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Original Research Article

Development and Evaluation of Asiaticoside Loaded Transethosomal Gel

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Abstract: The present study focuses on the development and evaluation of an asiaticoside-loaded transethosomal gel designed to enhance topical delivery, improve skin penetration, and provide sustained drug release for dermatological applications. Asiaticoside, a triterpenoid saponin derived from Centella asiatica, exhibits potent wound healing, anti-inflammatory, and antioxidant activities but suffers from poor aqueous solubility and low skin permeability. Transethosomes, ultra-deformable nanovesicles composed of phospholipids, ethanol, and edge activators, were prepared using the thin-film hydration method and optimized for particle size, polydispersity index, zeta potential, and entrapment efficiency. The optimized formulation (AT3) demonstrated a mean particle size of 187.2 nm, zeta potential of –22.3 mV, and entrapment efficiency of 83 ± 0.26%. Incorporation into a Carbopol-based gel resulted in desirable physicochemical characteristics (pH 6.9 ± 0.02, viscosity 19237 ± 67.8 cps) and excellent drug content uniformity (79 ± 0.12%). In vitro release studies revealed a sustained release pattern over 24 h, with the optimized gel following first-order kinetics (R^2 = 0.9997). Stability studies confirmed no significant changes in appearance, pH, or gelling properties over three months. The findings indicate that asiaticoside-loaded transethosomal gel offers a promising, patient-friendly platform for effective topical therapy in wound healing and related skin disorders.

Keywords: Asiaticoside, Centella asiatica, Transethosomes, Topical drug delivery

INTRODUCTION

Skin-related disorders and chronic wounds remain a significant clinical challenge due to delayed healing, inflammation, infection, and poor patient compliance with conventional therapies [1]. Topical drug delivery is widely preferred for the management of dermatological conditions because it allows localized drug action, minimizes systemic side effects, and improves patient adherence [2]. However, the effectiveness of topical therapy is often limited by the formidable barrier function of the stratum corneum, which restricts the penetration of many therapeutic agents, particularly those with high molecular weight or poor permeability. Therefore, the development of advanced carrier-based topical systems capable of enhancing dermal penetration while maintaining drug stability has become an important area of pharmaceutical research.

Asiaticoside, a triterpenoid saponin isolated from *Centella asiatica*, has been extensively reported for its wound healing, anti-inflammatory, antioxidant, and collagen synthesis–promoting properties [3]. It plays a crucial role in stimulating fibroblast proliferation, angiogenesis, and extracellular matrix remodeling, making it a promising therapeutic agent for the treatment of wounds, burns, scars, and inflammatory skin disorders [4]. Despite its pharmacological potential, the clinical application of asiaticoside via topical route is constrained by its poor skin permeation and limited bioavailability, which necessitates the development of an efficient delivery system to enhance its therapeutic performance.

Transethosomes are an advanced and ultra-deformable vesicular drug delivery system composed of phospholipids, ethanol, and an edge activator [5]. The presence of ethanol fluidizes the lipid bilayer of the stratum corneum, while edge activators impart high elasticity to the vesicles, enabling them to penetrate deeper skin layers through narrow intercellular pathways. Compared to conventional liposomes and ethosomes, transethosomes exhibit superior deformability, enhanced drug loading, and improved skin penetration, making them highly suitable for

transdermal and dermal drug delivery of both hydrophilic and lipophilic compounds [6]. Incorporation of transethosomal vesicles into a gel base further improves their applicability as a topical dosage form. Transethosomal gels offer advantages such as ease of application, prolonged residence time at the site of action, controlled drug release, improved stability, and enhanced patient acceptability. Carbopol-based gels, in particular, provide appropriate viscosity, spreadability, and bioadhesive properties, making them ideal carriers for vesicular systems intended for dermatological use.

In this context, the present study focuses on the development and evaluation of an asiaticoside-loaded transethosomal gel for topical delivery [7]. The formulation was designed to overcome the limitations associated with conventional topical preparations of asiaticoside by enhancing skin penetration and sustaining drug release. The prepared transethosomal gel was systematically evaluated for physicochemical characteristics, drug content, rheological behavior, in vitro drug release, and stability. The outcomes of this study aim to establish transethosomal gel as a promising and effective carrier system for improving the topical delivery and therapeutic efficacy of asiaticoside.

2. Materials and methods

2.1 Materials

All chemicals and materials employed in the present study were of analytical grade. Asiaticoside, used as the active pharmaceutical ingredient, was procured from Sigma Aldrich Pvt. Ltd., India. Lecithin and oleic acid, utilized as lipid components and penetration enhancers, were obtained from SRL Chem Pvt. Ltd., India. Ethanol, employed as a solvent and permeation enhancer, and phosphate buffer, used for preparation of various solutions and evaluation studies, were also purchased from SRL Chem Pvt. Ltd., India. Chloroform, used as an organic solvent during formulation development, was supplied by Molychem Pvt. Ltd., India. Carbopol 934P, a pharmaceutical-grade gelling agent, was obtained from Molychem Pvt. Ltd., India, while triethanolamine, used as a neutralizing agent for gel formation and pH adjustment, was also procured from Molychem Pvt. Ltd., India.

2.2 Methods

2.2.1 Organoleptic properties

The organoleptic characteristics of the drug were recorded and observed.

2.2.2 Melting point

Using a digital melting point instrument and capillary flow method, the melting point of asiaticoside was determined.

2.2.3 FTIR

The pure drug sample was subjected to infrared spectroscopy to identify the substance. By compressing the medication using IR-grade potassium bromide and exerting 5.5 metric tonnes of force in a KBr press, a drug pellet was created. The pellet was mounted in the infrared chamber and examined using an FTIR spectrum analyser between wave numbers 4000-450 cm^{-1}. The reference (B.P, 2009) was compared with the reserved peaks for various functional groups.

2.2.4 Solubility study

Solubility was determined using the pharmacopeial method. Based on the solubility results of asiaticoside in various solvents, the diffusible and dispersible fluids for drug release and pharmaceutical investigations, respectively, were selected. One part of asiaticoside was added to a different part of various organic solvents, including water, ethanol, DMSO, methanol, chloroform, and PBS (pH 7.4). The solution was then shaken reciprocally at 37°C for 5 min.

2.2.5 Ultraviolet/Visible spectrophotometric method development

The standard curve of asiaticoside was developed in PBS pH 7.4 to determine and quantify asiaticoside during various stages of formulation development.

2.2.5.1 Determination of Absorption Maximum (λmax) and calibration curve

A standard preparation of asiaticoside (1000 µg/mL) was initially formulated in PBS, pH 7.4, and its absorption maximum (λmax) was analyzed by scanning in the range of 200–800 nm using a UV-Visible spectrophotometer (UV-model Labindia 3000^{+}), with 278 nm identified as the wavelength of maximum absorbance. For the construction of the calibration curve, a first standard preparation was formulated by dissolved 100 mg of asiaticoside in 10 mL of methanol and diluting it to 100 mL with PBS (pH 7.4), followed by the preparation of a second stock (100 µg/mL) by further dilution. From this, standard solutions with concentrations ranging from 10 to 60 µg/mL were prepared in PBS (pH 7.4), and their absorbance was measured at 278 nm.

2.3 Formulation of asiaticoside loaded transethosomes

Transethsomoal were prepared using the thin film hydration method. Lecithin, oleic acid (as a permeation enhancer), and the drug were dissolved in 30 mL of a chloroform: methanol mixture (2:1 v/v). The resulting solution was placed in a round-bottom flask, and the organic solvents were evaporated under reduced pressure at 35 °C using a rotary vacuum evaporator for 1 hour to ensure complete removal of solvent residues. The resulting thin lipid film was then hydrated with 10 mL of phosphate buffer solution (PBS) and allowed to stand for 12 hours to form transethosomes **(Table 1)** [8].

RESULTS

Table 1: Formulation batch of asiaticoside-loaded transethosomes.

Ingredients	Formulation Codes								
	AT1	AT2	AT3	AT4	AT5	AT6	AT7	AT8	AT9
Asiaticoside (% w/v)	0.1	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Lecithin (%w/v)	6	6	6	4	4	4	2	2	2
Oleic acid (%w/v)	0.5	1	1.5	0.5	1	1.5	0.5	1	1.5
Ethanol (%v/v)	20	20	20	20	20	20	20	20	20
Phosphate buffer (% v/v)	80	80	80	80	80	80	80	80	80
Chloroform	20	20	20	20	20	20	20	20	20

2.4 Characterization of asiaticoside loaded liposome

2.4.1 Particle size distribution and Polydispersity index

The PDI and size of particle were analyzed by using the Zeta-sizer Nano ZS instrument manufactured by Malvern in the United States. The examinations were conducted using a conventional laser with a power output of 4 watts and a wavelength of 633 nanometers. The observations were taken at ambient temperature and at a constant angle of 90 degrees. The analysis was conducted using a constant sample volume of 1 ml. The equipment is supplied with suitable software for analyzing PDI and particle size [9].

2.4.2 Zeta potential

The zeta-potential is a quantitative measurement that characterizes the strength of the electrostatic forces, either repulsive or attractive, between particles. It is widely recognized that the zeta potential significantly impacts the stability of particle systems. The measurement of dispersion, aggregation, or flocculation provides a comprehensive understanding of their underlying causes and can be used to enhance the formulation of liposomes. The majority of particulate or macroscopic substances that come into contact with a liquid develop an electric charge on their surfaces.

2.4.3 % Entrapment efficiency (%EE)

The % EE of asiaticoside-loaded liposomes was analysed using the ultracentrifugation method. In a cold centrifuge, the optimized liposomes formulation was spun at 11,000 rpm for 2 hours at 4°C. A UV-Vis spectro-photometer was used to record the absorbance at 278 nm after separating and diluting the supernatant layer with PBS (pH 7.4). By deducting the total quantity of drug in preparation from the amount of unentrapped drug in the supernatant liquid, the percentage of EE was determined indirectly. The drug entrapment percentage was designed using the given equation.

$$\text{EE (\%)} = \frac{T-C}{T} \times 100 \quad \text{.....(Eq. 1)}$$

The total drug loading (T) refers to the initial amount of asiaticoside added, while C represents the portion of drug recovered in the supernatant after processing.

2.5 Preparation of transethosomal Gel

Carbopol 934 was employed as the gelling agent in the formulation. A concentration of 0.4% w/v Carbopol 934 was dissolved into distilled water under continuous stirring to ensure uniform mixing. The dispersion was then allowed to stand undisturbed for approximately 2 hours to facilitate complete swelling and gel formation. Subsequently, an appropriate preservative and triethanolamine were added to adjust the pH and complete the formation of the transethsomoal gel.

2.6 Evaluation of asiaticoside loaded transethsomoal gel

2.6.1 Physical Evaluation

Visual inspection was used to assess the asiaticoside loaded transethsomoal gel physical features, clarity, conclusiveness, washability, and organoleptic properties.

2.6.2 Determination of pH

A pH meter was used to measure the asiaticoside loaded transethsomoal gel. Three duplicate readings of the data were taken, and the average value was determined.

2.6.3 Spreadability

The asiaticoside loaded transethsomoal gel spreadability was measured by determining the dia of a 1 g gel after 5 minutes between horizontal plates (20 x 20 cm^2). 500g was the typical weight fastened to the top plate.

$$S = \frac{M \times L}{T} \quad \text{.....(Eq. 2)}$$

Where, M = Weight tied on the upper plate
T = Time taken (second)
S = Spreadability,
L = Length (cm) of glass plates

2.6.4 Viscosity

Using a Brookfield viscometer, the prepared asiaticoside loaded transethsomoal gel viscosity was measured. Using spindle number six, the reading was obtained at 100 rpm.

2.6.5 Extrudability study

The gel formulations were evaluated by filling collapsible tubes, with the formulation measured according to the weight in grams necessary to extrude a 0.8 cm ribbon of gel.66

2.6.6 Washability

By smearing a little quantity of the formulated gel formulation to the skin washability test was conducted, followed by rinsing with warm water to evaluate its ease of removal.67

2.6.7 Drug content

The drug content of the developed in asiaticoside loaded transethsomoal gel was analyzing by pouring 1

gm of formulation into a 10 mL volumetric flask (VF). In this VF a small amount of methanol was added, followed by continous shaking untill the gel was totally dispersed to give a clear solution. 10 ml of methanol was used for final make up. Filtered the solution. Drug concentration in the filterated solution was detrmined by UV spectroscopy and absorbance was noted.

2.6.8 *In-vitro* drug release study

The optimized gel was conducted on *In-vitro* release study encumbered with asiaticoside to determine the most effective formulation. This investigation used a dialysis membrane using Franz Diffusion Cell with size of 0.4 µm pore. The membrane is absorbed in a 7.4 buffer solution of phosphate for a duration of 24 hours. A quantity of 1 gram of asiaticoside loaded transethsomoal gel was applied to one side of the dialysis membrane. The receptor medium was filled with a 13.3ml volume of buffer solution contains phosphate at a pH of 7.4. The Franz diffusion cell was positioned on a magnetic stirrer and agitated with a magnetic bead at a stirring speed of 400 rpm. The temp is adjusted at 37±1°C. The investigation was carried out for a duration of 12 hours. At certain time intervals (0.5, 1, 1.5, 2, 3, 4, 6, 8, 10, and 12 hours), a sample of 0.2 ml was obtained. The same volume was then replaced with a new solution of phosphate buffer (pH 7.4). The collected trials were evaluated using a validated UV technique.

2.6.9 *In-vitro* drug release kinetics studies

An investigation was conducted on the medicine delivery from the gel by analyzing the release data using the Higuchi equation, zero-order kinetics, and first-order kinetics. Analysis of the data using the Korsmeyer Peppas model allowed for the identification of the process by which the substance is released.

Zero-order

Constant where drug release is independent of its concentration and release rate over time, typical for systems

The equation provided predicts a zero-order release.

$C = K_0 t$ ……(Eq. 3)

First order

Rate of release is proportional to the remaining amount of drug in the delivery system.

The equation provided predicts a first-order release.: -

$\text{Log } C = \text{Log} C_0 - Kt / 2.303$ ……(Eq. 4)

Higuchi's model

Describes drug release from matrix systems where release is diffusion-controlled through a matrix. The slope is equivalent to 'K'.

$Qt = Kt^{1/2}$ ……(Eq. 5)

Where,

Qt – quantity of drug delivery at time t,

K- kinetic of constant

t - time in hrs

Korsmeyer Peppas

Used for systems exhibiting non-Fickian diffusion or anomalous transport mechanisms.

$Mt / M\infty = Kt\ n$ ……(Eq. 6)

Where,

Mt - represents the quantity of the delivered drug at time t

K- Does the diffusional behavior of the medicine/polymer system remain consistent over time

n- is a diffusional exponent that defines the drug release mechanism

2.7 Stability Study

The drug retention capacity of vesicles in a gel formulation was evaluated by subjecting the gel to various temperatures. The gel was stored in airtight vials with a capacity of 10ml at a temperature of 4 ± 2ºC and at room temperature for a duration of 45 days. The drug content was measured at various time periods to ascertain the percentage.

3. Result and discussion

3.1 Pre-Formulation Studies

3.1.1 Organoleptic properties

Preformulation studies focusing on the organoleptic characteristics of asiaticoside indicated that the drug substance possesses acceptable and consistent sensory attributes. Asiaticoside was observed as a white to slightly yellowish, white to off-white amorphous or crystalline powder, suggesting good purity and uniformity of the raw material. The sample was found to be odorless or exhibited a very faint, characteristic herbal odor, indicating the absence of any undesirable or decomposed impurities. Taste evaluation revealed a slightly bitter nature, which is typical of many phytoconstituents and may be relevant while designing patient-acceptable formulations, particularly for oral or topical applications.

3.1.2 Melting point analysis

The melting point of asiaticoside analyzed by Stuart smp30 digital melting point apparatus. The sample analyzed in triplicate and mean was found to be 235 ℃. The mean was almost the similar as that of the reported melting point i.e., 235-238°C (Indian Pharmacopoeia).

3.1.3 Solubility study

The solubility of asiaticoside in dissimilar solvents was studied, namely water, ether, methanol and chloroform etc. The solubility of asiaticoside with Phosphate buffer (pH 7.4), Ethanol, DMSO, dimethyl formamide and distilled water were found to be 10.5, 5.2, 9.8, 22.5 and 0.25 mg/mL **(Fig. 1).**

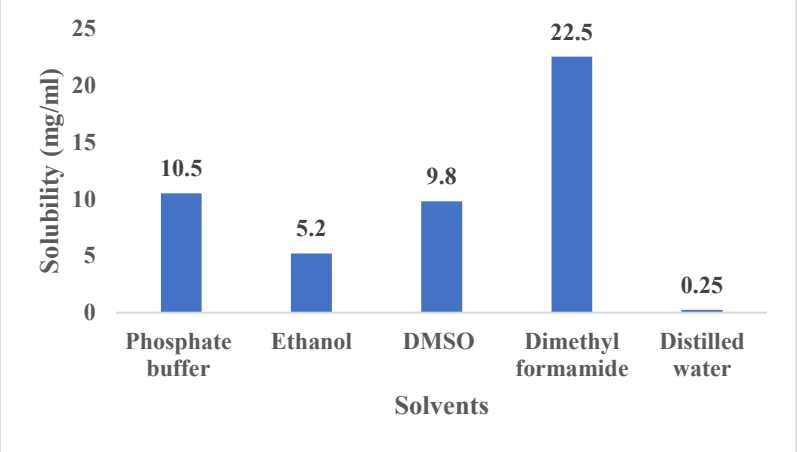

Fig. 1: Schematic representation of solubility study in different solvent system.

3.1.4 Preparation of calibration curve and Determination of λ_{max}

The spectrum of asiaticoside was examined and the wavelength of asiaticoside was found to be 278 nm which is as according to standard values**.** Then the selected wavelength of 278 nm was used for the further studies. The dilutions were prepared in the concentration range 0.1-0.9 µg/ml. The result of the linearity curve of asiaticoside was found to be R^2 0.9879 (**Table 2, Fig. 2**).

Table 2: Calibration curve data of asiaticoside.

Conc.	Abs.
0.1	0.123
0.2	0.246
0.4	0.426
0.6	0.636
0.8	0.789
1	0.928

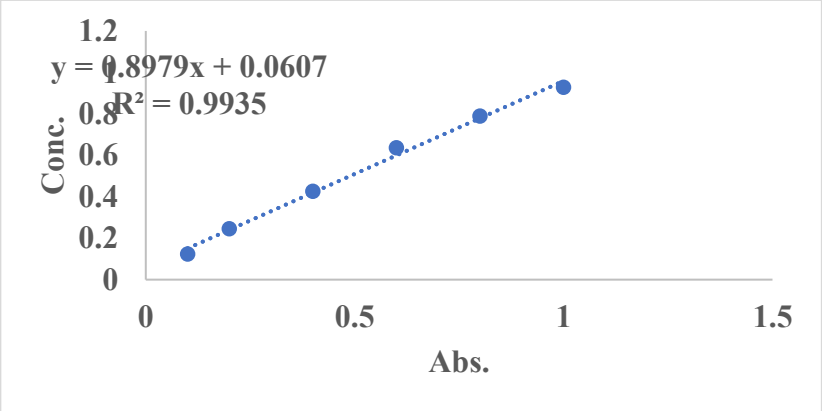

Fig. 2: Linearity curve of asiaticoside in PBS in PH 7.4 at 278 nm.

3.1.5. FT-IR spectrum of asiaticoside

The FTIR spectrum of asiaticoside typically exhibits characteristic absorption bands corresponding to its functional groups, confirming its chemical structure. A broad and intense band around 3400–3300 cm^{-1} is attributed to O–H stretching vibrations, indicating the presence of multiple hydroxyl groups. The absorption peak observed near 2920–2850 cm^{-1} corresponds to C–H stretching of aliphatic groups. A distinct peak around 1730–1720 cm^{-1} represents the C=O stretching vibration of the ester linkage present in the molecule. The strong band around 1650–1600 cm^{-1} is associated with C=C stretching of the triterpenoid skeleton. Additionally, bands appearing in the region 1450–1370 cm^{-1} correspond to C–H bending vibrations, while peaks in the range of 1200–1000 cm^{-1} are due to C–O–C stretching vibrations of glycosidic linkages. The fingerprint region below 900 cm^{-1} displays multiple small peaks, reflecting the complex structure of asiaticoside. These spectral features collectively confirm the presence of hydroxyl, carbonyl, and glycosidic functionalities characteristic of asiaticoside (Fig. 5.5).

3.2 Evaluation of asiaticoside loaded liposome

3.2.1 Particle size analysis and polydispersity index

An instrument Litesizer 500 used to analyse the prepared formulation AT3 particle size, and it was created to be 187.2 nm. This result demonstrates that the prepared transdermal possesses nano-sized particles, indicating their suitability for penetration through the skin. The PDI of the liposomes was analyzed to be 0.840, indicating a uniform particle size distribution and narrow dispersion within the formulations (**Fig. 3**).

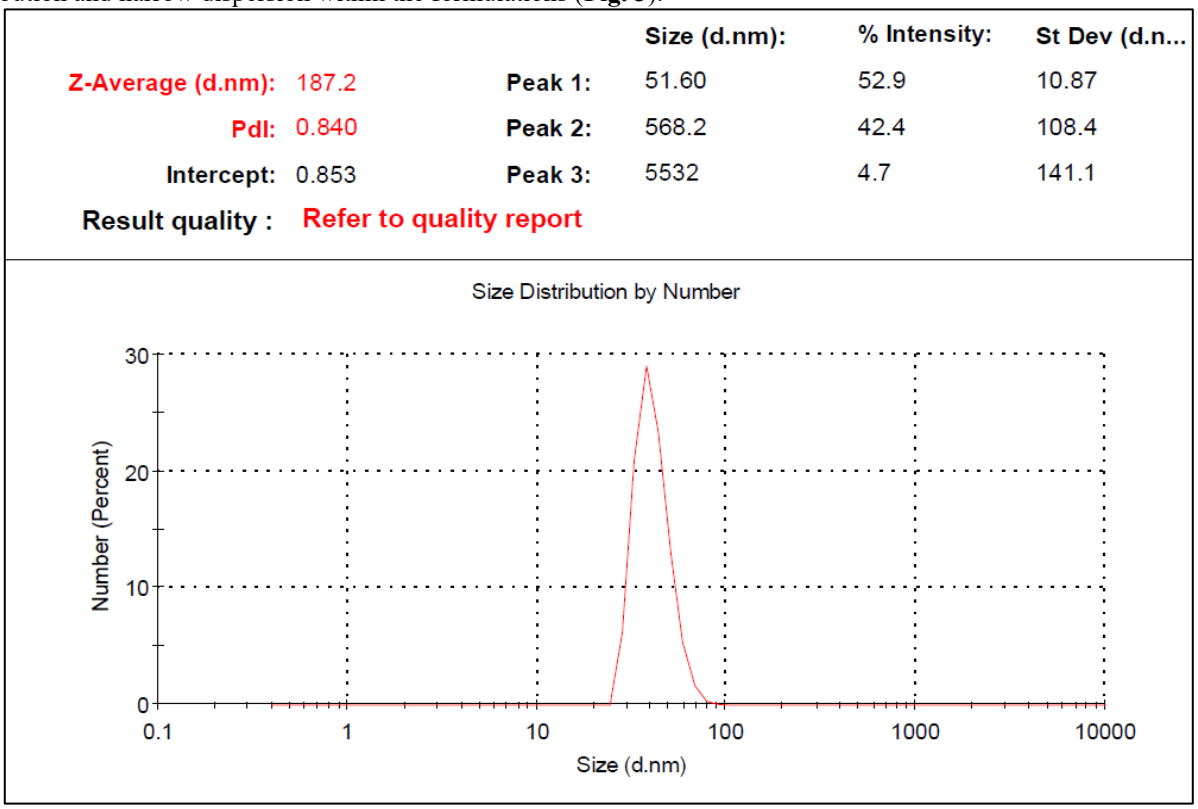

Fig. 3: Particle size of Optimized Formulation AT3.

3.2.2 Zeta potential

An increase in zeta potential leads to enhanced repulsion between charged particles, resulting in improved stability against aggregation. The optimized liposome formulation exhibited a zeta potential of -22.3 mV, indicating good stability (as depicted in **Fig. 4**).

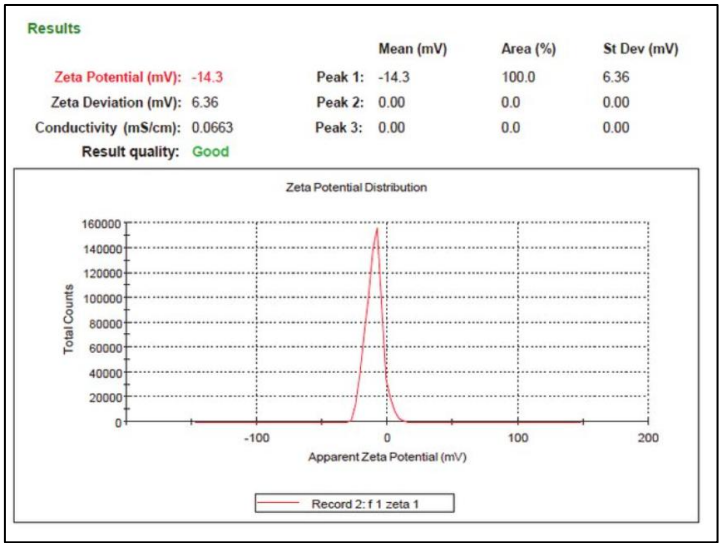

Fig. 4: Zeta Potential of Optimized Formulation AT3.

3.2.3 Entrapment efficiency (%EE)

The %EE of all formulations ranged from 56 ± 0.70 % to 83 ± 0.26%. Among the formulations, Formulation AT3 exhibited the highest entrapment efficiency at 83± 0.26% (**Table 3**). The data indicates that the entrapment efficiency of transethosomes as the soya lecithin concentration.

Table 3: Entrapment efficiency (%) of different formulations of asiaticoside loaded liposome.

S. No.	Formulation	Entrapment efficiency (%)
1.	AT1	82.7± 0.19
2.	AT2	81± 0.28
3.	AT3	83 ± 0.26
4.	AT4	72.7 ± 0.29
5.	AT5	78.2 ± 0.35
6.	AT6	75 ± 0.38
7.	AT7	56 ± 0.42
8.	AT8	67 ± 0.12
9.	AT9	79± 0.38

3.3 Characterization of asiaticoside-loaded transethosomes gel

3.3.1 Clarity

The colour of the transethosomes-loaded gel formulations was found to be whitish (refer to **Table 4).**

3.3.2 pH

The results of the pH prepared formulation were determined to be 6.9±0.02, indicating that the formulation was suitable and better (refer to **Table 4).**

3.3.3 Gelling Time

Gelling time of transethosomes loaded gel was found to be 65±0.123 sec **(refer in Table 4).**

3.3.4 Viscosity

The results of viscosity of the prepared formulation were 19237±67.8 cps (refer to **Table 4).**

3.3.5 Gelation Temperature

The results of the gelation temp of the prepared formulation were 31.34±0.23 (℃). The optimised formulations showed an acceptable gelling temperature (refer to **Table 4).**

3.3.6 Drug content

The content of the drug preparation was determined to be 79 ±0.12% (refer to **Table 4).**

Table 4: Analysis of asiaticoside-loaded transethosomes-loaded gel.

Parameters	Formulation (n=3)
Physical appearance	Whitish
Drug content (%)	79 ±0.12
pH	6.9±0.02
Gelling Time (sec.)	65±0.123
Viscosity (cps)	19237±67.8
Gelation Temperature (℃)	31.34±0.23

(mean ± S.D)

3.4 *In-vitro* diffusion study

The in vitro drug release study of asiaticoside from different formulations was carried out over a 24-hour period to compare the release profiles of the asiaticoside solution, plain gel, and transethsomoal gel. The asiaticoside solution exhibited a rapid initial release, with 23.12% released within 0.5 h, reaching 54.52% at 2 h and gradually increasing to 78.43% at 24 h. The plain gel showed a slower initial release (12.45% at 0.5 h) compared to the solution, followed by a sustained release pattern, achieving 38.42% at 2 h, 60.12% at 4 h, and 84.32% at 24 h. In contrast, the transethsomoal gel demonstrated the most controlled and prolonged release, with only 8.76% drug release at 0.5 h, 28.12% at 2 h, and 45.61% at 4 h, followed by a gradual increase to 82.23% at 12 h and the highest overall release of 98.82% at 24 h **(Fig.5)**. These results indicate that transethsomoal incorporation within the gel matrix significantly retarded the initial drug release and provided sustained delivery, making it a promising approach for prolonged therapeutic action of asiaticoside.

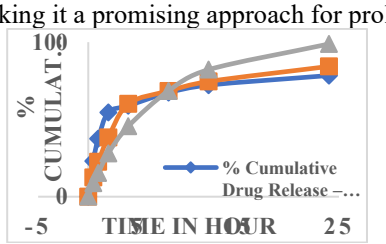

Fig. 5: % Cumulative drug release of drug solution, plain gel, transethsomoal gel formulation.

3.5 *In-vitro* drug release kinetics studies

The delivery rate was determined by calculating the gradient of the relevant graphs, and the coefficient of determination (R^2) was also evaluated. The model fitting data for the release kinetics of asiaticoside loaded transethsomoal gel is presented in **Table 5** and **Fig. 6, 7, 8, and 9**. Among the different models, the first-order model exhibited the highest R^2

value, indicating the best fit for the data. This observation was further confirmed by plotting the cumulative drug delivery % against the time (hr), where the R^2 value ranged between 0.9997.

Table 5: Model fitting to analyzed the kinetics of drug delivery.

Formulation	Zero Order model	First Order model	Higuchi's model	Peppa's model	Best fitted model
Asiaticoside loaded transethsomoal gel	0.9468	0.9997	0.997	0.9908	First order (0.9997)

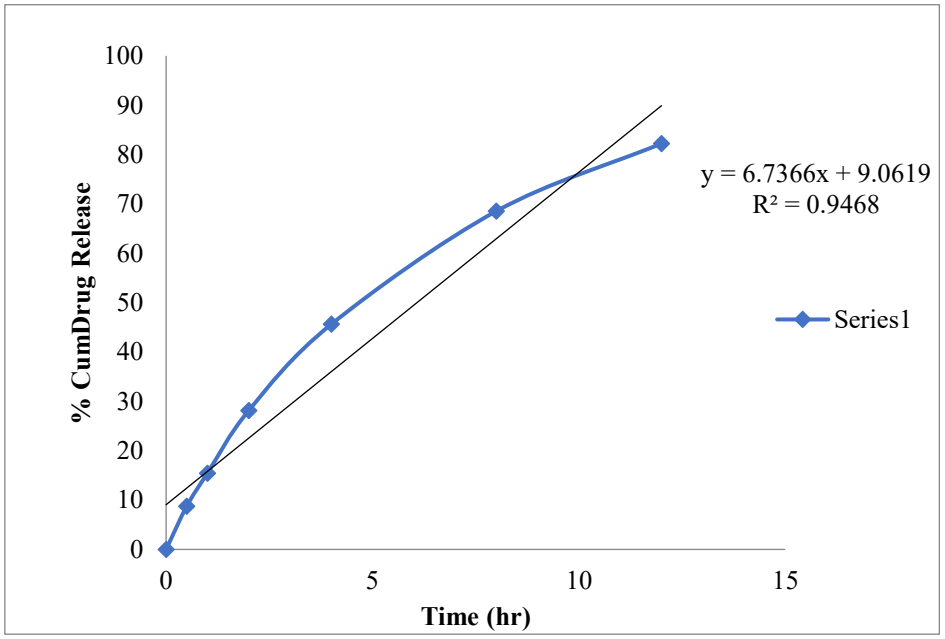

Fig. 6: Zero order plot of transethsomoal loaded gel.

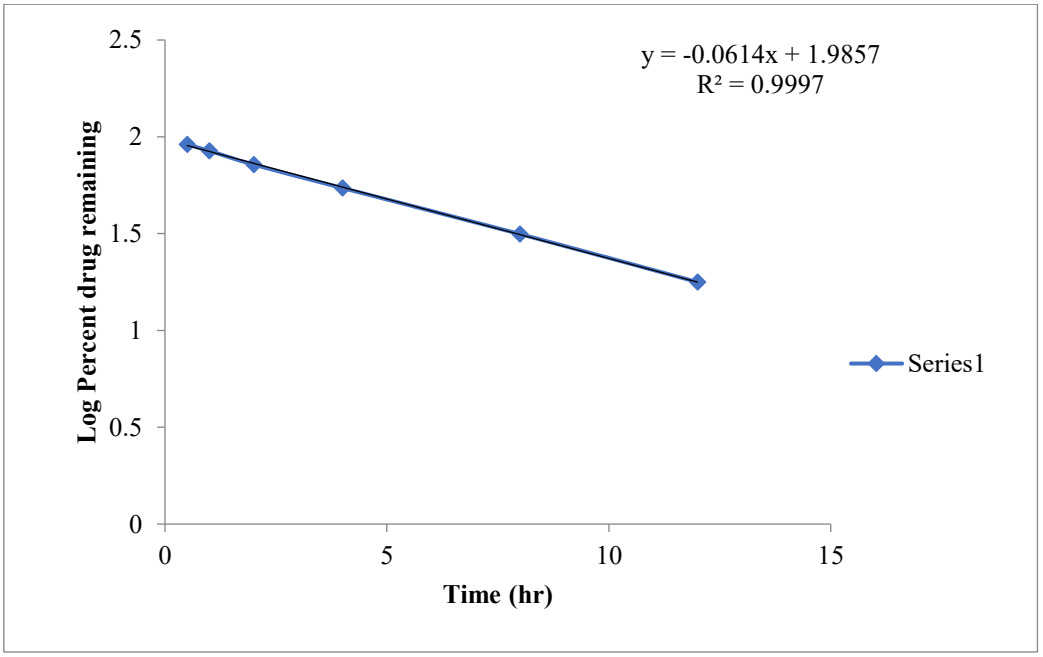

Fig. 7: First order plot of transethsomoal loaded gel.

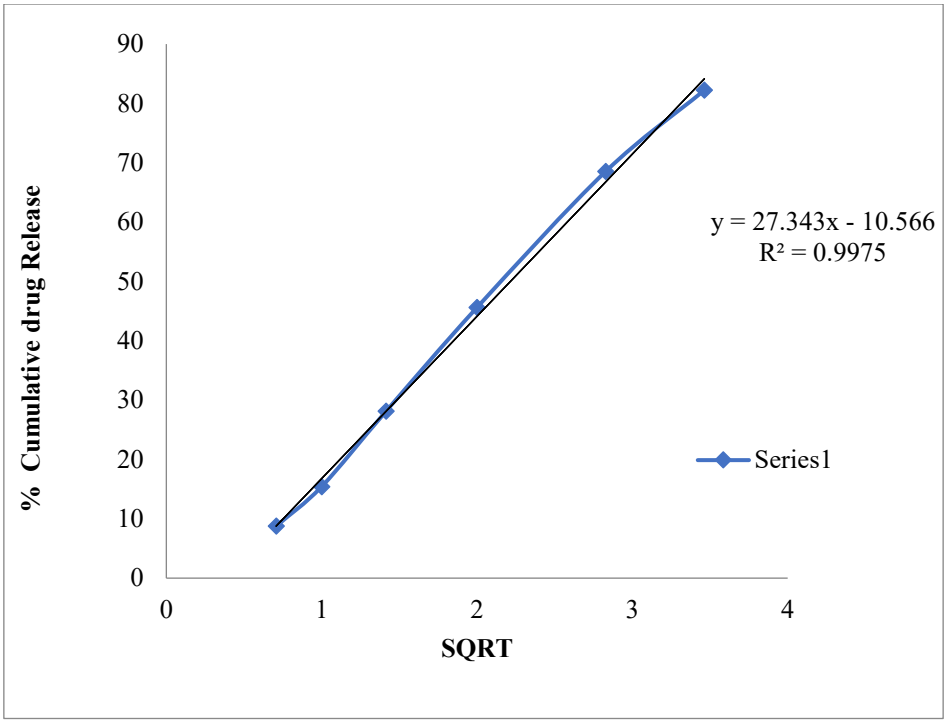

Fig. 8: Higuchi plot of transethsomoal loaded gel.

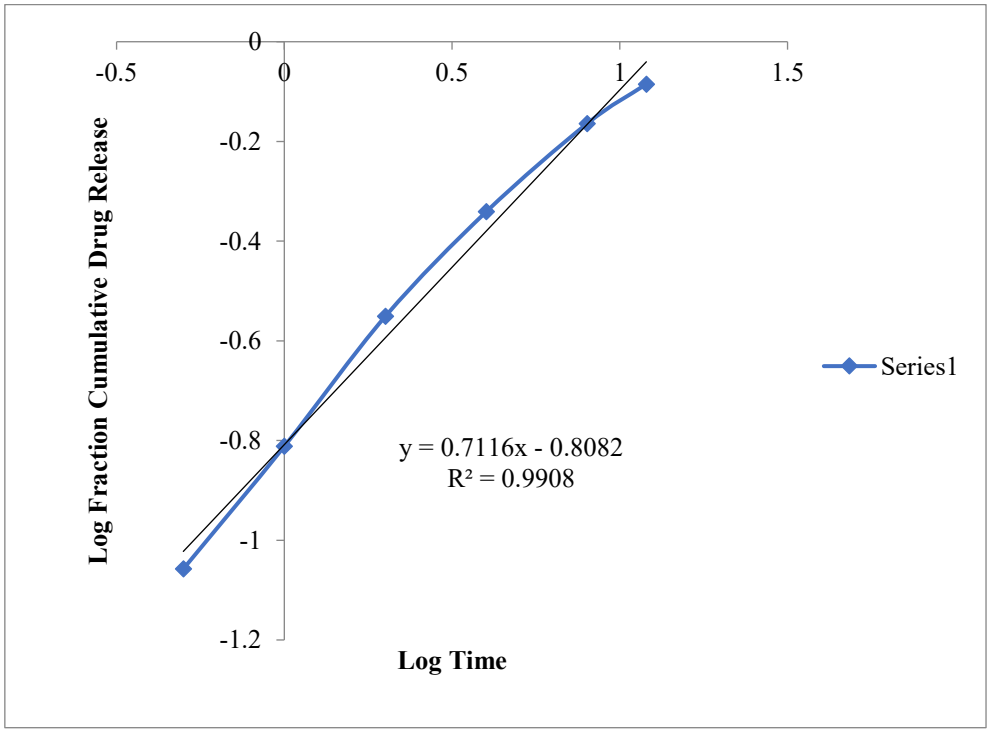

Fig. 9: Peppa's plot of transethsomoal loaded gel.

3.6 Stability studies

The developed transethsomoal loaded gel formulation demonstrated stability for three months, with no changes observed in its physical appearance, pH, or gelling time **(Table 6).**

Table 6 Stability data of transethsomoal loaded gel at 0, 3 and 6 months.

Parameters	For 0 month	For 2 months	For 3 months
Physical Appearance	Whitish	Whitish	Whitish
pH	6.9±0.43	6.8±0.28	6.9±0.11
Gelling Time (sec)	64±0.181	65±0.111	65±0.165

CONCLUSION

The present research focused on the development and evaluation of an asiaticoside-loaded transethosomal gel to enhance skin penetration, bioavailability, and sustained release of the drug for wound healing and dermatological applications. Asiaticoside, a triterpenoid saponin from Centella asiatica, was selected for its potent wound healing, anti-inflammatory, and antioxidant activities but suffers from poor solubility and low skin permeability. Transethosomes, composed of phospholipids, ethanol, and edge activators, were prepared via the thin-film hydration method and optimized to achieve high entrapment efficiency, suitable particle size, and stability. The optimized formulation (AT3) showed an entrapment efficiency of 83 ± 0.26%, particle size of 187.2 nm, PDI of 0.840, and zeta potential of –22.3 mV. SEM confirmed spherical, smooth-surfaced vesicles. The transethosomal gel, formulated with Carbopol 934P, displayed acceptable pH (6.9 ± 0.02), viscosity (19237 ± 67.8 cps), and drug content (79 ± 0.12%). In vitro release studies revealed that the transethsomoal loaded gel exhibited the most sustained release profile, with 98.82% cumulative release at 24 h, following first-order kinetics (R^2 = 0.9997). Stability studies over three months indicated no significant changes in physical or functional parameters, confirming the robustness of the formulation.

The study successfully demonstrated that incorporating asiaticoside into a transethosomal gel system significantly improved its entrapment efficiency, skin penetration potential, and sustained release characteristics compared to plain gel and solution forms. The optimized formulation (AT3) provided a controlled release over 24 hours, followed first-order release kinetics, and maintained stability during storage. This transethosomal gel approach offers a promising, patient-friendly, and effective topical delivery system for asiaticoside, potentially enhancing therapeutic outcomes in wound healing and other dermatological conditions. Future work may include ex vivo and in vivo skin penetration studies, clinical evaluations, and scale-up feasibility for commercial application.

References

1. H. Ujiie, D. Rosmarin, M.P. Schön, S. Ständer, K. Boch, M. Metz, M. Maurer, D. Thaci, E. Schmidt, C. Cole, Unmet medical needs in chronic, non-communicable inflammatory skin diseases, Frontiers in Medicine. 9 (2022) 875492.
2. X. Tan, S.R. Feldman, J. Chang, R. Balkrishnan, Topical drug delivery systems in dermatology: a review of patient adherence issues, Expert Opinion on Drug Delivery. 9 (2012) 1263–1271.
3. B. Sun, L. Wu, Y. Wu, C. Zhang, L. Qin, M. Hayashi, M. Kudo, M. Gao, T. Liu, Therapeutic potential of Centella asiatica and its triterpenes: a review, Frontiers in Pharmacology. 11 (2020) 568032.
4. M. Kumar, D. Kumar, S. Mahmood, V. Singh, S. Chopra, A.R. Hilles, A. Bhatia, Nanotechnology-driven wound healing potential of asiaticoside: a comprehensive review, RSC Pharmaceutics. (2024).
5. R. Seenivasan, P. Halagali, D. Nayak, V.K. Tippavajhala, Transethosomes: A Comprehensive Review of Ultra-Deformable Vesicular Systems for Enhanced Transdermal Drug Delivery, AAPS PharmSciTech. 26 (2025) 41.
6. D. Nayak, V.K. Tippavajhala, A comprehensive review on preparation, evaluation and applications of deformable liposomes, Iranian Journal of Pharmaceutical Research: IJPR. 20 (2021) 186.
7. H. Li, Q. Peng, Y. Guo, X. Wang, L. Zhang, Preparation and in vitro and in vivo study of asiaticoside-loaded nanoemulsions and nanoemulsions-based gels for transdermal delivery, International Journal of Nanomedicine. 15 (2020) 3123.
8. S.B. Gondkar, N.R. Patil, R.B. Saudagar, Formulation development and characterization of etodolac loaded transethosomes for transdermal delivery, Research Journal of Pharmacy and Technology. 10 (2017) 3049–3057.
9. [K. Huanbutta, N. Rattanachitthawat, K. Luangpraditkun, P. Sriamornsak, V. Puri, I. Singh, T. Sangnim, Development and evaluation of ethosomes loaded with zingiber zerumbet linn rhizome extract for antifungal skin infection in deep layer skin, Pharmaceutics. 14 (2022) 2765.
10. S. Majumdar, R. Dave, Formulation study of gel containing pterocarpus santalinus extract for its antiinflammatory activity, World J of Phar and Pharmaceu Sci. 2 (2013) 4951–4964.
11. [B.K. Shrikhande, D.C. Goupale, Development and evaluation of anti-inflammatory oleogels of Bosewellia serrata (gugul) and Curcuma longa (turmeric), Indian Drugs. 38 (2001) 613–616