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Research article

Design and evaluation of emulgel with a polyherbal basis for topical delivery

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ABSTRACT

Design and Evaluation of Emulgel with a Polyherbal Basis for Topical Delivery

METHOD

Step 1 - Preparation of Gel Base

Distilled water + Carbopol 940

Step 2 - Preparation of Emulsion

Organic Phase + Aqueous Phase → O/W Emulsion

Step 3 - Formulation of Herbal Emulgel

Carbopol Gel → Herbal Emulgel

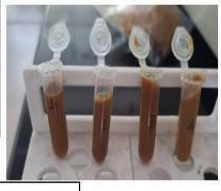
RESULTS

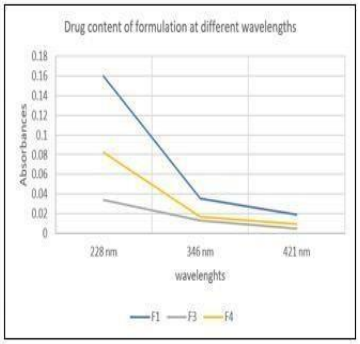
Evaluation of Emulgel Batch 1

Appearance	Homogeneity	Consistency	pH	Spreadability	Viscosity (cps)
Yellowish Brown	Excellent	Excellent	6.58	25.6	17800

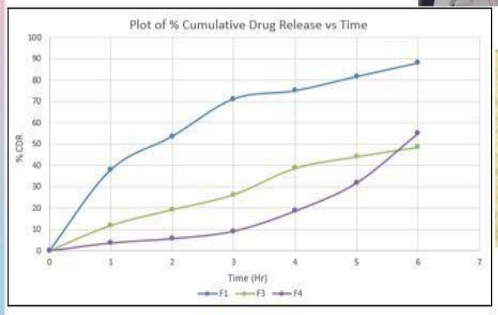
Centrifugation Study

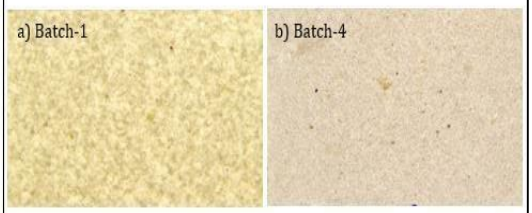
Batch 1	Batch 2	Batch 3	Batch 4
No Phase Separation	Phase Separation	No Phase Separation	No Phase Separation





Drug content in different batches





Microscopic Examination of Prepared emulgel a) Batch-1 b) Batch-4

The emulgel was prepared using polyherbal extracts and Carbopol 940 polymer and PEG400 of different concentration.
All the formulations were evaluated for different parameters, in that F1 adheres to all the acceptance criteria thus conforming its superiority.

Topical drug delivery systems involve applying formulations directly to the skin to treat various skin diseases, providing a localized therapeutic effect while minimizing systemic side effects. However, conventional gel formulations often face challenges in delivering hydrophobic drugs effectively due to their limited solubilizing capacity and poor drug permeability. To address these limitations, a novel approach called emulgel combines the advantages of gels and emulsions, enhancing the delivery of hydrophobic drugs through the skin. This study focuses on the development and evaluation of an herbal emulgel formulated using extracts of Curcuma longa, Tinospora cardifolia, and Salacia chinensis, known for their antimicrobial and therapeutic properties.

The prepared various batches for the formulation underwent rigorous assessment for various parameters, including physical appearance, pH, homogeneity, spreadability, viscosity, centrifugation stability, and in vitro drug release analysis. Additionally, it was characterized for swelling index, drug content uniformity, and globule size, ensuring a comprehensive evaluation. The emulgel exhibited pH levels compatible with skin application, excellent spreadability, uniform homogeneity, and optimal viscosity, ensuring better patient compliance and stability. The in vitro drug release studies demonstrated a controlled and sustained release profile, further enhancing its therapeutic potential. Overall, the formulation met satisfactory standards across all parameters, showcasing its efficacy as a promising antimicrobial agent, with the potential to improve topical drug delivery and patient outcomes significantly.

Keywords: Herbal extract, Herbal-based Emulgel, Polyherbal therapy, Skin permeation, Topical dosage forms.

INTRODUCTION

For many years, illnesses have been treated by delivering drugs to the human body through various routes such as oral, sublingual, rectal, parenteral, and vaginal administration. However, when these methods are less effective, particularly in cases of localized skin infections like fungal or bacterial conditions, the topical route is often used instead [1, 2].

Topical drug delivery involves applying a drug-containing formulation directly to the skin to target and treat skin-related disorders. Among the different types of semisolid preparations, transparent gels have gained popularity, not only in cosmetics but also in pharmaceutical application [3, 4].

An emulgel is an innovative drug delivery system that combines the properties of both emulsions and gels to improve the solubility, stability, and bioavailability of various therapeutic agents. Emulgel offer unique advantages over traditional topical formulations by facilitating better penetration through the skin, controlled drug release, and enhanced stability of lipophilic drugs. In particular, they have emerged as promising vehicles for delivering poorly soluble drugs, providing an optimal balance between the hydrophilic and lipophilic phases [5-7]. Topical drug delivery has gained significant attention due to its non-invasive nature, ease of application, and ability to target localized conditions with minimal systemic side effects. However, conventional topical formulations like creams, gels, and lotions often face challenges related to limited drug permeation, rapid degradation, and short retention times. Emulgel overcome these limitations by integrating the benefits of both emulsions (which can solubilize hydrophobic drugs) and gels (which offer a longer residence time and ease of application) [8-10]. The structure of an emulgel typically consists of an oil-in-water or water-in-oil emulsion stabilized by suitable surfactants, dispersed within a gel matrix formed by gelling agents such as carbomers or natural polymers. This dual nature enables the formulation to encapsulate both hydrophilic and lipophilic drugs, providing flexibility in the design of formulations for a wide range of therapeutic applications [11, 12].

The incorporation of plant-based active ingredients such as *Salacia chinensis*, *Curcuma longa*, and *Tinospora cordifolia* in an emulgel formulation offers a potent blend of therapeutic benefits due to their proven anti-inflammatory, antimicrobial, antioxidant, and wound-healing properties. These herbs have been extensively studied in traditional medicine and offer potential for use in modern topical drug delivery systems [13-16].

MATERIALS AND METHODS

The extracts of Salaia chinensis, Tinospora card folia and Curcuma longa were gifted by Shri Swami Samarth Ayurvedic Pharmaceuticals, Trimbakeshwar, and Nasik, India. Carbopol 940 polymer, polyethylene glycol, methyl paraben, propyl paraben, Tween 20, Span 20, propylene glycol, Triethanolamin were purchased from Merck. All other ingredients were of analytical grade. Distilled water was used throughout the study.

Preparation of Polyherbal Emulgel [17, 18]

The preparation of the emulgel involved an emulsion-solvent diffusion method and proceeded in three steps

Step 1

An emulgel base was first prepared by dispersing Carbopol 940P in a sufficient amount of distilled water. After the dispersion was complete, the solution was kept in a dark place for 24 hours to allow full swelling of the Carbopol 940P.

Step 2

The emulsion was prepared using a high-shear homogenizer. In this process, total 15 g of herbal extracts were dissolved in liquid paraffin oil. Surfactants were then added to this organic phase. The resulting organic mixture was gradually injected into an aqueous phase while homogenization was carried out, resulting in the instantaneous

formation of an oil-in-water (o/w) emulsion. The homogenizer was set to 3000 rpm, and the emulsion process continued for 30 minutes to ensure uniform mixing.

Step 3

The herbal extract-loaded emulsion was then slowly added to the pre-prepared viscous Carbopol 940P solution while continuously stirring until a homogeneous gel formed. Finally, Triethanolamin was added to the gel mixture in sufficient quantity to adjust the pH to a suitable level for the formulation batch. This process yielded the desired emulgel. The composition is shown in table 1.

Evaluation Parameters

Calibration Plot

The calibration plots of *Tinospora cordifolia*, *Curcuma longa*, and *Salacia chinensis* were established to determine their respective bioactive markers using UV-VIS spectrophotometry. For *Tinospora cordifolia*, the marker compound (e.g. berberine) exhibited maximum absorbance at 260 nm. Similarly, *Curcuma longa*, analyzed for curcumin content at 425 nm. For *Salacia chinensis*, often evaluated for mangiferin or related polyphenolic compounds, the λmax was found to be 360 nm, with calibration data showing a linearity range between 2–10 µg/mL. These calibration plots reflect precise analytical conditions optimized for the respective plant extracts, ensuring reliable quantification of their bioactive constituents.

Figure 1: Method of preparation of polyherbal emulgel

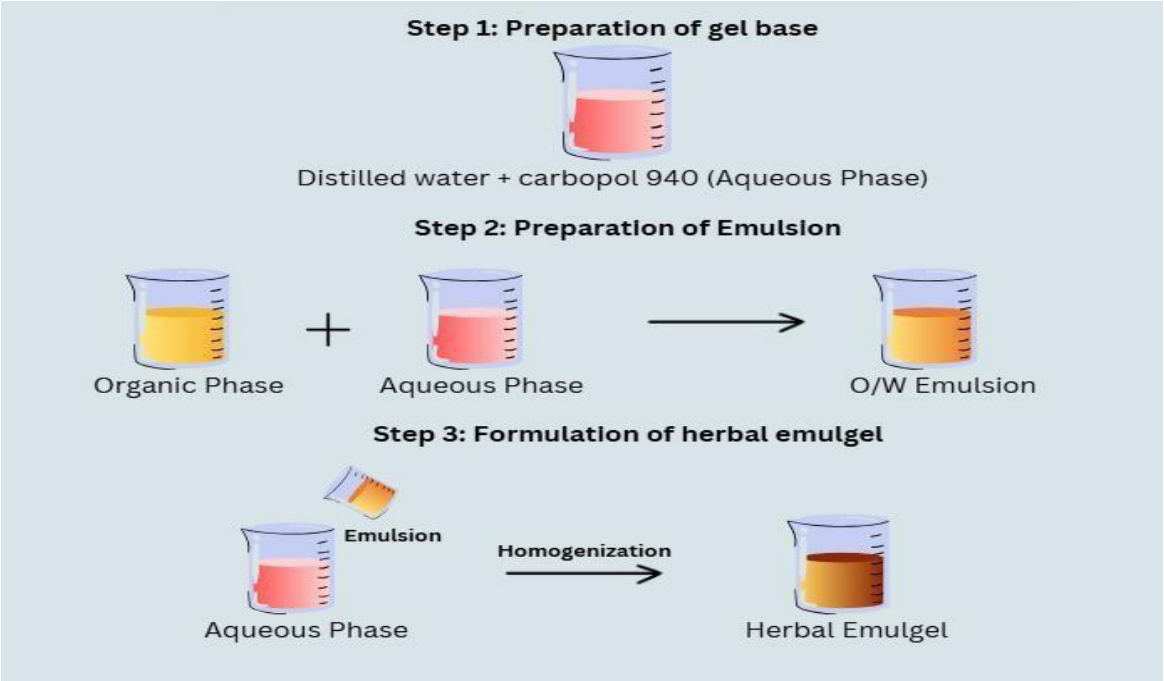


Table 1: Composition of herbal emulgel formulation batches

Formulation batches code	F1	F2	F3	F4
Salacia chinensis extract (%w/v)	5	5	5	5
Tinospora cardifolia extract (%w/v)	5	5	5	5
Curcuma longa extract (%w/v)	5	5	5	5
Liquid paraffin (%v/v)	5	10	5	10
Smix (%v/v) (Tween 80: Span 20)	10	10	10	10
Smix ratio (Tween 80: Span 20)	1:1	1:2	1:1	1:2
Carbopol 940 (%w/v)	0.5	1	1.5	2
Propylene Glycol 400 (%v/v)	5	10	5	10
Methyl Paraben (%w/v)	0.2	0.2	0.2	0.2
Propyl Paraben (%w/v)	0.2	0.2	0.2	0.2
Triethanolamine (%v/v)	0.5	0.5	0.5	0.5
Water (%v/v)	Up to 100 ml	Up to 100 ml	Up to 100 ml	Up to 100 ml

Physical Appearance

The prepared micro-emulgel was inspected for the colour, homogeneity and consistency [19].

Measurement of pH

The pH of micro-emulgel was measured by using digital pH meter (Digital pH meter, Systronics). The results were taken in triplicate, and then average of results was taken into consideration.

Viscosity

Viscosity of the gel was determined by using Brookfield viscometer (Model RVTDV II). Accurately weighed 50 g of emulgel was transferred to 50 ml glass beaker. Spindle no 6 was selected and it is immersed into the gel. The viscometer was operated at 10 rpm until the reading gets stabilized and reading was noted in centipoises.

Microscopic Evaluation

Microscopic evaluation of herbal emulgel is a crucial analytical method that helps in assessing the formulation's quality,

stability, and uniformity. It involves examining the dispersion of oil globules in the gel base, which can reveal the size and distribution of droplets, phase separation, and the presence of air bubbles. This technique aids in ensuring that the active herbal ingredients are evenly distributed within the emulgel, leading to better efficacy. By using a light or polarized microscope, the visual characteristics of the emulgel, such as homogeneity and particle size, are observed, which can influence the product's texture, absorption, and therapeutic properties.

Spreadability measurement

Spreadability was measured to express the extent of area to which emulgel readily spread on application to skin. To determine the spreadability, 0.5 g of emulgel was placed within circle of 1 cm diameter pre-marked on a glass plate, over which second plate is placed. A weight of 500 g was allowed to rest on the upper glass plate for 5 min. The increase in diameter was observed due to micro-emulgel, the spreading is noted. It was calculated by using the formula [20].

$$S = M \times L / T$$

M = wt. tied to upper slide; L = length of glass slides; T = time taken to separate the slides

Swelling index

Swelling index 1gm of prepared emulgel is taken on a porous aluminium foil. It was then placed in a 50ml beaker containing 10ml of 0.1N NaOH. Then, samples were removed from beakers at different time intervals kept in a dry place for some time and reweighed. The swelling index is calculated as follows [21].

Swelling index (SW) %=(Wt.-Wo) / Wo *100

(SW)%=Equilibrium per cent swelling

Wt. =Weight of swollen emulgel after time t

WO =Original weight of emulgel at zero time

Centrifugation

This parameter was measured to evaluate physical stability. The emulsion was centrifuged at 3000 rpm for 10 min to check creaming or phase separation. The system was observed visually for appearance.

Drug content

Drug content of the different batches was analysed with the help of UV-VIS spectrophotometry.

***In-vitro* release study**

Franz diffusion cell was used for the drug release studies. 1 gm of emulgel was applied onto the surface of cellophane membrane evenly. The membrane was clamped between the donor and the receptor chamber of diffusion cell. The receptor chamber was filled with freshly prepared phosphate buffer solution (pH 6.8). The receptor chamber was stirred by magnetic stirrer. The samples were collected at suitable time interval. Samples were analysed for drug content by UV visible spectrophotometer at λ max (nm) after appropriate dilutions. The cumulative amount of drug released was determined as a function of time [22].

RESULT

Preparation of standard stock solution of all three extracts

Accurately weighted 10 mg quantity of Tinospora cardifolia, Curcuma longa and Salacia chinensis was transferred into 10ml volumetric flask, dissolved & diluted up to the mark with Methanol this was given a stock solution having strength of 1000µg/ml. 100 µg/ml of working standard solution was prepared by diluting 1ml of std. stock solution with Methanol in 10ml volumetric flask up to the mark. From this stock solutions, prepare the aliquots of different concentration by suitable dilutions varying in between 2,4,6,8,10 µg/ml using methanol. These diluted solutions were analyzed at particular wavelength of that compound.

Table 2: Different concentration vs. absorbance of the three plants extract concentrates

Concentrations (µg/ml)	**Absorbance's**		
	Tinospora cardifolia	*Curcuma longa*	*Salacia chinensis*
2	0.125	0.165	0.160
4	0.254	0.295	0.309
6	0.375	0.468	0.454
8	0.483	0.606	0.587
10	0.591	0.745	0.708

Physical evaluation

During the research, the polymer concentrations were gradually increased and decreased as a result several problems were coming like homogeneity, spreadability and viscosity. These problems occurred in some of the batches (F2, F3) of polymer-based gel containing higher concentration of Carbopol 940P. The developed herbal emulgel was dark brown in colour, translucent in appearance. The formulated F1 preparation was much clear and translucent as compared to other formulations batches.

The prepared emulgel showed good homogeneity with absence of lumps. The pH ranges from 5.96 to 6.76. The viscosity ranges from 17800 to 33680 cps. The spreadability ranges from 12.2 to 74.61 gm.cm/s, in which F1 and F4 are comes between the ranges. The results are shown in table no. 3. From the results, it was concluded that topical herbal emulgel formulations prepared with gelling agent Carbopol 940P showed acceptable physical properties concerning colour, pH, spreadability and Viscosity. The swelling index results was compared. It was seen that the formulation batches containing Carpool 940 in 0.5% concentration showed maximum swelling index to other batches. Among all the formulation batch F1 emulgel with Carpool 934 (0.5%) showed the highest swelling index. The swelling index value may be dependent on the water uptake nature and chain strength of the polymer.

Figure 2: Calibration curve of a) *Tinospora cardifolia*, b) *Curcuma longa* and c) *Salacia chinensis*

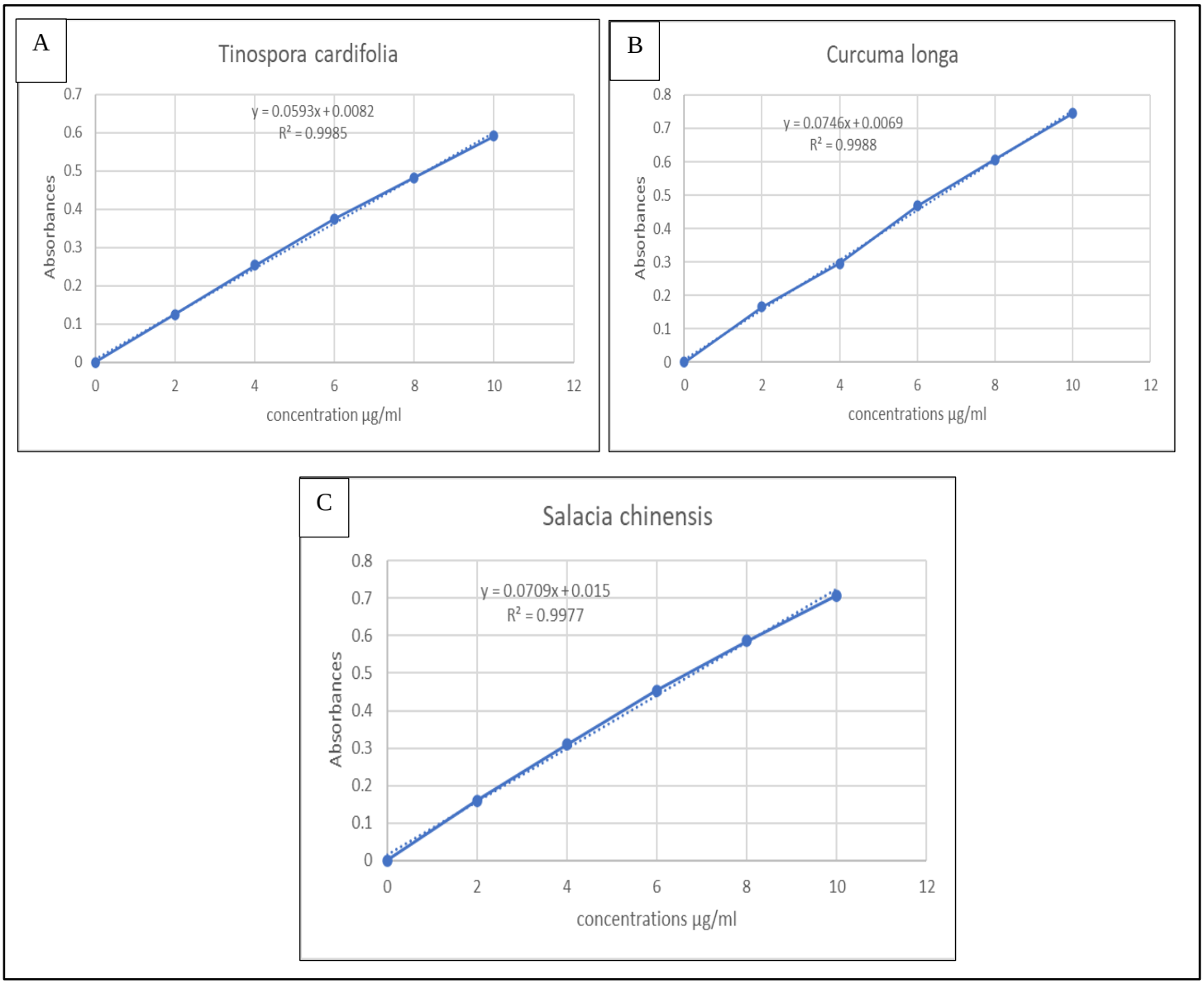
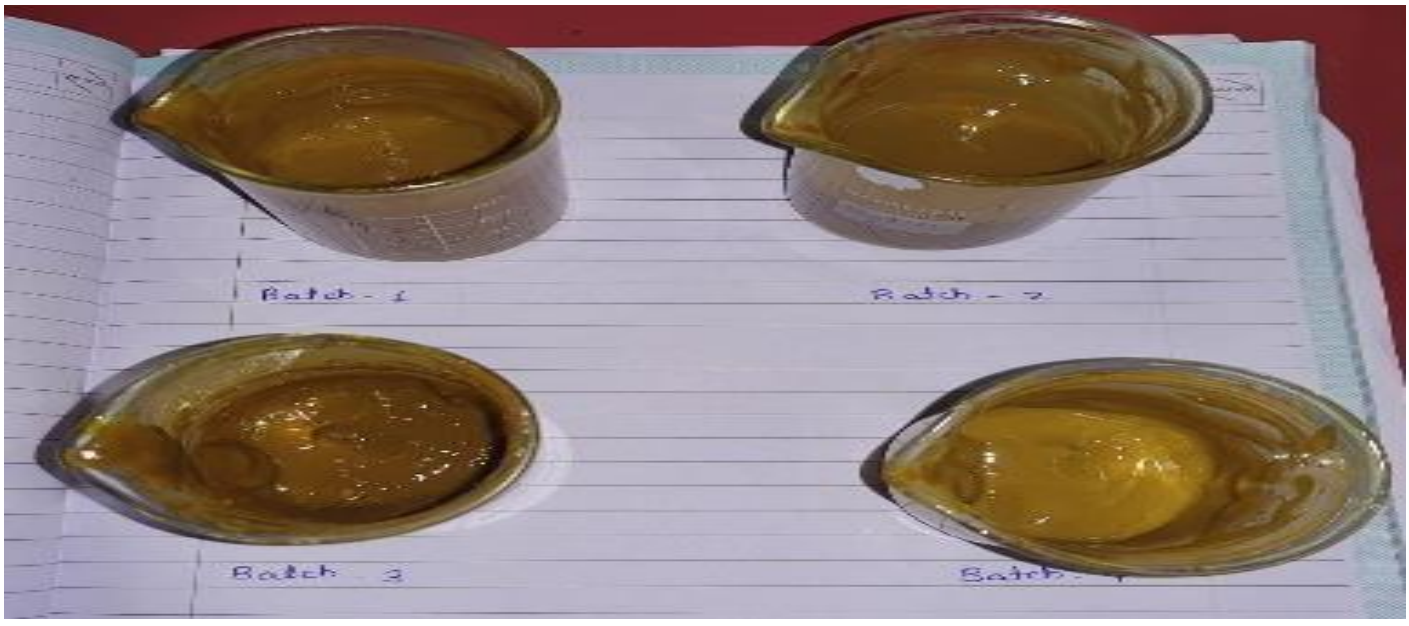


Figure 3: Prepared batches of Polyherbal emulgel

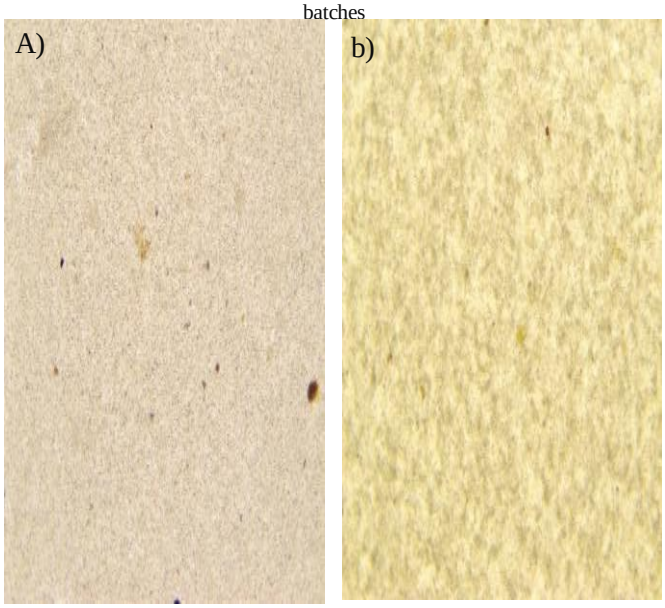


From the results, it was found that as the concentration of the polymer increase, the various parameters such as viscosity, spreadability, pH, drug content and in vitro release was also changed. The viscosity of the formulation batch was increased and spreadability decreased with increase in the concentration of polymer in the formulation's batches. Among all topical gel formulations batches F1 and F4 proved to be the formula of choice with maximum drug content as shown in table 3.

Centrifugation Evaluation

The centrifugation study of the herbal emulgel batches revealed that batch F1, F3 and F4 remained stable, showing no change in appearance, indicating good physical stability and resistance to stress. However, batch F2 exhibited phase separation, which suggests instability in the emulsion system under centrifugal force, pointing to potential issues with the emulsifying agents or the proportions used in this batch.

Figure 4: Microscopic Examination of Prepared emulgel a) F1 and b) F2 batches



Microscopic Evaluation

Upon microscopic examination of herbal emulgel batches, it is commonly observed that a stable emulsion presents spherical oil droplets uniformly dispersed in the aqueous phase. In a successful herbal emulgel, no oil globule aggregation is detected, ensuring the stability of the emulsion. The herbal actives, if incorporated in suspension, should appear as finely dispersed particles without signs of crystallization or precipitation. Furthermore, the microscopic evaluation helps in confirming the smooth, homogenous texture of the emulgel, contributing to its aesthetic appeal and functional efficacy. Microscopic images of emulgel are shown below figure 4.

Drug Content

The drug content evaluation of the prepared emulgel batches was a critical step to ensure uniformity and efficacy in drug delivery. Among the four batches formulated, Batch F2 was excluded from the analysis due to phase separation, which is a clear indicator of batches instability and incompatibility between the components. This issue in F2 highlights the importance of careful optimization of surfactant, co-surfactant, and gelling agent ratios during batches development. For the remaining three batches (Batches F1, F3, and F4), drug content analysis revealed significant differences. The drug content of different batches is given in following table 5. Batch F1 demonstrated the highest drug content, suggesting that its composition and processing parameters allowed for optimal solubilization and incorporation of the active pharmaceutical ingredient. The superior performance of F1 could be attributed to factors such as better emulsification, homogeneity, and compatibility of the active drug with the excipients used. In contrast, while F1 and F4 achieved acceptable drug content values, their slightly lower levels compared to F1 indicate less efficient drug entrapment or minor inconsistencies in the mixing process. These findings underline F1 as the most promising candidate for further development and testing, reflecting its stability, uniformity, and high drug incorporation potential.

Drug Release

The drug release of *Salacia chinensis, Tinospora cordifolia* and *Curcuma longa* was studied from the herbal emulgel. The centrifugation and characterization studies of the herbal emulgel batches revealed that batch F2 exhibited phase separation, indicating emulsion instability. Additionally, batch F3 demonstrated suboptimal performance in terms of spreadability and drug content, failing to meet the desired criteria. As a result, only batches F1 and F4, which maintained physical stability and met the required quality parameters, were selected for further in vitro drug release studies to evaluate their therapeutic efficacy. The in-vitro drug release results are shown in table 4. The percentage cumulative drug release was calculated. The drug release of *Salacia chinensis, Tinospora cordifolia* and *Curcuma longa* of batch F1 was found to be highest by performing dissolution studies for 6 hours. From in- vitro release study, F1 showed better control release rate in comparison to F4 batch. The highest release was found to be 92.37% and 90.75% of Curcumin and *Tinospora cordifolia* respectively. The F1 batch showed better drug release as compared the other batches.

Table 3: Evaluation Parameters of Herbal Emulgel

Batch No.	Appearance	Homogeneity	Consistency	pH	Spreadability	Viscosity (cps)
1	Yellowish Brownd	Excellent	Excellent	6.58	25.6	17800
2	Yellowish Brown	Better	Good	5.95	12.2	33680
3	Brown	Good	Good	6.24	74.61	26440
4	Yellowish Brown	Excellent	Excellent	6.76	29.57	20120

Figure 5: Drug content of different formulation batches

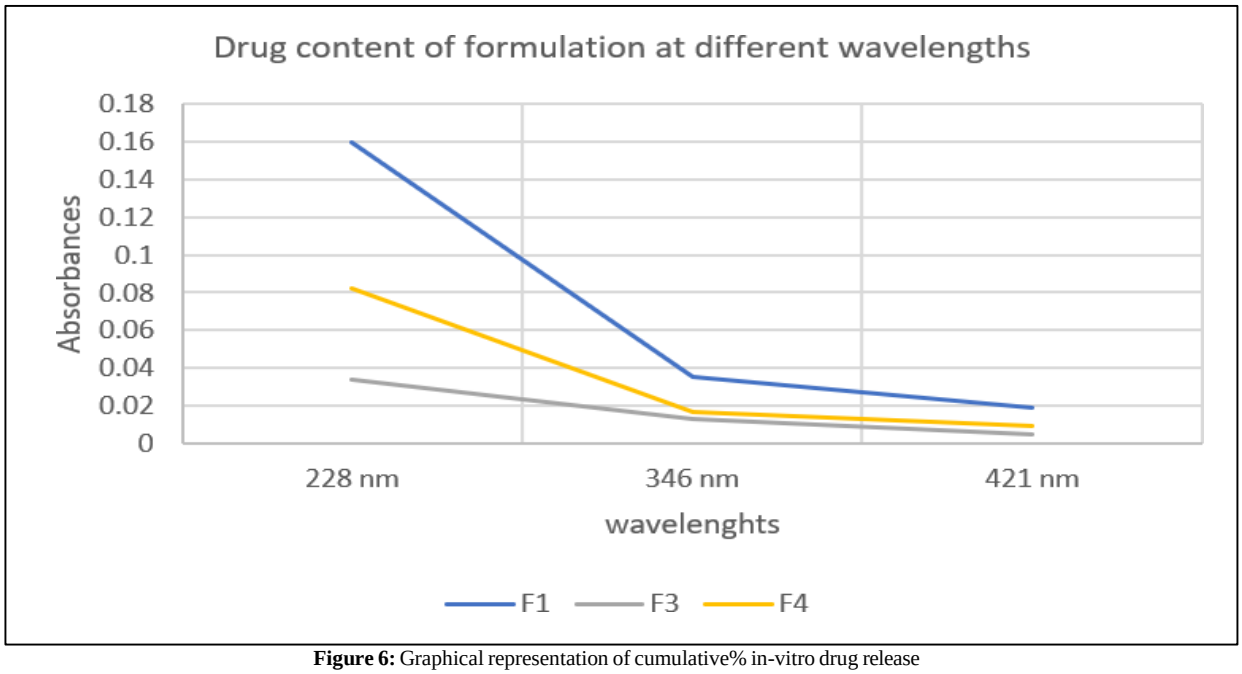


Figure 6: Graphical representation of cumulative% in-vitro drug release

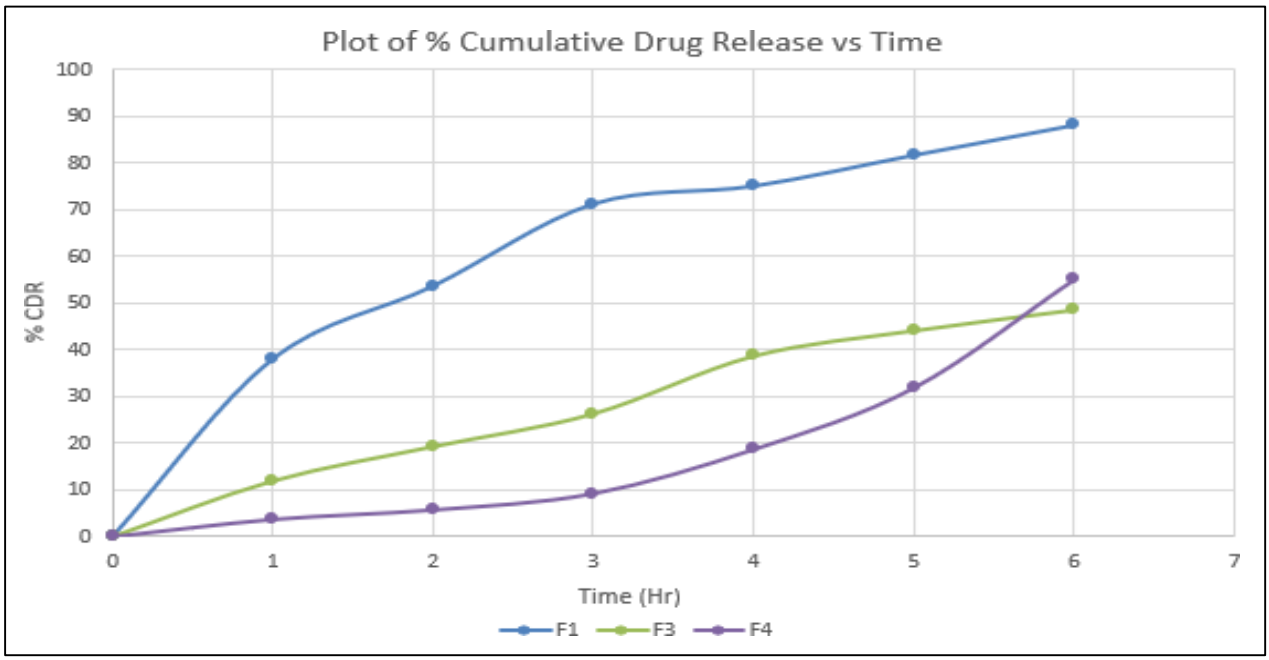


Table 4: Formulation batches and their absorbance at different wavelength

Batches	Absorbances		
	228 nm	346 nm	421 nm
F1	0.16	0.035	0.0186
F3	0.034	0.013	0.005
F4	0.082	0.017	0.009

Table 5: Total cumulative % in-vitro drug release of all the formulation batches

Time (Hr)	Formulation F1	Formulation F3	Formulation F4
0	0	0	0
1	38.03	11.96	3.71
2	53.67	19.34	5.75
3	71.25	26.38	9.24
4	75.07	38.76	18.7
5	81.68	44.2	31.89
6	88.1	48.65	55.09

DISCUSSION

The present study focused on developing novel polyherbal emulgel formulations using extracts of *Salacia chinensis*, *Tinospora cordifolia* and *Curcuma longa*. These herbal extracts were combined with Carbopol 940 and Polyethylene glycol in varying ratios to develop an effective topical treatment. The use of these three different plant extracts enhances the therapeutic potential of the emulgel,

providing a wider range of health benefits due to their combined medicinal properties. Among the various batches tested, Batch F1 demonstrated the most promising results, showing improved effectiveness and optimized performance compared to the other batches.

CONCLUSION

This research focused on formulating a polyherbal emulgel incorporating extracts of *Salacia chinensis, Tinospora cordifolia, and Curcuma longa* using the emulsion-solvent diffusion technique with Carbopol 940 as the gelling agent. The formulation underwent physicochemical studies, including assessments of appearance, pH, homogeneity, spreadability, viscosity, centrifugation, and in vitro drug release. All batches exhibited pH levels close to the skin's physiological pH, ensuring suitability for topical use. The optimized F1 batch demonstrated excellent viscosity, spreadability, and the highest drug release rate of 88.1% over 6 hours, confirming its potential for effective topical delivery and therapeutic efficacy.

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Conflict of Interests

Authors have declared that no conflict of interests exists.

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