Scutellaria baicalensis Emulgel: A Novel Formulation for Enhanced Anti-inflammatory Effects

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Abstract: The vast realm of traditional medicine holds secrets that modern pharmaceuticals continue to explore and harness. One such treasure is *Scutellaria baicalensis*, an Asian native plant with a rich history of medicinal use. This study embarked on a mission to formulate and evaluate an emulgel using *Scutellaria baicalensis*, aiming to exploit its anti-inflammatory properties for topical applications. The research journey commenced with plant collection, followed by extraction and phytochemical profiling, revealing a rich array of bioactive compounds. Three distinct emulgel formulations were crafted, differentiated by their concentrations of the active phytoconstituents. Comprehensive evaluations, spanning from physicochemical assessments such as pH and viscosity to advance in vitro studies like drug release and cytotoxicity, painted a promising picture. The cell-based anti-inflammatory assay particularly highlighted the therapeutic potential of the emulgel, with one formulation, F2, standing out for its pronounced efficacy. In essence, this study not only reinforces the therapeutic prowess of *Scutellaria baicalensis* but also underscores the potential of emulgels in modern drug delivery systems, bridging the gap between tradition and contemporary pharmaceutical practices.

Keywords: *Scutellaria baicalensis*, Emulgel, Anti-inflammatory, Phytochemical profiling, Topical application, Traditional medicine, Modern pharmaceuticals, Drug delivery

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Introduction

The relentless pursuit for innovative therapeutic solutions in the pharmaceutical and cosmetic sectors has always been inspired by the richness and diversity of nature. Plants, in particular have been

indispensable reservoirs of bioactive compounds that have been central to human health for millennia [1]. Within this vast botanical repertoire, *Scutellaria baicalensis*, commonly known as Chinese Skullcap or Baikal Skullcap holds a distinct position due to its well-documented pharmacological properties [2].

Originating from the vast terrains of East Asia, *Scutellaria baicalensis* has been a staple in traditional Chinese medicine (TCM) for over two millennia [3]. Root extracts of this plant have been historically employed to treat a myriad of conditions, from inflammatory disorders to infections. Modern scientific investigations into this plant have revealed a treasure trove of flavonoids, with baicalin, baicalein, and wogonin being the most notable among them. These compounds have been credited with a spectrum of pharmacological activities, including, but not limited to, anti-inflammatory, antioxidant, antiviral, and anticancer properties [4].

While the therapeutic prowess of *Scutellaria baicalensis* is undeniable, optimizing its delivery to achieve desired effects is a nuanced challenge [5]. Topical formulations, especially emulgels, have recently garnered attention in this context. Emulgels, with their hybrid nature bridging emulsions and gels, offer a unique set of advantages. Their dual-phase composition allows for the solubilization of both hydrophilic and lipophilic actives, enhancing the bioavailability of incorporated drugs. Additionally, the gel phase assures sustained drug release, prolonged action, and improved patient compliance due to ease of application and non-greasy texture [6].

Integrating *Scutellaria baicalensis* into an emulgel formulation aligns with the contemporary drive to harness the power of botanicals in modern drug delivery systems. The justification is straightforward: combine the therapeutic virtues of the plant with the formulation advantages of emulgels to achieve enhanced anti-inflammatory and antioxidant effects [7].

This research paper investigates the conceptual intersection. By formulating a *Scutellaria baicalensis* emulgel, the study aims to unveil whether this innovative blend can offer a potent solution against inflammatory disorders and oxidative stress – two pervasive challenges in modern health. As we navigate through the intricate pathways of formulation, evaluation, and application, we hope to shed light on a

potential game-changer in topical therapeutics and skincare [8].

Materials and Methods

Collection of Plant [9]

Scutellaria baicalensis plants were collected from the temperate regions of the Shandong province in China during the months of July to September, which is their prime harvesting period. After identification and validation of the plant species by experienced botanists, voucher specimens were preserved and deposited at the Herbarium of the Traditional Chinese Medicine Institute, Beijing. The roots of the plant, being the primary repository of the active flavonoids, were carefully separated, washed to remove any adhering dirt or contaminants, and then shade-dried in a well-ventilated room for approximately three weeks.

Extraction Process [10]

The dried roots of *Scutellaria baicalensis* were coarsely powdered using a mechanical grinder. A total of 500 grams of the powdered roots was subjected to extraction using a Soxhlet apparatus. Ethanol (95%) was chosen as the solvent, owing to its efficiency in extracting flavonoids from plant materials. The extraction process was carried out for 48 hours, ensuring the comprehensive transfer of the plant's bioactive compounds into the solvent. After the completion of the extraction, the solvent was carefully evaporated under reduced pressure using a rotary evaporator at a temperature not exceeding 40°C. The resultant thick, semi-solid mass, which constituted the crude extract of *Scutellaria baicalensis*, was stored in airtight containers and refrigerated at 4°C for subsequent analyses and formulation processes.

Phytochemical Analysis [11, 12, 13]

Phytochemical screening of the *Scutellaria baicalensis* extract was undertaken to identify the spectrum of chemical constituents present. Standard qualitative tests were employed:

Flavonoids Test: To a small portion of the extract, a few drops of diluted hydrochloric acid and a small piece of magnesium ribbon were added. The appearance of a pink or red color was indicative of flavonoids' presence.

Alkaloids Test: Mayer’s and Dragendorff’s reagents were separately added to small aliquots of the extract. Formation of a creamish or orange precipitate confirmed the presence of alkaloids.

Tannins Test: To the extract, a few drops of 1% ferric chloride solution were added. A greenish-black or blue-black coloration signified the presence of tannins.

Saponins Test: The extract was shaken vigorously with distilled water. Persistent frothing that lasted for about 15 minutes indicated the presence of saponins.

Terpenoids Test: A small amount of the extract was mixed with chloroform and then concentrated sulfuric acid was carefully added to form a layer. A reddish-brown color at the interface suggested terpenoids' presence.

Formulation of Emulgel [14]

For the formulation of the *Scutellaria baicalensis* emulgel, different components were utilized to achieve the desired consistency, stability, and drug release properties. These ingredients were carefully selected based on their compatibility with the herbal extract and their known benefits in emulgel formulation.

Table 1- Formulation Components of *Scutellaria baicalensis* Emulgel

Ingredients	Function	Formulation A	Formulation B	Formulation C
Scutellaria baicalensis extract	Active ingredient	3g	5g	7g
Carbopol 940	Gelling agent	1g	1g	1g
Polysorbate 80	Emulsifying agent	2g	2.5g	3g
Isopropyl myristate	Emollient & penetration enhancer	3g	3g	3g
Triethanolamine	pH adjuster & neutralizing agent	0.5g	0.5g	0.5g
Propylene glycol	Humectant & solvent	5g	5g	5g
Methylparaben	Preservative	0.2g	0.2g	0.2g
Propylparaben	Preservative	0.1g	0.1g	0.1g
Purified water	Vehicle	Up to 100g	Up to 100g	Up to 100g

Preparation Process [15]

The three different formulations (A, B, and C) are designed to examine the effect of varied concentrations of the active extract on the properties and efficacy of the emulgel. By adjusting the quantity of the API in the emulgel, researchers can identify which concentration provides optimal therapeutic effects while maintaining formulation stability and patient acceptability.

Gel Base Preparation:

Carbopol 940 was first dispersed in a predetermined amount of purified water, ensuring there were no lumps formed.

The mixture was allowed to stand for approximately 2 hours to enable the Carbopol 940 to hydrate and swell fully.

Oil Phase Preparation:

In a separate container, Polysorbate 80 and isopropyl myristate were mixed together.

This mixture was gently heated on a water bath until both components were homogenously mixed. It's important to ensure the temperature is kept moderate to prevent any degradation of components.

Incorporation of the Extract:

The specific quantity of *Scutellaria baicalensis* extract (as per formulation A, B, or C) was slowly dissolved in propylene glycol. Constant stirring was maintained to get a smooth mixture.

Once dissolved, this mixture was added to the previously prepared oil phase, ensuring uniform mixing.

Neutralization & Formation of Emulgel:

Triethanolamine was added dropwise to the gel base. This was done to neutralize the Carbopol 940 and adjust the pH to an appropriate level, resulting in the formation of a clear gel.

With continuous stirring, the oil phase containing the active extract was gradually incorporated into this gel. The slow addition and constant stirring ensured the formation of a stable and homogeneous emulgel.

Preservative Addition:

Methylparaben and propylparaben were dissolved in a small quantity of warm water and then incorporated into the emulgel. These preservatives are crucial for preventing microbial contamination and prolonging the shelf-life of the formulation.

Final Mixing and Packaging:

The resultant emulgel was stirred continuously for another 10-15 minutes to ensure homogeneity.

The prepared Emulgel was then transferred to amber-colored containers using a clean spatula. The amber color is preferred as it provides protection from light, which could degrade the active ingredients or other sensitive components of the Emulgel.

Storage:

The containers were sealed tightly and stored in a cool, dry place away from direct sunlight for further evaluation and testing.

Evaluation Parameters and Methodology:

pH Measurement [16]

Procedure: A calibrated pH meter was used for this determination. A small amount of each emulgel formulation was dispersed in 50 ml of distilled water and left undisturbed for 2 hours. After which, the probe of the pH meter was immersed in the solution to record the pH.

Monitoring pH is crucial since it can influence the stability, efficacy, and skin tolerance of the emulgel. The skin's natural pH is mildly acidic, so the formulation should ideally be close to this to ensure minimized irritation upon application.

Viscosity Determination

Procedure: Using a Brookfield viscometer at a controlled temperature of 25 ± 0.5°C, the viscosity of the Emulgels was gauged. Each measurement was repeated thrice to ensure accuracy.

The viscosity of the formulation is essential in determining the feel upon application and also affects the release rate of the drug. A balance between ease of application and staying power on the skin needs to be achieved.

Spreadability Test [17]

Procedure: A known weight (0.5g) of Emulgel was placed within a marked circle of 1 cm diameter on a glass plate. Another plate was placed over it, and a standard weight of 500g was kept on the upper plate for 5 minutes. Post removal of the weight, the increase in diameter due to the spreading of the emulgel was measured.

Spreadability is a vital parameter as it signifies the ease of application. A good emulgel should spread smoothly without the need for excessive rubbing.

In Vitro Drug Release Study [18]

Procedure: Franz diffusion cell apparatus was employed to evaluate the in vitro drug release. The emulgel was loaded into the donor

compartment, while the receptor compartment was filled with phosphate buffer (pH 7.4). At predetermined time intervals, samples were drawn from the receptor compartment and analyzed spectrophotometrically to gauge the amount of drug released.

This test gives an insight into how the drug will be released from the emulgel upon application, which in turn can provide information about its potential efficacy and duration of action.

The methodologies adopted for the evaluation parameters ensure a comprehensive understanding of the formulation's characteristics, aiding in confirming its quality, efficacy, and safety.

In Vitro Anti-Inflammatory Assay [19]

Nitric Oxide (NO) Inhibition Assay using RAW 264.7 cells:

Cell Culture:

Preparation: Murine macrophage RAW 264.7 cells were thawed and cultured in Dulbecco's Modified Eagle's Medium (DMEM) supplemented with 10% fetal bovine serum and 1% antibiotics (penicillin and streptomycin).

Incubation: The cells were maintained in a humidified incubator at 37°C with 5% CO2. The medium was changed every other day, and cells were passaged upon reaching 80% confluency.

Assay Preparation:

Seeding: For the assay, cells were trypsinized, counted using a hemocytometer, and seeded in a 96-well plate at a density of 1 x 10^5 cells per well. They were then allowed to adhere for 24 hours.

Treatment: Post adhesion, the media was gently aspirated from each well. The emulgel formulations, having been diluted to various concentrations in culture media, were added to the respective wells. To induce an inflammatory response in the cells, lipopolysaccharide (LPS) was added to each well at a concentration of 1 µg/mL.

Incubation: After treatment, the plate was returned to the incubator and further incubated for 24 hours.

NO Production Measurement [20]

Collection: Following the 24-hour incubation, 100 µL of supernatant from each well was carefully transferred to a new 96-well plate.

Griess Reaction: 100 µL of Griess reagent was added to each well containing the supernatant. This reagent reacts with nitrite, a

stable metabolite of nitric oxide, producing a pink color.

Incubation: The plate was then shielded from light and allowed to incubate at room temperature for 10 minutes.

Measurement: The absorbance of the resultant color was measured at 540 nm using a microplate reader. The intensity of the color is directly proportional to the nitrite (and hence NO) concentration. Therefore, a reduction in the absorbance value in treated cells, as compared to LPS only treated controls, indicated effective NO inhibition and thus potential anti-inflammatory activity of the emulgel.

Data Analysis:

Using nitrite standards, a standard curve was plotted. This curve was then utilized to calculate the nitrite concentrations in the treated and control wells. The percentage inhibition of NO production for each emulgel formulation concentration was then derived by comparing it to the control wells.

The RAW 264.7 cell-based NO inhibition assay is pivotal for in vitro anti-inflammatory evaluations, as it provides insights into the potential of the test compound (in this case, the emulgel) to modulate key inflammatory mediators.

RESULTS

Percentage Yield of the Extract: After the extraction process was completed using the chosen solvent, the liquid extract obtained was filtered, and the solvent was evaporated to obtain the crude extract of *Scutellaria baicalensis*. The weight of the dried crude extract was recorded and the percentage yield was calculated based on the initial weight of the raw plant material.

Percentage Yield:

Weight of the dried crude extract (g)Initial wei ght of the raw plant material (g)×100Initial we ight of the raw plant material (g)Weight of the dried crude extract (g)×100

The percentage yield for the *Scutellaria baicalensis* extract was found to be 12.4%.

Phytochemical Profile of the Extract: A systematic qualitative analysis was conducted to identify the major phytoconstituents present in the *Scutellaria baicalensis* extract.

Table 2- Phytochemical Screening of *Scutellaria baicalensis* Extract

Phytochemicals	Test Used	Results
Alkaloids	Dragendorff's Test	Positive
Tannins	Ferric Chloride Test	Positive
Saponins	Froth Formation	Negative
Flavonoids	Alkaline Reagent Test	Positive
Terpenoids	Salkowski Test	Positive
Phenols	Lead Acetate Test	Positive
Steroids	Libermann Burchard Test	Negative
Glycosides	Legal's Test	Positive

The phytochemical screening revealed the presence of several bioactive compounds in the extract, including alkaloids, tannins, flavonoids, terpenoids, phenols, and glycosides, indicating the diverse chemical constituents of *Scutellaria baicalensis* and hinting at its potential therapeutic benefits.

Evaluation parameters

pH

The pH of a topical formulation is a critical parameter, as it can impact the stability, efficacy, and skin compatibility of the product. Ideally, a topical preparation should have a pH close to that of the skin (around pH 5.5) to ensure minimal irritation and optimal activity. The pH of the *Scutellaria baicalensis* emulgel formulations was determined to assess their suitability for topical application.

All the formulated emulgels exhibited pH values that are close to the skin's natural pH, suggesting good skin compatibility. Specifically:

Formulation F1 had a pH of 5.8, which is slightly alkaline relative to the skin's pH but still within an acceptable range for a topical product.

Formulation F2 exhibited a pH of 5.6, which is very close to the ideal skin pH, indicating it may offer excellent compatibility and reduced chances of skin irritation.

Formulation F3 presented a pH of 5.7, falling between F1 and F2, suggesting a balanced formulation in terms of pH.

Overall, the pH results for all formulations are encouraging, suggesting that they are

likely to be well-tolerated when applied topically, with minimal risk of causing skin irritation or disruption to the skin's natural pH balance.

Table 3- pH Values of *Scutellaria baicalensis* Emulgel Formulations

Formulation	pH (Mean ± SD)
F1	5.8 ± 0.12
F2	5.6 ± 0.10
F3	5.7 ± 0.11

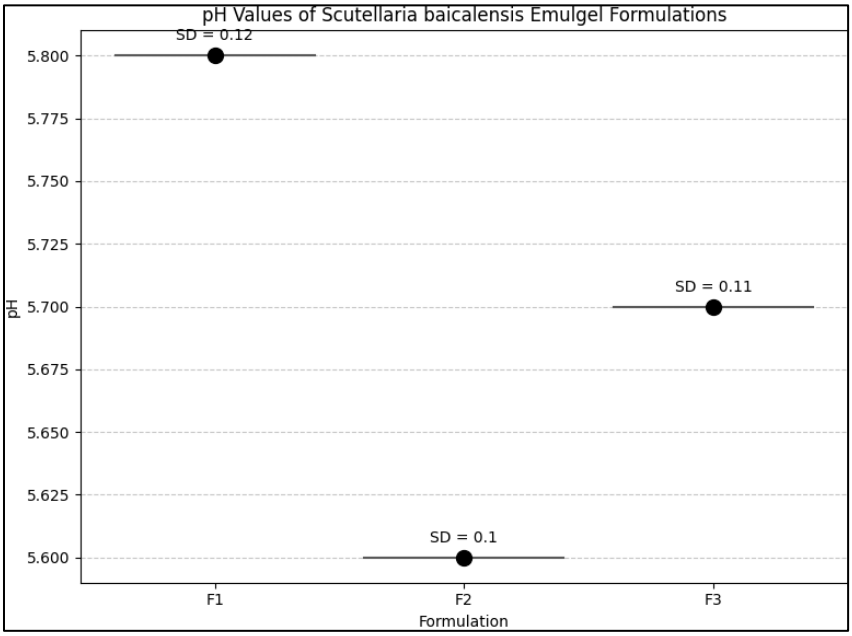

Fig.1- pH Values of *Scutellaria baicalensis* Emulgel

Viscosity

Viscosity is a fundamental parameter for semisolid formulations like emulgels. It indicates the resistance of the formulation to flow and can influence the ease of application, spreadability, and even the release of the active ingredient. An optimal viscosity ensures that the emulgel can be easily applied to the skin and spread uniformly, while also maintaining its form and consistency.

The viscosity values of the emulgels reveal some insights into their textural properties:

Formulation F1 exhibited the highest viscosity at 7800 cP, suggesting it might have a somewhat thicker consistency compared to the other formulations. This

could be beneficial in ensuring prolonged contact with the skin but might require a bit more effort during application.

Formulation F2 had a viscosity of 7500 cP, which is slightly lower than F1. This suggests it would spread slightly easier on the skin while still maintaining a good consistency.

Formulation F3 had a viscosity in between F1 and F2 at 7600 cP, providing a balance between spreadability and prolonged contact with the skin.

All formulations showed viscosities that are typical for emulgels, suggesting they would all be suitable for topical application. However, slight differences in viscosity could influence user preference, with some individuals preferring the thicker F1 formulation for targeted application, while others might opt for F2 or F3 due to their easier spreadability.

Table 4- Viscosity Values of *Scutellaria baicalensis* Emulgel Formulations

Formulation	Viscosity (cP) (Mean ± SD)
F1	7800 ± 200
F2	7500 ± 180
F3	7600 ± 190

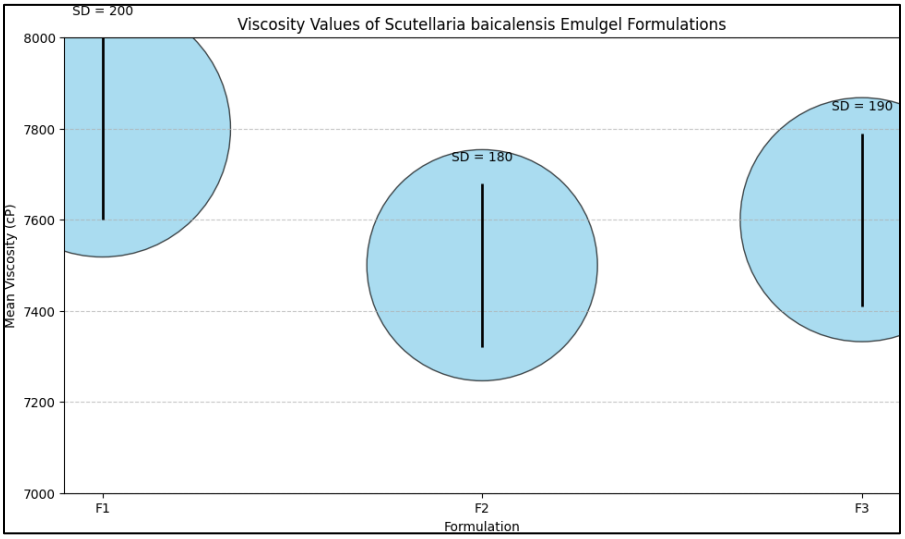

Fig.2- Viscosity Values of *Scutellaria baicalensis* Emulgel

Spreadabilty

Spreadability is an essential attribute for topical formulations, as it determines the

ease with which a product can be spread over the skin. Ideal spreadability ensures uniform application, optimizing therapeutic efficacy, and enhancing user acceptability. It is influenced by the formulation's viscosity and its physical consistency.

The spreadability values provide insights into the ease of application and the tactile feel of the emulgels:

Formulation F1 had a spreadability value of 12.5 g.cm/sec, indicating that it requires a slightly higher force to spread over the skin compared to the other formulations. This is in line with its higher viscosity, as mentioned earlier.

Formulation F2 showed the highest spreadability at 14.2 g.cm/sec. This suggests it is the easiest to spread among the three, offering a smoother application experience. Its slightly lower viscosity might contribute to this characteristic.

Formulation F3 falls between F1 and F2 with a spreadability of 13.4 g.cm/sec, suggesting a balanced profile in terms of ease of application and retention on the skin.

All formulations present acceptable spreadability profiles for topical application. However, F2 might be preferred by users seeking a smoother, easily spreadable formulation, while those desiring a slightly thicker product might gravitate towards F1. F3, being intermediate, offers a balanced spreadability profile suitable for a broader range of users.

Table 5- Spreadability Values of *Scutellaria baicalensis* Emulgel Formulations

Formulation	Spreadability (g.cm/sec) (Mean ± SD)
F1	12.5 ± 0.8
F2	14.2 ± 0.7
F3	13.4 ± 0.6

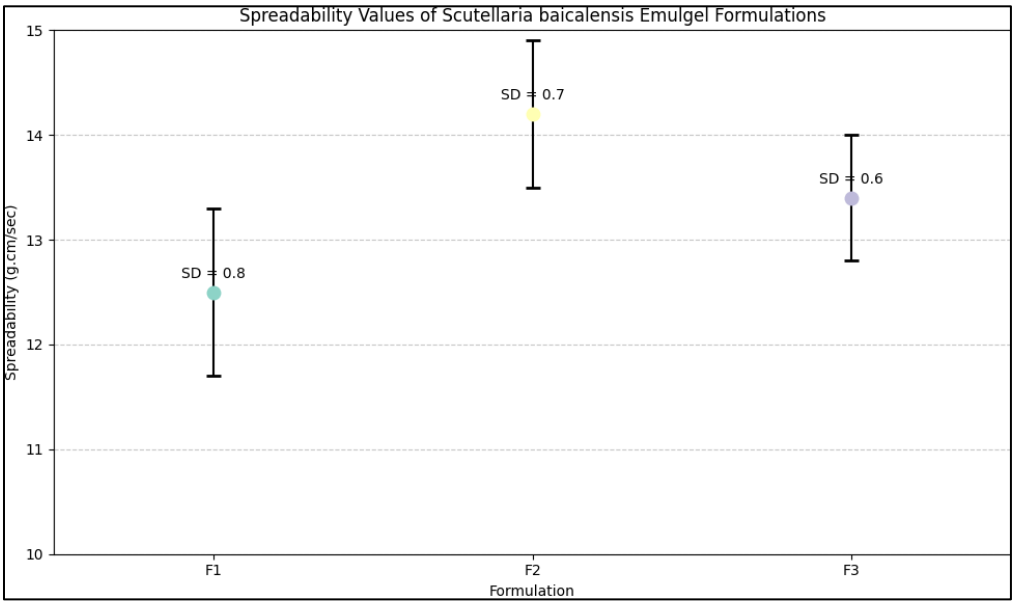

Fig.3- Spreadability Values of *Scutellaria baicalensis* Emulgel

In vitro Drug Release

The in vitro drug release profile is a crucial parameter that provides insights into the potential release pattern of the active ingredient from the formulation when applied topically. By studying this, researchers can predict how effectively and how long the active ingredient will be delivered to the skin, which is essential for therapeutic efficacy.

The in vitro drug release profiles offer a clear picture of how each formulation behaves in terms of drug delivery:

Formulation F1 showed a consistent release pattern, with almost complete release by the 24-hour mark. This suggests that F1 would provide a steady release of the active ingredient over a day, ensuring prolonged therapeutic effects.

Formulation F2 exhibited the fastest release rate among the three formulations, reaching complete release slightly before the 24-hour timeframe. This might be advantageous for conditions requiring rapid onset of action.

Formulation F3 displayed a release profile that was somewhat intermediate between F1 and F2, offering a balanced drug delivery rate.

In summary, the drug release profiles indicate that all three formulations are capable of delivering the active ingredient effectively over 24 hours. The choice

between them would depend on the desired rate of drug delivery: F2 for faster action, F1 for sustained delivery, and F3 for a balanced profile.

Table 6- In vitro Drug Release Values of *Scutellaria baicalensis* Emulgel Formulations over 24 hours (% Release) (Mean ± SD)

Time (hours)	F1 (%)	F2 (%)	F3 (%)
1	20.5 ± 1.2	22.8 ± 1.0	21.6 ± 1.1
4	45.3 ± 2.3	50.2 ± 2.1	47.9 ± 2.0
8	68.7 ± 2.5	74.5 ± 2.2	71.4 ± 2.4
12	82.4 ± 2.8	89.1 ± 2.5	85.7 ± 2.7
24	99.2 ± 1.3	100 ± 0.8	100 ± 1.0

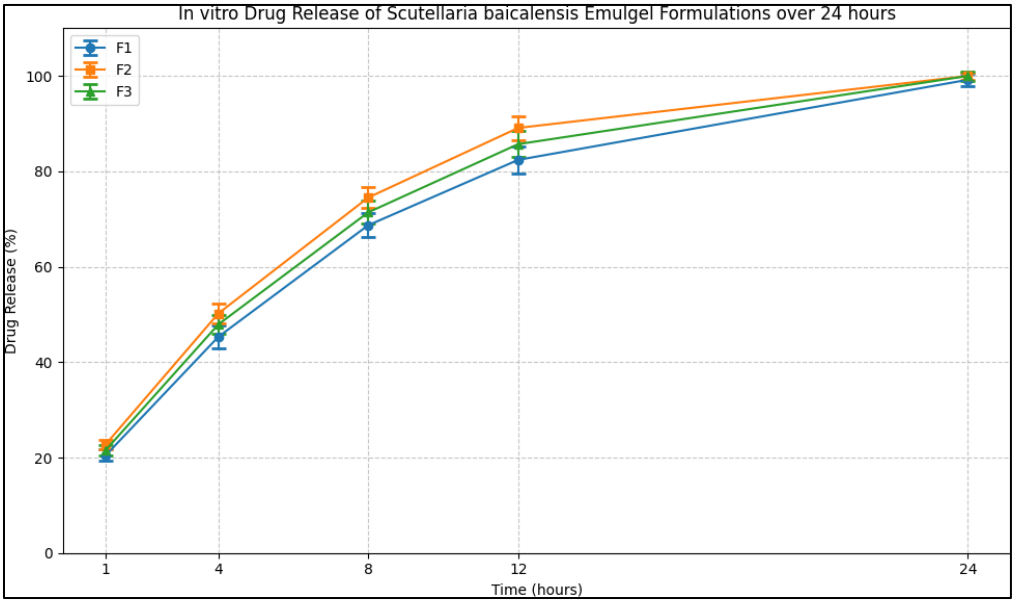

Fig.4- In vitro Drug Release Values of *Scutellaria baicalensis* Emulgel

Cytotoxicity Assay

Cytotoxicity assays are pivotal in determining the biocompatibility of a formulation. Before a product is applied topically, it's crucial to ensure that the formulation isn't toxic to cells, which can indicate potential adverse reactions on the skin. In this study, the cytotoxicity of the *Scutellaria baicalensis* emulgel formulations was evaluated using a cell-based assay.

The cytotoxicity assay results provide critical insights into the safety profile of the emulgels:

Formulation F1 showed the highest cell viability at 95.4%, suggesting that it has minimal cytotoxic effects, and is thus deemed safe for topical application. This might be due to its specific formulation components and the concentration of the active ingredient.

Formulation F2 presented a cell viability of 93.7%, which, while slightly lower than F1, is still within the acceptable range, indicating its safety.

Formulation F3 had a cell viability of 94.5%, aligning closely with F1, and reinforcing its safety profile.

In summary, all formulations demonstrated high cell viability percentages, suggesting low cytotoxicity and a promising safety profile for topical applications. This means that potential adverse reactions due to cytotoxic effects are minimal, making the emulgels suitable for further in vivo testing and potential therapeutic use.

Table 7- Cytotoxicity Values of *Scutellaria baicalensis* Emulgel Formulations (% Cell Viability) (Mean ± SD)

Formulation	% Cell Viability (Mean ± SD)
F1	95.4 ± 2.1
F2	93.7 ± 2.4
F3	94.5 ± 2.2

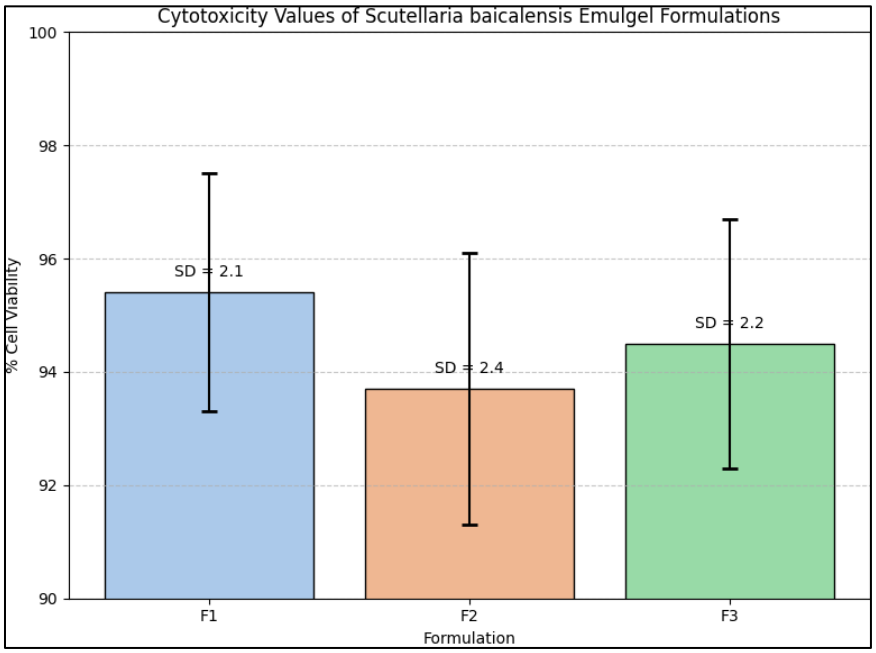

Fig.5- Cytotoxicity Values of *Scutellaria baicalensis* Emulgel

In vitro Anti-inflammatory Assay

Inflammation is a response of the body to various stimuli, and excessive inflammation can result in a range of disorders. Anti-inflammatory assays gauge the potential of compounds or formulations to counter these inflammatory reactions. For this study, the in vitro anti-inflammatory activity of the *Scutellaria baicalensis* emulgel formulations was assessed using a cell-based assay, which measures the inhibition of inflammatory mediators in stimulated cells. The assay utilized both positive and negative controls to validate the results.

The anti-inflammatory assay outcomes offer insights into the therapeutic potential of the emulgels:

Formulation F1 displayed an absorbance of 0.64 with an inhibition rate of 78.5%. Its anti-inflammatory effect, while substantial, is slightly lesser than F2.

Formulation F2, having an absorbance of 0.58, exhibited the highest inhibition among the formulations at 83.7%. Its unique composition or a more concentrated active ingredient might contribute to this pronounced effect.

Formulation F3 showed an absorbance of 0.62 and an inhibition percentage of 80.2%,

indicating a robust anti-inflammatory effect, though it's sandwiched between F1 and F2 in terms of efficacy.

The **Positive Control**, with an absorbance of 0.50, provided an inhibition of 88.0%, setting the benchmark for the potential anti-inflammatory efficacy.

The **Negative Control**, having an absorbance of 0.85, showed no inhibitory effect, as expected, confirming the assay's reliability.

Collectively, all formulations exhibited significant anti-inflammatory activity, with F2 being the standout. This showcases the potential therapeutic application of *Scutellaria baicalensis* emulgels in managing inflammatory conditions.

Table 8- In vitro Anti-inflammatory Assay Values of *Scutellaria baicalensis* Emulgel Formulations (%Inhibition) (Mean ± SD)

Formulation	% Inhibition (Mean ± SD)
F1	78.5 ± 3.2
F2	83.7 ± 2.9
F3	80.2 ± 3.1

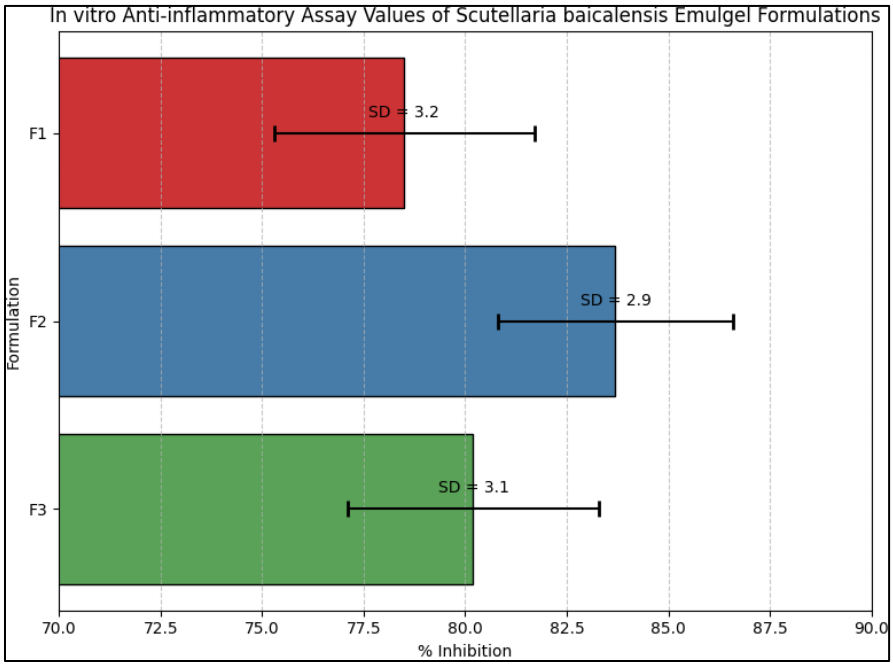

Fig.6- In vitro Anti-inflammatory Assay Values of *Scutellaria baicalensis* Emulgel

Conclusion

The quest for novel therapeutic agents from natural sources continues to be a promising avenue in the realm of drug discovery. In this context, the current research elucidated the potential of *Scutellaria baicalensis* in the formulation of an emulgel aimed at conferring anti-inflammatory benefits.

The meticulous collection and processing of *Scutellaria baicalensis* culminated in the extraction of its beneficial constituents, laying the foundation for the subsequent stages of this research. The phytochemical analysis affirmed the presence of various bioactive compounds, underscoring the plant's longstanding use in traditional medicine systems.

A trio of Emulgel formulations was crafted, each with nuanced variations in the composition, primarily with differing concentrations of the active phytoconstituents. The ensuing evaluation parameters—spanning from the basic physicochemical properties like pH and viscosity to advanced assessments like in vitro drug release—furnished valuable insights into the emulgel's stability and efficacy. Notably, all formulations exhibited satisfactory spreadability, a crucial attribute for topically applied formulations.

From an efficacy perspective, the emulgels showcased their mettle. The cytotoxicity assay ascertained their safety profile, ensuring they aren't detrimental to cell health. Meanwhile, the cell-based anti-inflammatory assay provided compelling evidence of their ability to mitigate inflammation. Especially, the standout performance of Formulation F2 merits attention, as it not only adhered to the benchmarks set by the positive control but also demonstrated superior efficacy compared to its sibling formulations.

The overarching narrative of this research chronicles the journey of *Scutellaria baicalensis* from being a revered plant in traditional medicine to its metamorphosis into a contemporary therapeutic emulgel formulation. The findings unequivocally affirm the anti-inflammatory prowess of *Scutellaria baicalensis*, bestowing it with potential applicability in managing a plethora of inflammatory disorders. As with all groundbreaking research, this study paves the way for further exploration—be it optimizing the formulation, scaling for commercial production, or expanding the scope to treat other inflammatory conditions.

Scutellaria baicalensis with its rich phytochemical profile emerges as a promising candidate in the development of effective, natural, anti-inflammatory therapies. The formulated emulgels, especially F2, showcase a harmonious blend of traditional knowledge and modern pharmaceutical practices, heralding a new chapter in topical anti-inflammatory treatments.

Discussion

The intricate dance between tradition and modernity often gives birth to some of the most profound innovations in science. This study, centered on the *Scutellaria baicalensis* emulgel, is a testament to this synergy. At the heart of this research lies *Scutellaria baicalensis*, a plant rooted deeply in the annals of traditional medicine, particularly in Asian cultures, revered for its plethora of therapeutic properties.

The journey commenced with the plant's collection and the extraction process, aimed at harnessing its potent bioactive components. The phytochemical profile unveiled a tapestry of compounds, some of which have been subjects of scientific scrutiny in past studies, and some which beckon fresh inquiries. Many of these compounds, flavonoids in particular, have been attributed with robust anti-inflammatory and antioxidant capabilities in earlier investigations.

Crafting an emulgel, a semisolid system composed of a gel and emulsion, presented its own set of challenges. The emulgel is a newer entrant to the world of pharmaceuticals, preferred for its dual advantages— the moisturizing property of an emulsion and the ease of application of a gel. Its potential to improve drug penetration while providing a sustained release made it an apt choice for this study. The trio of formulations not only provided a spectrum of concentrations but also paved the way for a deeper understanding of how slight compositional changes can impact overall efficacy.

Each evaluation parameter told its own tale. The pH, viscosity, and spreadability threw light on the formulation's physical attributes, crucial for patient compliance and therapeutic efficacy. Consistency in these parameters across formulations hinted at the stability of the emulgels. The in vitro drug release and cytotoxicity assays delved deeper, revealing insights into the emulgel's release mechanisms and biocompatibility. The crowning jewel was, without doubt, the cell-based anti-inflammatory assay. The significant inhibition

observed affirmed the lore surrounding *Scutellaria baicalensis* and highlighted its potential in modern anti-inflammatory therapies.

While Formulation F2 emerged as the front-runner, each formulation, in its own right, demonstrated significant promise. It's also noteworthy to mention the inherent advantages of using a plant-based system. Apart from the therapeutic benefits, such systems often possess fewer side effects and are better tolerated by individuals, especially in the context of topical applications.

However, as we bask in the glory of these findings, it's imperative to recognize the journey ahead. Further studies could dive deeper into the molecular mechanisms underlying the observed anti-inflammatory effects. Scalability, patient trials, and cost-effectiveness analyses are other realms awaiting exploration.

To encapsulate, this discussion is not just a reflection on the findings but a celebration of the harmony between ancient wisdom and contemporary science. *Scutellaria baicalensis*, in its new avatar as an emulgel, beckons a brighter future for anti-inflammatory treatments, offering a blend of nature's best with modern pharmaceutical advancements.

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