

DEVELOPMENT AND EVALUATION OF PHYTOSOME-BASED HYDROGEL OF *BOSWELLIA SERRATA* FOR ANTI-INFLAMMATORY ACTIVITY

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ABSTRACT

Creation and Assessment of Boswellia serrata Phytosome-Based Hydrogel for Anti-Inflammatory Action

A significant pathological condition linked to a number of acute and chronic illnesses, inflammation frequently necessitates long-term therapy with traditional anti-inflammatory medications that may have unfavorable side effects. The safety, effectiveness, and therapeutic potential of herbal remedies have drawn a lot of attention. Among these, the well-known medicinal plant Boswellia serrata, which is high in boswellic acids, has notable anti-inflammatory properties. However, boswellic acids' low absorption and poor water solubility limit their therapeutic efficacy.

The goal of the current study was to create and assess a Boswellia serrata hydrogel based on phytosomes for improved topical anti-inflammatory efficacy. Boswellia serrata crude oleo-gum resin was obtained, verified, and extracted using Soxhlet extraction with ethanol. The extract's appropriateness for formulation development was proven by preformulation investigations such as organoleptic assessment, solubility analysis, melting point determination, UV spectrophotometric analysis, and FTIR compatibility research.

Phosphatidylcholine and cholesterol were used in the thin-film hydration approach to create Boswellia phytosomes. Particle size, zeta potential, polydispersity index, entrapment efficiency, drug content, surface morphology, and in vitro drug release were assessed for five phytosome formulations (F1–F5) that were created by adjusting the phosphatidylcholine concentration. With a particle size of 142.8 nm, zeta potential of –35.6 mV, polydispersity index of 0.176, entrapment efficiency of 93.28%, and drug content of 98.41%, F5 showed the most desirable properties among the produced formulations.

Five hydrogel formulations (H1–H5) were created by incorporating the improved phytosome formulation into Carbopol 934 hydrogel. The produced hydrogels' appearance, pH, viscosity, spreadability, extrudability, drug content, swelling index, and homogeneity were all assessed. With pH 6.71, viscosity 31,260 cP, drug content 99.18%, and swelling index 212.84%, H3 demonstrated the best physicochemical properties of all the formulations, making it appropriate for topical application. According to the Higuchi kinetic model, the improved hydrogel demonstrated sustained in vitro drug diffusion with 94.72% cumulative drug release over 12 hours, demonstrating diffusion-controlled release. A non-Fickian diffusion process was proposed by the Korsmeyer–Peppas release exponent. With 86.58% inhibition at 500 µg/mL, the protein denaturation assay showed notable in vitro anti-inflammatory effect that was comparable to the common medication Diclofenac sodium.

Excellent stability of the optimized formulation was confirmed by stability studies carried out in accordance with ICH guidelines for three months, which showed no discernible changes in physical appearance, pH, viscosity, drug content, spreadability, or homogeneity under refrigerated, room temperature, and accelerated storage conditions.

Overall, Boswellia serrata's physicochemical characteristics, prolonged drug release, and anti-inflammatory effectiveness were greatly enhanced by the phytosome-based hydrogel that was created. Further preclinical and clinical research is necessary since the formulation shows promise as a topical herbal medication delivery system for the efficient treatment of inflammatory illnesses.

Keywords

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1 INTRODUCTION

1.1 Introduction to Inflammation

Vascular tissues' intricate biochemical and defensive reaction to pathogens, damaged cells, irritants, toxins, or physical trauma is known as inflammation. It is regarded as a vital defense system of the body that aids in removing necrotic cells and tissues, starting the process of tissue repair and healing, and getting rid of the original cause of cell harm. In order to restore normal physiological function, the inflammatory response entails the

coordinated activation of immune cells, blood vessels, and other chemical mediators. Even though inflammation is a healthy and protective process, excessive or unchecked inflammation can cause tissue damage and a number of chronic illnesses. [1, 2].

The Latin word "inflammare," which means "to burn," is where the word "inflammation" originates. This word mirrors the traditional signs of inflammation, which include redness, heat, swelling, pain, and loss of function. The Roman physician

Celsus was the first to describe these symptoms. Immune cells, inflammatory mediators, cytokines, chemokines, prostaglandins, leukotrienes, and reactive oxygen species interact intricately to cause inflammatory reactions [3,4].

Acute inflammation and chronic inflammation are the two main categories of inflammation. While chronic inflammation is long-lasting and frequently linked to tissue damage and a number of chronic illnesses, acute inflammation is the body's quick and transient reaction to damaging stimuli. [5].



Figure: 1.1 Common physical presentations of inflammation

1.2 Herbal Drug Delivery System

The growing need for safe, effective, and natural medicinal agents has drawn a lot of attention to herbal drug delivery systems in recent years. Traditional medical systems including Ayurveda, Unani, Siddha, and Traditional Chinese Medicine have long employed herbal remedies to treat and prevent a wide range of illnesses. Alkaloids, flavonoids, glycosides, tannins, terpenoids, saponins, and polyphenols are among the many bioactive phytoconstituents found in medicinal plants. These compounds have a wide range of pharmacological activities, including anti-inflammatory, antioxidant, antimicrobial, anticancer, and immunomodulatory effects. [6,7].

1.3 Introduction to *Boswellia serrata*

In ancient medical systems like Ayurveda, *Boswellia serrata*, commonly known as Salai guggul or Indian frankincense, is an important medicinal herb belonging to the Burseraceae family. It has traditionally been used for wound healing, inflammatory conditions, asthma, arthritis, and other chronic illnesses. Its oleo-gum-resin contains bioactive constituents such as terpenoids, polysaccharides, essential oils, and boswellic acids, with boswellic acids considered the major active components responsible for analgesic and anti-inflammatory effects [80,81]. Boswellic acids exert anti-inflammatory activity mainly by inhibiting the 5-lipoxygenase (5-LOX) enzyme and reducing leukotriene production. In addition to anti-inflammatory activity, *Boswellia serrata* has demonstrated antibacterial, antioxidant, hepatoprotective, anticancer, immunomodulatory, and wound-healing properties [8].

2 Material and methods

2.1 Materials

The materials employed in the current study to create and assess a phytosome-based hydrogel of *Boswellia serrata* were purchased from

reliable vendors and used exactly as supplied, requiring no additional purification. Pharmaceutical or analytical grade phospholipids, polymers, solvents, preservatives, and analytical reagents were utilized in the formulation and evaluation investigations.

2.2 Methods [9,10]

2.2.1 Procurement and Authentication of Plant Material

The *Boswellia serrata* crude oleo-gum resin used in this study was purchased from online platform. Until it was needed again, the resulting resin was kept in airtight containers in a suitable environment.

2.2.3 Preformulation Studies

Prior to formulation development, preformulation tests were conducted to examine the physicochemical characteristics of the produced *Boswellia serrata* extract. These investigations were carried out in order to properly choose excipients and create a stable hydrogel formulation based on phytosomes.

The following preformulation studies were carried out:

- Organoleptic evaluation
- Solubility analysis
- Melting point determination
- Determination of λ_{max}
- Drug-excipient compatibility study by FTIR

2.2.4 Preparation of Phytosome

Phospholipid complexation was used in the thin-film hydration process to create *Boswellia* phytosomes. The technique was chosen because it is easy to use, repeatable, has a high entrapment efficiency, and can be used to produce vesicular systems with lipophilic phytoconstituents.

In order to improve the solubility, permeability, and bioavailability of boswellic acids, the produced *Boswellia serrata* extract was complexed with phospholipids in the presence of appropriate organic solvents.

Thin Film Hydration Method

Phosphatidylcholine, cholesterol, and *Boswellia serrata* extract were precisely weighed in accordance with the content of the formulation. In a dry, clean round-bottom flask, the phospholipid and cholesterol were dissolved in a solution of ethanol and chloroform. To create a homogenous solution, the *Boswellia* extract was subsequently added to the solvent combination and thoroughly mixed. To create a thin lipid coating on the flask's inner wall, the organic solvent combination was evaporated under low pressure using a rotary vacuum evaporator at a regulated temperature. To ensure that any remaining solvents were completely removed, the resulting thin coating was left undisturbed. The dried lipid film was hydrated with distilled water under continuous magnetic stirring to obtain phytosomal vesicles. The resulting dispersion was sonicated for a specified period to reduce vesicle

size and obtain uniform phytosomal suspension. The prepared Boswellia phytosomes were collected and stored under refrigerated conditions until further evaluation and incorporation into hydrogel formulation. [11]

Table 2.1 Composition of Boswellia Phytosome Formulations

Ingredients	F1	F2	F3	F4	F5
Boswellia serrata Extract (mg)	10	10	10	10	10
Phosphatidylcholine (mg)	0	0	0	0	0
Cholesterol (mg)	25	25	25	25	25
Ethanol (mL)	10	10	10	10	10
Chloroform (mL)	10	10	10	10	10
Distilled Water (mL)	20	20	20	20	20

2.2.5 Evaluation of Phytosome

The prepared Boswellia phytosome formulations were evaluated for various physicochemical and pharmaceutical parameters to determine their suitability, stability, vesicle characteristics, and drug release behavior. Evaluation studies were carried out using standard analytical and instrumental methods. [12]

The following evaluation parameters were studied:

- Particle size analysis
- Zeta potential determination
- Polydispersity index (PDI)
- Entrapment efficiency
- Drug content determination
- Surface morphology by SEM/TEM
- In vitro drug release study

2.2.6 Preparation of Hydrogel

Carbopol 934 was used as the gelling agent to create the phytosome-based hydrogel formulation with optimized Boswellia phytosomes. The hydrogel system was created to offer appropriate viscosity, extended retention, improved topical application, and sustained drug release properties. To improve gel consistency, spreadability, viscosity, and release behavior, different hydrogel batches were made by adjusting the polymer content. Using the appropriate mixing and neutralizing methods, the improved Boswellia phytosome formulation was added to the gel base. [13, 14]

Procedure for Preparation of Hydrogel

To prevent lump formation, a precisely weighed amount of Carbopol 934 was gradually mixed with distilled water while being continuously stirred magnetically. To create a homogenous gel basis, the polymer dispersion was given enough time to fully hydrate and swell. After being individually dissolved in propylene glycol, methyl and propyl

parabens were added to the hydrated polymer dispersion while being continuously stirred. To guarantee that the phytosomal vesicles were evenly distributed throughout the formulation, the tailored Boswellia phytosome suspension was then gradually added to the gel base while being gently stirred. Triethanolamine was added dropwise to the mixture while it was continuously stirred to attain the correct pH and gel consistency. The polymer dispersion was transformed into a transparent, homogeneous hydrogel as a result of the neutralization procedure. The prepared phytosome-based hydrogel formulations were transferred into airtight containers and stored under refrigerated conditions until further evaluation.

2.2.7 Evaluation of Hydrogel

To ascertain if the generated phytosome-based hydrogel compositions were suitable for topical administration, a number of physicochemical and medicinal properties were assessed. Evaluation experiments were carried out utilizing conventional protocols to test the quality, consistency, stability, and performance of hydrogel formulations. [15]

The following evaluation parameters were studied:

- Appearance
- pH determination
- Viscosity
- Spreadability
- Extrudability
- Drug content
- Swelling index
- Homogeneity

3. RESULTS

3.1 Extraction of Boswellia serrata Oleo-Gum Resin

The Soxhlet extraction method was effectively used to extract Boswellia serrata oleo-gum resin ethanolic. A dark brown, semi-solid, viscous extract with a distinctive aromatic smell was the result of the extraction process. After the solvent was completely removed, the concentrated extract had a smooth, uniform appearance and was devoid of obvious contaminants.

3.2 Preformulation Studies

3.2.1 Organoleptic Evaluation

The organoleptic properties of the produced ethanolic extract of Boswellia serrata were visually assessed. The extract was deemed appropriate for additional formulation research since it had the distinctive look and smell of Boswellia serrata oleo-gum resin.

The presence of resinous phytoconstituents in the ethanolic extract was verified by the dark brown color and distinctive aromatic smell. Effective extraction and solvent removal were demonstrated by the extract's smooth, uniform texture and lack of apparent contamination or particle debris. These

findings aligned with the documented organoleptic properties of extracts from *Boswellia serrata*.

3.2.2 Solubility Analysis

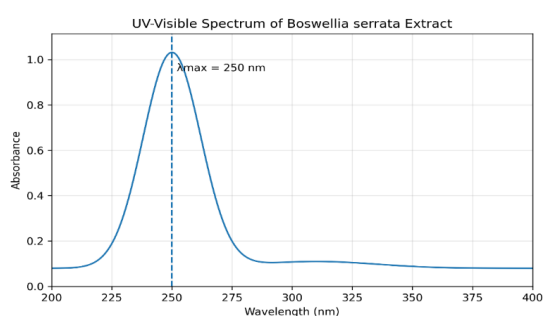
Table 3.1 Solubility Profile of *Boswellia serrata* Extract

Solvent	Solubility
Distilled water	Practically insoluble
Ethanol	Freely soluble
Methanol	Freely soluble
Chloroform	Soluble

3.2.3 Melting Point Determination

Under the experimental conditions, the *Boswellia serrata* extract demonstrated acceptable thermal stability with a melting point of $154.8 \pm 1.2^\circ\text{C}$.

3.2.4 Determination of λ_{max}

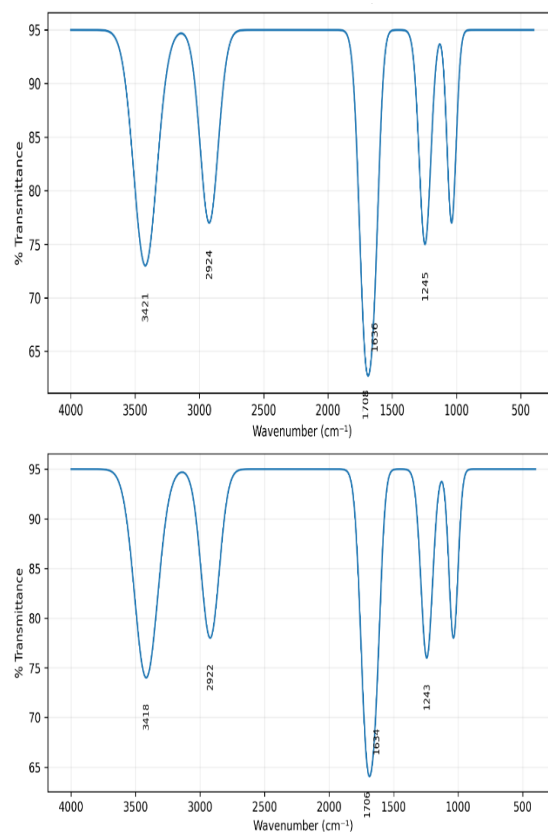


Graph 3.1. UV-Visible spectrum of *Boswellia serrata* extract showing λ_{max} at 250 nm.

The *Boswellia serrata* extract exhibited maximal absorbance at 250 nm, according to the UV spectral analysis, suggesting the presence of conjugated phytoconstituents, such as boswellic acids and related triterpenoids. The clear absorption peak made it easier to choose a suitable wavelength for quantitative estimation in in vitro release studies and drug content analysis. The suitability of the analytical approach was confirmed when the obtained λ_{max} was found to be consistent with previously published investigations on ethanolic *Boswellia serrata* extracts.

3.2.5 Drug–Excipient Compatibility Study by FTIR

Using Fourier Transform Infrared Spectroscopy (FTIR), the compatibility of *Boswellia serrata* extract with the chosen formulation excipients was examined. To find any potential chemical interactions, the FTIR spectra of the pure extract and its physical mixture with formulation excipients were examined.



Graph 3.2. FTIR spectrum of pure *Boswellia serrata* extract, physical mixture and excipients respectively.

3.3 Evaluation of Boswellia Phytosomes

3.3.1 Particle Size Analysis

The dynamic light scattering (DLS) method was used to determine the particle size of each phytosome formulation.

Table 3.2 Particle Size of Boswellia Phytosome Formulations

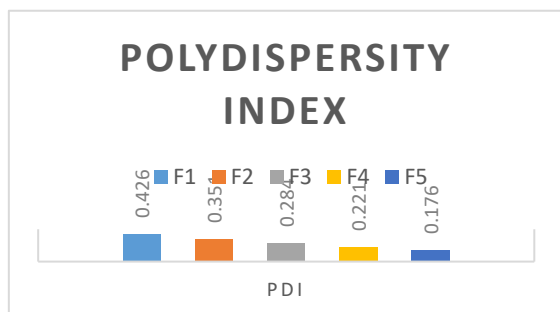
Formulation	Particle Size (nm)
F1	286.4 ± 4.8
F2	238.7 ± 3.6
F3	192.5 ± 2.9
F4	168.2 ± 2.4
F5	142.8 ± 2.1

3.3.2 Zeta Potential Determination

The surface charge of the prepared phytosomes was measured to evaluate their colloidal stability. Every formulation showed negative zeta potential values, indicating adequate physical stability and electrical repulsion between vesicles. As the concentration of phosphatidylcholine rose, so did the zeta potential's magnitude. F5 had the largest negative zeta potential (-35.6 mV), indicating minimal risk of vesicle aggregation during storage and good dispersion stability.

3.3.3 Polydispersity Index (PDI)

The PDI was determined to assess the uniformity of particle size distribution.

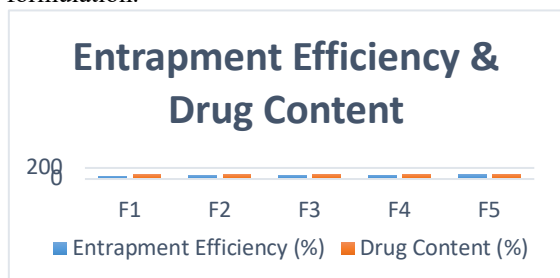


Graph 3.3: Graphical presentation of Polydispersity Index of Boswellia Phytosome Formulations

3.3.4 Entrapment Efficiency and Drug Content

Centrifugation was used to separate the untrapped medication, and UV spectrophotometric estimate was used to measure the entrapment effectiveness of the phytosome formulations.

Using the calibration curve of Boswellia serrata extract at the predefined λ_{max} , UV-visible spectrophotometry was used to determine the drug concentration of the produced phytosome formulations. The findings showed that the extract was satisfactorily incorporated into every formulation.



Graph 3.4 Graphical presentation of Entrapment Efficiency and drug content of Boswellia Phytosome Formulations

3.3.5 In Vitro Drug Release Study

The dialysis membrane diffusion method in phosphate buffer (pH 7.4) was used for the in vitro drug release investigation. Over a 12-hour period, the phytosome formulations' cumulative percentage drug release was tracked.



Figure 3.5 Comparative cumulative drug release profile of Boswellia phytosome formulations (F1–F5).

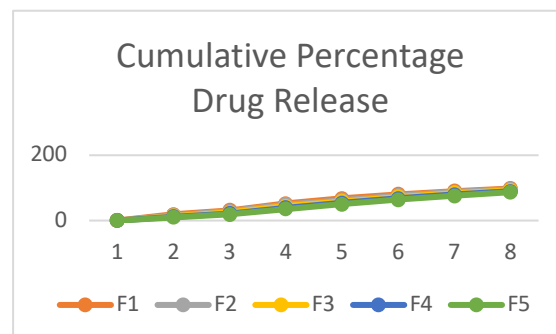


Figure 3.6 Graphical presentation of Cumulative Percentage Drug Release of Boswellia Phytosome Formulations

3.4 Preparation of Phytosome-Based Hydrogel

Carbopol 934 hydrogel bases made with varying polymer concentrations (0.5–1.5% w/w) were successfully combined with the improved Boswellia phytosome formulation (F5). The dispersion and neutralization method was successfully used to prepare all hydrogel formulations (H1–H5). Carbopol 934 was hydrated to create a smooth polymer dispersion, which was then neutralized with triethanolamine to create a transparent to translucent gel. Without any discernible aggregation or phase separation, the tailored phytosome solution was evenly integrated into the gel foundation. Throughout the preparation procedure, every formulation maintained its physical stability.

3.5 Evaluation of Phytosome-Based Hydrogel

3.5.1 Appearance

All formulations were free from visible particulate matter, phase separation, and air bubbles. H3 exhibited the most desirable appearance with a smooth, transparent, and homogeneous gel structure.

3.5.2 pH and viscosity

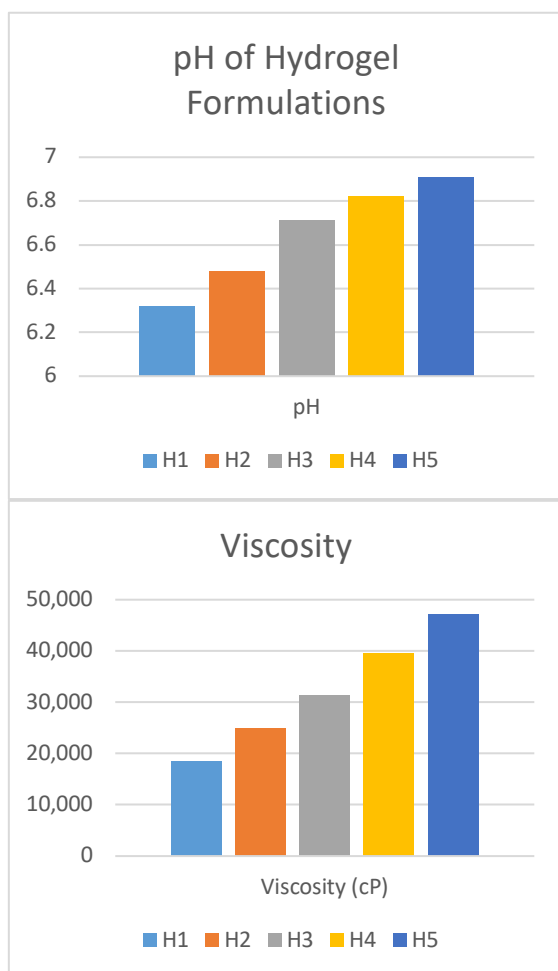


Figure 3.7 Graphical presentation of pH and viscosity of Hydrogel Formulations

3.5.3 Spreadability

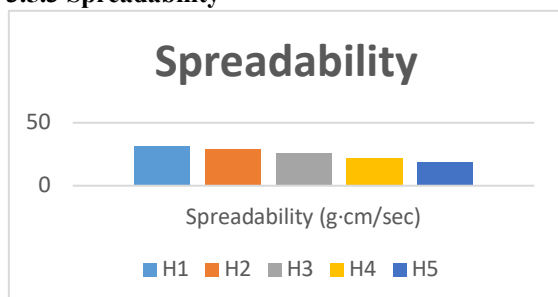


Figure 3.8 Graphical presentation of Spreadability of Hydrogel Formulations

Because of the accompanying rise in viscosity, spreadability reduced as polymer content increased. Despite being the most easily dispersed, H1's lesser viscosity may result in less retention at the application site. H3 was suitable for topical administration because it offered a reasonable mix between gel consistency and ease of spreading.

3.5.4 Determination of Drug Content

Using the *Boswellia serrata* extract calibration curve, UV-visible spectrophotometry was used to evaluate the drug concentration of the phytosome-based hydrogel formulations. The drug loading in all formulations was good and varied very little,

suggesting that the phytosome dispersion was evenly distributed throughout the hydrogel matrix. The swelling behaviour of the hydrogel formulations was evaluated in phosphate buffer (pH 7.4) to determine their water absorption capacity and hydration characteristics.

Table 3.3 Drug Content of Hydrogel Formulations

Formulation	Drug Content (%)	Swelling Index (%)
H1	95.14 ± 0.82	148.42 ± 3.26
H2	97.08 ± 0.74	176.35 ± 3.08
H3	99.18 ± 0.56	212.84 ± 2.74
H4	98.41 ± 0.61	201.76 ± 2.91
H5	97.32 ± 0.69	188.58 ± 3.15

3.5.5 Determination of Homogeneity

The prepared hydrogel formulations were visually examined for homogeneity, consistency, phase separation, grittiness, and the presence of lumps. It was discovered that all hydrogel formulations were uniform and devoid of phase separation, grittiness, and lumps. In every batch, the phytosomes were distributed uniformly across the Carbopol gel matrix. The successful integration of the tailored phytosomes into the hydrogel basis was confirmed by Formulation H3's outstanding homogeneity, smooth texture, and uniform appearance. The developed formulation's adequate physical stability is further indicated by the lack of phase separation.

3.6 In Vitro Diffusion Study

Phosphate buffer (pH 7.4) was used as the receptor medium in a Franz diffusion cell for the in vitro diffusion evaluation of the improved phytosome-based hydrogel formulation (H3). Over a 12-hour period, the cumulative percentage of drug diffusion was calculated.

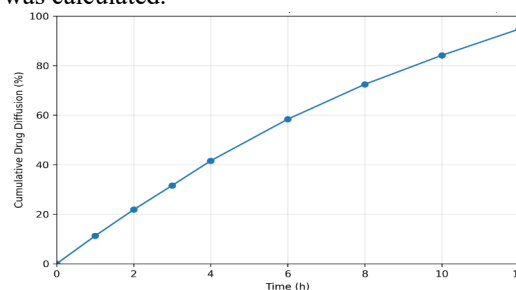


Figure 3.9. In vitro drug diffusion profile of optimized Boswellia phytosome hydrogel (H3).

During the course of the 12-hour investigation, the optimized phytosome-based hydrogel (H3) demonstrated a regulated and persistent drug diffusion pattern. The diffusion of phytosomes close to the hydrogel's surface may be the cause of the initial, mild release seen during the first few hours. Because of the gradual diffusion through the

hydrated Carbopol matrix, drug diffusion subsequently happened at a slower and more regulated rate.

Boswellia phytosomes were effectively released from the hydrogel system after 12 hours, as evidenced by the cumulative drug diffusion reaching $94.72 \pm 1.41\%$. The sustained diffusion profile indicates that adding phytosomes to the hydrogel matrix successfully extended drug release, which is advantageous for topical anti-inflammatory therapy since it sustains therapeutic drug levels for a longer amount of time.

3.7 Drug Release Kinetic Study

The in vitro diffusion data of the optimized hydrogel formulation (H3) were fitted to various kinetic models to determine the mechanism of drug release. Drug release from the phytosome-based hydrogel was primarily controlled by diffusion through the hydrated polymer matrix, according to the Higuchi model, which had the highest correlation coefficient ($R^2 = 0.994$) among the kinetic models assessed.

Non-Fickian (anomalous) diffusion was revealed by the Korsmeyer–Peppas release exponent ($n = 0.61$), indicating that a combination of diffusion and polymer relaxation regulated drug release. These results show that the hydrogel based on carbopol effectively maintained the release of Boswellia phytosomes for a long time, which qualifies the formulation for long-term topical treatment.

3.8 Anti-inflammatory Activity

3.9 Protein Denaturation Assay

By inhibiting the denaturation of bovine serum albumin, the optimized Boswellia phytosome hydrogel (H3) was tested for its in vitro anti-inflammatory efficacy and contrasted with the conventional anti-inflammatory medication (diclofenac sodium).

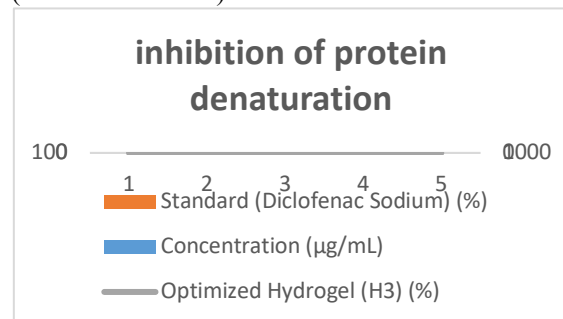


Figure 3.10 Comparative inhibition of protein denaturation by optimized hydrogel (H3) and Diclofenac sodium.

Discussion

Protein denaturation was inhibited in a concentration-dependent manner by the optimized Boswellia phytosome hydrogel. Effective anti-inflammatory efficacy was demonstrated by the percentage inhibition, which grew gradually with

concentration. The modified hydrogel generated $86.58 \pm 1.30\%$ inhibition of protein denaturation at the maximum tested dose (500 µg/mL), whereas the standard medication (diclofenac sodium) showed $91.82 \pm 1.36\%$ inhibition. The inclusion of boswellic acids and their improved transport through the phytosomal carrier system are responsible for the optimized formulation's significant anti-inflammatory effect, which was marginally lower than the norm. Improved solubility, greater dispersion of the active ingredients, and prolonged release from the hydrogel matrix are probably the causes of the increased activity seen in the phytosome-loaded hydrogel. These results suggest that the hydrogel based on phytosomes has considerable anti-inflammatory potential and could be a useful topical preparation for the treatment of inflammatory diseases.

3.10 Stability Study

In accordance with ICH requirements, a stability study was conducted on the optimized phytosome-based hydrogel formulation (H3) at room temperature, under refrigeration, and under accelerated storage settings. Over the course of three months, the formulation's physicochemical characteristics were assessed on a regular basis.

Over the course of the three-month storage period, the improved hydrogel maintained its stability. Although there was a modest drop in pH, it was still within the permissible range for topical administration. During storage, there was a little rise in viscosity, which might be explained by the polymer network's structural reconfiguration and ongoing hydration. Throughout the investigation, the drug content stayed above 98%, demonstrating the Boswellia phytosomes' exceptional chemical stability within the hydrogel matrix.

Spreadability very slightly decreased following storage, indicating that the formulation maintained acceptable application properties.

4. CONCLUSION

A phytosome-based hydrogel containing Boswellia serrata for topical anti-inflammatory application was successfully developed and evaluated in this study. The goal of the work was to use phytosomal drug delivery and hydrogel system incorporation to address the low bioavailability and poor water solubility of boswellic acids.

Preformulation studies were used to successfully prepare and characterize the ethanolic extract of Boswellia serrata. The extract's compatibility with the chosen excipients was verified by FTIR analysis, which also showed that there was no notable chemical interaction that would have compromised the stability of the formulation.

Phosphatidylcholine and cholesterol were used in the thin-film hydration approach to successfully manufacture Boswellia phytosomes. Formulation F5 showed the most desirable physicochemical

properties among the five phytosome formulations that were created. These properties included the smallest particle size, narrow particle size distribution, high zeta potential, maximum entrapment efficiency, and great drug content. These results verified the development of stable phytosomal vesicles that can enhance boswellic acid administration.

Topical formulations that were homogenous and physically stable were created by successfully incorporating the improved phytosome formulation into Carbopol 934 hydrogel. The produced hydrogels were evaluated, and it was shown that the polymer concentration had a substantial impact on the drug release properties, swelling behavior, viscosity, and spreadability.

Out of all the hydrogel formulations, H3 showed the best combination of physicochemical characteristics, such as appropriate pH, ideal viscosity, outstanding spreadability, high drug content, favorable swelling behavior, and consistent homogeneity.

Diffusion-controlled release from the hydrated polymeric matrix was indicated by the optimized hydrogel's 12-hour sustained drug diffusion and Higuchi kinetic model. According to the non-Fickian diffusion mechanism, polymer relaxation and diffusion worked together to release the medication.

The improved phytosome hydrogel's strong in vitro anti-inflammatory efficacy was validated by the protein denaturation experiment, which showed inhibition on par with the conventional anti-inflammatory medication. These results suggest that by increasing drug availability and offering extended release at the application site, phytosomal encapsulation enhanced *Boswellia serrata*'s therapeutic efficacy.

Additionally, the improved hydrogel showed no appreciable changes in appearance, pH, viscosity, drug content, or spreadability during the course of the three-month stability trial conducted in accordance with ICH criteria.

In summary, the phytosome-based hydrogel of *Boswellia serrata* that was created turned out to be a reliable, efficient, and promising topical medication delivery method. The formulation demonstrated outstanding anti-inflammatory efficacy and successfully improved the physicochemical properties and sustained release of boswellic acids. Therefore, the created mixture could be a viable herbal substitute for the topical treatment of inflammatory conditions. To determine its long-term safety, effectiveness, and therapeutic usefulness in people, more pharmacological, toxicological, and clinical research is advised.

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