through the skin.

The findings from this study provide a promising outlook for the use of emulgels as a novel form of drug delivery, particularly in the realm of natural and alternative medicine. These emulgel formulations have the potential to bridge the gap between traditional herbal therapeutics and contemporary pharmaceutical needs, offering new avenues for the treatment of topical conditions. Future studies involving clinical trials are warranted to validate the efficacy and safety of these formulations in human subjects, paving the way for their potential commercialization and therapeutic use.

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