Journal of Young Pharmacists, 2025; 17(1):176-186.
https://www.jyoungpharm.org

Original Article

Formulation and Evaluation of Phytosomes Loaded Polyherbal Gel for Pharyngitis

Vandhana Vijayakumar, Thirumalaikumaran Rathinam*, Sharan Raj Rajmohan, Kowsik Elumalai

Department of Pharmacognosy, Saveetha College of Pharmacy, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, INDIA.

ABSTRACT

Background: Sore throat, or pharyngitis, is a common viral or bacterial infection. Conventional drug delivery techniques may not target inflamed areas due to their lack of specificity. To enhance treatment efficacy, improved vesicular drug delivery methods such as phytosomes must be developed. This study developed and evaluated a polyherbal phytosomal gel for pharyngitis treatment using *Acalypha indica, Pergularia daemia* and *Coleus amboinicus* extracts to improve drug bioavailability and targeted distribution. **Materials and Methods:** Extracts were produced from the three plants and subsequently combined to produce phytosomes using the antisolvent precipitation method. The evaluation parameters were percentage yield, entrapment efficiency, particle size and zeta potential. The gel vehicle forms were produced using a combination of excipients. Various quality parameters, such as homogeneity, pH, drug content, spreading and extruding properties, were evaluated as well. *In vitro* antimicrobial and anti-inflammation studies were also evaluated. **Results:** Homogenous vesicle production with 72.5% yield, 86.94% entrapment efficiency, 158 nm particle size and -8 mV zeta potential were observed in phytosomes. Gels were homogeneous, pH was 5.1-5.4, drug concentration was good (82.37%-90.09%), viscosity was ideal (35123 centipoises) and Spreadability was adequate (3.9-4.1 cm). *In vitro* anti-inflammatory action decreased inflammation most in formulation F3. The compounds then showed strong antibacterial action against pharyngitis-associated pathogenic microorganisms. **Conclusion:** Synergizing phytosomes from the plants extracts in a polyherbal phytosomal gel may deliver particular drugs for pharyngitis. The new formulation has good qualities and potentially treats pharyngitis due to its *in vitro* anti-inflammatory and antibacterial activity. *In vivo* and clinical investigations are needed to prove its therapeutic efficacy and safety.

Keywords: Anti-inflammatory activity, Antisolvent precipitation, Cyclooxygenase, Lipid-bound complex, Phytosomes, Polyherbal phytosomal gel.

Correspondence:
Dr. Thirumalaikumaran Rathinam
Department of Pharmacognosy, Saveetha College of Pharmacy, Saveetha Institute of Medical and Technical Sciences, Chennai-602105, Tamil Nadu, INDIA.
Email: thirumalaikumaranr.scop@saveetha.com

Received: 21-06-2024;
Revised: 06-07-2024;
Accepted: 18-08-2024.

INTRODUCTION

Pharyngitis, also referred to as sore throat, is the inflammation of the pharynx, which leads to a painful throat. Therefore, pharyngitis should be understood as a manifestation of an underlying ailment, rather than a standalone condition itself.[1] This syndrome commonly occurs due to viral and/or bacterial infections, such as the common cold and flu (both viral disorders) or infection with the Streptococcus bacterium (strep throat). Pharyngitis may sometimes manifest in conjunction with mononucleosis, which is an alternative term for the viral infection often known as "mono".[2] Fungal pharyngitis typically happens when a person's immune system is weakened or when they have been using steroids or antibiotics for a long time. Occasionally, allergies such as hay fever or allergic rhinitis can cause throat discomfort. Inadequate humidity levels in indoor spaces and chronic mouth breathing, especially in the winter months, can lead to recurring throat irritation, particularly upon waking up in the morning.[3]

Novel vesicular drug delivery systems aim to administer the medication at a pace determined by the body's requirement during the treatment time, while also routing the active ingredient to the site of action. To accomplish targeted and strictly controlled medication delivery, several innovative vesicular drug delivery systems with varying routes of administration have emerged. Phytosome is a novel developing technology used in phytopharmaceuticals that incorporates phytocomponents of herbal extracts that are enveloped and bound by lipids.[4] Traditional medicines and phytomedicines have been used therapeutically for health maintenance purposes since ancient times. Developments in the discipline of medicinal product delivery commenced recently intending to effectively handle human ailments. Phytosomes are a distinctive botanical formulation and drug-delivery technology that produces

DOI: 10.5530/jyp.20251325

lipophilic molecular complexes to increase the absorption and bioavailability of phytoconstituents.[5,6]

The herbaceous annual *Acalypha indica* features cup-shaped involucres around tiny flowers and catkin-like inflorescences. It is best known for its root's attraction to domestic cats and for its multiple medicinal properties like anti-inflammatory, anti-microbial and analgesics. It is found across the Tropics. The chief constituents present in this plant are acalypin, acalyphamide, aurantiamide, succinimide and flindersin.[7,8] *Pergularia daemia* is common in tropical and subtropical regions. It is a perennial twining plant that produces milky sap. The plant has some active principles like calactin, lupeol, oleanolic acid, corotoxigenin, calotropin, β-sitosterol, daucosterol, etc. It has anti-inflammatory, antioxidant and anti-diabetic properties.[9,10] *Plectranthus amboinicus*/Indian Borage is another name for *Coleus amboinicus*. It is from the Lamiaceae family. Indian Borage is commonly grown in Asian nations such as India, Sri Lanka, Malaysia, Indonesia and others. They are used to treat whooping cough, phlegm, microbial infections and inflammation. The pharmacological action of aerial plant parts is investigated. This plant is well-known as oregano, which improves the flavour of food. Chemical constituents like Thymol, Cis-caryophyllene and P-cymene was present in the plant.[11-14]

The main objective of this study is to develop a combination of Phytosomes derived from *Acalypha indica, Pergularia daemia* and *Coleus amboinicus* in order to enhance the bioavailability in comparison to traditional drugs. Additionally, the study aims to examine the properties of the phytosomes and to develop and evaluate a polyherbal phytosomal gel for the treatment of Pharyngitis.

MATERIALS AND METHODS

Standard plant drugs were bought from Yucca Enterprises, Mumbai, India. We purchased the soy lecithin, PEG 400 and Carbopol 934 from Anandsupra Chemicals in Chennai, India. All other chemicals and reagents were of analytical grade.

Preparation of extracts

Acalypha indica, Pergularia daemia and *Coleus amboinicus* fresh leaves were collected, dried and roughly pulverized. In a Soxhlet apparatus, dried coarsely powdered leaves were extracted with 99.9% ethanol (60-70ºC). Antisolvent Precipitation was used to precipitate the extracts.[15,16]

Phytochemical screening

Using standard methods, ethanolic extracts from each plant species were examined for alkaloids, glycosides, carbohydrates, proteins, phenolic compounds, saponins, tannins, flavonoids, steroids, terpenoids, gums and mucilage.[17-19]

Preparation of Phytosomes

The combined phytosomes were prepared by the antisolvent precipitation method which involves the controlled addition of a non-solvent (antisolvent) to a solution containing a solute. Initially, the combined extracts were prepared by blending equal proportions of 1:1:1 ratio from all three plant extracts. The appropriate quantity of combined extracts and soy lecithin (1:1) were added to a 100 mL round bottom flask and refluxed for 2 hr at a temperature under 60ºC with 20 mL of dichloromethane. The mixture is reduced to 5-10 mL. The precipitate was produced by carefully adding 20 mL of hexane while stirring continuously. The precipitate was then filtered, combined and overnighted in vacuum desiccators. An amber-colored glass bottle is used to keep the crushed dried precipitate at room temperature Table 1.[20-22]

Evaluation of Phytosomes

The phytosomes were evaluated based on several parameters, including percentage yield, entrapment efficiency, particle size determination, zeta potential and SEM analysis. These parameters were measured to assess the quality and stability of the phytosomes.[23-25]

Preparation of phytosomal gel

The gels containing phytosome complexes and plant drugs were formulated utilizing the various excipients and solvents outlined in Table 2. 10 mL of distilled water was used to dissolve the required amount of propyl and methylparaben in the beaker. The mixture was then supplemented with carbopol 934P while being vigorously stirred. The Carbopol dispersion was mixed with the phytosome complex solution, which had been dissolved in 0.1 mL of ethanol in a separate beaker. Gels were developed by adding triethanolamine to the dispersion. Utilizing varying concentrations (1%, 3% and 5%) of prepared combined phytosomes, multiple formulations, such as F1, F2 and F3, were developed. For further investigation, the developed gels were stored at room temperature in appropriate containers.[26-28]

Evaluation of gels of Phytosomal complex

The gel was then evaluated for various quality parameters such as homogeneity, pH, drug content, Viscosity, spreading and extruding properties. The homogeneity test ensured uniform distribution of the phytosomes within the gel. The pH was measured to ensure compatibility with the skin. Drug content analysis determined the amount of active phytosomal compounds in the gel. Spreading and extruding properties assessed the gel's ease of application.[29]

Biological effect

Pharyngitis, a prevalent condition distinguished by inflammation of the larynx, presents considerable obstacles on account of its complex aetiology. Inflammation and microbial invasion are

fundamental to its pathogenesis, necessitating the implementation of efficacious therapeutic interventions. This research aims to accomplish endeavour is to assess the potential therapeutic effects of novel compounds that possess anti-inflammatory and antimicrobial properties on pharyngitis. Orchestrated by a variety of mediators including cytokines and chemokines, the inflammatory response in pharyngitis significantly contributes to the severity of symptoms and tissue injury. Our objective in evaluating the anti-inflammatory properties of our compounds is to ameliorate patient discomfort and mitigate this response. Furthermore, the presence of pharyngitis, which is frequently caused by bacterial or viral pathogens, highlights the critical need for antimicrobial interventions. By employing meticulous microbial assays, our objective is to identify compounds that possess the ability to selectively bind to and eradicate these pathogens, thereby impeding their growth and alleviating the spread of infection. By identifying novel therapeutics, our research has the potential to significantly impact the management of pharyngitis, providing millions of individuals afflicted with this incapacitating condition with respite.

Table 1: **Preparation of phytosomes.**

Sl. No.	Ingredients	Quantity
1	Combined extract: Soya lecithin	1:1
2	Dichloromethane(ml)	20
3	Hexane(ml)	20

Antimicrobial activity

The antimicrobial activity of the polyherbal phytosomal gel was assessed using the agar well diffusion technique. Plates of Mueller Hinton agar was prepared and sterilized by placing them in an autoclave set at 121°C for 15 to 20 min. The next step was to pour the sterile media onto the previously sterilized Petri plates and then to wait for them to cool to room temperature. The bacterial suspension containing *Streptococcus mutans* and *Staphylococcus aureus* was uniformly distributed on the agar plates using sterile cotton swabs. Using a sterile polystyrene point, we formed wells with a diameter of 9 mm in the agar plates. The wells were subsequently filled with polyherbal phytosomal gel at varying concentrations (25 µg, 50 µg, 100 µg). The plates were placed in an incubator set at a temperature of 37°C for 24 hr. The antibacterial activity was assessed by measuring the diameter of the zone of inhibition surrounding the wells. The diameter of the zone of inhibition was measured using a ruler and recorded in mm and the value was used to compute the zone of inhibition.[30,31]

Table 2: **Formula for preparation of phytosomes loaded polyherbal gel.**

Sl. No.	Ingredients	F1	F2	F3
1	Phytosomes	1%	3%	5%
2	Carbopol 934	1%	1%	1%
3	Propyl paraben	0.1%	0.1%	0.1%
4	Methyl paraben	0.1%	0.1%	0.1%
5	Triethanolamine	q. s	q. s	q. s

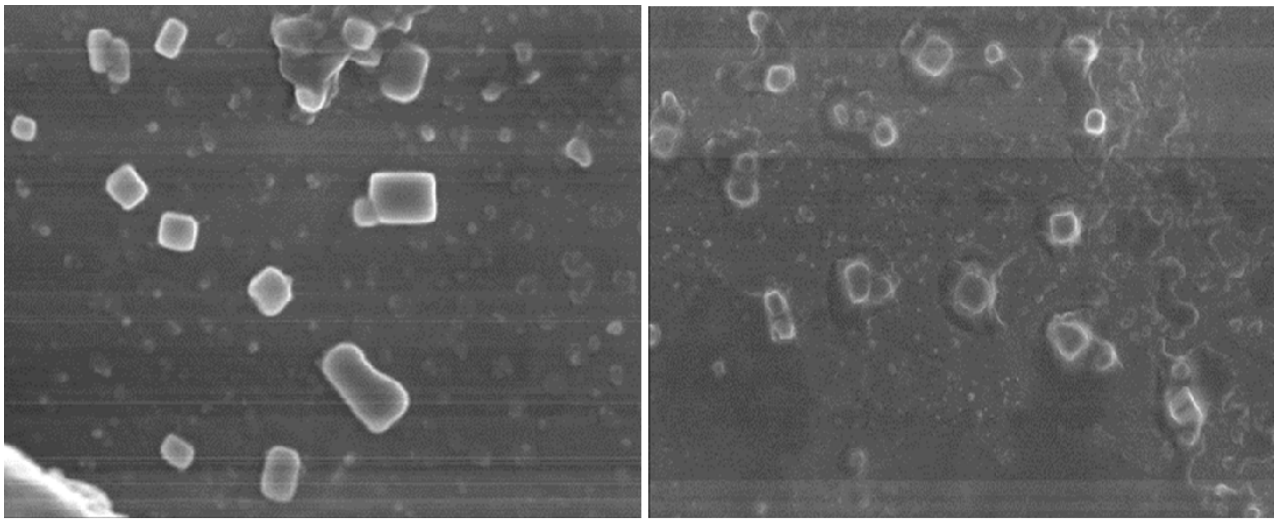

Figure 1: SEM images of the phytosome.

Table 3: **Phytochemical screening of the plant extract.**

Sl. No.	Phytoconstituents	*Acalypha indica*	*Pergularia daemia*	*Coleus amboinicus*
1.	Alkaloids	++	++	++
2.	Glycosides	++	--	++
3.	Steroids and Terpenoids	--	++	--
4.	Flavonoids	++	++	++
5.	Carbohydrates	++	++	++
6.	Phenolic compounds	++	++	++
7.	Proteins	--	++	--
8.	Tannins	++	++	++
9.	Saponins	++	++	++
10.	Gums and Mucilage	--	--	--
11.	Fixed oils and Fats	++	++	++

++ indicates present: -- indicates absent.

Table 4: **Evaluation of phytosomes.**

Method	Percentage yield (%)	Entrapment efficiency (%)	Particle size (nm)	Zeta potential
Anti-solvent precipitation method (1:1)	72.5	86.94±0.3	158	-8 mv

(Entrapment efficiency was mean±SD; *n*=3).

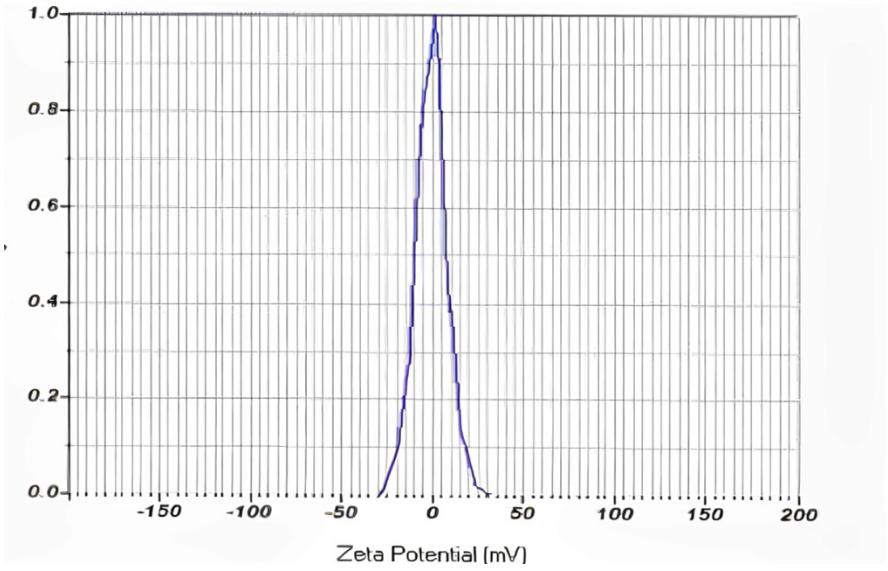

Figure 2: Zeta Potential of Phytosomal complex.

Anti-inflammatory activity

Three tests, including the Bovine Serum Albumin Denaturation Assay, the Egg Albumin Denaturation Assay and the Membrane Stabilisation Method, were used to evaluate the polyherbal phytosomal gel's anti-inflammatory effectiveness.

Bovine serum albumin denaturation assay

About 0.05 mL of polyherbal phytosomal gel at various doses (10-50 g/mL) was combined with 0.45 mL of bovine serum albumin. The pH was adjusted to 6.3. Following a 10 min interval at room temperature, it was incubated in a water bath that was heated to 55°C for 30 min. The standard group utilised was

Table 5: **Evaluation of phytosomes loaded polyherbal gel.**

Formulations	Homogeneity	pH	Drug content (%)	Rheology (centipoise)	Spreadability (CM)	Extrudability (gm/cm²)
F1	Good	5.1±0.04	82.37	34650±0.08	3.9±0.04	8.9±0.09
F2	Good	5.3±0.06	86.78	34990±0.09	4.0±0.06	9.0±0.05
F3	Good	5.4±0.03	90.09	35123±0.04	4.1±0.03	9.2±0.05

(All values are mean±SD; *n*=3).

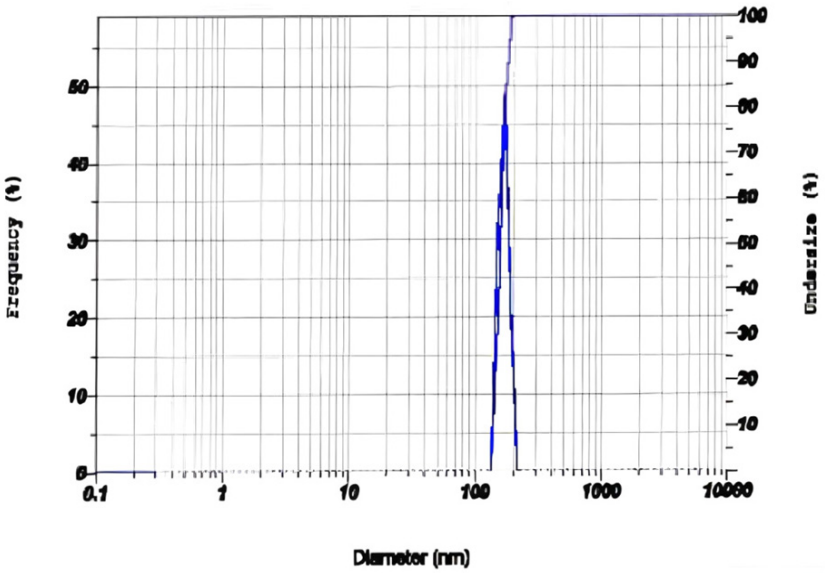

Figure 3: Particle Size Determination of Phytosomal Complex.

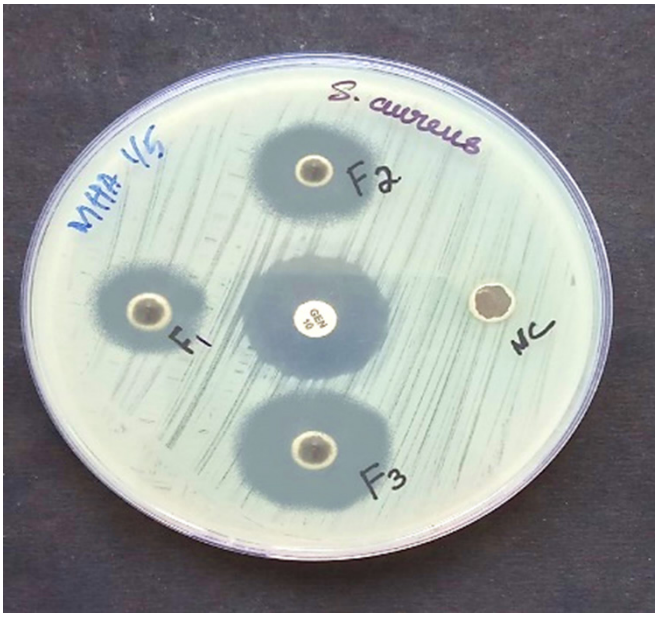

Figure 4 A: Anti-Microbial Test performed against *Staphylococcus aureus.*

diclofenac sodium, while the control group used was dimethyl sulphoxide. The samples were then spectrophotometrically analysed at 660 nm. The protein denaturation percentage was calculated.[32]

Egg Albumin denaturation assay

The egg albumin denaturation experiment was conducted using 2.8 mL of phosphate buffer and 0.2 mL of fresh egg albumin. Various amounts of polyherbal phytosomal gel (10-50 g/mL) were added to the reaction mixture. We adjusted the pH to 6.3. After 10 min at room temperature, it was incubated in a water bath at 55ºC for 30 min. The standard group utilized was diclofenac sodium, while the control group used was dimethyl sulphoxide. The samples were then spectrophotometrically analyzed at 660 nm. The protein denaturation percentage was calculated.[33]

Membrane stabilization assay

Take fresh human blood samples in sterile tubes with an anticoagulant. Separate the RBCs from other blood components by centrifuging the blood at a 1000 g rate for 10 min at room temperature. Take away the supernatant, then PBS-wash the RBCs three times. To obtain a 10% (v/v) RBC suspension, resuspend the RBCs in the Tris-HCl buffer. 1mL of the RBC suspension should be pipetted into each centrifuge tube. Each tube was then filled with varying quantities of polyherbal phytosomal gel. Gently mix the tubes and incubate them at 37ºC for 30 min. To pellet the RBCs, centrifuge the tubes at 1000 g for 10 min at room temperature. Using a UV-Vis spectrophotometer, determine the absorbance of the supernatant at 540 nm.[34]

Statistical analysis

All the measurements were performed in triplicates and the results were expressed as the mean±standard error of mean using GraphPad Prism 5.0. Two-way Analysis of Variance (ANOVA) was performed and a p value of less than 0.05 was deemed significantly different.

RESULTS

The extractions were performed for all the plant drugs by using the Soxhlet apparatus the physical nature of the drug was semisolid which yields 6.2%, 6.88% and 7.82% respectively. Preliminary phytochemical screening of extract for the presence of multiple chemical components were performed and results were tabulated in Table 3. Combined phytosomes were prepared by the antisolvent precipitation method. The formulated phytosomes contain phospholipids and drug extracts. The evaluation parameters were performed and the results were discussed. Vesicle development could be observed in the phytosomes' microscopical image, which was noted. It was found that the produced vesicles were all similar in size and shape. No clumsy particles were found. The prepared phytosomes showed better percentage yield, entrapment efficiency, particle size and Zeta potential. Data for these parameters are 72.5%, 86.94%±0.3, 158 nm and -8 mv respectively and results were tabulated in Table 4. Figures 1 and 2 shows the reports of particle size and zeta potential. Figure 3 displays the surface morphology, shape and structure of the combined phytosomes under various magnifications. It was found that the phytosomes are irregular in shape with a rough surface.

All the developed gel formulations passed a visual evaluation and it was found that they all had an acceptable look and homogeneity. The pH of the gel formulations was between 5.4 and 5.1, which is between the skin's normal pH range and won't cause irritation to the skin. Using spectrophotometry, the drug content of the gel formulations was calculated between 200 and

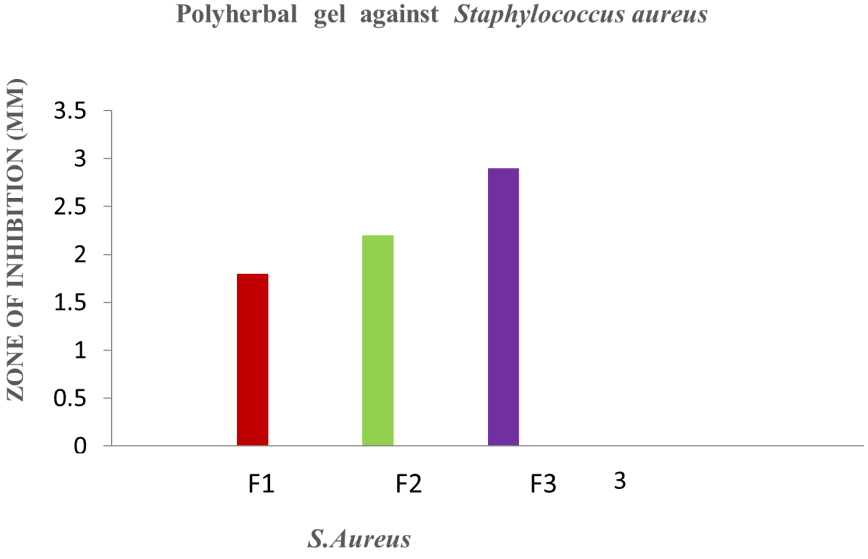

Figure 4 B: Graphical representation of Polyherbal gel against *Staphylococcus aureus.*

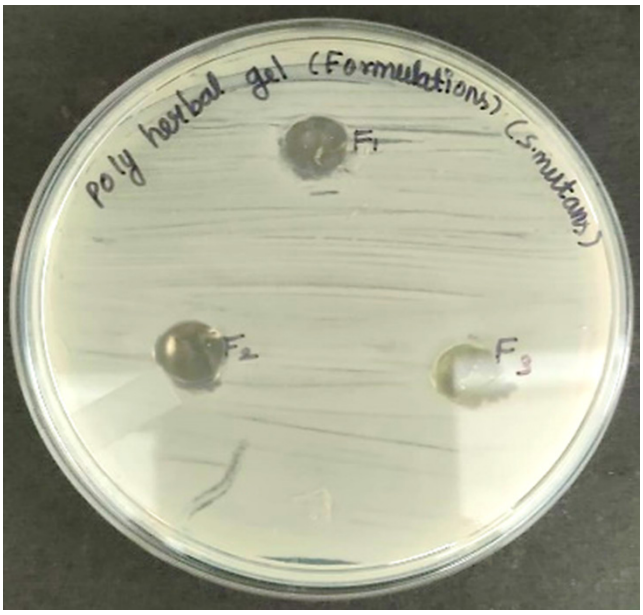

Figure 5 A: Anti-microbial test performed on *Streptococcus Mutants.*

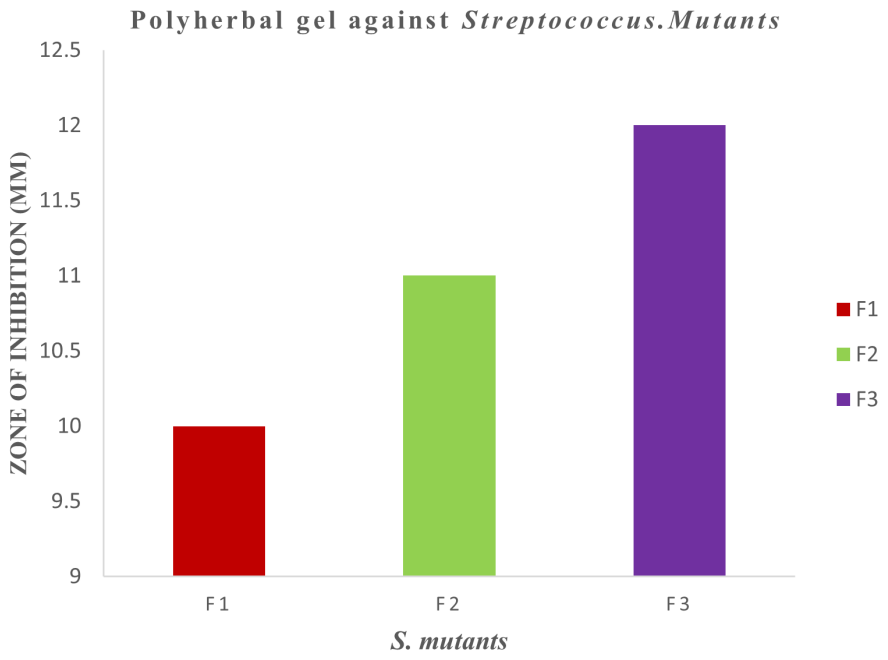

Figure 5B: Graphical representation of Polyherbal gel Against *Streptococcus mutants.*

600 nm. All the formulations' drug contents were found to range from 82.37% to 90.09%, with the best formulation F3 having the highest drug concentration at 90.09%. The formulations' viscosities were measured and the formulation with the best viscosity F3 measured at 35123 centipoises. The developed gel formulations' spreadability was tested and it was determined that all of the formulations displayed a respectable spreadability. The best formulation, F3, had a spreadability coefficient of 4.1 cm. It was discovered that the concentration of the gelling ingredients affected the extrudability of the manufactured gel formulation. With an increase in gelling agent concentration, extrudability decreased. The best formulation F3's extrudability was determined to be 9.2 gm/cm^2. By comparing three formulations the F3's extrudability was determined to be 9.2 gm/cm^2 which is better than F1 and F2. As a result, the prepared gel has the best extrudability and the data were tabulated in Table 5.

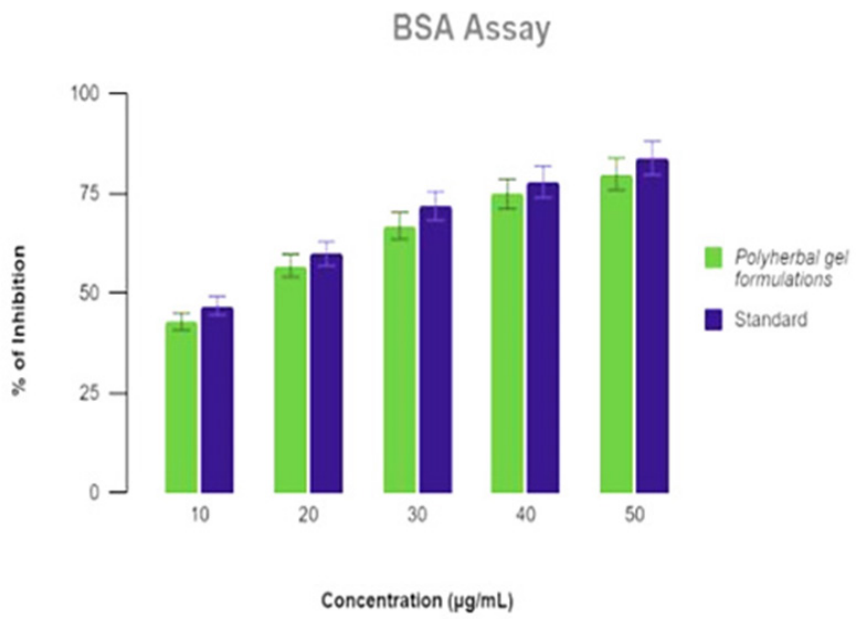

Figure 6A: Bovine Serum Albumin Denaturation Assay. Each value represents the mean±SEM of three replicates.

+/- SD

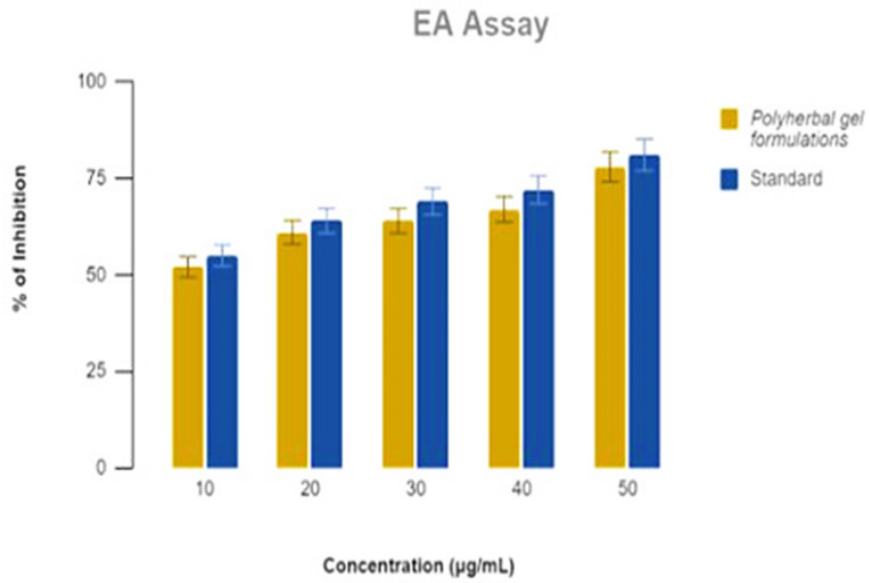

Figure 6 B: Egg Albumin Denaturation Assay. Each value represents the mean±SEM of three replicates.

+/- SD

Biological Activity

In vitro Antimicrobial activity

Antimicrobial *in vitro* experiments demonstrated that formulations F1, F2 and F3 were effective against *S. aureus* and *S. mutans* as shown in the Figures 4 and 5. Specifically, the antibacterial activity of formulation F3 was found to be 30% higher than that of F1 and 20% higher than that of F2. This observation highlights the strong antimicrobial effects of F3, which inhibits the growth of *S. aureus* and *S. mutans*.

In vitro Anti-inflammatory activity

Formulation F3 outperforms the other formulations in the antimicrobial assay. Thus, the F3 formulation is evaluated in the *in vitro* anti-inflammatory assay and it is deemed the optimized batch. Various doses ranging from 10 to 50 µg/mL were used to

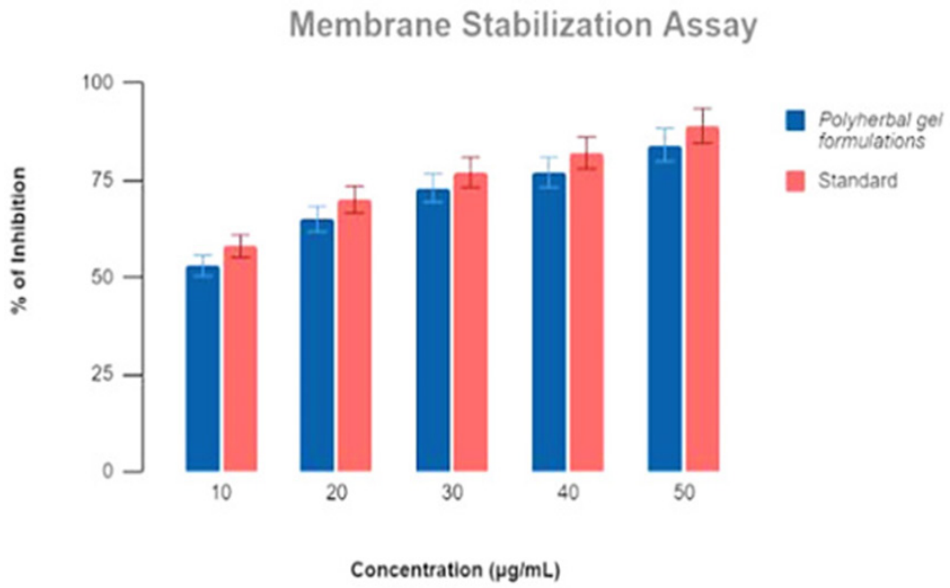

Figure 6C: Membrane Stabilization Assay. Each value represents the mean±SEM of three replicates.

analyze the F3 formulation. To reduce the body's inflammatory response, anti-inflammatory medicines act by blocking specific biochemical pathways or mediators. In order to determine the anti-inflammatory effect, this study employed the BSA assay, which measures the ability of a substance to prevent protein denaturation. This involves maintaining the functional form of proteins by stabilizing their structure, preventing misfolding by minimizing protein aggregation and even providing insights into how chemicals protect proteins like BSA from harm during inflammation by interfering with inflammatory processes. Figure 6 A shows the comparison of anti-inflammatory activities and it can be shown that the newly produced Phytosomal polyherbal gel, which is mediated by *Acalypha indica, Pergularia daemia* and *Coleus amboinicus*, had anti-inflammatory activity that was comparable to the standard. A specific attribute was evaluated by analyzing the samples at 660 nm. The standard reference compound, diclofenac, was examined at concentrations varying from 10 to 50 µg/mL, while the produced phytosomal gel was evaluated at concentrations that were equivalent to it. In comparison to the reference, which demonstrated an anti-inflammatory action of 75.10±0.30% at a concentration of 40 µg/mL, the Phytosomal gel demonstrated 73.50±0.40%. In comparison to the standard's 89.10±0.40% activity, the Phytosomal gel showed an anti-inflammatory activity of 86.03±0.80% at 50 µg/mL. The anti-inflammatory activity of the phytosomal gel was found to be significantly equivalent to that of standard Diclofenac at concentrations from 10 to 50 µg/mL.

In Egg Albumin denaturation assay, egg albumin is heated or acidified at various degrees and its functional and structural modifications are observed. We can gain insight into the stability and response of egg albumin to various environmental circumstances by assessing its denaturation. Protein activity in biological systems can be better understood using this data. The reference substance, diclofenac and Phytosomal gel were tested at doses ranging from 10 to 50 µg/mL as shown in Figure 6B. The Phytosomal gel had a significant anti-inflammatory effect of 69.90±0.30% compared to the reference, which showed an anti-inflammatory action of 71.80±0.40% at a concentration of 40 µg/mL.

In Membrane stabilization assay, the Phytosomal gel exhibited an anti-inflammatory activity of 84.40±0.80% at a concentration of 50 µg/mL, which is slightly less than the standard's activity of 88.50±0.30%. The phytosomal gel demonstrated an equivalent degree of anti-inflammatory effectiveness to the standard Diclofenac at dosages ranging from 10 to 50 µg/mL. The test evaluates a drug's ability to prevent cell contents from leaking through broken membranes. Drugs protect cells' structural integrity, vital to their function and health, by stabilizing these membranes. The phytosomal gels display 75.90±0.20% at 40 µg/mL, while the standard yields 79.80±0.60%. At 50 µg/mL, the gel will likely show 84.92±0.30%, while the standard yields 89.80±0.54% as shown in Figure 6C. In contrast to the highest-quality medication, these findings show that the phytosomal gel is much more efficacious.

DISCUSSION

The current investigation focused on formulating and assessing a polyherbal phytosomal gel using extracts derived from *Acalypha indica, Pergularia daemia* and *Coleus amboinicus*. The Soxhlet extraction method yielded substantial quantities of semi-solid extracts from these plants, verifying the extraction process's efficacy. The preliminary phytochemical screening revealed the existence of various bioactive components, which are essential for the healing properties of the extracts.

The phytosomes were prepared using the antisolvent precipitation method, which effectively combined phospholipids with drug extracts. The assessment of phytosomes demonstrated encouraging outcomes, with a substantial percentage yield of 72.5% and an entrapment efficiency of 86.94%±0.3. The phytosomal formulation demonstrated good stability and uniformity, as evidenced by a particle size of 158 nm and a zeta potential of -8 mV.[35] SEM examinations provided additional verification of the morphological features, demonstrating the presence of vesicles with irregular shapes and a coarse surface, which can augment the available surface area for interaction with biological membranes.[36,37]

Formulation F3's promising topical uses are highlighted by its outstanding performance in the gel matrix. Essential for successful cutaneous distribution, Formulation F3 displayed ideal viscosity and Spreadability in addition to high drug content (90.09%), appropriate pH and excellent homogeneity. Because of its extrudability, it is easy to administer and increases patient compliance, two important factors in patient care settings.

Results from the antimicrobial test showed that F3 formulation was highly effective against *S. aureus and S. mutans*.[30] It is suggested that the plant extracts and phospholipids interact synergistically, increasing the antibacterial efficacy by 30% compared to other formulations. Investigating the causes and possible synergies with conventional antibiotics in the fight against multidrug-resistant infections should be the focus of future research. The strong anti-inflammatory effects of formulation F3 were confirmed by *in vitro* anti-inflammatory assessments, which showed a notable reduction of protein denaturation and membrane stabilization. As a natural alternative to diclofenac, it shows promise in inflammatory conditions, with comparable efficacy throughout studied concentrations. To better understand its precise action mechanisms, possible interactions with inflammatory mediators and safety profile over the long term, additional research is necessary.[33]

To sum up, the produced polyherbal phytosomal gel has a lot of potential in the pharmaceutical and dermatological fields, especially in formulation F3. Further preclinical and clinical investigations are warranted due to its improved bioavailability, powerful antibacterial efficacy and potent anti-inflammatory properties. Thorough clinical trials to confirm its therapeutic effectiveness and safety in varied patient groups should be the focus of future research, along with optimising formulation parameters, investigating synergistic effects with conventional medicines and scaling up manufacturing.

CONCLUSION

This study focused on the formulation and evaluation of combined phytosomes derived from *Acalypha indica, Pergularia daemia* and *Coleus amboinicus* for enhanced bioavailability and targeted drug delivery in the treatment of Pharyngitis. The developed phytosomal system demonstrated the successful formation of uniform vesicles with desirable characteristics such as high yield, excellent entrapment efficiency, small particle size and appropriate zeta potential. These properties indicate the potential of the phytosomes for the efficient delivery of herbal extracts. Furthermore, the formulated polyherbal phytosomal gel exhibited suitable attributes for topical application, including pH compatibility with the skin and optimal viscosity. The *in vitro* evaluation of the polyherbal phytosomal gel demonstrated significant anti-inflammatory and anti-microbial activity, comparable to the standard drug, in various assays. This suggests the potential therapeutic effectiveness of the developed formulation in managing Pharyngitis conditions. The utilization of phytosomes as a drug delivery system holds promise for improved bioavailability and targeted action, which may enhance the overall therapeutic outcomes. Overall, the findings of this study support the potential of combined phytosomes derived from *Acalypha indica, Pergularia daemia* and *Coleus amboinicus* as an innovative approach for effective drug delivery in the treatment of Pharyngitis. Further studies, including *in vivo* experiments and clinical trials, are warranted to validate the efficacy and safety of the developed formulation for broader clinical applications.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

mm: Millimeter; **mL:** Milliliter; **BSA:** Bovine Serum Albumin; **µg/mL:** Microgram per milliliter; **nm:** Nanometer; ***S. aureus*:** *Staphylococcus aureus*; ***S. mutans*:** *Streptococcus mutans.*

AUTHORS CONTRIBUTION

Vandhana wrote the manuscript, Sharan Raj and Kowsik contributed to the research work and Thirumalaikumaran reviewed and corrected the manuscript. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

REFERENCES

1. Brkic FF, Besser G, Janik S, Gadenstaetter AJ, Parzefall T, Riss D, *et al.* Peaks in online inquiries into pharyngitis-related symptoms correspond with annual incidence rates. Eur Arch Oto-Rhino-Laryngol. 2021;278(5):1653-60. doi: 10.1007/s00405-020-06362-4.
2. Luo R, Sickler J, Vahidnia F, Lee YC, Frogner B, Thompson M. Diagnosis and management of group a streptococcal pharyngitis in the United States, 2011-2015. BMC Infect Dis. 2019;19(1). doi: 10.1186/s12879-019-3835-4.
3. Alharbi WS, Almughem FA, Almehmady AM, Jarallah SJ, Alsharif WK, Alzahrani NM, *et al.* Phytosomes as an emerging nanotechnology platform for the topical delivery of bioactive phytochemicals. Pharmaceutics. 2021;13(9). doi: 10.3390/pharmaceutics13091475.
4. Kumar A, Kumar B, Singh SK, Kaur B, Singh S. A review on phytosomes: novel approach for herbal phytochemicals. Asian J Pharm Clin Res. 2017;10(10). doi: 10.22159/ajpcr.2017.v10i10.20424.
5. Barani M, Sangiovanni E, Angarano M, Rajizadeh MA, Mehrabani M, Piazza S, *et al.* Phytosomes as innovative delivery systems for phytochemicals: A comprehensive review of literature. Int J Nanomedicine. 2021;Volume(16):6983-7022. doi: 10.2147/IJN.S318416.

6. Zahidin NS, Saidin S, Zulkifli RM, Muhamad II, Ya'akob H, Nur H. A review of *Acalypha indica* L. (*Euphorbiaceae*) as traditional medicinal plant and its therapeutic potential. J Ethnopharmacol. 2017;207:146-73. doi: 10.1016/j.jep.2017.06.019.
7. Seifunnisha O, Swathi R, Shanthi J. Non-wettable antibacterial thin film: *Aloe vera* and *Acalypha indica*. Polym Polym Compos. 2021; 29(9_suppl):S622-30. doi: 10.1177/0967391121101786 9.
8. Karthishwaran K, Mirunalini S. Therapeutic potential of *Pergularia daemia* (Forsk.): the ayurvedic wonder. Int J Pharmacol. 2010;6.
9. Dailah HG. Anticancerous and antioxidant activity of *Pergularia daemia* Inspired zinc oxide Nanoparticles against Lung Cancer. Cell Line IJPER. 2022;A549:56.
10. Nazliniwaty N, Laila L. Formulation and antibacterial activity of *Plectranthus amboinicus* (Lour.) spreng leaves ethanolic extract as herbal mouthwash against halitosis caused bacteria. Open Access Maced J Med Sci. 2019;7(22):3900-3. doi: 10.3889/oamjms.2019.529.
11. Caroline L, Muthukumar R S, Priya AH, N N. Anticancer effect of *Plectranthus amboinicus* and *Glycyrrhiza glabra* on oral cancer cell line: an *in vitro* experimental study. Asian Pac J Cancer Prev. 2023;24(3):881-7. doi: 10.31557/APJCP.2023.24.3.881.
12. Arumugam G, Swamy MK, Sinniah UR. *Plectranthus amboinicus* (Lour.) Spreng: botanical, Phytochemical, Pharmacological and Nutritional Significance. Molecules. 2016;21(4). doi: 10.3390/molecules21040369.
13. Cheng CY, Kao CL, Li HT, Yeh HC, Fang ZY, Li WJ, *et al.* A new flavonoid from Plectranthus amboinicus. Chem Nat Compd. 2021;57.
14. Tiwari P, Kumar B, Mandeep K, Kaur G, Kaur H. Phytochemical screening and Extraction: a review. Int Pharm Sci. 2011;1.
15. Pandey A, Tripathi S, Pandey CA. Concept of standardization, extraction and pre phytochemical screening strategies for herbal drug. J Pharmacogn Phytochem. 2014;115.
16. Prem Kumar K, Nirmalababurao R. Rani A. Antimicrobial, antioxidant activity and phytochemical screening of *Acalypha indica* crude leaf extract. Int J Pharm Clin Res. 2016;8.
17. Doss A, Anand SP. Preliminary phytochemical screening of *Asteracantha longifolia* and *Pergularia daemia*. World Appl Sci J. 2012;18.
18. Deepika Thenmozhi C, Premalakshmi V. Preliminary phytochemical screening and antibacterial activity of *Pergularia daemia* forsk. Int J Pharm Biol Sci. 2011;2.
19. Romadhonsyah F, Gemantari BM, Nurrochmad A, Wahyuono S, Astuti P. Antioxidant, cytotoxic Activities and Characterization of Secondary Metabolites of endophytic Fungus Schizophyllum commune isolated from *Coleus amboinicus* (Lour.) Leaves. Res J Pharm Technol. 2022;15:357-64. doi: 10.52711/0974-360X.2022.00058.
20. Dhase AS, Saboo SS. Preparation and evaluation of phytosomes containing methanolic extract of leaves of *Aegle marmelos* (Bael). Int J PharmTech Res. 2015;8.
21. Wardana MS, Jufri M, Mun'im A. Physicochemical properties and nutrition of *Moringa oleifera* lam. Leaf extract: a preliminary study on preparation phytosomes as herbal supplement for children. Int J Appl Pharm. 2022;14:281-7. doi: 10.22159/ijap.2022v14i1.43477.
22. Naik AA, Gadgoli CH, Naik AB. Formulation Containing Phytosomes of Carotenoids from *Nyctanthes arbortristis* and *Tagetes patula* Protect D-galactose Induced Skin Aging in Mice. Clin Complement Med Pharmacol. 2023;3(1). doi: 10.1016/j.ccmp.2022.100070.
23. Kaur B, Saxena A, Roy K, Bhardwaj M, Bisht M. Development and *in vitro* evaluation of phytosomes containing herbal extract of *Centella asiatica* for antiulcer and antioxidant activity. J Adv Sci Res. 2023;14.
24. Karole S, Gautam GK, Gupta S, Girendra C, Gautam K. Preparation and evaluation of phytosomes containing ethanolic extract of leaves of *Bombax ceiba* for hepatoprotective activity. J Pharm Innov. 2019;8.
25. B JJ, KR. Development and *in vitro* evaluation of phytosomes of ellagic acid. Asian J Pharm Clin Res. 2023.
26. Purnamasari NA, Dzakwan M, Pramukantoro GE, Mauludin R, Elfahmi Myricetin nano-phytosomes peel-off gel mask formulation as an antioxidant. Int J Appl Pharm. 2021;13:278-81. doi: 10.22159/ijap.2021v13i4.40376.
27. Chauhan P, Monika. Formulation and Evaluation of antibacterial Gel containing ethanol Extract of Thorns of *Bombax ceiba*. Int J Drug Deliv Technol. 2022;12(3):1015-9. doi: 10.25258/ijddt.12.3.16.
28. Baitule AW, Tawar MG, Pande SD. Formulation and evaluation of polyherbal gel. Res J Pharm Technol. 2023;16:2013-6. doi: 10.52711/0974-360X.2023.00330.
29. Kashyap A, Das A, Ahmed AB. Formulation and evaluation of transdermal topical gel of ibuprofen. J Drug Deliv Ther. 2020;10(2):20-5. doi: 10.22270/jddt.v10i2.3902.
30. Eswar P, Devaraj CG, Agarwal P. Antimicrobial activity of tulsi *Ocimum Sanctum* (Linn.) extract on a periodontal pathogen in human dental plaque: an *in vitro* study. J Clin Diagn Res. 2016;10.
31. Kubasad S. Tamase AS, Kadam KK. Evaluation of preliminary antimicrobial efficacy of curcumin and chitosan nanoparticles with and without photoactivation against – an *in vitro* study. IP Indian J Conserv Endod. 2022;7.
32. Adetutu OA, Olukorede AO. Evaluation of *in vitro* anti-inflammatory Potential of Aqueous *Solanum aethiopicum* (Garden Egg) Leaf Extract. J Biomed Biosens. 2021;1.
33. Kumari CS, Yasmin N, Hussain MR, Babuselvam M. *In vitro* anti-inflammatory and anti-artheritic property of *Rhizopora mucronata* leaves. Int J Pharm Sci Res. 2015;6.
34. Ruba Priya M, Girija K, Ravichandran N. *In vitro* study of anti-inflammatory and antioxidant activity of 4-(3H) - Quinazolinone derivatives. Gnana. Rasayan J Chem. 2011;4.
35. Pande SD, Wagh AS, Bhagure LB, Patil SG, Deshmukh AR. Preparation and evaluation of phytosomes of pomegranate peels. Res J Pharm Technol. 2015;8.
36. Chouhan A, Shah SK, Tyagi CK, Budholiya P, Wazid A, Khan F. Formulation, development and evaluation of phytosomes of *Swertia perennis*. AJPER JOURNAL. 2021;10(2):55-66. doi: 10.38164/AJPER/10.2.2021.55-66.
37. Varadkar M, Gadgoli C. Preparation and evaluation of wound healing activity of phytosomes of crocetin from *Nyctanthes arbortristis* in rats. J Tradit Complement Med. 2022;12(4):354-60. doi: 10.1016/j.jtcme.2021.10.002.

Cite this article: Vandhana V, Thirumalaikumaran R, Raj SR, Kowsik E. Formulation And Evaluation of Phytosomes Loaded Polyherbal Gel for Pharyngitis. J Young Pharm. 2025;17(1):176-86.