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FORMULATION AND *IN-VITRO* EVALUATION OF *CRYPTOLEPIS BUCHANANI'S* EXTRACT LOADED EMULGEL

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ABSTRACT
This study presents the formulation and *in vitro* evaluation of an emulgel containing extract of *Cryptolepis buchanani's*, a medicinal plant recognized for its significant anti-inflammatory, antibacterial and antioxidant properties. Emulgels, which combine the benefits of emulsions and gels, offer a suitable delivery system for poorly water-soluble herbal compounds. Ethanolic extracts of *C. buchanani* leaves were prepared and incorporated into an oil-in-water emulgel base using Carbopol 940 as the gelling agent. The formulations were optimized for physicochemical parameters including pH, viscosity, spreadability, homogeneity and stability. Various formulations of the extract were evaluated to identify the most effective and stable composition. The optimized formulation displayed favorable characteristics, with an ideal pH range (5.8–6.5), desirable viscosity and excellent spreadability, indicating its suitability for topical application. Drug release studies revealed a sustained release profile over 8 hours.These findings highlight the potential of the *C. buchanani* based emulgel as a promising alternative for the treatment of inflammation. The study demonstrates the effective integration of traditional herbal medicine with modern pharmaceutical delivery systems, offering probability of enhanced therapeutic potential and patient compliance. Further antimicrobial study and *in vivo* studies are recommended to substantiate the therapeutic efficacy and safety of this novel formulation in clinical settings.

KEYWORDS: Emulgel, *Cryptolepis buchanani*, Antibacterial, Spreadability.

1. INTRODUCTION
Cryptolepis buchanani (Asclepiadaceae) is a climbing tree found in evergreen forest in Thailand, China, India, Nepal and Indo-China.[1] It is widely used in folk medicine in Southeast Asia. In Thailand, *C. buchanani* known as "Thao En On" has been used for treating inflammatory conditions such as muscle and joint pain.[2] Its stems are used in the treatment of muscle tension, stiffness of tendon and arthritis. Its leaves are used as poultice on inflamed area for the treatment of myalgia and arthritis. Few studies have examined the anti-inflammatory effect of this plant and found that its extract could reduce inflammation both in *in vitro* and *in vivo* studies. However, scientific reports of the analgesic and chondroprotective activities of *C. buchanani* are limited.[3,4]

As part of this research, a novel *Cryptolepis buchanani* based emulgel formulation has been developed to explore its potential as an effective and targeted drug delivery system. This innovative emulgel combines the advantages of both emulsions and gels, offering enhanced drug penetration, improved stability and sustained release characteristics.[5,6]

The incorporation of *Cryptolepis buchanani*, known for its therapeutic properties, into an emulgel base represents a promising strategy to overcome the limitations associated with conventional topical formulations i.e. ointment, creams, gels, lotions etc.[7] This approach not only enhances the bioavailability of the active phyto-constituents but also allows for localized and controlled drug delivery, potentially leading to improved therapeutic outcomes.[8] By integrating a plant-based bioactive agent with advanced formulation technology, this study presents a novel and efficient platform for drug delivery that may contribute significantly to the field of phyto-pharmaceuticals and topical therapeutics.[9]

This research presents a novel emulgel formulation designed for enhanced topical delivery of hydrophilic drugs. Unlike conventional emulgels, which often suffer from poor stability and suboptimal drug release, this study introduces a novel combination of biocompatible natural polymers and surfactants that not only stabilize the emulsion but also significantly improve the controlled release properties. The emulgel was further characterized using advanced rheological and texture analysis, demonstrating improved spreadability and

patient compliance. This formulation offers a promising new approach for the treatment of dermatological conditions, particularly where enhanced drug absorption is crucial. Moreover, this research addresses gaps in the stability and performance of emulgel systems, contributing valuable insights to the field of topical drug delivery.

2. EXPERIMENT

2.1 MATERIALS AND METHODS

The materials utilized in this study were carefully sourced from reputable suppliers to ensure the integrity and reliability of the experimental findings. Plant material *Cryptolepis buchanani*, the primary active pharmaceutical ingredient was obtained from Vital Herbs Pvt. Ltd., New Delhi, while chloroform and acetone were sourced from Fisher Scientific India Pvt. Ltd., Ethanol, methanol and n-octanol serving as solvents and excipients were procured from Thomas Baker and Fisher chemical limited, India. Additionally methyl parabene and propyl parabene were sourced from CG Chemikalein. Glycerol and light liquid paraffin, a key ingredient influencing vesicle properties, was sourced from Sisco Research Laboratories Pvt. Ltd. in a meticulous effort to ensure its purity and consistency.

2.2. Preformulation studies

2.2.1 Organoleptic properties

The organoleptic properties of the drug sample were comprehensively evaluated to determine its physical attributes, encompassing appearance, color and odor.

2.2.2 Identification by HPLC Selection of detection wavelength

In the High-Performance Liquid Chromatography (HPLC) method employed for the analysis of drug, careful selection of the detection wavelength is required. The selection of the mobile phase and optimization of chromatographic conditions were carried out to achieve efficient separation with a stable baseline and sharp peaks. C_{18} column (250 × 4.6 mm, 5 µm particle size) was used as the stationary phase and the separation was performed under isocratic conditions.

The mobile phase consisted of water and acetonitrile in a ratio of 45:55 containing 0.1% O-phosphoric acid which provided optimal resolution and peak symmetry. The detection was carried out using a UV detector at an absorption maximum of 340 nm. The column temperature was maintained at 25°C with a flow rate of 1.0 ml/min and an injection volume of 20 µl. The mobile phase was also used as the diluent and the total run time for each injection was 7 minutes.

Standard stock solution preparation

a) Blank solution

Diluent was filtered through 0.22 µ millipore membrane filters and injected in HPLC system.

b) Standard solution preparation

10 mg of each standard (Chlorogenic acid and Caffeic acid) were taken in 10 ml volumetric flask and dissolved in 10 mL of diluents (as mentioned above) to obtain a solution of 1000 µg/ml as stock.

c) Working solution

From the stock solution, 0.15ml, 0.3ml, 0.45ml, 0.6ml, 0.75ml and 0.9ml was taken and diluted upto 10ml diluent to make necessary dilutions of 15µg/ml, 30µg/ml, 45µg/ml, 60µg/ml, 75µg/ml and 90µg/ml filtered through 0.22 µ millipore membrane filters and injected in HPLC system.

Quantitative estimation of samples

Weighed 100 mg of extract and transferred it into 10 ml volumetric flask and dissolved the sample up to the mark with diluent. After that centrifuge the sample at 15000 rpm for 10 minutes and take the supernatant of the sample and filtered through 0.22 µ millipore membrane filters and injected in HPLC system.[10]

2.2.3 Drug-excipients compatibility study by FTIR

FTIR spectra of a combination of *Cryptolepis buchanani* and other substances was obtained to look for any possible drug interactions with excipients. *Cryptolepis buchanani* (1-2 mg) was used to determine the functional groups. The infrared spectrum's range of 4000 to 400 cm^{-1} was recorded.[11]

2.2.4 Preparation of emulsions

The oil phase of the emulsion was prepared by dissolving span 80 in light liquid paraffin while the aqueous phase was prepared by dissolving tween 20 in purified water. Methyl and propyl parabens were dissolved in propylene glycol whereas extract was dissolved in water and both solutions were mixed with the aqueous phase. Both the oily and aqueous phases were separately heated to 70–80°C then the oily phase was added to the aqueous phase with continuous stirring until it got cooled to room temperature. The composition of different formulations has been discussed in Table 1.

Table 1: Composition of various emulsion formulation.

Ingredient	F1	F2	F3	F4	F5	F6	F7	F8
Extract (mg)	100	100	100	100	100	100	100	100
Light Liquid paraffin (mg)	500	550	600	750	800	850	900	950
Span 80 (mg)	100	100	100	100	100	100	100	100
Tween 20 (mg)	50	50	50	50	50	50	50	50
Propylene glycol (mg)	500	500	500	500	500	500	500	500
Methyl paraben (mg)	30	30	30	30	30	30	30	30
Propyl paraben (mg)	10	10	10	10	10	10	10	10

2.3 Evaluation of prepared formulations of emulsions

2.3.1 Physical appearance and pH

One milliliter of the emulsion was mixed with 100 ml of distilled water and the pH was measured using a pH meter after mixing the mixture for 1 minute. The pH was determined in triplicate and the average values were calculated.[12]

2.3.2 Centrifugation test

This is a type of accelerated stability test. This test was used to characterize the physical stability of formulated emulsion under the influence of stress induced by vibration during transportation. A sample of 6 ml composed emulsion was subjected to centrifugation for 30-minute interval at 4000 rpm. At the end of centrifugation, the samples were observed for any change.[13]

2.3.3 Drug content

One milliliter of extract loaded emulsion (equivalent to 10 mg of extract) was dissolved in 10 mL of water and sonicated for 1 minute to obtain a clear solution. The resulting solution was then centrifuged at 15000 rpm for 15 minutes. Using water as the blank, the drug content was determined by analyzing the emulsion spectrophotometrically.[14]

$$\% \text{ Drug content} = \frac{\text{Final amount of drug}}{\text{Initial amount of drug}} \times 100$$

2.3.4 Viscosity

The viscosity of the emulsion was measured by taking 20 ml of the formulation, adjusting the spindle speed (L3) to 100 rpm and applying a temperature of 37 ± 0.5°C for 10 minutes. Viscosity was determined using a Brookfield viscometer (ViscoQC100). All measurements were performed in triplicate.[15]

2.3.5 Particle size measurement

The particle size of an emulsion was measured using an optical microscope. The eye piece micrometer was calibrated using a stage micrometer. To estimate the average emulsion size, a small volume of emulsion was spread out on a clean glass slide and the particle diameters of roughly 100 of them were measured at random.[16]

2.3.6 Zeta potential

Zeta potential (ZP) depends on the composition of emulsion and is a function of the particle's environment. Electrophoretic light scattering (ELS) and electroacoustic determination are the techniques used for ZP analysis. ELS provide better resolution and more reliable results than other methods. Aggregation of emulsion can be created by small size, large surface area and free energy of emulsion.[17]

2.3.7 Incorporation of emulsion into emulgel

After evaluation of all formulation (F1 to F8), it was concluded that F5 shows better result than other hence, emulgel was prepared using composition of F5. Four groups G1 to G4 were prepared by using various concentration of carbopol with constant stirring of 100 rpm at 37℃ temperature.

Table 2: Composition of different formulations of emulgel.

S. No.	Ingredients	Formulation Code			
		G1	G2	G3	G4
1	Emulsion (ml)	10	10	10	10
2	Carbopol 934 (w/v)	0.5	1	1.5	2
3	NaOH solution (ml)	q.s	q.s	q.s	q.s

3. EVALUATION OF EMULGEL OF *CRYPTOLEPIS BUCHANANI*

3.1 Physical appearance

The freshly prepared emulgel were examined visually and physical characteristics (such as color and homogeneity) were carefully examined.

3.2 pH

After precisely weighing 1g of emulgel was distributed in 100 ml of water. A digital pH meter was used to determine pH of formulation.

3.3 Viscosity

20ml of emulgel was taken in suitable beaker and viscosity was measured using spindle no. L3 at 100 rpm 37 ± 0.5°C for 10 minutes. Viscosity was determined using a Brookfield viscometer (ViscoQC100). All measurements were performed in triplicate.

3.4 Spreadability

Glass slides with standard dimension (length of 6.0 cm) were taken. Emulgel formulation was placed on the one side of the glass slide and sandwiched with the help of another slide. Remove the adhering gel on the outer surface of the glass slides by wiping. Slides are fixed in a stand that only upper slide to slip off freely without any disturbance by force of weight (20 g) tied to it. Time taken for the movement of upper slide to the distance of 6.0 cm was measured. Measurement of spreadability was done in triplicate and calculated by using the following. Formula.[16]

$$S = \frac{m \times l}{t}$$

Where, S= Spreadability, m=Weight tied to the upper slide (20 g), l=Length of the glass (6.0 cm), t=Time taken in seconds.

3.5 Drug content

Take 1 gm of formulation in 100ml volumetric flask and then add diluent to dissolve it and makeup volume upto mark. Then drug content was determined by HPLC method.[17]

$$\% \text{ Drug content} = \frac{\text{actual amount of drug}}{\text{theoretical value of drug}} \times 100$$

3.6 FTIR Study

The FTIR spectrum of optimized formulation was measured by using FTIR spectroscopy.[18]

3.7 *In-vitro* drug release study

In vitro release studies were carried out using franz diffusion cell and therefore, the temperature was adjusted to 37º C ± 0.5º C. Dialysis membrane was soaked overnight in 40% ethanol solution. One gram sample was applied on to the membrane and therefore, the membrane was placed in between donor and receptor compartment of the cell consisting of phosphate buffer pH 7.4. The temperature of the receptor medium was maintained at 37°C and agitated employing a magnetic stirrer. Aliquotes of 1ml sample were withdrawn from the receptor compartment via the sampling part at 0.08, 0.25, 0.5, 1, 2, 3, 4, 6 and 8h and immediately replaced with an equal volume of fresh receptor solution. Samples were withdrawn at periodic intervals and picked up, samples were analyzed using HPLC. Same procedure was performed in triplicate.[19]

3.8 Drug release kinetic studies

The % drug release and release kinetics of *Cryptolepis buchanani* from topical gel were determined in the current study by analyzing raw data from *in vitro* release trials and fitting the data to various equations and kinetics models. The kinetic models utilized were the Korsmeyer-Peppas equation, Higuchi's model, First-order equation and Zero-order equation.[20]

4.0 RESULTS AND DISCUSSION

4.1 Preformulation study of drug

4.1.1 Organoleptic properties

Organoleptic properties of extract *Cryptolepis buchanani* were found to be as per literature and is given in Table no. 3.

Table 3: Organoleptic properties of *Cryptolepis buchanani.*

S. No.	Properties	Acquired Extract	Reference
1.	Colour	Golden brown	Golden brown
2.	Odour	Characteristic odour	Characteristic odour
3.	Form	Fine powder	Fine powder

The organoleptic properties of acquired extract were compared with reference and were found to be comparable.

4.1.2 HPLC

4.1.2.1 Determination of chromatogram of blank & standard (chlorogenic acid and caffeic acid)

According to the provided approach, the HPLC analysis of the standard solutions of Chlorogenic acid and Caffeic acid at 60 µg/ml was optimized and looked at. The HPLC analysis of the chromatograms of a blank and a standard is shown in Figures 1 and 2.

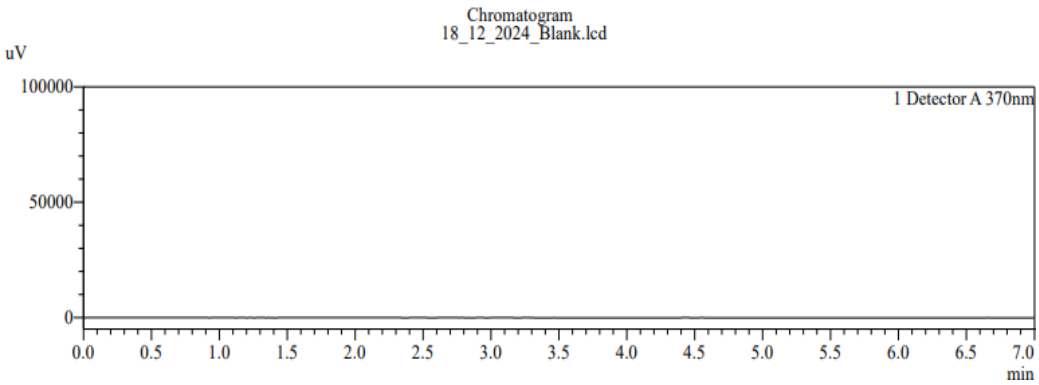

Figure 1: Chromatogram of blank.

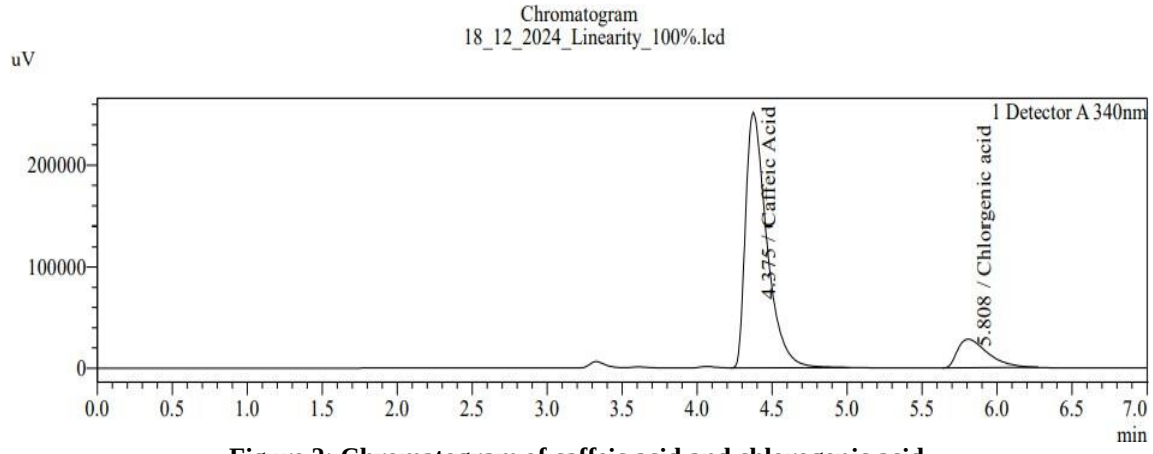

Figure 2: Chromatogram of caffeic acid and chlorogenic acid.

Table 4: Data of chlorogenic acid and caffeic acid solution of 60 µg/ml.

S. No.	Compound Name	Conc. (µg/ml)	Retention time	Area
1	Chlorogenic acid	60	5.808	400743
2	Caffeic acid	60	4.475	2483710

4.1.2.2 Preparation of standard curve of chlorogenic acid

Table 5: Calibration curve of chlorogenic acid (λ_{max}= 340 nm).

S. No.	Concentration (µg/ml)	Absorbance (Chlorogenic acid)	Absorbance (Caffeic acid)
1	15	101712±4299.22	620855±19096.81
2	30	200736±4264.82	1246805±31510.27
3	45	297648±5537.38	1835699±28007.34
4	60	398017±2499.58	2453692±30014.00
5	75	499381±8417.83	3072443±55673.99
6	90	606064±4956.81	3748719±24057.24

Table 6: Result of regression analysis for estimation of chlorogenic acid.

Statistical parameters	Results Chlorogenic acid	Result Caffeic acid
λ max	340 nm	340 nm
Regression equation: y=mx+c	Y = 6701.1x - 1213.5	Y = 41399x - 10387
Slope (m)	6701.1	41399
Intercept (C)	1213.5	10387
Correlation coefficient (r^2)	0.9998	0.9996

The calibration curve for chlorogenic acid was obtained by using the 15 to 90 µg/ml solution of Chlorogenic acid. The calibration curve of Chlorogenic acid indicated the regression equation Y = 6701.1x - 1213.5 and R^2 value 0.9998, which showed good linearity.

The calibration curve for caffeic acid was obtained by using the 15 to 90 µg/ml solution of Caffeic acid. The calibration curve of Caffeic acid indicated the regression equation Y = 41399x - 10387 and R^2 value 0.9996, which showed good linearity.

4.1.3 FTIR of drug and excipients

4.1.3.1 FTIR of *Cryptolepsis buchanani*

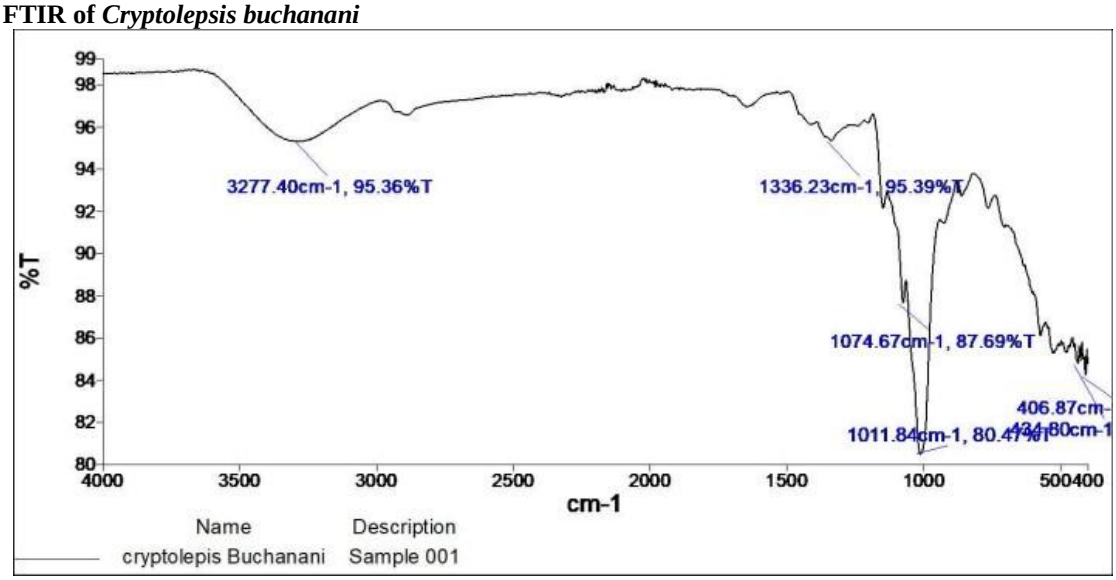

Figure 3: FTIR spectrum of *Cryptolepsis buchanani.*

4.1.3.2 FTIR of physical mixture

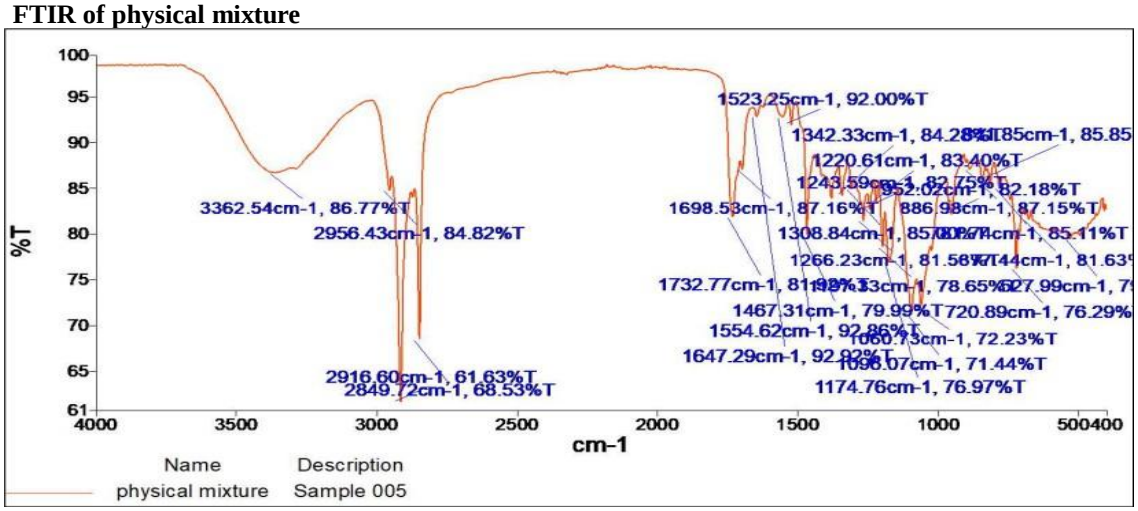

Figure 4: FTIR spectrum of physical mixture.

Table 7: FTIR interpretation of physical mixture.

Reported peak (cm-1)	Observed peak (cm-1)	Functional group
3450	3475.17	OH- stretching
1250	1248.82	C-O-C stretching
1458.84	1458.36	Benzene ring
1736	1734.79	C=O stretching
2871	2859.67	Symmetric C–H

Physical mixture's FTIR spectra has been displayed in the Figure 4, Table 7. The principal IR absorption peaks of physical mixture at 3475.17cm^{-1} (OH-stretching), 1248.82 cm^{-1} (C–O-C Stretching), 1458.36cm^{-1} (Benzene ring stretching band), 1734.79 cm^{-1} (C=O stretching) and 2859.67 cm^{-1} are due to Symmetric C–H, were all observed in the spectra of physical mixture. This observation confirmed the purity and authenticity of the physical mixture.

4.2. Evaluation of emulsion

4.2.1 Appearance and pH

Table 8: Physical appearance and pH of the formulations F1 to F8.

Formulation code	Appearance	pH
F1	Cloudy or opaque appearance	5.91±0.04
F2	Cloudy or opaque appearance	5.93±0.01
F3	Cloudy or opaque appearance	5.90±0.01
F4	Cloudy or opaque appearance	6.55±0.05
F5	Cloudy or opaque appearance	6.76±0.04
F6	Cloudy or opaque appearance	6.27±0.06
F7	Cloudy or opaque appearance	5.87±0.07
F8	Cloudy or opaque appearance	5.65±0.04

All emulsion formulations F1 to F8 exhibited a cloudy or opaque appearance, indicating the formation of stable emulsions. The pH values ranged from 5.65 ± 0.04 to 6.76 ± 0.04, which were found to be within the acceptable range for topical applications and compatible with skin pH.

4.2.2 Centrifugation test

The centrifugation study of formulations F1 to F8 showed no phase separation in any of the samples, indicating good physical stability of the emulsions. The absence of separation under centrifugation stress suggested that the emulsifying agents used were effective in maintaining homogeneity and preventing breakdown of the emulsion system.

4.2.3 Viscosity

The viscosity study of emulsion formulations F1 to F8 showed values ranging from 515 ± 0.54 to 568 ± 0.73 cPs.

4.2.4 Drug content (caffeic acid)

The λ_{max} of the drug was determined to be 340 nm, confirming the absorbance measurement for drug content estimation. This indicated efficient drug incorporation and uniform distribution in the formulations confirming good formulation consistency. The drug content analysis of emulsion formulations F1 to F8 were found to be within range 74.83% to 87.65% with F5 exhibiting the highest content.

4.2.5 Drug content (chlorogenic acid)

The λ_{max} of the drug was determined to be 340 nm, confirming the absorbance measurement for the drug content estimation. This indicated superior drug loading efficiency. The drug content analysis of emulsion formulations F1 to F8 showed values ranging from 79.303 ± 0.212 to 89.719 ± 0.423 with F5 showing highest drug content.

4.2.6 Particle size measurement and zeta potential

The particle size analysis of formulations F1 to F8 showed noticeable variation, indicating the effect of formulation parameters on droplet size. F4 had the largest particle size (20.842 ± 0.018 µm), while F1 showed the smallest (10.810 ± 0.204 µm), suggesting better emulsification in F1. Formulations F5 to F8 exhibited sizes around 13–14 µm with minimal deviation, reflecting more consistent droplet distribution.

Table 9: Evaluation of emulsion formulations F1-F8.

S. No.	Formulation code	Centrifugation	Viscosity (cPs)	% Drug content (Caffeic acid)	Drug content (Chlorogenic acid)	Particle size (µm)
1	F1	No Phase Separation	515±0.54	74.835±0.260	80.306±0.84	10.810±0.204
2	F2	No Phase Separation	572±0.61	80.371±0.333	82.990±0.969	14.690±0.321
3	F3	No Phase Separation	514±0.79	83.333±0.104	84.465±0.636	16.353±0.280
4	F4	No Phase Separation	588±0.83	85.552±0.146	87.286±0.047	20.842±0.018
5	F5	No Phase Separation	526±0.69	87.654±0.241	89.719±0.423	13.660±0.026
6	F6	No Phase Separation	558±0.65	86.045±0.627	85.077±0.988	14.343±0.076
7	F7	No Phase Separation	568±0.73	82.529±0.654	81.054±0.732	13.318±0.270
8	F8	No Phase Separation	528±0.78	80.018±0.069	79.303±0.212	14.140±0.009

4.2.6.2 Zeta potential

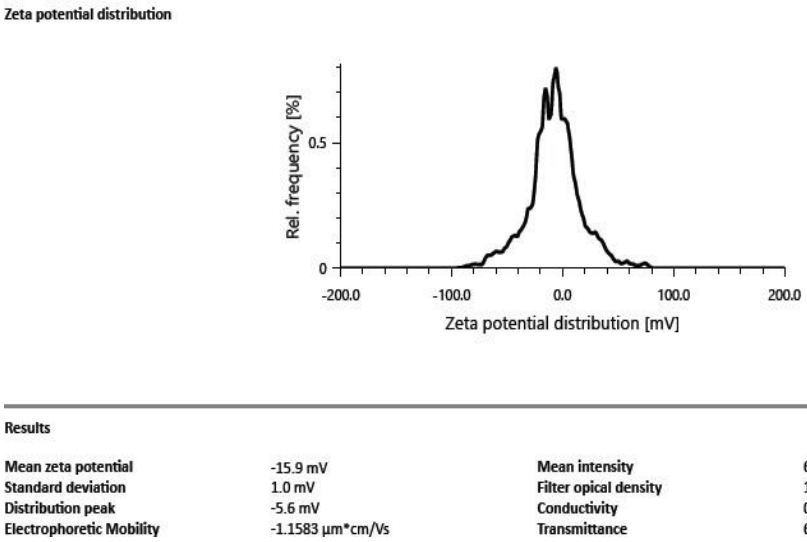

Figure 5: Zeta potential graph of formulation.

DISCUSSION

Figure 5, demonstrated zeta potential of F5 formulation, -15.9 mV represented stability of formulation.

4.3 FTIR of emulgel

Before proceeding the preparation of emulgel from optimized batch F5 of emulsion, FTIR was done for mixture of F5 and all excipients utilized for preparation of emulgel.

The emulgel formulation was found to contain functional groups consistent with its expected components such as gelling agents, emulsifiers and solvents. The presence of hydroxyl and carbonyl groups suggested hydrogen bonding and polar interactions, contributing to the stability and performance of the emulgel. This confirmed that formulation's chemical structure and compatibility with its intended purpose.

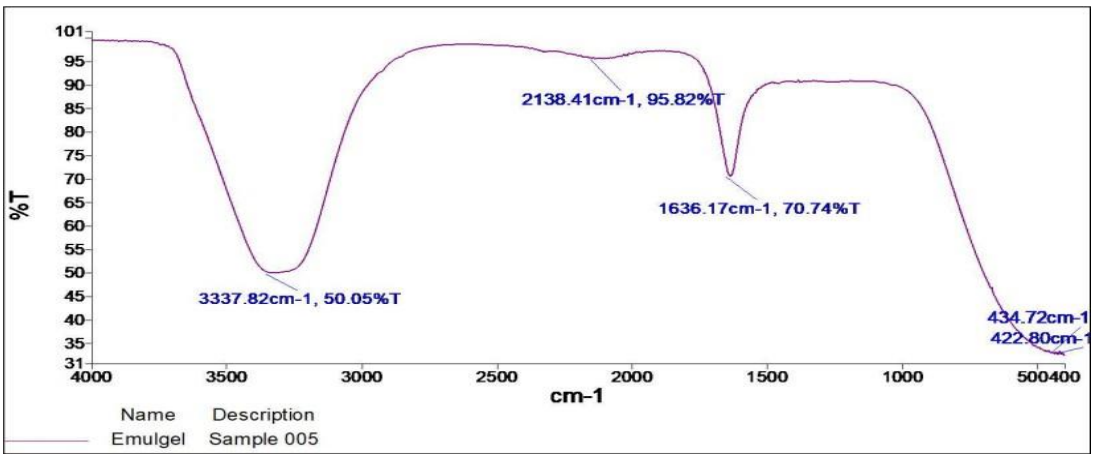

Figure 6: FTIR of formulation G4.

4.3.1 Evaluation of *Cryptolepis buchanani* loaded emulgel

4.3.2 Physical appearance and clarity of the emulgel

The prepared gel was examined visually for their consistency and found to exhibit smooth appearance.

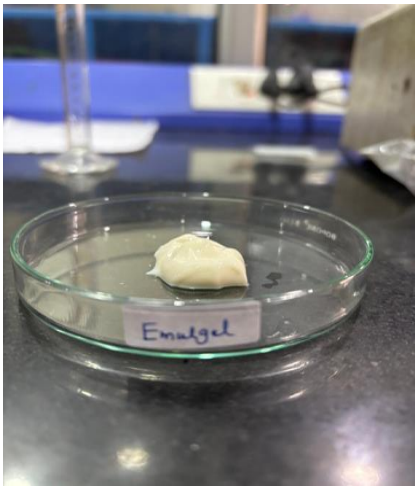

Figure 7: Physical appearance of emulgel.

4.3.3 pH of the formed gels

The pH of formulations G1 to G4 was found to be in range from 5.29 to 5.78, all within the skin-friendly range. G4 showed the highest pH (5.78), indicating good compatibility for topical use with minimal risk of irritation.

4.3.4 Viscosity

The measurement of viscosity of the prepared emulgel was done with Brookfield viscometer (Brookfield DV-E viscometer). The highest viscosity was found in emulgel G4 it may be due to high level of carbopol. The lowest viscosity was found in formulation G1.

4.3.5 Spreadability

The spreadability of the emulgel formulations G1 to G4 ranged from to 5.144±0.741 to 9.857±0.575, reflecting variations in their ease of application and viscosity. Overall formulations with moderate spreadability are preferred for effective application and therapeutic performance.

4.3.6 Drug content (chlorogenic acid)

The percent drug content in gel batches was found to be within limits. The percent drug content value of all gel batches within range indicated uniformity of mixing. The percent drug content uniformity in all formulated batches is shown in Table 10.

Table 10: Results of emulgel G1 to G4.

S. No	Formulation Code	Visual Appearance	pH	Viscosity (cps)	Spreadability (cm.g/sec)	% Drug Content (Caffeic acid)	% Drug Content (Chlorogenic acid)
1	G1	Light yellow uniform gel formed	5.37±0.06	2012±0.781	9.857±0.575	91.729±0.713	92.573±0.477
2	G2	Light yellow uniform gel formed	5.64±0.05	2671±0.947	7.956±0.571	94.550±0.164	93.591±0.246
3	G3	Light yellow uniform gel formed	5.29±0.09	2923±0.115	6.904±0.506	95.726±0.630	96.074±0.477
4	G4	Light yellow uniform gel formed	5.78±0.07	3483±0.502	5.144±0.741	96.845±0.180	97.370±0.724

4.3.7 *In vitro* release study

In vitro release study showed that the optimized emulgel formulation G4 significantly enhanced the release of chlorogenic and caffeic acids compared to the control gel. After 8 hours, F5 released 98.98% of chlorogenic acid and 95.13% of caffeic acid, while the control gel released only 39.59% and 35.39%, respectively as results shown in Table 10. The improved release from F5 suggested better drug diffusion and highlighted its potential for more effective topical delivery.

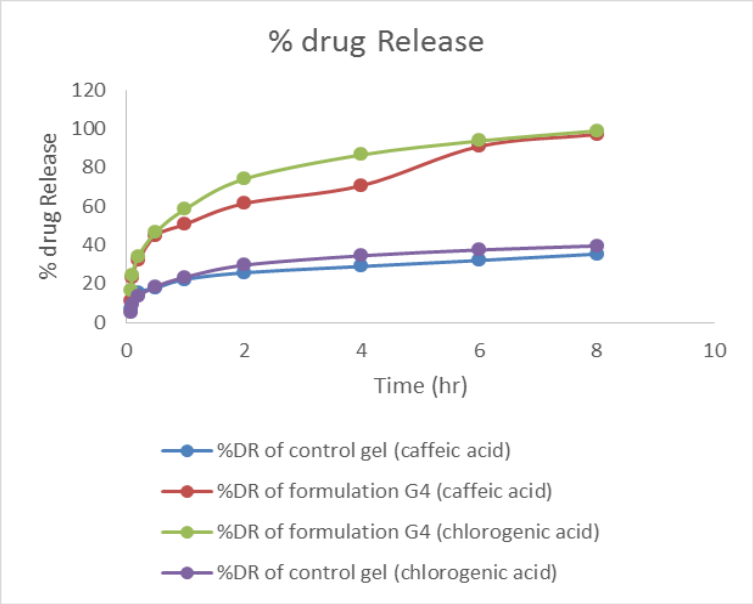

Figure 8: Percentage drug release of control gel caffeic acid, control gel chlorogenic acid and formulation G4.

Table 11: *In vitro* drug release of control gel & optimized formulation G4.

S. No.	Time (hrs)	% drug Release of control gel Chlorogenic acid	% drug release of Control gel Caffeic acid	% drug release of Formulation G4 Chlorogenic acid	% drug release of Formulation G4 Caffeic acid
1	0	0	0	0	0
2	0.08	5.24±0.02	6.81±0.03	16.7±0.64	11.14±0.07
3	0.25	9.71±0.26	10.98±0.02	24.28±0.65	23.48±0.06
4	0.5	13.62±0.39	15.67±0.05	34.04±0.98	32.11±0.14
5	1	18.63±0.25	17.95±0.31	46.58±0.62	44.99±0.04
6	2	23.40±0.03	22.28±0.54	58.5±0.07	53.72±0.29
7	3	29.63±0.28	25.7±0.35	74.07±0.70	63.47±0.37
8	4	34.52±0.25	29.01±0.27	86.60±0.62	76.77±0.12
9	6	37.51±0.18	32.09±0.28	93.77±0.44	82.60±0.62
10	8	39.59±0.09	35.39±0.31	98.98±0.21	95.13±0.78

4.3.8 *In-vitro* drug release kinetics of G4 formulation

In-vitro drug release kinetics study data of formulation G4 has been given below.

Table 12: Kinetic equation parameter of formulation G4.

Formulation Code	Zero order		First order		Higuchi		K. Peppas	
	K_0	R^2	K_0	R^2	K_0	R^2	K_0	R^2
G4 (Caffeic acid)	11.08	0.8882	-0.1739	0.9583	32.879	0.9867	0.4457	0.9832
G4 (Chlorogenic acid)	11.357	0.8465	-0.2221	0.9663	33.877	0.9837	0.4046	0.9959

Mathematical models were commonly applied to predict the drug release mechanism and to compare the release profiles of formulations. For formulation G4, the drug release data were fitted into various kinetic models, including % drug release vs. time (Zero-order), log % drug remaining vs. time (First-order), % drug release vs. square root of time (Higuchi model) and log cumulative % drug release vs. log time (Korsmeyer–Peppas model). The correlation coefficients (R^2 values) obtained from each model has been recorded in Table 12. Based on the highest R^2 value, the Korsmeyer–Peppas model (R^2 = 0.9959 for chlorogenic acid and 0.9832 for caffeic acid) was found to be best described to be fitted in drug release kinetic studies. This suggested that the drug release from the optimized formulation G4 was found to follows a sustained, anomalous diffusion-controlled mechanism, supporting its potential for prolonged topical delivery.

CONCLUSION

In the present study a stable emulgel formulation of Cryptolepis buchanani extract has been prepared. The

prepared emulgel demonstrated desirable physicochemical properties, including appropriate viscosity, good spreadability and overall stability, ensuring better patient compliance. From the in vitro studies, formulation F5 showed maximum release of 98.98% for chlorogenic acid and 95.13% for caffeic acid in 8 hours. The findings suggest that this formulation holds promising potential as a topical drug delivery system for analgesic and anti-inflammatory applications. The results also indicated good compatibility and stability of the developed preparation, supporting its future use in pharmaceutical and therapeutic interventions.

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