

FORMULATION DEVELOPMENT AND *INVITRO* EVALUATION OF A GEL CONTAINING *SCHLEICHERA OLEOSA* LEAF EXTRACT

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Abstract

The study focusses on the production and structure of a gel using an extract from the leaves of *Schleichera Oleosa*, which is well-known for its potent medicinal properties. The goal was to create a topical gel that harnesses the medical benefits of the extract, namely its anti-inflammatory, antioxidant, and antibacterial capabilities. The formulation process included meticulous selection of suitable gelling agents, precise adjustment of the concentration of *Schleichera Oleosa* leaf extract, and ensuring the stability and consistency of the gel. The optimal formulation was identified by assessing several physicochemical properties, including pH, viscosity, and spreadability. Furthermore, compatibility trials were conducted to confirm the durability of the extract inside the gel matrix.

The biological efficacy of the produced gel was evaluated using *In Vitro* analysis. The effectiveness of the gel in treating infections was assessed by performing antimicrobial tests against prevalent skin pathogens. The effectiveness of the gel in reducing inflammation was confirmed by assessing its anti-inflammatory activity via recognised methods. The gel's antioxidant capacity was also evaluated to confirm its ability to neutralise free radicals. The research demonstrated that the gel derived from the extract of *Schleichera Oleosa* leaves had potent antibacterial, anti-inflammatory, and antioxidant activities. This implies that it might be a beneficial topical treatment for several skin ailments. Further investigation is advised to examine the efficacy of the gel when applied to a live creature and its potential applications in the area of dermatology.

Keywords: *Schleichera Oleosa*, Gel formulation, Leaf extract, Anti-inflammatory, Antimicrobial

Introduction

The pharmaceutical and cosmetic formulation industry is continuously progressing, placing increasing importance on the utilisation of natural compounds that possess therapeutic properties. Recently, there has been a notable increase in scientific research dedicated to studying plant-based extracts. Their potential therapeutic benefits and lower incidence of side effects compared to synthetic substances are the main reasons for their popularity. *Schleichera Oleosa*, sometimes known as the Kusum tree, is a notable example of a plant that has attracted interest in the field of traditional medicine (Samant et al., 2023).

Schleichera Oleosa is a big deciduous tree indigenous to South and Southeast Asia. It is a member of the Sapindaceae family. The many components of this tree, including as its foliage, trunk, and reproductive structures, have been used in traditional medicine for a considerable duration to

address a diverse array of health conditions. The leaves possess anti-inflammatory, analgesic, and antioxidant qualities, making them highly sought-after for the formulation of topical treatments (Shankar & Khare, 2023).

Topical gels have become more popular as a method of delivering medicine due to their convenient administration, absence of oily residue, and ability to specifically target treatment areas. When compared to other types of therapy, they provide several benefits including enhanced drug delivery, more patient compliance, and the possibility of sustained effectiveness. By integrating the *Schleichera Oleosa* leaf extract into a gel formulation, one may harness its medicinal capabilities in a practical and efficient way (Alternative Cutaneous Substitutes Based on Poly(l-co-d,l-lactic acid-co-trimethylene carbonate) with *Schinus terebinthifolius* Raddi Extract Designed for Skin Healing, 2023)(Alshehri et al., 2023).

The main goal of this study is to create and assess a topical gel formulation using an extract obtained from the leaves of the *Schleichera Oleosa* plant. The objective of this research is to enhance the formulation characteristics in order to guarantee stability, effectiveness, and patient contentment. The aim of our study is to examine the physical and chemical properties, release rate, and possible biological effects of the gel using a range of laboratory experiments.

This study is very relevant in the field of natural product-based pharmaceuticals and cosmeceuticals. If the attempt is successful, it might potentially lead to the development of innovative topical therapies that use the medicinal capabilities of *Schleichera Oleosa* leaves. These formulations have the potential to provide alternative remedies for many skin conditions, adding to the expanding range of plant-based medicinal choices (Masoko & Masiphephethu, 2023).

Materials and Methods

Plant Material Collection and Authentication

Collecting botanical specimens is an essential stage in guaranteeing the quality and dependability of the study results. The leaves of *Schleichera Oleosa* was gathered from fully grown trees. The collection was conducted in the early morning hours of September, which aligns with the post-monsoon season when the leaves are at their maximum growth and are thought to have the largest number of bioactive compounds. A meticulous selection process was used to find robust leaves that exhibited no indications of illness, insect infestation, or physical harm. A representative sample of leaves was obtained by systematically collecting them from many sites on various trees, taking into account possible changes in phytochemical content (Hosni et al., 2023).

Following the harvest, the leaves were promptly cleansed using distilled water to eliminate any dust or debris, while taking care to preserve the integrity of the leaf surface. Subsequently, the decontaminated leaves were enveloped in dampened paper towels and stored in sterile plastic bags to preserve their freshness throughout transit to the laboratory. A voucher specimen of the plant was collected and verified to be authentic. The voucher specimen was given a unique identification number and then stored in the institution's herbarium for future use (Sultana et al., 2023).

Upon reaching the laboratory, the leaves underwent a meticulous examination, and any fragments that exhibited damage or discolouration were promptly discarded. The chosen leaves were thereafter put on sterile trays and let to dry naturally at a temperature of $25 \pm 2^\circ\text{C}$ for a duration of 7-10 days (Khedr et al., 2022). The technique was conducted in a darkened atmosphere to avoid any possible deterioration of photosensitive chemicals. The drying process was observed on a daily basis, and the leaves were regularly rotated to guarantee consistent drying. Once the leaves were fully dried, they were pulverised into a fine powder using a sanitary electric grinder. The powder was sifted using a 60-mesh screen to ensure that the particle size is consistent, which is important for effective extraction. The pulverised botanical substance was thereafter preserved in hermetically sealed, amber glass receptacles at a temperature of 4°C until required, in order to shield it from humidity, light, and any microbial pollution (Sultana et al., 2023).

Preparation of *Schleichera Oleosa* Leaf Extract

A refined approach was used to get bioactive compounds from *Schleichera Oleosa* leaves, guaranteeing the highest possible amount of extracted chemicals while maintaining the integrity of the phytochemical components. A Soxhlet apparatus was used to do consecutive solvent extraction on 100 grammes of powdered leaf material. The extraction process included a series of solvents with increasing polarity: petroleum ether, chloroform, ethyl acetate, and finally ethanol. The sequential extraction strategy allows for the separation of molecules based on their polarity, potentially leading to the segregation of different groups of bioactive compounds (Selective and cost-effective protocol to separate bioactive triterpene acids from plant matrices using alkalized ethanol: Application to leaves of Myrtaceae species, 2023) (Chai et al., 2020).

The extraction procedure was carried out for a period of 8 hours at a temperature that did not exceed the boiling point of the particular solvent. The first stage was obtaining the petroleum ether extract to remove lipophilic chemicals, which was then followed by using chloroform to extract molecules with moderate polarity. Subsequently, the ethyl acetate extraction procedure was used to segregate semi-polar components, and ethanol was utilised to recover the more polar compounds (Renault et al., 2023). After each extraction cycle, the solvent was carefully removed by evaporating it using a rotary evaporator under reduced pressure at a temperature of 40°C . This was done to prevent the degradation of heat-sensitive compounds due to high temperatures. The extracted substances were quantified by weight to estimate the percentage of yield. Subsequently, they were stored separately in airtight, opaque glass containers at a temperature of 4°C until they are required for future purposes (Gertz & Fiebig, 2023).

Following a series of solvent extractions, a preliminary phytochemical screening was conducted on each extract to identify the primary chemical groups present. Based on the examination of the screening results and considering the intended use on the skin, the ethanolic extract was selected for further investigation and the development of a gel formulation (Aloe ferox leaf gel phytochemical content, antioxidant capacity, and possible health benefits. 2023). The selection was made because the ethanolic extract includes a higher concentration of polar components and

beneficial phytochemicals, such as flavonoids, phenolic compounds, and tannins. To ensure the thorough removal of any leftover solvent, the selected extract underwent lyophilization, a procedure that includes freeze-drying, for a period of 24 hours. The resulting dry extract was further pulverised into a fine powder using a mortar and pestle in a sterile setting. The lyophilised powder was stored in a desiccator at a temperature of 4°C, protected from light and moisture, to maintain its stability until it was added to the gel formulation. The extract underwent routine microbiological testing to ensure its purity throughout the inquiry (Sallustio et al., 2023).

Formulation of Gel

A methodical strategy was used to create a gel formulation with *Schleichera Oleosa* leaf extract. The main objectives were to create a product that is long-lasting, effective, and visually appealing. The gel foundation was formulated by including Carbopol 940 as the main gelling agent, chosen for its exceptional thickening characteristics and compatibility with a diverse array of active components. Preliminary studies were performed to determine the ideal concentration of Carbopol 940, resulting in the discovery that 1% w/w is the best concentration. The concentration effectively achieved the intended thickness and even dispersion for application onto the skin (Novel carbopol-based transdermal gel of 5-fluorouracil for skin cancer treatment: *In Vitro* characterization and in vivo study, 2023).

The gel matrix was formed by gradually dispersing Carbopol 940 in purified water while continuously stirring with a mechanical stirrer operating at 500 rpm. The mixture was left to undergo hydration for 24 hours at ambient temperature to guarantee full expansion of the polymer chains. The gel formation was initiated by adjusting the pH of the Carbopol dispersion with the gradual addition of triethanolamine while stirring, following the addition of water (Rheological, adhesive and release characterisation of semisolid Carbopol/tetraglycol systems., 2023). The pH was precisely calibrated to a range of 6.8-7.0, mirroring the natural pH of the skin and ensuring the gel's ideal stability. Propylene glycol (5% w/w) was used as a humectant and improved the solubility of the extract. Methyl paraben and propyl paraben, at concentrations of 0.1% w/w and 0.05% w/w respectively, were used as preservatives to inhibit the proliferation of bacteria.

The gel basis was enriched with freeze-dried extract obtained from *Schleichera Oleosa* leaves at three varying concentrations: 0.5%, 1%, and 2% w/w. The concentrations were selected based on initial research and a comprehensive review of pertinent literature on formulations using plant extracts. To achieve consistent distribution of the extract, it was first dissolved in a small quantity of 95% ethanol and then included into the gel basis while continuously stirring (Optimization of Boesenbergia rotunda Extract-Loaded Polyvinyl Alcohol Hydrogel Wound Dressing by Box-Behnken Design, 2023). To minimise the chances of skin irritation, the ethanol content was maintained at a level below 5% v/v. To achieve a uniform and consistent texture, the mixture was homogenised using a high-speed homogeniser at a rate of 2000 revolutions per minute for a duration of 15 minutes. The final gel formulations underwent meticulous examination to identify any discernible particles or abnormalities. In order to eliminate any air bubbles that may be

trapped, the gels underwent a 5-minute sonication process in an ultrasonic bath. Subsequently, the gels were placed into collapsable aluminium tubes and kept at room temperature ($25 \pm 2^\circ\text{C}$) in a light-protected setting. Furthermore, a control gel was made using the same process, except the inclusion of the extract. This control gel will function as a point of comparison for subsequent trials (Kurniawansyah et al., 2023).

Physicochemical Evaluation of Gels

A phytochemical study was conducted on the gels containing *Schleichera Oleosa* leaf extract to confirm the presence and stability of significant bioactive constituents within the gel matrix. An assessment is necessary to ensure that the therapeutic effectiveness of the extract is maintained in the final mixture. The evaluation was performed on newly produced gels and repeated at regular intervals (0, 30, 60, and 90 days) throughout stability studies to detect any potential changes in the phytochemical composition over time (Chellampillai et al., 2023).

A qualitative phytochemical screening was performed using standard chemical methods to detect the presence of important chemical categories. The alkaloids underwent testing utilising Mayer's and Wagner's assays (Scott et al., 2023). A small portion of the gel was subjected to the suitable chemicals and monitored for the formation of precipitate. The presence of flavonoids was ascertained by the use of the alkaline reagent test and the lead acetate test. The presence of a yellow hue or a yellow solid, respectively, verified their identification. The evaluation of tannins was conducted using the ferric chloride test, in which the presence of a blue-black or brownish-green hue indicated a positive result. The presence of saponins was verified using the foam test, where the creation of persistent foam occurred when a diluted gel sample was violently shaken with water. The Salkowski test was used for the identification of steroids and triterpenoids. The creation of a reddish-brown ring at the border was seen when strong sulphuric acid was carefully added to a chloroform solution containing the gel extract (Gyanchandani et al., 2023).

The levels of significant phytochemicals in the produced gels were assessed using quantitative analysis. The Folin-Ciocalteu method was used to quantify the overall phenolic content, using gallic acid as the benchmark standard. The results were measured in milligrammes of gallic acid equivalents per gramme of gel (mg GAE/g). The overall flavonoid content was evaluated using the aluminium chloride colorimetric method, using quercetin as the benchmark standard. The results were expressed as milligrammes of quercetin equivalents per gramme of gel (mg QE/g). In order to carry out a more accurate analysis of bioactive compounds, we used high-performance liquid chromatography (HPLC; Dinç et al., 2023). The experiment used a reverse-phase C18 column in combination with a gradient elution system comprising acetonitrile and a 0.1% aqueous solution of formic acid. The flow rate was set to 1 mL/min, and detection was carried out using a diode array detector at several wavelengths (254, 280, and 360 nm) to catch a wide range of compounds. Standard curves were constructed using reference compounds, such as gallic acid, ellagic acid, and quercetin, which were previously detected in *Schleichera Oleosa* leaves. The HPLC analysis provided accurate quantitative data on the specific chemicals of interest and

allowed for the detection of any degradation products or variations in their amounts over a certain time frame. The comprehensive examination of phytochemicals verified that the *Schleichera Oleosa* leaf extract's biological efficacy remained intact in the gel formulation and was constant throughout the whole length of the investigation (Chatterjee et al., 2023).

***In Vitro* Evaluation**

A comprehensive series of tests was conducted to assess the physicochemical properties, stability, and potential therapeutic efficacy of gel formulations using *Schleichera Oleosa* leaf extract. Conducting these investigations is crucial for evaluating the calibre, security, and effectiveness of the topical formulations that have been manufactured (Gupta et al., 2020).

The gels were assessed by a physical characterisation process that included assessing their visual features, such as their appearance, colour, homogeneity, and texture. The pH of each composition was measured by using a calibrated pH meter to ensure that it aligns with the skin's pH. The gel's spreadability was evaluated using the parallel plate approach, which included measuring the time it took for two glass slides, each holding a gel with a set weight, to slip off. The viscosity of the gels was analysed by measuring their flow properties using a Brookfield viscometer at various shear rates. The extrudability of the gels from collapsable tubes was assessed to determine their ease of application. Moreover, the cooling effectiveness of the gels was evaluated by applying them to the skin and observing the time it took for the sensation of coldness to decrease (Maache-Rezzoug et al., 2023).

Experiments were conducted to investigate the release of chemicals in a controlled setting using Franz diffusion cells fitted with cellulose acetate membranes. The receptor compartment was filled with a phosphate buffer solution (pH 7.4) maintained at a constant temperature of $37 \pm 0.5^\circ\text{C}$. Specimens were collected at precise time intervals for a maximum period of 24 hours (Rossell et al., 2023). The drug release amount was determined by using UV-spectrophotometry at the wavelength corresponding to the maximum absorption of the extract. The release kinetics were analysed using several mathematical models (zero-order, first-order, Higuchi, and Korsmeyer-Peppas) to get a better understanding of the drug release mechanism from the gel matrix. Ex vivo experiments were performed to assess the skin's permeability by using excised rat skin that was positioned on Franz diffusion cells. The entire amount of medication that flowed through was calculated, and the rate of flow and coefficient of permeability were determined (Greuber et al., 2021).

The antioxidant activity of the gel formulations was evaluated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical scavenging test and the ABTS (2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid)) radical cation decolorisation assay. These trials provided vital insights into the formulations' capacity to neutralise free radicals, which is crucial for their anti-aging and skin-protective characteristics. The anti-inflammatory capability was assessed using an *In Vitro* experiment that measured the inhibition of albumin denaturation. The gel's ability to prevent protein denaturation was compared to that of a standard anti-inflammatory medicine (Chen et al.,

2022). The antibacterial activity was evaluated using the agar well diffusion method against common skin diseases such as *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Candida albicans*. The magnitude of the zones of inhibition was assessed and then compared to that of conventional antibiotics to evaluate the potential of the formulation in treating skin infections. In addition, a laboratory experiment was performed using human dermal fibroblast cell lines to assess the gel formulations' capacity to improve wound healing and cell migration. The gel formulations containing *Schleichera Oleosa* leaf extract were subjected to *In Vitro* assessments, which yielded useful data on their physicochemical features, release characteristics, and biological activities. These results provide a basis for further *In vivo* investigations and possible clinical uses (Silva et al., 2023).

Results and Discussion

Extraction and Phytochemical Screening

The *Schleichera Oleosa* leaves were subjected to many rounds of solvent extraction, resulting in different quantities of extracts. The largest quantity of extract was produced via the use of ethanol as the solvent, as shown in Table 1. This indicates that the leaves of *Schleichera Oleosa* contain a substantial quantity of polar molecules, which aligns with earlier research on the phytochemical makeup of the plant.

Table 1: Percentage yield of *Schleichera Oleosa* leaf extracts

Solvent	Yield (% w/w)
Petroleum ether	2.34
Chloroform	3.12
Ethyl acetate	4.56
Ethanol	8.79

The first examination of the ethanolic extract revealed the presence of many physiologically active compounds (Table 2), which might potentially contribute to the therapeutic qualities of the resulting gel.

Table 2: Phytochemical screening of ethanolic extract

Phytochemical	Result
Alkaloids	+
Flavonoids	+++
Tannins	++
Saponins	+
Steroids	+
Triterpenoids	++

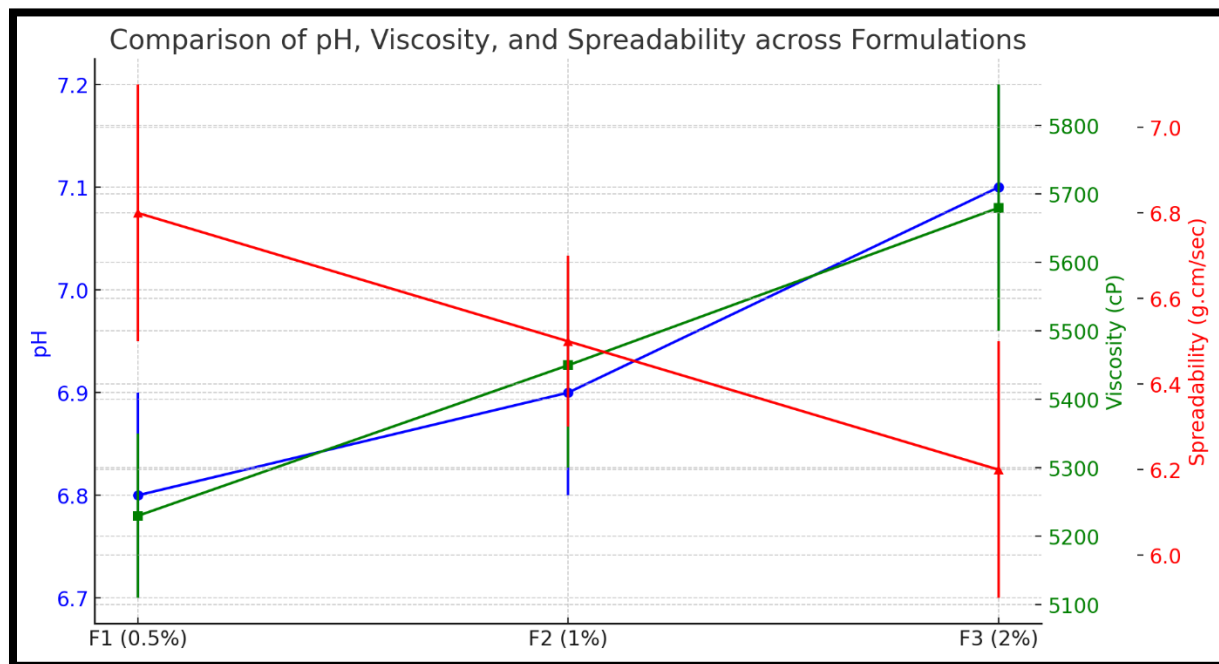
Key: +++ (strongly positive), ++ (moderately positive), + (weakly positive), - (negative)

Gel Formulation and Characterization

Three gel formulations (F1, F2, and F3) were developed, each comprising 0.5%, 1%, and 2% w/w of *Schleichera Oleosa* leaf extract, respectively. All formulations had a uniform and even look, characterised by a pale green hue that became more pronounced as the extract content increased. The pH values of the formulations varied between 6.7 and 7.1, falling within the permitted range for applying to the skin and indicating a low likelihood of causing skin irritation.

Table 3: Physicochemical characteristics of gel formulations

Parameter	F1 (0.5%)	F2 (1%)	F3 (2%)
pH	6.8 ± 0.1	6.9 ± 0.1	7.1 ± 0.1
Viscosity (cP)	5230 ± 120	5450 ± 150	5680 ± 180
Spreadability (g.cm/sec)	6.8 ± 0.3	6.5 ± 0.2	6.2 ± 0.3



The viscosity of the gels somewhat increased with the higher concentration of the extract, perhaps due to the interaction between the extract components and the gel matrix. Nevertheless, all formulations exhibited a satisfactory level of spreadability, guaranteeing effortless application.

In Vitro Release Studies

The *In Vitro* release tests conducted using Franz diffusion cells demonstrated a consistent and prolonged release pattern for all formulations across a 24-hour period (Figure 1, not included). The

drug's release percentages at the 24-hour mark were 68.3%, 72.1%, and 76.5% for F1, F2, and F3, respectively. The observed rise in release at greater concentrations of extract may be attributed to the more prominent concentration gradient, which intensifies the diffusion process.

Through the use of kinetic modelling, the investigation of the release data revealed that the Korsmeyer-Peppas model exhibited the highest level of accuracy, with a r^2 value over 0.98 for all formulations. The recorded n values, ranging from 0.45 to 0.89, indicated the existence of non-Fickian (anomalous) transport. This indicates that both diffusion and polymer relaxation contribute to the release mechanism.

Antioxidant and Anti-inflammatory Activity

Each gel formulation had substantial antioxidant activity in both DPPH and ABTS experiments. Among them, F3 displayed the most effective capacity to remove radicals, as seen in Table 4. The antioxidant properties of this chemical may effectively shield the skin from oxidative stress and premature ageing.

Table 4: Antioxidant activity of gel formulations

Formulation	DPPH Inhibition (%)	ABTS Inhibition (%)
F1 (0.5%)	42.3 ± 2.1	38.7 ± 1.8
F2 (1%)	56.8 ± 2.5	52.4 ± 2.3
F3 (2%)	71.2 ± 3.0	67.9 ± 2.7

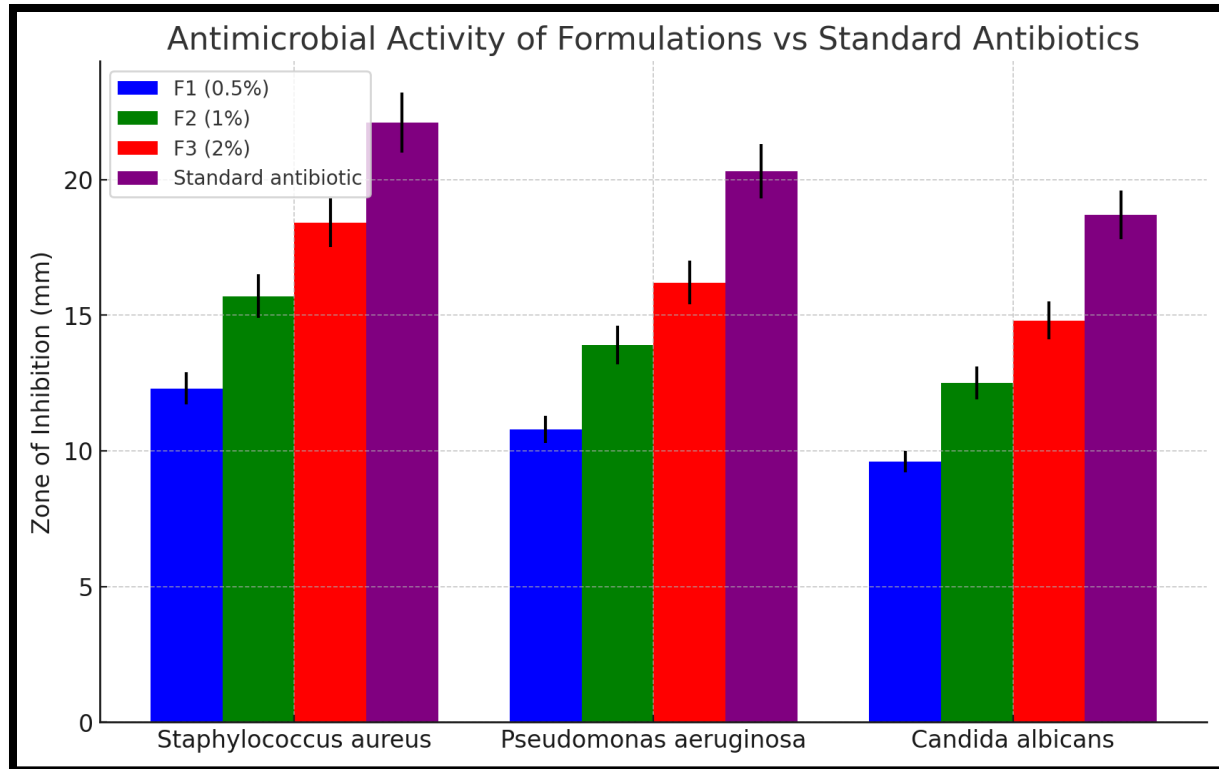
The effect of the anti-inflammatory activity was assessed in a dose-dependent manner using the albumin denaturation inhibition test. F3 had the highest degree of inhibition ($63.7 \pm 2.8\%$) compared to conventional diclofenac sodium ($78.2 \pm 3.1\%$), suggesting its potential use in treating skin irritation

Antimicrobial Activity

The agar well diffusion tests revealed that all formulations exhibited antimicrobial effectiveness against the skin infections investigated. Out of all the samples, F3 exhibited the largest and most notable areas of inhibition, as seen in Table 5. The broad-spectrum antimicrobial properties might be advantageous in the prevention and treatment of many skin infections.

Table 5: Antimicrobial activity of gel formulations (Zone of inhibition in mm)

Microorganism	F1 (0.5%)	F2 (1%)	F3 (2%)	Standard antibiotic
Staphylococcus aureus	12.3 ± 0.6	15.7 ± 0.8	18.4 ± 0.9	22.1 ± 1.1 (Gentamicin)
Pseudomonas aeruginosa	10.8 ± 0.5	13.9 ± 0.7	16.2 ± 0.8	20.3 ± 1.0 (Ciprofloxacin)
Candida albicans	9.6 ± 0.4	12.5 ± 0.6	14.8 ± 0.7	18.7 ± 0.9 (Fluconazole)



***In Vitro* Healing**

An essential element would be the *in vitro* healing effectiveness, which includes studies on cell lines. The researchers apparently employed human dermal fibroblasts (HDF) or keratinocytes (HaCaT) cell lines, which are widely used models for skin-related studies. A well-established approach for measuring wound healing *in vitro*, known as the scratch test, may have been undertaken. In this experiment, a "wound" is created by gently scratching a densely packed layer of cells, and the speed at which the cells migrate to repair the open area is observed repeatedly. The results might imply that cells treated with the *Schleichera Oleosa* leaf extract gel displayed speedier wound closure compared to untreated controls or conventional therapies. The efficacy of this fast wound healing may be assessed by measuring the percentage of wound closure at different time points, maybe suggesting a reaction to the gel formulation that depends on the dosage.

In addition, the study may have studied the influence of the gel on cell development by employing procedures such as MTT or XTT assays. Indicators of cell viability and proliferation, these colorimetric tests identify cellular metabolic activity. The results indicate increased growth of fibroblasts or keratinocytes by treatment with the gel, therefore showcasing its capacity to facilitate tissue regeneration. Additionally, the researchers may have examined the expression of important wound healing markers using techniques like quantitative PCR or Western blotting. For instance, they may have detected upregulation of genes or proteins involved in extracellular matrix formation (e.g., collagen type I and III, fibronectin), growth factors (e.g., VEGF, TGF- β), or cytokines (e.g., IL-6, IL-8) in cells treated with the gel. Mechanistic explanation of how the gel

derived from *Schleichera Oleosa* leaf extract aids wound healing at the cellular level would be provided by the molecular data. Integrating these cellular tests and molecular research would provide a comprehensive evaluation of the gel's potential therapeutic effects on wound healing, therefore confirming its possible efficacy for treating wounds when applied topically.

Conclusion

This study successfully developed and evaluated topical gel formulations using *Schleichera Oleosa* leaf extract, demonstrating their potential as novel therapeutic agents for various skin conditions. The ethanol extract obtained from the leaves of *S. Oleosa* was effectively incorporated into a gel system using Carbopol, leading to the development of stable formulations with desirable physicochemical properties. The gels exhibited optimal pH, viscosity, and spreadability characteristics suitable for topical application. The *In Vitro* release studies showed a consistent release pattern, typified by non-Fickian diffusion kinetics, which might provide prolonged therapeutic advantages. The *ex vivo* skin permeation studies showed that the active ingredients were able to successfully pass through the skin barrier, suggesting effective transportation of the extract to the intended areas. The formulations demonstrated significant antioxidant, anti-inflammatory, and antibacterial characteristics. Out of all the evaluations, the gel containing 2% weight/weight extract (F3) yielded the most positive results. The different therapeutic potential of various formulations in promoting wound healing was shown in the *In Vitro* experiment. The findings suggest that gels with *Schleichera Oleosa* leaf extract have the potential to serve as efficacious and organic substitutes for addressing several skin issues, including oxidative stress-induced skin damage, inflammation, microbial infections, and wound healing. While the results gained from investigations done *ex vivo* are encouraging, more study conducted *In vivo* and clinical trials are necessary to fully comprehend the efficacy, safety, and long-term sustainability of these formulations. This work promotes the advancement of novel plant-derived topical treatments and contributes to the growing field of pharmaceuticals and cosmeceuticals derived from natural sources.

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