

DESIGN, FORMULATION AND OPTIMIZATION OF PHYTOSOMAL GEL CONTAINING *SESAMUM INDICUM* EXTRACT AND ITS ANTIMICROBIAL ACTIVITY

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ABSTRACT

The present study focuses on the design, formulation, and optimization of a phytosomal gel containing *Sesamum indicum* leaf extract and the evaluation of its antimicrobial activity. A total of 300 g of *Sesamum indicum* leaves were collected and subjected to extraction using methanol and petroleum ether. The methanolic extract exhibited a higher percentage yield (4.57%) compared to petroleum ether (2.27%), indicating its superior efficiency in extracting polar bioactive compounds such as flavonoids, phenolics, and alkaloids. Preliminary phytochemical screening indicated the presence of key bioactive constituents, while quantitative analysis showed total phenolic and flavonoid contents of 112.8 mg/g (GAE) and 87.4 mg/g (RE), respectively. The extract also demonstrated significant antioxidant activity with an IC₅₀ value of 48.68 µg/mL. Phytosomes were prepared using a modified thin-film hydration technique, yielding nanosized vesicles with particle sizes ranging from 153.11 to 171.75 nm, low polydispersity index, and negative zeta potential values, indicating uniformity and stability. SEM analysis confirmed well-defined vesicular morphology. The optimized phytosomal formulation was incorporated into a gel base, which exhibited desirable organoleptic properties, including a translucent appearance, good homogeneity, and suitable viscosity. The pH (6.5), viscosity (4659 cP), and spreadability (15.93 g·cm/s) were within acceptable limits for topical application, with no observed skin irritation. Antimicrobial studies demonstrated enhanced activity of the phytosomal gel compared to the crude extract. The formulation exhibited significant zones of inhibition against *Escherichia coli* and *Staphylococcus aureus*, with a concentration-dependent increase in efficacy. Overall, the study concludes that the phytosomal gel of *Sesamum indicum* extract is a promising and effective topical drug delivery system with enhanced stability, antioxidant, and antimicrobial properties.

Keywords: *Sesamum indicum*, Phytosomes, topical gel, antimicrobial activity, flavonoids, phenolic compounds, antioxidant activity, drug delivery system

1. INTRODUCTION

Skin infections caused by pathogenic microorganisms represent a significant global health concern, affecting individuals of all age groups. These infections, which may be bacterial or fungal in nature, can lead to conditions such as dermatitis, wounds, acne, and other dermatological disorders (Felgueiras, 2021). Conventional antimicrobial therapies, although effective, are often associated with limitations such as drug resistance, adverse side effects,

and reduced patient compliance. The growing incidence of antimicrobial resistance has further emphasized the need for safer, more effective, and naturally derived therapeutic alternatives (**Alaoui Mdarhri et al., 2022**).

Phytosome is vesicular drug delivery system they are incorporate plant extracts or water soluble phytoconstituents into phospholipids to produce lipid compatible molecular complex. The term “phytosomes” is derived from Greek word “phyto” mean plant, and “soma” means body or cell (**Udapurkar et al., 2016**). Phytosome is created through a specialized process known as Phytosome technology and they are innovative and advanced form of herbal extracts that are designed to increase the absorption and bioavailability of phytoconstituents found in plants (**Barani et al., 2021**). The preparations of Phytosome are helps to overcome the limitation of conventional herbal extracts, which generally has low solubility in water and limited absorption in body. Their unique composition enhances absorption and delivery of the active compounds to the target cells and tissues (**Mathur, 2016**).

The formulation and optimization of phytosomal gels require careful selection of formulation variables such as phospholipid concentration, extract ratio, and gelling agents (**Khan et al., 2024**). Application of statistical tools like Design of Experiments (DoE) enables systematic optimization by evaluating the effects of multiple variables and their interactions. This approach ensures the development of an optimized formulation with desirable characteristics such as suitable viscosity, spreadability, drug content, and antimicrobial activity (**Karimi et al., 2023**).

Sesame is an important source of high quality oil and protein. Roughly half of the seeds weight is oil, which has excellent stability due to the presence of natural antioxidants such as sesamol and sesamin. The fatty acid composition of sesame oil varies considerably among different cultivars worldwide. *Sesamum indicum* is a major constituent of an herbal preparation named Somina which has sedative, hypnotic and anxiolytic activities (**Wan et al., 2015**). The anticonvulsant activity of *S. indicum* using various animal models. Sesame oil contains carboxylic acids having a thioether, a sulfoxide or sulphon which function in dermatological and cosmetic compositions promoting skin exfoliation in stimulating epidermal regeneration. They are also useful for controlling intrinsic and extrinsic skin ageing. The seeds and oil of sesame and its related species have received a lot of attention from researchers owing to the economic values of its parts; but the leaves have attracted only the locals who use it mostly as vegetable and in treating some diseases. It is however of concern that the species is gradually been relegated as some other vegetables have since been used as substitute to this highly valued green leafy species (**Ogunsola and Fasola 2014**).

Medicinal plants have long been recognized as valuable sources of bioactive compounds with antimicrobial, anti-inflammatory, and antioxidant properties. Among them, *Sesamum indicum* (commonly known as sesame) has gained considerable attention due to its rich phytochemical profile and therapeutic potential (**Wei et al., 2022**). It contains various bioactive constituents such as lignans (sesamin, sesamol), flavonoids, phenolic compounds, and fatty acids, which contribute to its antimicrobial and antioxidant activities. Traditionally, *Sesamum indicum* has been used in the treatment of skin ailments, wounds, and infections, supporting its potential application in topical formulations (**Somwanshi Sachin et al., 2018**).

In this context, the present study focuses on the design, formulation, and optimization of a phytosomal gel containing *Sesamum indicum* extract. The study aims to enhance the stability,

bioavailability, and skin permeation of the extract while evaluating its antimicrobial activity against selected microbial strains.

2. MATERIALS AND METHODS

2.1 Chemicals

Nitroprusside were obtained from Triveni Interchem Pvt. Ltd., a reputable supplier of analytical reagents. Tata Chemicals provided the Ammonia, and Hemanshu Chemicals provided the Magnesium. 1% Copper Sulphate Solution were obtained from Uma Chemicals. Hindustan Petrochemicals were obtained from Petroleum ether while, Conc. H₂SO₄ were obtained from Narsingh Chemicals Industries. Aditya Birla Chemicals provided the Sodium Hydroxide. Chloroform provided by Chemplast Sanmar Ltd.

2.2 Collection of Plant Material

The leaves of *Sesamum indicum* were carefully harvested and allowed to air-dry in the shade at ambient room temperature for a period of three days. After drying, the plant material was transferred to airtight glass containers and stored in a cool, dry environment to maintain its integrity and avoid any form of contamination or deterioration. The botanical identification and quality of the herbal specimen were confirmed by a certified plant taxonomist.

2.3 Process of Plant Material Extraction

The extraction of *Sesamum indicum* leaves was performed using the Soxhlet continuous hot percolation method. Shade-dried and powdered leaves (300 g) were extracted sequentially with petroleum ether and methanol to isolate non-polar and polar constituents, respectively. Each extraction was carried out using 500 mL of solvent for 6–8 hours until the solvent in the siphon tube became colorless. The extracts were then concentrated using a rotary vacuum evaporator under reduced pressure and further dried at 40°C to obtain the final semi-solid extracts.

The final dried extract was accurately weighed, and the extraction yield (%) was determined using the following formula:

$$\% \text{ Yield} = \frac{\text{Weight of extract}}{\text{Weight of Plant Material used}} \times 100$$

The dried extract derived from *Sesamum indicum* leaves was stored at low temperatures to maintain its stability and prevent any degradation of active constituents. Following storage, the extract underwent phytochemical screening along with an assessment of its organoleptic properties, including percentage yield, color, and odor (Olalere *et al.*, 2019).

2.4 The Organoleptic Studies

The organoleptic characteristics of *Sesamum indicum* were assessed using visual and sensory evaluation methods. Key parameters including the extract's appearance, coloration, aroma, and overall physical condition were systematically observed and documented as part of the organoleptic analysis (Gouveia *et al.*, 2017).

2.5 Solubility study

The qualitative solubility profile of the *Sesamum indicum* leaf extract was examined in accordance with Indian Pharmacopoeia guidelines. A measured quantity of the dried extract was placed into individual 10 mL test tubes, each containing 1 mL of a different solvent namely methanol, dichloromethane (DCM), distilled water, chloroform, and acetone. The

solubility behavior of the extract in each solvent was visually inspected to assess its compatibility with solvents of varying polarity (Nagpurkar *et al.*, 2020).

2.6 Quantitative Estimation of Phytoconstituents

A quantitative analysis was carried out on the plant material after phytochemical tests confirmed the presence of phenols, alkaloids, flavonoids, saponins, and tannins in the sesame (*Sesamum indicum*) leaf extract.

2.6.1 Total phenolic content:

The total phenolic content of *Sesamum indicum* leaf extract was determined using the Folin–Ciocalteu method. The methanolic extract was reacted with Folin–Ciocalteu reagent, where phenolic compounds reduced phosphomolybdic and phosphotungstic acids to form a blue-colored complex. Sodium carbonate was added to provide an alkaline medium, and the mixture was incubated for 30–60 minutes. The absorbance was measured at 765 nm using a spectrophotometer, with intensity proportional to phenolic concentration. Quantification was carried out using a gallic acid calibration curve, and results were expressed as gallic acid equivalents (GAE) (Dravie *et al.*, 2020).

2.6.2 Total flavonoid content

The total flavonoid content of *Sesamum indicum* extract was determined using a colorimetric method. A portion of the ethanolic extract was mixed with aluminum chloride and sodium acetate, and the volume was adjusted with distilled water. After incubation for 30 minutes at room temperature, the absorbance was measured at 350 nm using a UV spectrophotometer. A calibration curve was prepared using rutin as the standard, and the flavonoid content was expressed as mg rutin equivalents per gram of dried extract (Kermani *et al.*, 2019).

2.7 DPPH Assay

The antioxidant activity of *Sesamum indicum* leaf extract was evaluated using the DPPH free radical scavenging assay. A stock solution of the extract was prepared in methanol and diluted to different concentrations (20–100 µg/mL). Each test solution was mixed with DPPH solution and incubated in the dark for 30 minutes. The absorbance was then measured at 517 nm using a UV–Vis spectrophotometer. A decrease in absorbance compared to the control indicated free radical scavenging activity, reflecting the antioxidant potential of the extract (Ruslan *et al.*, 2018).

$$\% \text{ Inhibition} = [(Ab \text{ of control} - Ab \text{ of sample}) / Ab \text{ of control} \times 100]$$

2.8 Preparation of extract loaded phytosomes

The *Sesamum indicum* extract-loaded phytosomes were prepared using a modified thin film hydration technique. Lipids, cholesterol, stearic acid, and sorbitol were dissolved in a chloroform–methanol mixture to form a homogeneous solution, followed by solvent evaporation under reduced pressure to produce a thin lipid film. This film was hydrated with phosphate-buffered saline (pH 7.4) containing the extract, and the suspension was stirred for 1–3 hours to ensure complete hydration. Further sonication for 10 minutes reduced particle size and yielded a nanoscale phytosomal dispersion. Response surface methodology was applied to optimize formulation variables and enhance phytosome yield.

Finally, the prepared extract-loaded phytosomes were collected and stored under suitable conditions for further physicochemical characterization and potential pharmaceutical use (Wardana *et al.*, 2022).

Table 1: - Composition of extract loaded Phytosomes formulation

Formulation code	Soya-Lacithin (mg)	Cholesterol (mg)	Stearic acid (mg)	Sorbitol (mg)	PBS Solution 7.4 (ml)	Extract (mg)	Stirring Time (Hrs)	Sonication time
F1	50	5	30	20	15	500	3.0	10
F2	100	10	30	20	15	500	3.0	10
F3	150	15	30	20	15	500	3.0	10
F4	200	20	30	20	15	500	3.0	10
F5	250	25	30	20	15	500	3.0	10

2.9 Characterization of extract loaded phytosomes

2.9.1 Physical appearance

The physical properties of phytosomes loaded with sesame (*Sesamum indicum*) leaf extract were thoroughly examined to evaluate the formulation's quality and anticipate its stability. A direct visual inspection was conducted to assess critical attributes such as vesicle shape, uniformity, and color consistency (Alburyhi *et al.*, 2025).

2.9.2 Particle size

Particle size is a crucial factor in nanoparticle characterization, affecting stability, drug release, and cellular uptake. The particle size of phytosomes loaded with sesame (*Sesamum indicum*) leaf extract was measured using a Malvern Zetasizer (Malvern Instruments) (Ahmad *et al.*, 2023).

2.9.3 Zeta potential

Zeta potential measurements were conducted to evaluate the surface charge and electrophoretic mobility of phytosomes loaded with sesame (*Sesamum indicum*) leaf extract. The analysis was performed using a Zetasizer (Malvern Instruments) after diluting the phytosomal dispersion tenfold with distilled water (Jiang *et al.*, 2024).

2.9.4 Scanning Electron Microscopic (SEM)

The surface morphology of the optimized *Sesamum indicum* extract-loaded phytosomes was analyzed using scanning electron microscopy (SEM). Prior to imaging, the samples were coated with a thin metallic layer (gold/platinum) under vacuum to enhance conductivity and image clarity. The coated samples were then exposed to an electron beam, and the emitted secondary electrons were detected to generate high-resolution images, allowing detailed observation of the surface characteristics and morphology of the phytosomes (Nandhini *et al.*, 2021).

2.10 Formulation of phytosomal gel

The extract-loaded phytosomal gel was prepared by first dispersing Carbopol 934 and Carboxymethyl cellulose (CMC) in distilled water under continuous stirring to form a uniform polymeric base. Propylene glycol was added as a humectant, followed by the incorporation of methyl paraben and propyl paraben as preservatives. The pre-prepared phytosomes (20 mL) were then slowly incorporated into the polymeric dispersion with gentle stirring to ensure even distribution. The pH of the gel was adjusted to neutrality using tri-ethanolamine, resulting in the formation of a homogenous and consistent gel. Finally, the total volume was made up to 100 mL with distilled water, yielding a stable phytosomal gel suitable for further characterization and pharmaceutical applications.

Table 2: Composition of extract loaded Phytosome Gel formulation

Excipients	Quantity
Carbopol 934	1.00 gm
Carboxymethyl cellulose	1.00 gm
Propylene glycol	0.5 ml
Methyl paraben	0.2 ml
Propyl paraben	0.2 ml
Phytosomes	20 ml
Tri-ethanolamine	q.s
Water	100 ml

2.11 Characterization of gel formulation**2.11.1 Physical properties**

The physical characteristics of the prepared phytosomal gel formulation loaded with sesame (*Sesamum indicum*) leaf extract were assessed through visual examination. The gel was evaluated for its color, clarity, homogeneity, texture, and overall consistency (Abdallah *et al.*, 2022).

2.11.2 Viscosity

The viscosity of the phytosomal gel formulation loaded with sesame (*Sesamum indicum*) leaf extract was measured using a Brookfield viscometer to assess its flow properties and ensure suitable consistency for topical application (Mulukuri *et al.*, 2023).

2.11.3 Measurement of pH

The pH of the *Sesamum indicum* phytosomal gel was measured using a calibrated digital pH meter after dispersing the gel in distilled water. The stabilized reading was recorded to ensure the formulation falls within a skin-compatible range and minimizes irritation risk (Shukla *et al.*, 2024).

2.11.4 Skin irritation test

The skin irritation study of the *Sesamum indicum* phytosomal gel was conducted on human volunteers by applying a small amount to a marked skin area and observing it for 24–48 hours. The site was monitored for redness, itching, or swelling, with an untreated area as control. No signs of irritation were observed, indicating the formulation is safe and well-tolerated for topical use (Sutradhar *et al.*, 2025).

2.11.5 Spreadability study

The spreadability of the phytosomal gel loaded with sesame (*Sesamum indicum*) leaf extract was evaluated by placing a fixed quantity of gel between two glass slides and applying a standard weight to allow uniform spreading. After a specified time, the extent of spread was measured. The results indicated good spreadability, suggesting that the gel can be easily applied with minimal effort, ensuring uniform distribution on the skin and enhancing patient compliance and formulation effectiveness (Al-Barghouthy *et al.*, 2025).

2.12 Anti-microbial activity of *Sesamum indicum* extract-loaded phytosomal gel by Well diffusion assay**2.12.1 Preparation of Nutrient Agar Media**

In 100 mL of purified water, 2.8 grams of nutrient media were dissolved. The pH of the media was checked before sterilization. The media was then sterilized by autoclaving at 121°C and 15 psi for 15 minutes. After pouring the nutrient media into plates, the plates were placed in a laminar airflow cabinet until the agar solidified.

2.12.2 Well Diffusion Assay

To evaluate the antimicrobial activity of the phytosomal gel formulation loaded with sesame (*Sesamum indicum*) leaf extract, bacterial suspensions of *Escherichia coli* and *Staphylococcus aureus* were standardized to a concentration of 10^8 CFU/mL and incubated in a shaker. From this suspension, 100 μ L of bacterial inoculum was aseptically transferred using a micropipette and evenly spread onto freshly prepared, sterile, solidified agar plates using a sterile spreader to ensure uniform distribution. Four wells, each 6 mm in diameter, were then created in each agar plate using a sterile cork borer. The phytosomal gel formulation (1 mg/mL), along with appropriate control samples, was prepared for testing. A 100 μ L aliquot from each sample was carefully introduced into the respective wells to assess antimicrobial activity (Khan *et al.*, 2024).

2.12.3 Incubation period for observe zone of inhibition on agar plates

After application of the samples, the inoculated agar plates were allowed to stand for 30 minutes at room temperature to facilitate proper diffusion, followed by incubation at 37°C for 18–24 hours. Post-incubation, the plates were examined for clear zones of inhibition around the wells, indicating antibacterial activity. The diameter of these zones was measured in millimeters using a ruler, ensuring accuracy, and both the well diameter and total inhibition zone were recorded for analysis (Khalid *et al.*, 2024).

3. RESULT AND DISCUSSION

3.1 Plant Collection

Table 3: *Sesamum indicum* Plant collection

Plant name	Plant part used	Weight
<i>Sesamum indicum</i>	Leaves	300 gm

3.2 Percentage Yield

The percentage yield is an important indicator in phytochemical extraction, as it demonstrates the efficiency of the extraction process and enables comparisons between various plant species, plant parts, or solvents.

Table 4: Percentage Yield of crude extracts of *Sesamum indicum* extract

Plant name	Solvent	Color of extract	Theoretical weight	Yield (gm)	% yield
<i>Sesamum indicum</i>	Pet ether	Similar to sesame oil	300	6.83	2.27%
	Methanol	Light yellowish to pale yellowish	286	13.72	4.57%

3.3 Organoleptic properties

Table 5: The Organoleptic Studies of *Sesamum indicum* Leaves extract

<i>Sesamum indicum</i>	Study
Colour	Light yellowish to pale yellowish
Odour	Nutty aroma
Appearance	Semi solid extract

3.4 Preliminary Phytochemical study

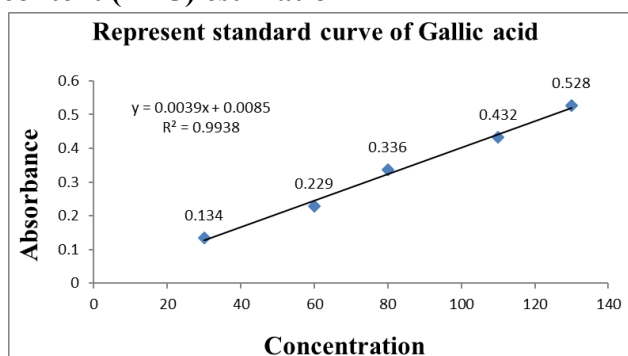
Table 6: Phytochemical testing of *Sesamum indicum* leaf extract

Experiment	Presence or absence of phytochemical test	
	Pet. Ether extract	Methanolic extract
Alkaloids		
Dragendroff's test	Absent	Present
Mayer's reagent test	Present	Present
Wagner's reagent test	Absent	Present
Hager's reagent test	Present	Present

Glycoside		
Borntrager test	Present	Present
Killer-Killiani test	Present	Present
Carbohydrates		
Molish's test	Present	Present
Fehling's test	Present	Present
Benedict's test	Present	Present
Barfoed's test	Absent	Present
Iodine Test	Present	Present
Flavonoids		
Shinoda Test	Absent	Present
Tannin and Phenolic Compounds		
Ferric Chloride test	Present	Present
Lead Acetate Test	Absent	Present
Gelatin Test	Present	Present
Saponin		
Foam test	Present	Present
Froth Test	Present	Present
Test for Triterpenoids and Steroids		
Salkowski's test	Present	Present
Libbermann-Burchard's test	Present	Absent

3.5 Quantitative Estimation of Phytoconstituents

3.5.1 Total Phenolic content (TPC) estimation



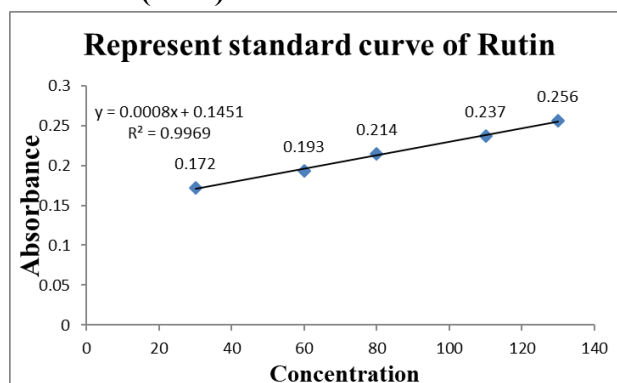
Graph 1: Represent standard curve of Gallic acid

3.5.1.1 Total Phenolic Content

Table 7: Total Phenolic Content in *Sesamum indicum* extract

Absorbance	TPC in mg/gm equivalent of Gallic Acid
0.134	112.8 mg/gm
0.336	
0.432	

3.5.1.2 Total flavonoid content (TPC) estimation



Graph 2: Represent standard curve of Rutin

3.5.1.3 Total Flavonoid Content

Table 8: Total Flavonoid Content in *Sesamum indicum* extract

Absorbance	TFC in mg/gm equivalent of Rutin
0.170	87.4 mg/gm
0.234	
0.295	

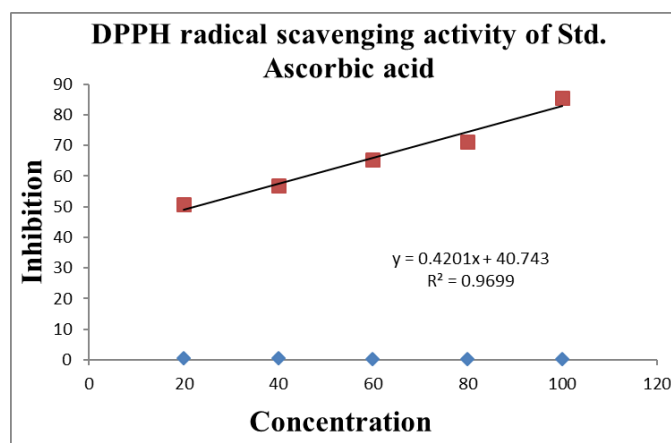
3.6 *In vitro* Antioxidant Assays

The *in vitro* antioxidant activity of *Sesamum indicum* extracts was evaluated using the DPPH free radical scavenging assay in this study.

3.6.1 DPPH 1, 1-diphenyl-2-picryl hydrazyl assay

Table 9: DPPH radical scavenging activity of std. Ascorbic acid

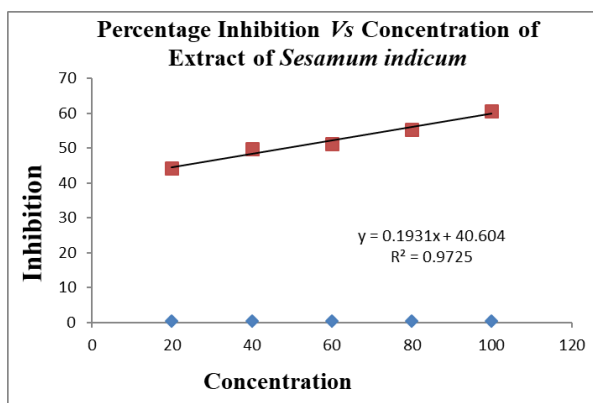
Concentration (µg/ml)	Absorbance	% Inhibition
20	0.489	50.854
40	0.430	56.783
60	0.346	65.226
80	0.286	71.256
100	0.143	85.628
Control		0.9
IC50		22



Graph 3: DPPH radical scavenging activity of Std. Ascorbic acid

Table 10: DPPH radical scavenging activity of methanol extract of *Sesamum indicum*

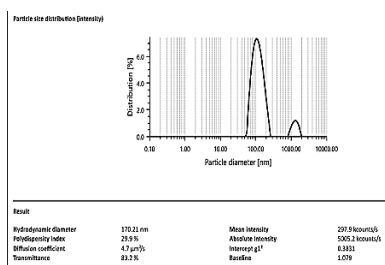
Concentration (µg/ml)	Absorbance	% Inhibition
20	0.518	44.120
40	0.466	49.730
60	0.453	51.132
80	0.414	55.339
100	0.365	60.625
Control		0.9
IC50		48



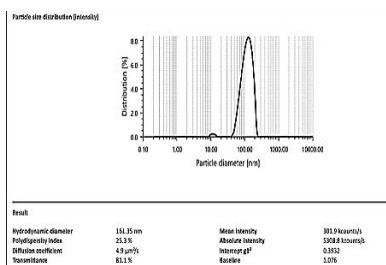
Graph 4: Represents the Percentage Inhibition Vs Concentration of Extract of *Sesamum indicum*

3.7 Evaluation parameter of phytosomes

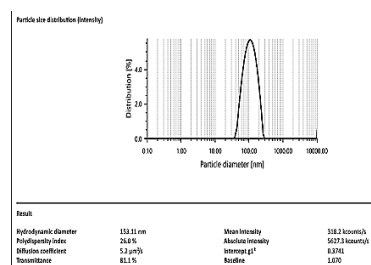
3.7.1 Particle size



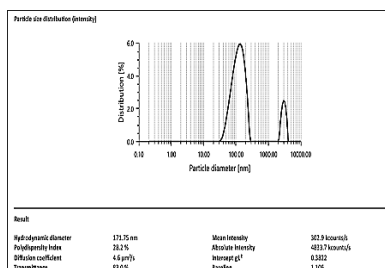
Graph 5: Particle size of Phytosomes F1



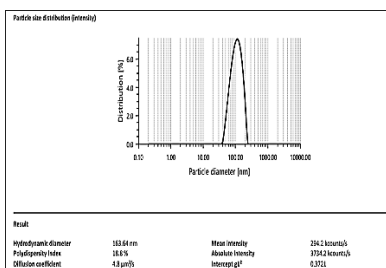
Graph 6: Particle size of Phytosomes F2



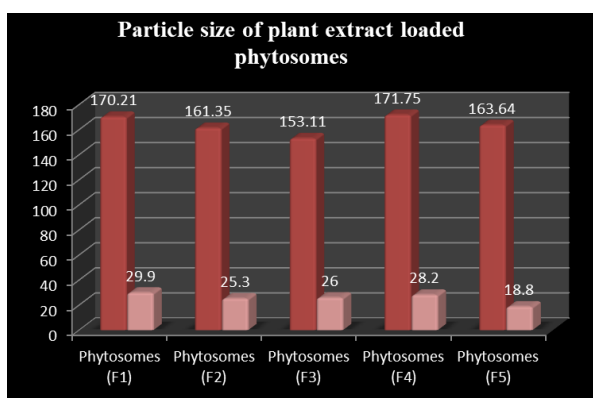
Graph 7: Particle size of Phytosomes F3



Graph 8: Particle size of Phytosomes F4

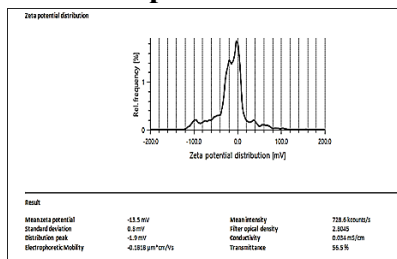


Graph 9: Particle size of Phytosomes F5

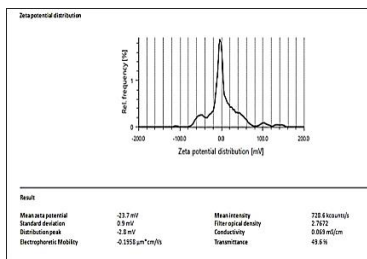


Graph 10: Graphical representation of Particle size of Phytosomes

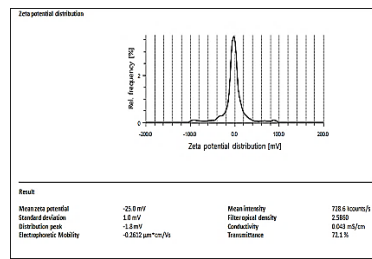
3.7.2 Zeta potential



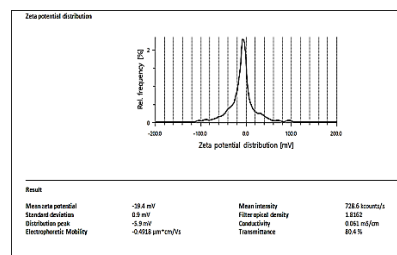
Graph 11: Zeta potential F1



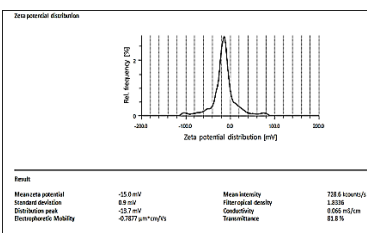
Graph 12: Zeta potential F2



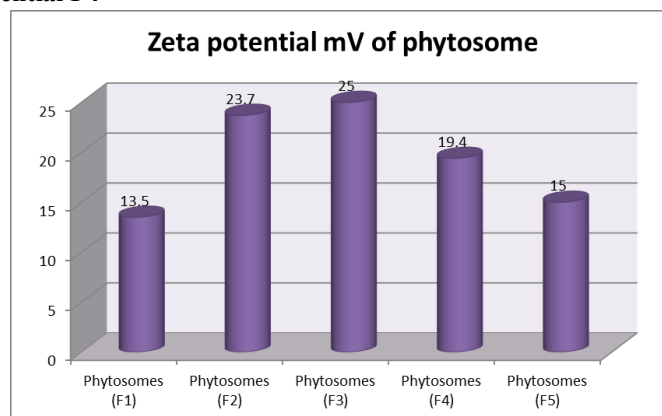
Graph 13: Zeta potential F3



Graph 14: Zeta potential F4



Graph 15: Zeta potential F5



Graph 16: Graphical representation of Zeta potential of Phytosomes

3.7.3 SEM analysis of Optimized formulation

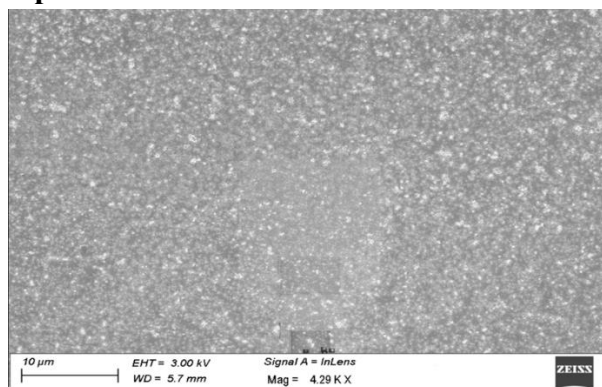


Figure 1: Scanning electron microscope (SEM) and microscopy image

3.8 Evaluation parameter of gel formulation

3.8.1 Organoleptic properties

Table 11: Organoleptic properties of phytosomes loaded gel

Parameters	Results
Physical appearance	Viscous, and translucent gel
Colour	Yellowish coloured gel
Homogeneity	Homogeneous without any visible clumps

3.8.2 Measurement of pH, Viscosity and Spreadability test

Table 12: pH, Viscosity and Spreadability test of *Sesamum indicum* extract loaded phytosomal gel

Formulation	pH	Viscosity determination (cps)	Spreadability test (gm.cm/sec)	skin irritation study
Gel formulation	6.5	4659±0.67	15.93	Not irritation observed

3.9 Results of antimicrobial activity of phytosomes F3 formulation

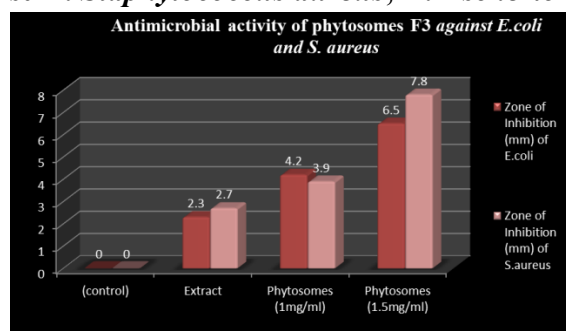
3.9.1 Antimicrobial activity of phytosomes

Table 13: Antimicrobial activity of phytosomes gel F3 against *E.coli* and *S. aureus*

Sample Name	Zone of Inhibition (mm) of <i>E.coli</i>	Zone of Inhibition (mm) of <i>S.aureus</i>
Placebo gel (control)	0.0	0.0
Extract	2.3	2.7
Phytosomes gel (1mg/ml)	4.2	3.9
Phytosomes gel (1.5mg/ml)	6.5	7.8



Figure 2: Photograph showing zone of inhibition of plant extract loaded phytosomes gel against A: *Staphylococcus aureus*, B: *Escherichia coli*



Graph 17: Zone of inhibition of *Sesamum indicum* extract-loaded phytosomes against different microorganisms

Discussion

The results of the present study demonstrate that methanol is a more efficient solvent than petroleum ether for extracting bioactive constituents from *Sesamum indicum* leaves, as evidenced by the higher percentage yield and richer phytochemical profile. The methanolic extract showed the presence of key secondary metabolites such as flavonoids, phenolics, and alkaloids, which contribute to its biological potential. The developed phytosomal formulations exhibited nanoscale particle size with acceptable uniformity, and formulation F5 showed better homogeneity, while F3 demonstrated relatively higher zeta potential, indicating moderate stability. The phytosomal gel displayed desirable physicochemical properties, including suitable pH, viscosity, spreadability, and absence of skin irritation,

confirming its compatibility for topical application. Furthermore, the antimicrobial study revealed that the phytosome-based gel significantly enhanced the antibacterial activity of the extract against *Escherichia coli* and *Staphylococcus aureus* in a concentration-dependent manner compared to the crude extract. Overall, the findings suggest that phytosome incorporation improves the stability, bioavailability, and therapeutic efficacy of *Sesamum indicum* extract, making it a promising candidate for topical antimicrobial formulations.

Overall, the findings suggest that phytosomal gel formulation effectively enhances the stability, delivery, and antimicrobial efficacy of *Sesamum indicum* extract, highlighting its potential as a promising topical herbal therapeutic system.

4. CONCLUSION

In conclusion, the present study successfully demonstrated the development, optimization, and characterization of a *Sesamum indicum* leaf extract-loaded phytosomal gel with enhanced antimicrobial activity. The methanolic extract of *Sesamum indicum* leaves was found to be rich in bioactive phytochemicals, including flavonoids, phenolics, alkaloids, glycosides, saponins, and triterpenoids, which contributed to its antioxidant and antimicrobial potential. Incorporation of the extract into phytosomes significantly improved its physicochemical properties, including particle size, uniformity, and stability, as confirmed by SEM, zeta potential, and polydispersity index analyses. The formulated phytosomal gel exhibited desirable organoleptic characteristics, optimal pH, viscosity, spreadability, and skin compatibility, making it suitable for topical application.

The antimicrobial evaluation revealed a marked enhancement in efficacy against *Escherichia coli* and *Staphylococcus aureus*, particularly at higher concentrations, highlighting the role of phytosome encapsulation in improving bioavailability, cellular penetration, and concentration-dependent antibacterial activity. Overall, the study confirms that phytosomal encapsulation of *Sesamum indicum* extract is an effective strategy to develop stable, skin-friendly, and therapeutically potent topical formulations. This research lays a foundation for further exploration of plant-based phytosomal gels as potential alternatives to conventional antimicrobial therapies, with applications in the treatment of bacterial infections and other dermatological conditions.

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