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DEVELOPMENT OF AN ALOE VERA-BASED EMULGEL FOR THE TOPICAL DELIVERY OF ANTIFUNGAL DRUG

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ABSTRACT

Objectives: Terbinafine HCl (TB) is a widely recommended drug for the topical treatment of plaque psoriasis. However, low water solubility and short half life of Terbinafine present major obstacles in the development of an effective topical formulation. Thus, there is a demand for the development of a safe and effective topical system to deliver hydrophobic Terbinafine. The present study aimed to develop an Aloe vera-based emulgel formulation to ensure enhanced skin deposition of Terbinafine for effective treatment of plaque psoriasis. **Materials and Methods:** Different formulations (TE1-TE4) of Aloe vera emulgel were prepared using dispersion technique, wherein varying concentrations of propylene glycol (6-14% w/w) and carbopol 934 (0.5-1.0% w/w) were used. **Results:** Zetasizer measurements revealed that the globule size of the formulations ranged from 10.34 µm±0.9 to 14.60 µm±1.4 (n=50). Extrudability analysis for the TE3 and TE2 formulations revealed an extrudability of 5.6±0.11 g/cm2 and 5.8±0.13 g/cm2, respectively. The pH of the formulations was recorded in the range of 5.8-6.8. Among these formulations, TE3 showed a maximum drug content of 94.64%±0.29 (n=3), and thus was used for further *in vitro* evolutions. A texture analyzer showed that an optimized DE3 formulation was

firmer and exhibited optimal spreadability in comparison with the TE2 formulation. For TE3, the mean max force that represented "firmness" was recorded to be 833.37 g, where as the mean area, denoting "work of shear", was 324.230g.sec. The TE3 formulation exhibited (TB) permeation of 95.40±1.6% over a period of 7 h, as determined using an in house fabricated Franze diffusion cell. Evaluation of *in vitro* release kinetics revealed that the release of (TB) fitted into the Korsmeyer-Peppas model. **Conclusion:** Physicochemical characteristics and enhanced *in vitro* permeation of (TB) from Aloe vera emulgel highlight its suitability to be efficiently employed for the topical treatment of skin ailments.

Key words: Aloe vera, Terbinafine HCl, plaque psoriasis, emulgel, skin diseases, kinetic models

INTRODUCTION

Terbinafine is an ally amine with antifungal action in a wide range of fungal diseases of the hair and skin, including Pityriasis versicolor. Because of first-pass hepatic metabolism, oral bioavailability is estimated to be around 40% **[1]**. As a result, the increased use of topical terbinafine may enhance bioavailability. Terbinafine is mildly soluble in water, thus emulsion can develop due to its hydrophilicity. Emulsions are utilized for both hydrophilic and hydrophobic drugs; however emulsion stability is a key issue. When a gel is introduced into an emulsion, the emulsion's stability problem is solved. Gel is greaseless, readily spreadable, quickly removable, nonstaining, and emollient, but it has a severe disadvantage in terms of delivering hydrophobic drugs. In recent years, emulgel has emerged as a potential technique for successful medication delivery, which is often reliant on a mix of methods. Emulgel is a generic term for a formulation that combines both gels and emulsions in one dose form. Anti-inflammatory medicines, antifungal agents, antiviral drugs, antibacterial drugs, local anesthetics, have been developed using emulgel formulation for the treatment of plaque psoriasis **[2]**. Currently, emulgels are utilized to deliver a variety of medicines to the skin **[3]**. Emulsifying agent, gelling agent, and oil phase are the three main components of an emulgel **[4]**. The concentration of these components has a major impact on a drug's release from the formulation, and therefore on the drug's bioavailability **[5]**. One of the benefits of an emulgel is that it uses oil in water emulsion system to readily entrap water-insoluble medicines in a gel foundation **[6]**. This improves cargo loading capacity, stability,

and medication release in a regulated way **[7]**.

Biocompatibility, thixotropic nature, easy spreadability, gracelessness, simple removal, water solubility, transparency, non-staining influence, attractive look, and stability are some of the features of an emulgel that make it a viable alternative for the treatment of fungal infections. In addition, an emulgel applied topically softens the skin. **[8]**. The capacity of aloe vera to increase medication penetration and generate an excellent emulsion makes it a good candidate for use in the creation of an Emulgel **[9]**.

Terbinafine has been commercially delivered via a variety of traditional drug delivery methods, including cream, lotion, and gel. However, due to the brief contact duration and poor localized bioavailability of the medication from these formulations, their utility for the treatment of fungal infection is restricted **[10]**. In a prior study, the ability of aloe vera to stay in touch with skin was investigated in order to produce an emulgel formulation that could be maintained on the skin for extended periods of time and offer effective and controlled drug release **[11]**.

Topical medication delivery has gotten a lot of interest since the beginning of the twenty-first century. One of the main advantages of transdermal administration is that it avoids the metabolic process **[12]**. Furthermore, topical preparations reduce off-target effects including pH fluctuation, empty stomach duration, and enzyme presence. As a result, topical preparations avoid the difficulties and pain of endovenous treatment **[13]**. The goal of this study was to create a terbinafine-loaded emulgel using aloe vera for better penetration.

MATERIALS AND METHODS

Materials

Terbinafine was purchased from Dolfin Ltd., Mumbai, India. Carbopol 934, Tween 20, Span 20, light liquid paraffin, triethanolamine, potassium dihydrogen phosphate, and sodium hydroxide were procurred from Lobachemie Pvt. Ltd., Mumbai, India. Propyl paraben and propylene glycol were obtained from Molychem, Mumbai, India. Methyl paraben was procured from Merk specialities Pvt. Ltd., Mumbai, India and ethanol from Institute of Pharmacy, Akola (MS).

Methods

Preparation of a gel from aloe vera juice

Using a spatula, the central parenchymatous pulp of aloe vera was extracted from a fresh leaf and rinsed multiple times with distilled water **[14]**. To neutralize the acidity of the aloe vera pulp, it was treated with 0.1 N sodium hydroxide **[15]**. The treated pulp was

then mixed for 20 minutes at 10,000 rpm in a mechanical blender (Dolphin Ltd, Mumbai), and the resulting juice was filtered three times using a cotton bed to remove any remaining peel **[16]**. A Buchner funnel vacuum suction filtering device (Elico Ltd, Hyderabad) was used to vacuum the prefiltered juice, and clear fluid was recovered **[17]**. Furthermore, 1 % w/w carbopol 934 was added and mixed for 30 minutes using a dual-shaft mechanical stirrer (Elico Ltd, India) at 2.000 rpm **[11]**. To avoid lumps, aloe vera gel was produced using the dispersion process. Carbopol 934 was mixed with propyl paraben and methyl paraben during the dispersion of aloe vera juice, and gel formation was aided by the progressive addition of 1 N sodium hydroxide solution **[18, 19]**.

Formulation of Terbinafine HCl Emulgel

Span 20 was dissolved in liquid paraffin to make the oil phase of the emulsion, while Tween 20 was dissolved in filtered water to make the aqueous phase. Both methyl and propyl paraben were dissolved in propylene glycol, while Terbinafine HCl (1%) was dissolved in ethanol and both solutions were combined with the aqueous phase. Both the oily and aqueous phases were heated to 70 to 80°C separately, and then the oily phase was added to the aqueous phase, stirred for 15-20 minutes before being cooled to room temperature. The developed 1% emulsion was added to the prepared aloe vera gel and stirred continuously for 60 minutes on a mechanical stirrer at 1.000 rpm. To make the emulgel, the emulsion was combined with the gel in a 1:1 ratio with moderate stirring 7. The pH of the produced 1 % (TB) emulgel was kept at 6.4 by using triethanolamine **[20]**.

Table 1: Formulation of Terbinafine HCl emulgel

Sr. No.	Name of ingredients (% w/w)	TE1	TE2	TE3	TE4
1	Terbinafine HCl	1	1	1	1
2	Span 20	1	1	1	1
3	Tween 20	0.5	0.5	0.5	0.5
4	Propylene glycol	6	10	14	8
5	Methyl paraben	0.03	0.03	0.03	0.03
6	Ethanol	4	4	4	4
7	Liquid paraffin	16	16	16	16
8	Aloe Vera	10	15	20	10
9	Carbopol 934	1	0.75	0.5	1
10	Propyl paraben	0.02	0.02	0.02	0.02
11	Distilled water	q.s	q.s	q.s	q.s
12	Triethanolamine	Adjust pH 5.8 to 6.8			

TE formulation denotes Terbinafine emulgel.,

An *in vitro* release study of the optimized Terbinafine emulgel

Using a modified dissolving assembly, an *in vitro* release analysis for the improved emulgel formulation was conducted **[21]**. The stainless steel basket assembly's bottom and inner walls were lined with filter paper grade no. 41 (Whatman®), which was cut to the required size. For the drug release medium, the modified basket assembly was put in a 50 mL glass beaker containing 30 mL phosphate buffer (pH 7.4).

At a temperature of 32°C± 0.5°C, the dissolving assembly was put on a magnetic stirrer and the drug release medium was stirred with a teflon-coated magnetic bead. Weighed emulgel corresponding to 1 mg Terbinafine HCL was applied as a thin coating to the modified basket assembly. 3 mL of drug release media was removed and 3 mL of new buffer medium was added at various time intervals. A double beam ultraviolet (UV)/visible spectrophotometer (Shimadzu® 1700) was used to measure the concentration of the test material in terms of absorbance at 283.2 nm **[22]**.

Globule size analysis

Using a zetasizer, the globule size of the produced aloe vera emulgel of terbinafine was investigated (Malvern instrument 3.000 HSA, UK). At a temperature of 25°C, size measurements were taken. Before analysis, the samples were diluted. All measurements were carried out in sets of three **[23]**.

Determination of extrudability

The load applied (grammes) to extrude a 0.5 cm strip of emulgel from a collapsible tube of lacquered aluminium in 10 seconds was used to assess extrudability **[24]**. In triplicates, the scalability of the improved preparation was tested. The following equation (1) was used to determine extrudability:

$$\text{Extrudability} = \frac{\text{Applied load (g) to extruded emulgel from tube}}{\text{Area (in cm}^2\text{)}}$$

equation (1)

pH studies of Terbinafine emulgel

A digital pH meter (Mettler Toledo India Pvt. Ltd., Mumbai, Maharashtra, India) was used to measure the pH of emulgel formulations **[25]**. All measurements were carried out in triplicates.

Determination of drug content in TE1-TE4 emulgel formulations

In a petri dish, 200 mg of emulgel was placed, and 5 mL of ethanol (65% v/v) was added to assess the drug content in the formulations. Emulgel was dissolved in ethanol for 15 minutes of moderate shaking with a glass rod. The resultant solution was sonicated for 10 minutes in a 10-mL volumetric flask. Using ethanol **[26]**, the

final volume of the solution was made up to 10 mL. The solution was then filtered using filter paper grade 41 (Whatman) and spectrophotometrically examined at 242 nm (Shimadzu 1700, Shimadzu analytical Pvt. Ltd., Mumbai, India) **[27]**. The drug content was calculated using the following equation (I2):

$$\text{Drug content (\%)} = \frac{\text{Actual amount of drug determined in 200 mg emulgel}}{\text{Theoretical amount of drug present in 200 mg emulgel}} \times 100$$

equation (2)

An *in vitro* release study of the optimized Terbinafine HCl emulgel

Using a modified dissolving assembly, an *in vitro* release analysis for the improved emulgel formulation was conducted **[28]**. The stainless steel basket assembly's bottom and inner walls were lined with filter paper grade no. 41 (Whatman®), which was cut to the required size. As a drug release medium, the modified basket assembly was put in a 50 mL glass beaker with 30 mL phosphate buffer (pH 7.4). At a temperature of 32°C±0.5°C, the dissolving assembly was put on a magnetic stirrer and a teflon coated magnetic bead was employed to agitate the drug release medium. Emugel corresponding to 1 mg Terbinafine HCl was weighed and put to the modified basket assembly as a thin coating. 3 mL of drug release media was removed and 3 mL of new buffer medium was added at various time intervals. A double beam ultraviolet (UV)/visible spectrophotometer (Shimadzu® 1700) was used to measure the concentration of the test material in terms of absorbance at 283.2 nm after it was filtered through the filter paper **[29]**.

Assessment of Terbinafine permeation using a Franz diffusion cell

A Franz diffusion assembly was used to test Terbinafine HCl permeability for the improved emulgel formulation **[30]**. There are donor and receptor chambers in the Franz diffusion cell. In the present study, the donor chamber was kept in contact with the environment and unclosed at the top, with a diffusion area of 1.43 cm^2. Phosphate buffer (pH 7.4) was used as a dissolution medium, and 0.0025% w/v sodium azide solution was added to prevent microbial growth in the receptor chamber. In the receptor chamber, arice magnetic bead was inserted. The donor chamber was sealed with a cellophane membrane, and the excised diffusion cell was sandwiched between the diffusion cell's chambers and clamped in place. At 37°C±0.5°C **[31]**, the entire system was placed on a magnetic stirrer. To hydrate the membrane, it was placed in the cell for two hours. The Terbinafine emulgel formulation (5 mL) was then applied to the membrane's

surface. 1 mL of penetrated drug sample was removed from the receptor compartment at different time intervals, and 1 mL of new release medium was added. A double beam UV/visible spectrophotometer (Shimadzu® 1700 analytical Pvt. Ltd., Mumbai, India) was used to examine the test sample at 283.2 nm **[32]**.

Consistency of the optimized Terbinafine HCl emulgel formulation

A texture analyzer was used to assess the consistency of the improved emulgel formulation (TA.XT Plus). Prior to the test, the probe's distance calibration was done by setting the return distance to 30 mm. A standard-sized container was used to test the consistency of the prepared emulgel (back extrusion 50 mm diameter). A 40 mm extrusion disc was put in the centre, over the test container, and the container was filled with 75 percent emulgel formulation. Great care was taken to keep the container securely in place so that it did not lift when the prob returned to its original position **[33]**. The disc was placed into the deepest section, where the active surface, i.e. the point where the disc's bottom surface comes into touch with the product, was measured. When maximum force was exerted, the probe returned to its original position. The formulation's hardness was assessed at its highest force or peak value. At this stage, the area under the curve was used to determine consistency, with the larger the area, the more dense the consistency of the created emulgel. Back extrusion was used to assess the gripping effect of the improved emulgel formulation, with consistency in the negative area of the graph. Maximum negative force or a greater negative value indicated a higher cohesiveness value of the emulgel formulation. The work of cohesion is the negative area region of the curve. The improved emulgel formulation's consistency revealed that the larger the area of the curve, the greater the resistance to withdrawing the emulgel formulation **[34]**.

Spreadability of the optimized emulgel

A texture analyzer was used to assess the spreadability of emulgel (TA.XT Plus). Spreadability fixity is a collection of male and female cones that are perfectly aligned (fabricated with Perspex 90). The test necessitated the use of a sturdy platform on which the female probe with the sample was mounted. The male cone was placed in the centre of the female cone, which held the sample. The male cone probe was lowered downward and placed into the female cone sample container before the experiment began. Prior to the test, the instrument was distance calibrated using a void female

holder. A spatula was used to put the Terbinafine HCL emulgel into the female holder. The male cone probe moved toward the female cone and pierced the sample container surface as the test began (depth of 2 mm). The maximum penetration depth for the given penetration force was reached at this point, and firmness was assessed at a defined depth in terms of force value. The entire amount of force necessary to accomplish the shearing procedure was represented by a larger region of stiffer sample. After then, the male probe was permitted to return to its original location in relation to the female probe. The curve was used to compute the mean maximum force and mean area **[35]**.

***In vitro* release kinetics**

Using several kinetic models, the release profile for prolonged Terbinafine release from the emulgel formulation may be interpreted in numerous ways, including diffusion, erosion, or osmosis. For *in vitro* release kinetics assessment, zero-order models were used for cumulative % drug released vs. time, Higuchi kinetic model represented cumulative % drug release vs. square root of time, first-order kinetic model as log of cumulative % drug left vs. time, Korsmeyer-Peppas model as log of % drug released vs. log time, and Hixson-Crowell cube root model as cube root of % drug remaining vs. time. The desired model was chosen based on the results of the fit test **[36]**.

The release data for emulgels containing Terbinafine indicated that the drug was released slowly in this equation, which was assessed using the following equation 3:

$M0 - Mt = k0t$ equation (3)

Where, "Mt" denotes the quantity of Terbinafine dissolved in time t, "M0" denotes the initial quantity of drug in the release medium (times, M0=0), and "k0" is the kinetic zero-order release constant (concentration/time).

First-order model: This equation was used to explain the absorption and/or elimination of Terbinafine. The drug release profile following the first-order kinetics model was measured using the equation 4:

$\ln (M0/Mt) = k1t$ equation (4)

Krate constant of first order (time-1).

Higuchi model: This model was used to explain drug release from the matrix, wherein the obtained data were calculated using equation 5:

$Mt = k\sqrt{t}$ equation (5)

Here, $k\sqrt{t}$ is the Higuchi dissolution constant.

Korsmeyer-Peppas model: The proposed equation was used to explain the release of drugs from a polymer system. To find out the

release mechanism of drug, the obtained data were calculated as per the given equation 6:

$Mt/M\infty = Ktn$ equation (6)

Where, "$Mt/M\infty$" denotes the amount of drug released due to friction at time t, "K" is the rate release constant and "n" denotes the release exponent.

Hixson-Crowell model: According to this model, area of the particle is proportional to the cube root of volume, and the obtained data were calculated as per the given equation 7:

$(W0)\ 1/3 - (Wt)\ 1/3 = kt$ equation (7)

Where, "W0"represents the initial quantity of Terbinafine, "Wt" denotes the quantity of remaining dug at time t, and "k" is a constant incorporating surface volume relation.

Stability study of the TE3 emulgel formulation

The stability of the TE3 emulgel formulation was assessed as per the international conference on harmonization guideline for 6 months. The optimized TE3 emulgel formulation was placed at an accelerated temperature of 40°C±2°C/75±5% RH. The drug content of the optimized Terbinafine emulgel formulation was measured at an interval of 0 (beginning), 1, 2, 3, and 6 months **[37]**.

Statistical analysis

All results are presented as mean ± standard deviation (SD). The results were analysed using Duncan's multiple range test, wherein mean values were considered to be well separated at $p \leq 0.05$.

RESULTS AND DISCUSSION

Determination of globule size, extrudability, and pH

The Terbinafine emulgel formulation's (TE) average globule size was determined to be between 10.17 and 14.60 um. The concentration of emollient was connected to the extrudability of emulgel formulation. TE3 and TE2 had the best extrudability among the various formulas. In fact, TE3 was shown to have a stronger extrudability than other formulations, which was ascribed to a higher emollient content in TE3. A calibrated pH meter (Mettler-Toledo India Pvt. Ltd., Mumbai, India) was used to determine the pH of emulgel formulations. The skin must be compatible with the optimal topical formulation. Extrudability, globule size, and pH value were all measured in triplicates and reported as mean± SD **(Table 2)**.

Average globule size, extrudability, pH, and drug contents of various formulation codes. The globule size results are presented as mean ± SD (n=50).The extrudability results are presented as mean ± SD (n=3). The pH of all Terbinafine HCl emulgel formulations

was within acceptable limits, which is crucial to avoid skin irritation. The measurement of drug content is critical in determining the performance of topical dose forms. The data is provided as a mean standard deviation (n=3). SD: stands for standard deviation.

Determination of the drug content in formulated batches of emulgel formulations

A UV spectrophotometer was used to determine the proportion of medication contained in the produced emulgel formulations in terms of absorbance at 283.2 nm (Shimadzu 1700, Shimadzu analytical Pvt. Ltd., Mumbai). The drug concentrations in the TE2 and TE3 emulgel formulations were found to be 92.30 ± 0.21% and 94.06 ± 0.29%, respectively. Importantly, these drug percentages lied within the pharmacopoeia limits **(Table 2)**. **Figure 1** depicted the drug composition of the prepared batches visually. Thus, based on these results, the TE2 and TE3 formulations were selected for further analysis.

***In vitro* release study of optimized emulgel**

In vitro drug release testing indicated that the TE3 emulgel formulation released more drug than the TE2 formulation. The amounts of aloe vera and propylene glycol employed as gel basis and penetration enhancer, respectively, were shown to affect drug release from emulgel. Drug release of 87.8±42.5 % was reported in 7 hours for the TE3 formulation. As a result, the TE3 formulation was chosen as an optimum formulation for *in vitro* permeation testing. The results for cumulative % released measured using a cellophane membrane are graphically presented in **Figure 2**.

***In vitro* permeation study using the Franz diffusion cell**

The drug permeability of the TE3 emulgel formulation was greater than the TE2 formulation. The drug penetration of TE3 was determined to be 95.401.6 %, which remained constant throughout a 7-hour period. As a result, TE3 was chosen as the best emulgel formulation for testing hardness, cohesion, consistency, and viscosity. The findings of the *in vitro* permeation research, which are graphically shown in **Figure 3**.

The Franz diffusion cell was used to determine the penetration rate of Terbinafine HCL for TE3 and TE2 emulgel formulations. The drug diffusion medium was chosen to be phosphate buffer (pH 7.4). At a temperature of 37°C0.5°C, a cellophane membrane was employed to evaluate permeability. The data are presented as mean ± SD (n=3)

SD: Standard deviation

Evaluation of the consistency, cohesiveness, viscosity, and firmness of the optimized emulgel formulation

A texture analyzer was used to assess the consistency, cohesion, viscosity, and hardness of the improved emulgel formulations (TE3 and TE2). The TE3 emulgel formulation was shown to be harder, more cohesive, and more consistent than the TE2 emulgel formulation. The highest positive force for stiffness was measured at 67.604 g. The maximum negative area indicating emulgel cohesiveness was determined to be -49.480 g, while the consistency value of emulgel was found to be 591.697 g.sec when assessed in terms of mean positive area of curve. The negative index of viscosity's mean area was found to be 450.153 g.sec. A texture analyzer revealed that the TE3 emulgel formulation had better consistency than the TE2 formulation. Table 3 summaries all of these findings, which are visually shown in **Figures 4, 5**.

Determination of spreadability

The spreadability of the improved emulgel formulations (TE3 and TE2) were determined, with TE3 being found to be stiffer and exhibiting ideal spreadability, which was superior to that of TE2. For TE3, a very high value of mean maximum force of 833.37 g was measured, which indicated "firmness," and a mean area of 324.230 g.sec, which represented "work of shear." **Table 4** presents a summary of the findings. **Figures 6 and 7** exhibit spreadability graphs for the improved emulgel formulations. *In vitro* release kinetics model for the optimized emulgel formulation.

Based on the regression results, the optimum model for analyzing the release kinetics of the improved emulgel formulation was established. The regression result for the zero-order model was 0.996 **(Figure 8A)**. The regression value for the first-order model was 0.926 **(Figure 8B)**, whereas the regression value for the Higuchi kinetic model was 0.941. **(Figure 8C)**. The regression values for the Korsmeyer-Pappas and Hixon-Crowell models were 0.972 (Figure 8D) and 0.967 **(Figure 8E)**, respectively. The regression values for the aforementioned models were entered as < 1. The first release data for 60% of the medication fit into the Korsmeyer-Peppas model, suggesting that the release mechanism followed the Korsmeyer-Peppas model and confirming that the drug was released via a diffusion mechanism.

Stability study of the emulgel formulation

The emulgel formulation was shown to be stable for 6 months according to the stability

data. **Table 5** summaries the stability findings.

Study limitations

Traditional ointment and cream formulations demonstrated a slower rate of drug release than emulgel formulations. Despite the emulgel's many advantages, delivering water-insoluble medicines is a difficult task. The goal of this research was to make an emulgel utilizing a traditional approach. The goal of this study was to create an emulgel with aloe vera that is regarded safe to use, non-irritating, and has good spreadability and penetrability over the skin. An emulgel is a technology that helps to transport drugs deeper into the skin. The research constraint thus extends to the strategies for creating and exploiting such compositions.

Table 2: Globule size, extrudability, pH, and drug contents of the developed emulgel formulation

Sr. No.	Formulation code	Globule size (µm) (n=50)	Extrudability (g/cm2)	pH	Drug content (%) (n=3)
1	TE1	12.21±1.3	5.4±0.15	5.8	83.74±0.64
2	TE2	10.34±0.9	5.6±0.11	6.4	92.30±0.21
3	TE3	10.17±0.5	5.8±0.13	6.2	94.06±0.29
4	TE4	14.60±1.4	4.4±0.26	6.8	87.37±0.82

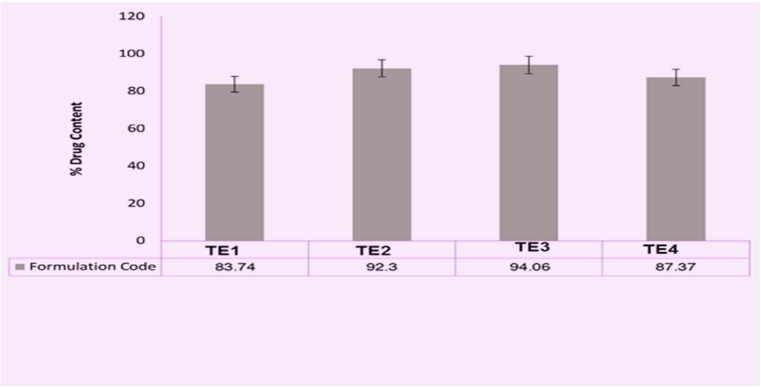

Figure 1: Drug content of the prepared emulgel formulations. TE3 displayed the highest drug content as compared with other formulations, but with non-significant differences (p<0.01); TE: Terbinafine Emulgel

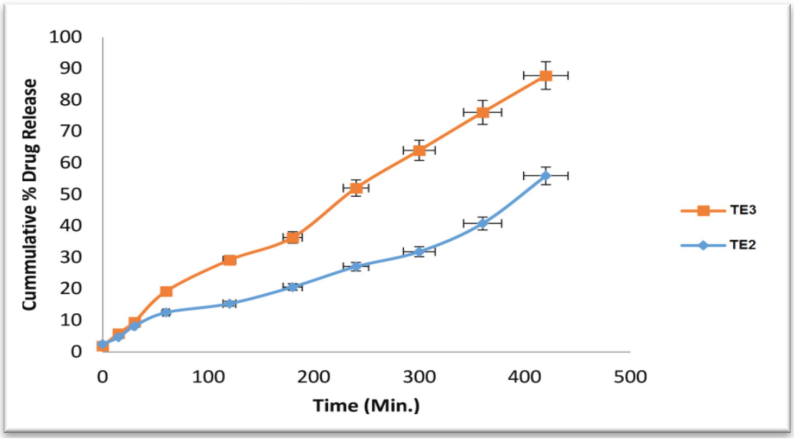

Figure 2: *In vitro* cumulative % drug release evaluated using a modified dissolution assembly. *TE3* showed better drug release than TE2. Values are represented as mean ± SD (n=3); TE: Terbinafine Emulgel, SD: Standard deviation

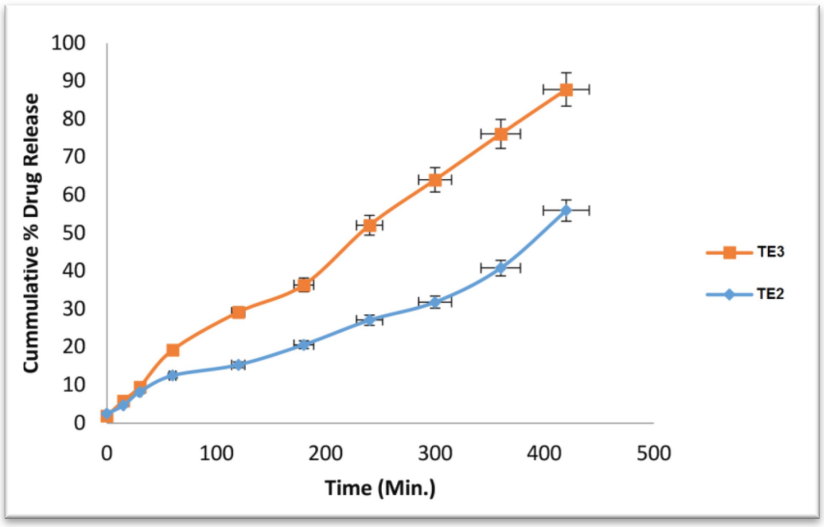

Figure 3: *In vitro* permeation study using a Franz diffusion cell

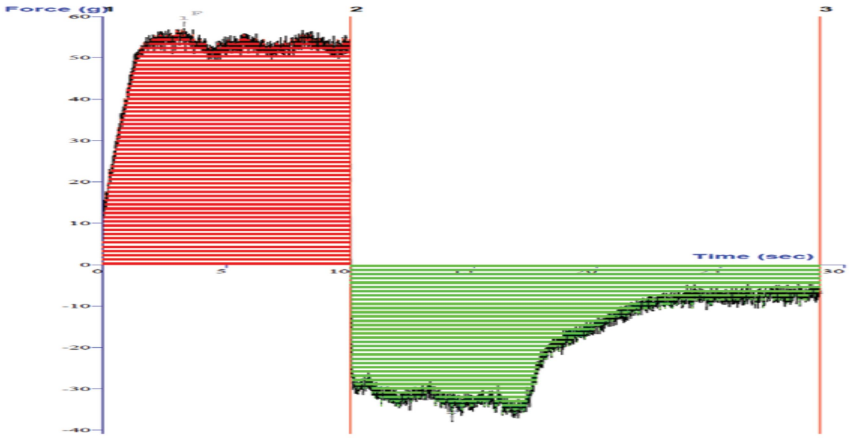

Figure 4: Consistency graph of emulgel formulation (formulation code TE3)

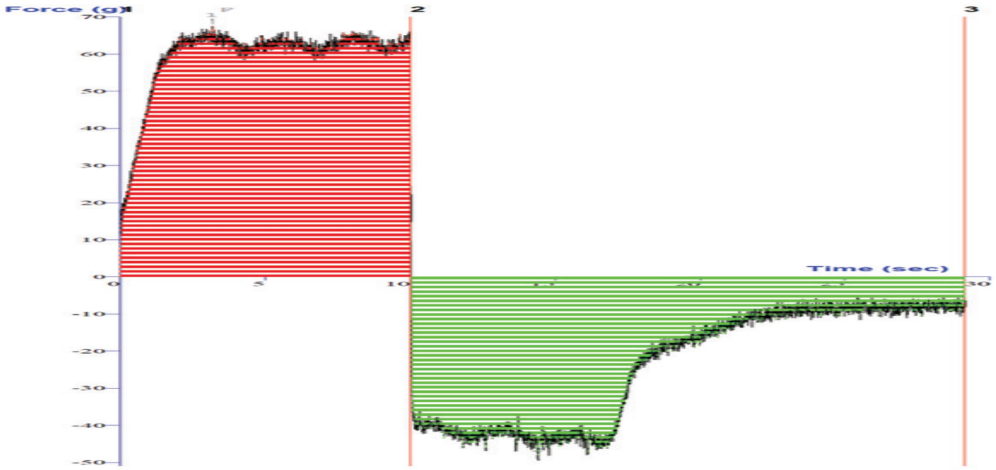

Figure 5: Consistency graph of an optimized emulgel formulation (formulation code TE2)

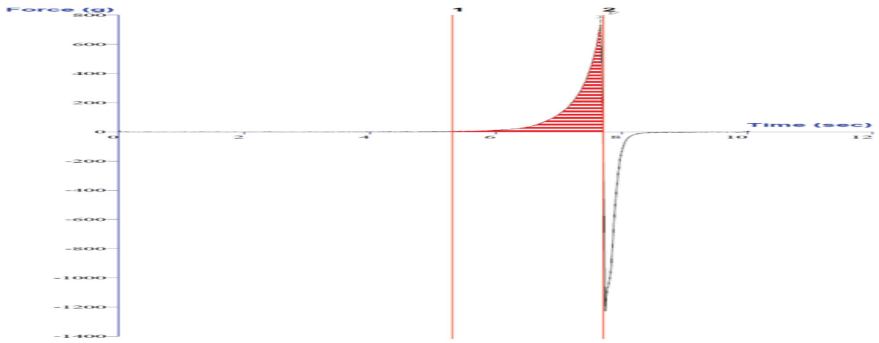

Figure 6: Spreadability graph of an optimized Terbinafine emulgel formulation (formulation code TE2) TE: Terbinafine Emulgel

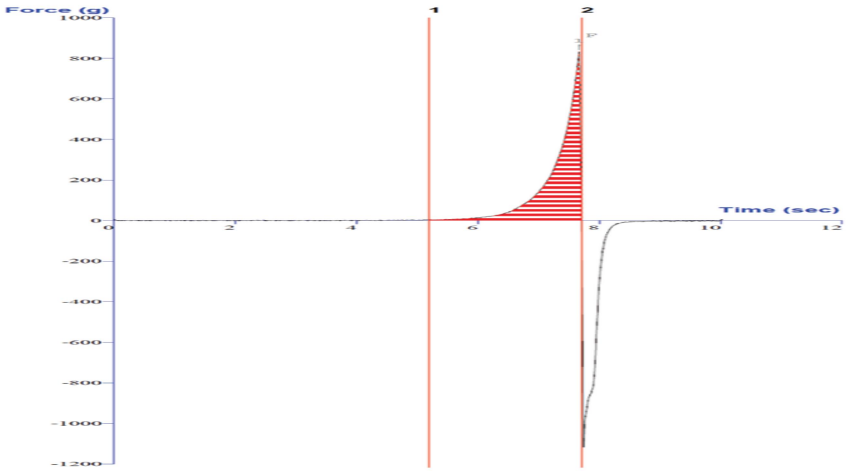

Figure 7: Spreadability graph of an optimized emulgel formulation (formulation code TE3)

Table 3: Results of consistency study of optimized emulgel formulations of Terbinafine HCl

S. No.	Formulation code	Mean maximum positive force "firmness" (g)	Mean positive area "consistency" (g.sec)	Mean maximum negative force "cohesiveness" (g)	Mean negative area "index of viscosity" (g.sec)
1	TE2	57.152	504.173	-38.027	-364.294
2	TE3	67.604	591.697	-49.480	-450.153

Table 4: Results of spreadability study of optimized emulgel formulations of Terbinafine HCl

S. No.	Formulation code	Mean max force "firmness" (g)	Mean area "work of shear" (g.sec)
1	TE2	734.522	276.821
2	TE3	833.37	324.230

max: Maximum

Table 5: Preliminary results of stability study of the emulgel formulation (formulation code TE3) (n=3)

Storage condition	Assay (%)				
	0 day	First month	Second month	Third month	Sixth month
40±2oC/75±5% RH	98.86±0.57	97.68±0.37	96.74±1.3	96.03±0.04	94.73±0.5

RH: Relative humidity

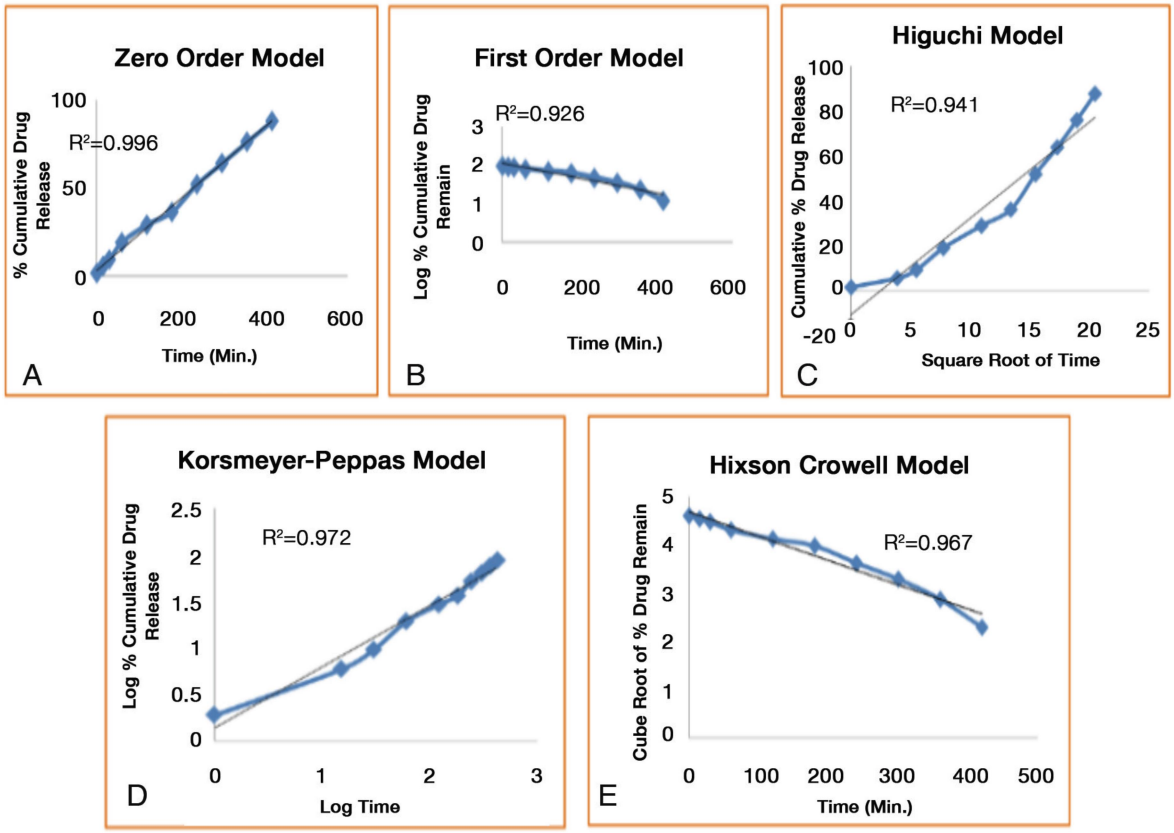

Figure 8: *In vitro* release kinetics model. A) Zero-order model, B) first-order model, C) Higuchi, D) Korsmeyer-Peppas model, and E) Hixson-Crowell model. For *in vitro* release study, a modified dissolution assembly was employed. Values are represented as mean ± SD (n=3)
SD: Standard deviation

CONCLUSION

The current work developed, formulated, and evaluated an aloe vera-based topical emulgel of Terbinafine HCl as a promising option for local drug administration into the skin. The new formulation offered a compelling option for improved patient compliance, extended contact duration at the target location, and simplicity of usage. TE3 formulation was shown to stick to biological membrane for a longer length of time and offer optimal medication release for the successful treatment of plaque psoriasis among the various formulations. Traditional formulations, such as ointment and cream, had longer contact duration than the TE3 formulation. These findings demonstrated the potential of an aloe vera-based emulgel formulation of Terbinafine HCl to penetrate epidermal barriers and treat plaque psoriasis effectively. In vivo and clinical investigations are also needed to confirm its potential for commercial development.

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