

FORMULATION AND DEVELOPMENT OF LIPID-BASED VESICLE SYSTEM CONTAINING SUCONAZOLE FOR TOPICAL DISEASE

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ABSTRACT

The present study was undertaken to formulate and evaluate a Sulconazole-loaded liposomal cream for improved topical antifungal therapy. Sulconazole-loaded liposomes were prepared by the thin-film hydration method using varying concentrations of soya lecithin and cholesterol, followed by incorporation of the optimized liposomes into a cream base. Preformulation studies confirmed the physicochemical suitability of Sulconazole, including a melting point of 132°C and λ_{max} of 235.0 nm. Among the developed formulations, F2 showed the optimum characteristics, with a particle size of 144.31 nm, zeta potential of -57.8 mV, and entrapment efficiency of 94.83%. SEM analysis revealed predominantly spherical, smooth, and non-aggregated vesicles. The optimized liposomal cream exhibited satisfactory physical properties, including a pH of 6.8, viscosity of 3562 cps, and spreadability of 12.56 g-cm/s. In vitro drug release demonstrated sustained release, with approximately 98% Sulconazole released over 13 h. The release profile showed the best fit to the Higuchi model ($R^2 = 0.9766$), indicating predominantly diffusion-controlled release. Antifungal evaluation against *Candida albicans* showed a greater zone of inhibition for the liposomal cream (16 mm) compared with the pure drug solution (11 mm). Overall, the developed Sulconazole-loaded liposomal cream demonstrated high drug entrapment, nanosized vesicles, sustained drug release, and enhanced antifungal activity, indicating its potential as an effective topical delivery system for superficial fungal infections.

KEYWORDS: Sulconazole, Liposomes, Liposomal Cream, Lipid-Based Vesicles, Topical Drug Delivery, Entrapment Efficiency, Sustained Drug Release, Antifungal Activity, *Candida albicans*, Higuchi Model.

1. INTRODUCTION

Liposomes are colloidal, concentric bilayered vesicles where aqueous compartment is entirely enclosed by a bilayer membrane, mainly composed of natural or synthetic lipids. The essential components of liposomal drug delivery system include phospholipids (mainly phosphatidylcholine) and cholesterol where cholesterol acts as a fluidity buffer. Although cholesterol do not participate in bilayer formation, it can be added to phosphatidylcholine up to 1:1 or even 2:1 molar ratio of cholesterol to phosphatidylcholine. Liposomes have gained much importance as potential drug carrier systems for targeted drug delivery (Grimaldi *et al.*, 2016).

Liposomes are mostly synthesized with cholesterol and an array of phospholipids constituents; whose chemical properties ultimately dictate liposomal properties. The most commonly used phospholipids are

phosphatidylcholines (PC), phosphatidylethanolamine (PE), phosphatidylserines (PS), phosphatidylglycerol (PG), and sphingomyelin. Liposomal net charges vary depending on the charges of phospholipids and can be neutral, cationic, or anionic (Drescher and van Hoogevest, 2020). Since both positively and negatively charged liposomes tend to be cleared faster due to their interactions with opsonizing proteins, liposomes with neutral charges are more commonly used. The physicochemical properties of liposomes, which include size, charge, surface properties and encapsulation efficiency, can greatly affect their stability and activity in vivo. For instance, liposomes made of unsaturated egg or soybean PC are usually highly permeable and less stable, whereas saturated phospholipids with long acyl chains such as 1,2-dipalmitoyl-sn-glycero-3-phosphatidylcholine (DPPC) give more rigid and stable liposomes with an impermeable bilayer (Nsairat *et al.*, 2022).

Sulconazole is an imidazole-class broad-spectrum antifungal agent widely used for the treatment of superficial fungal infections. It exhibits activity against dermatophytes, yeasts, and other pathogenic fungi by interfering with fungal ergosterol biosynthesis, thereby disrupting the integrity and function of the fungal cell membrane (**Saini et al., 2026**). Despite its therapeutic potential, the effectiveness of conventional topical Sulconazole formulations may be limited by its physicochemical properties, particularly its poor aqueous solubility and lipophilic nature. These characteristics can influence drug release, penetration through the skin, and availability at the site of infection. Therefore, development of an appropriate delivery system capable of improving drug localization, retention, and controlled release is desirable (**Yang et al., 2019**).

The thin-film hydration method is a widely employed technique for the preparation of liposomes because of its simplicity and ability to produce vesicles with desirable drug-entrapment characteristics (**Pande, 2023**). The physicochemical properties of liposomes, including particle size, surface charge, morphology, and entrapment efficiency, are strongly influenced by formulation variables such as phospholipid and cholesterol concentration. Optimization of these variables is therefore essential for obtaining a stable and effective vesicular formulation. Incorporating optimized liposomes into a suitable cream base can additionally improve spreadability, residence time, patient acceptability, and ease of topical application (**Lombardo and Kiselev, 2022**).

In vitro drug-release studies are important for evaluating the performance of lipid-based topical delivery systems and determining the release pattern of the incorporated drug. Mathematical kinetic models such as zero-order, first-order, Higuchi, and Korsmeyer-Peppas models can be applied to understand the rate and mechanism of drug release (**Waghule et al., 2019**). Furthermore, evaluation of antifungal activity provides an indication of the biological effectiveness of the developed formulation and helps determine whether vesicular delivery can improve the therapeutic performance of Sulconazole compared with the conventional drug (**Samee et al., 2023**).

Therefore, the present study was designed to formulate and develop a Sulconazole-loaded liposomal cream using the thin-film hydration technique for topical application. The prepared liposomes were optimized and evaluated for particle size, zeta potential, entrapment efficiency, and surface morphology. The optimized liposomal formulation was subsequently incorporated into a cream base and evaluated for its physicochemical properties, in vitro drug release, release kinetics, and antifungal activity against *Candida albicans*.

2. MATERIAL AND METHODS

2.1 Chemicals

Conc. HCl and Petroleum ether was obtained from Merck India Ltd. Mumbai, India. Sulconazole were procured from Jigs Chemical Limited, while Propylene glycol, Methyl paraben and Triethanolamine was supplied by Loba chemie. Glacial Acetic Acid was obtained from Research lab. Fizmerck provided the Sodium Hydroxide. Ethanol was obtained from Molychem. Clorofiltind procured from 95 % Alcohol, Ammonia and 1% Copper Sulphate Solution. All other reagents and solvents used were of analytical grade.

2.2 Pre-formulation Study

The pre-formulation study was conducted to evaluate the physicochemical properties of Sulconazole and to determine its suitability for incorporation into a stable and effective pharmaceutical dosage form (**Jones, 2018**).

2.2.1 Organoleptic Evaluation

Organoleptic evaluation was carried out to assess the physical characteristics of Sulconazole using visual observations such as appearance, color, odor, and texture. This preliminary assessment provides important information regarding the identity, purity, and overall quality of the drug substance (**Shah et al., 2026**).

2.2.2 Solubility Study Analysis

The solubility characteristics of Sulconazole were investigated as an important part of the pre-formulation study, since drug solubility significantly influences formulation development, selection of excipients, dosage form design, and therapeutic performance.. In the present study, the solubility profile of Sulconazole was evaluated in various pharmaceutical solvents, including methanol, ethanol, distilled water, chloroform, dimethyl sulfoxide (DMSO), and ethyl acetate (**Baseet et al., 2025**).

2.2.3 Melting Point Analysis

Melting point determination is an important pre-formulation parameter employed to evaluate the purity, identity, and thermal characteristics of pharmaceutical compounds. In the present study, the melting point of Sulconazole was determined using a calibrated digital melting point apparatus (**Albu, 2026**).

2.2.4 Determination of pH

Determination of pH is an important pre-formulation parameter used to assess the chemical stability of a drug and its compatibility with formulation excipients. In the present study, the pH of Sulconazole was determined using a calibrated digital pH meter (**David et al., 2026**).

2.2.5 Determination of Maximum Absorption Wavelength (λ_{max})

2.2.5.1 Preparation of Standard Stock Solution of Sulconazole in Methanol

A standard stock solution of Sulconazole was prepared by accurately weighing 5 mg of the drug and transferring it

into a 5 mL volumetric flask. Methanol was added gradually to dissolve the drug completely, and the volume was adjusted up to the mark with the same solvent to obtain a primary stock solution having a concentration of 1000 µg/mL. For the preparation of the working standard solution, 1 mL of the primary stock solution was withdrawn accurately and transferred into a 10 mL volumetric flask. The volume was then made up to the mark with methanol to obtain a solution containing 100 µg/mL of Sulconazole. The prepared solution was used for subsequent spectrophotometric analyses (Samee *et al.*, 2023).

2.2.5.2 Determination of λ_{max} of Sulconazole

For determination of λ_{max} , 2 mL of Sulconazole working standard (100 µg/mL) was diluted to 10 mL with methanol to obtain 20 µg/mL. The solution was scanned from 200–400 nm using a UV-Visible spectrophotometer with methanol as blank. The maximum absorbance was observed at 235.0 nm, which was selected as the analytical wavelength for further quantitative estimation (Shah *et al.*, 2026).

2.2.5.3 Linearity and Calibration Curve of Sulconazole

The linearity of Sulconazole was evaluated using standard solutions prepared from a 100 µg/mL working stock solution. Concentrations of 5–30 µg/mL were prepared in methanol, and absorbance was measured at 235.0 nm using methanol as blank. A calibration curve of absorbance versus concentration was plotted, and the regression equation and R^2 value were determined. The method showed good linearity over the selected concentration range, confirming its suitability for quantitative estimation of Sulconazole (Ma *et al.*, 2022).

2.2.6 Functional Group Identification by FTIR Spectroscopy

FTIR spectroscopy was used to identify the characteristic functional groups of Sulconazole and assess possible drug-exciipient interactions. Approximately 1 mg of Sulconazole was mixed with 100 mg of dried KBr, compressed into a pellet, and scanned over 4000–400 cm^{-1} using an FTIR spectrophotometer. The obtained spectra of the pure drug and liposomal formulations were compared for characteristic peaks. The analysis confirmed drug compatibility with the formulation excipients and the structural stability of Sulconazole after formulation (Mohamed *et al.*, 2017).

2.3 Preparation of Liposome formulation

Sulconazole-loaded liposomes were prepared by the thin-film hydration method using a rotary evaporator. Sulconazole (100 mg), soya lecithin (200–600 mg), and cholesterol (50–250 mg) were dissolved in chloroform (8 mL) and ethanol (2 mL). The mixture was evaporated at 40°C and 80 rpm for 30 min under reduced pressure to form a thin lipid film. The film was further dried under vacuum and hydrated with 10 mL phosphate buffer (pH 6.8) containing methyl paraben (0.02%) and propyl paraben (0.02%), with continuous stirring for 2 h. The resulting milky-white liposomal dispersion was centrifuged at 3000 rpm for 30 min to remove untrapped drug. Formulations LSF1–LSF5 were prepared by varying soya lecithin and cholesterol concentrations while maintaining a constant Sulconazole concentration (Abdelbari *et al.*, 2026).

Table 1: Composition of Liposome formulation.

Ingredients	Formulations				
	LSF1	LSF 2	LSF 3	LSF 4	LSF 5
Sulconazole (mg)	100.0	100.0	100.0	100.0	100.0
Soya lecithin (mg)	200.0	300.0	400.0	500.0	600.0
Cholesterol (mg)	50.0	100.0	150.0	200.0	250.0
Phosphate buffer pH (6.8)(ml)	10.0	10.0	10.0	10.0	10.0
Chloroform (ml)	8.0	8.0	8.0	8.0	8.0
Ethanol (ml)	2.0	2.0	2.0	2.0	2.0
Methyl paraben (%)	0.02%	0.02%	0.02%	0.02%	0.02%
Propyl paraben (%)	0.02%	0.02%	0.02%	0.02%	0.02%

2.4 Evaluation Parameters of Drug-Loaded Liposomal Formulation

2.4.1 Physical Properties

The prepared liposomal formulations were evaluated for their physical characteristics, including color, odor, appearance, texture, and homogeneity. These parameters were assessed by visual inspection to ensure the uniformity, consistency, and overall quality of the formulations (Maheshwari *et al.*, 2025).

2.4.2 Entrapment Efficiency (EE)

The entrapment efficiency of the Sulconazole-loaded liposomal formulations was determined to evaluate the amount of drug successfully encapsulated within the liposomal vesicles. The prepared formulations were centrifuged using a REMI ultracentrifuge at an appropriate speed for 30 min to separate the entrapped drug from the untrapped fraction. After centrifugation, the supernatant containing the free drug was carefully collected and filtered (Dave *et al.*, 2019).

$$\%EE = \frac{(\text{Initial amount of drug added} - \text{Drug amount in supernatant}) \times 100}{\text{Initial amount of drug added}}$$

Higher entrapment efficiency indicates better incorporation of Sulconazole within the liposomal vesicles and reflects the effectiveness of the formulation process.

2.4.3 Particle Size Analysis

The particle size of the Sulconazole-loaded liposomal formulations was determined using a Malvern Zetasizer based on the principle of dynamic light scattering (DLS) (Yang *et al.*, 2019).

2.4.4 Zeta Potential Analysis

Zeta potential analysis was carried out to determine the surface charge and electrostatic stability of the Sulconazole-loaded liposomal formulations. Subsequently, the samples were transferred into the zeta potential cell, and measurements were performed using a Malvern Zetasizer (Samee *et al.*, 2023).

2.4.5 Surface Morphology Analysis by SEM

The surface morphology of Sulconazole-loaded liposomes was evaluated using Scanning Electron Microscopy (SEM) (Pandey *et al.*, 2025).

2.5 Formulation of Liposomal Cream

The liposomal cream was prepared by the fusion method using oil and aqueous phases. The oil phase containing liquid paraffin and beeswax was heated at $75 \pm 2^\circ\text{C}$ until a homogeneous mixture was obtained. Simultaneously, borax and methyl paraben were dissolved in distilled water and heated to the same temperature. The aqueous phase was gradually added to the oil phase with continuous trituration to form a smooth cream base. The optimized Sulconazole-loaded liposomal dispersion was then incorporated into the cream base with gentle mixing to ensure uniform distribution. Finally, lavender oil was added as a fragrance, and the formulation was mixed thoroughly and stored in suitable containers for further evaluation (Kavian *et al.*, 2019).

Table 2: Composition of Liposome-Loaded Cream Formulation.

Ingredients	Formulation (Qty.)	Functional Role/Uses
Liposomes (equivalent to 1% drug)	10 mL	Active pharmaceutical ingredient (API)
Beeswax	4.0 g	Emulsifying agent, thickening agent
Liquid paraffin	15 mL	Emollient, moisturizing agent, skin softener
Methyl paraben	0.03 g	Preservative, antimicrobial agent
Lavender oil	3–4 drops	Fragrance, skin conditioning agent
Borax	0.4 g	Buffering agent, emulsifying aid, preservative

2.6 Evaluation Parameters of Liposome Cream Formulation

2.6.1 Physical Properties

The prepared liposome cream formulations were evaluated for various physical parameters, including color, appearance, odor, texture, homogeneity, and pH, to assess their quality, stability, and suitability for topical application (Radulescu *et al.*, 2026).

2.6.2 pH Analysis

The pH of the prepared liposome cream formulation was determined to evaluate its compatibility with the skin and its suitability for topical application using pH meter (Singh *et al.*, 2026).

2.6.3 Viscosity Analysis

The viscosity of the Sulconazole-loaded liposomal cream formulation was determined using a Brookfield DV-III Programmable Viscometer equipped with spindle S-6 (Părvănescu *et al.*, 2025).

2.6.4 Spreadability Analysis

The spreadability of the Sulconazole-loaded liposomal cream formulation was determined using the horizontal slide method to evaluate its ease of application and uniform distribution over the skin surface. Approximately 1 g of the cream was placed uniformly on a glass slide fixed to a flat wooden platform, and a second glass slide was carefully placed over the sample.

A weight of 125 g was applied on the upper slide for 5 min to obtain a uniform film of the cream between the two slides. Subsequently, the time required for the upper slide to move a specified distance under the influence of the applied weight was recorded. The spreadability of the formulation was calculated using Equation 04. Higher spreadability values indicate better consistency, ease of application, and improved patient acceptability of the topical formulation (Yang *et al.*, 2019).

The spreadability was calculated using the following equation:

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

2.7 In Vitro Drug Release Study of Drug-Loaded Liposomal Cream Formulation

The in vitro drug release of Sulconazole-loaded liposomal cream was evaluated using the dialysis bag diffusion method. A weighed quantity of formulation equivalent to a predetermined amount of Sulconazole was placed in a pre-soaked dialysis membrane and immersed in 100 mL phosphate buffer (pH 7.4). The system was maintained at $37 \pm 2^\circ\text{C}$ and stirred at 100 rpm. At predetermined intervals, 2 mL samples were withdrawn and replaced with an equal volume of fresh buffer. The samples were analyzed using UV-Visible spectrophotometry at 235.0 nm, and cumulative percentage drug release was calculated and plotted against time (Pandey *et al.*, 2025).

2.7.1 Drug Release Kinetic Modelling

The in vitro drug release data of Sulconazole-loaded liposomal cream were fitted to zero-order, first-order, Higuchi, and Korsmeyer–Peppas models to determine the release pattern and mechanism. The models describe constant-rate, concentration-dependent, diffusion-controlled, and anomalous release behavior, respectively. The best-fit model was determined by comparing the correlation coefficient (R^2) values obtained for each model, providing insight into the predominant mechanism of Sulconazole release from the liposomal cream (Patel, 2023).

The kinetic models employed for data analysis were as follows

- Zero-order kinetic model: Cumulative percentage drug released versus time.
- First-order kinetic model: Log cumulative percentage drug remaining versus time.
- Higuchi model: Cumulative percentage drug released versus square root of time.

- Korsmeyer–Peppas model: Log cumulative percentage drug release versus log time.

2.8 Antifungal Activity

The antifungal activity of the Sulconazole-loaded liposomal formulation was evaluated by the agar well diffusion method against selected fungal strains, namely *Candida albicans* and *Aspergillus niger*. Sabouraud Dextrose Agar (SDA) medium was prepared, sterilized, and inoculated with freshly cultured fungal suspensions under aseptic conditions. Wells of uniform diameter were made in the agar plates, and predetermined quantities of the liposomal formulation were introduced into the wells. A standard Sulconazole solution was used as the reference, while a blank formulation served as the control. The inoculated plates were incubated at 28–30°C for 24–48 h, after which the antifungal activity was assessed by measuring the diameter of the zones of inhibition around each well. The extent of fungal growth inhibition was considered an indicator of the antifungal efficacy of the formulation (Acharya and Hare, 2022).

3. RESULTS

3.1 Pre-formulation study of drug

3.1.1 Organoleptic properties

Table 3: Organoleptic properties of Sulconazole.

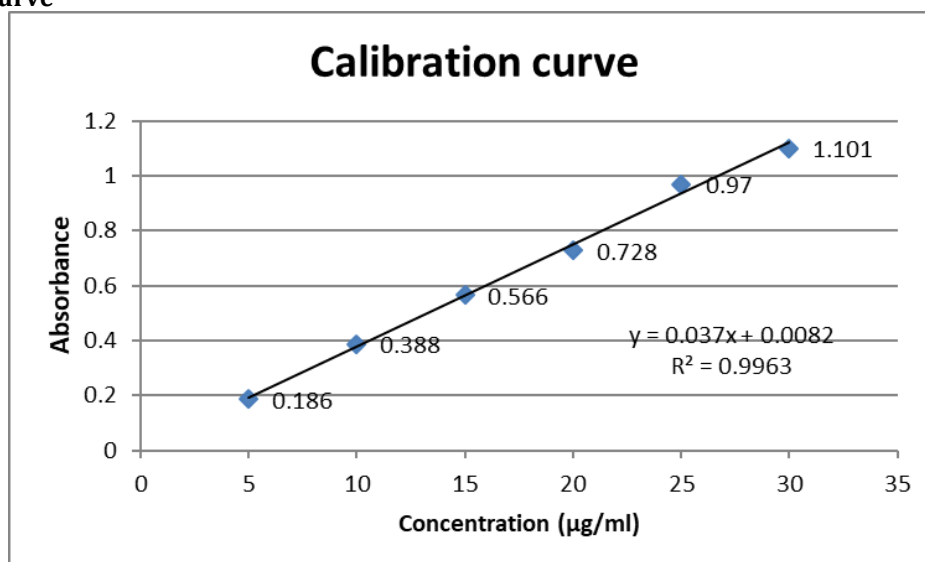
Drug	Organoleptic properties	Observation
Sulconazole	Color	White
	Odor	Characteristics
	Appearance	White powder
	State	Solid

3.1.2 pH and melting point determination

Table 4: pH and melting point of Sulconazole.

Drugs	Observed (pH)	Observed (melting point)	Reference (melting point)
Sulconazole	6.7	132°C	130.5 to 132°C

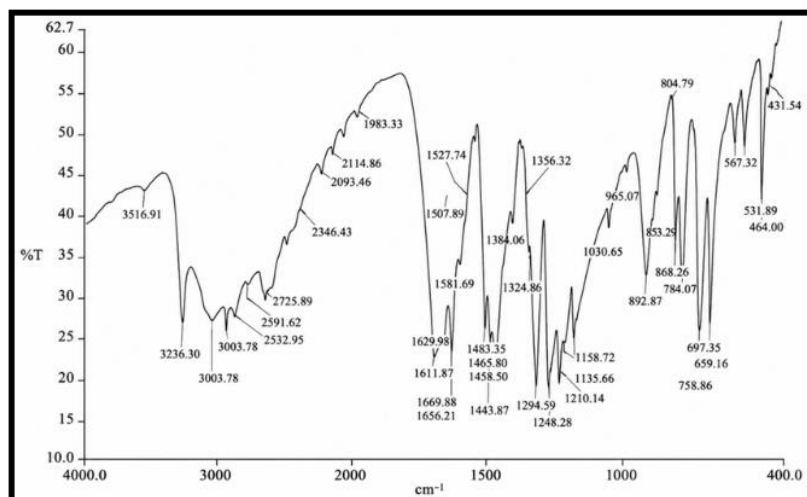
3.1.3 Calibration curve



Graph 1: Calibration curve of Sulconazole.

3.1.4 Functional group identified by Fourier transform infrared (FTIR) study

1. FTIR of Sulconazole



Graph 2: Sulconazole FTIR.

Table 5: Interpretation of IR spectrum of Sulconazole.

Peak Position (cm ⁻¹)	Functional Group	Assignment
3236.30	Aromatic C-H	Stretching vibration
1629.98	C=N	Imidazole ring stretching
1581.69	C=C	Aromatic ring stretching
1527.74	C=C	Aromatic skeletal vibration
1384.06	C-N	Heterocyclic ring stretching
1248.28	C-N	Imidazole ring vibration
1030.65	C-O/C-N	Stretching vibration
804.79	Aromatic C-H	Out-of-plane bending
697.35	C-Cl	Stretching vibration
567.32	C-S	Sulfide group stretching

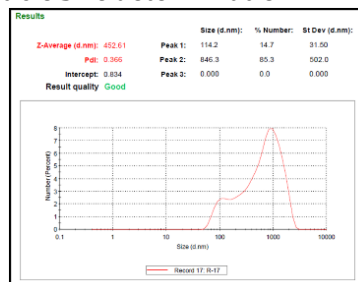
3.2 Characterization of Liposomes formulation

3.2.1 Physical appearance of liposomes

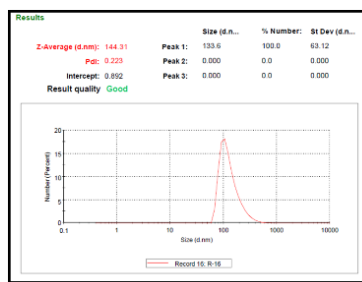
Table 7: Physical Appearance.

Parameter	Observation
Color	Milky white
Appearance	Homogeneous suspension
Texture	Smooth
Phase separation	Absent
Sedimentation	Absent
Aggregation	Not observed

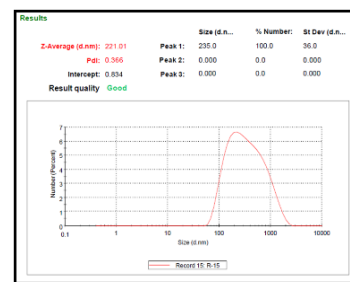
3.2.2 Particle Size determination



Graph 3: Particle size of liposome (F1)



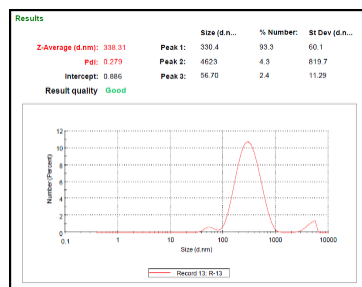
Graph 4: Particle size of Liposome (F2)



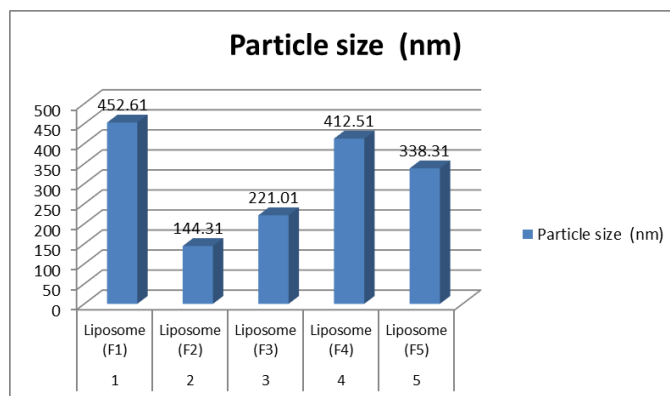
Graph 5: Particle size of Liposome (F3)



Graph 6: Particle size of Liposome (F4)

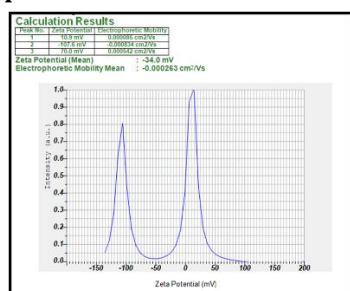


Graph 7: Particle size of Liposome (F5)

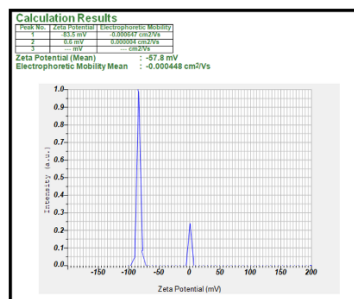


Graph 8: Graphical representation of Particle size.

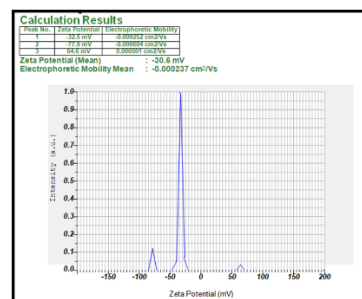
3.2.3 Zeta potential determination



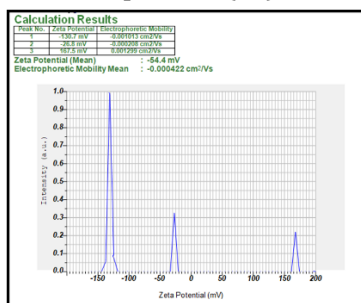
Graph 9: Zeta potential of Liposome (F1)



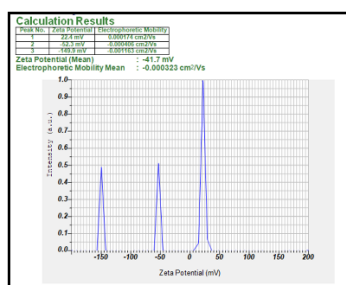
Graph 10: Zeta potential of Liposome (F2)



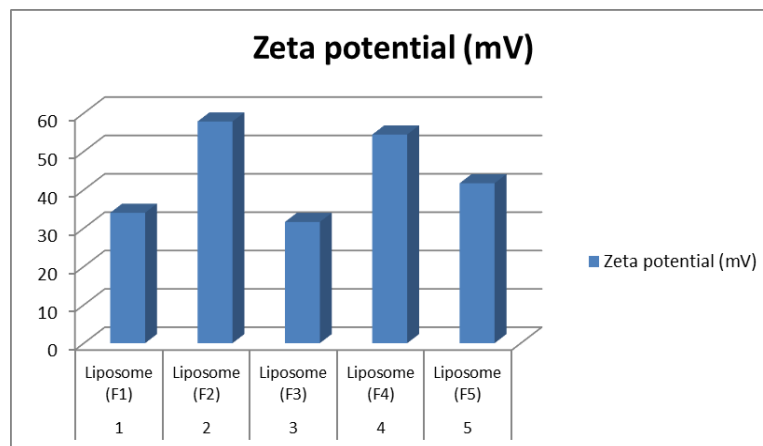
Graph 11: Zeta potential of Liposome (F3)



Graph 12: Zeta potential of Liposome (F4)

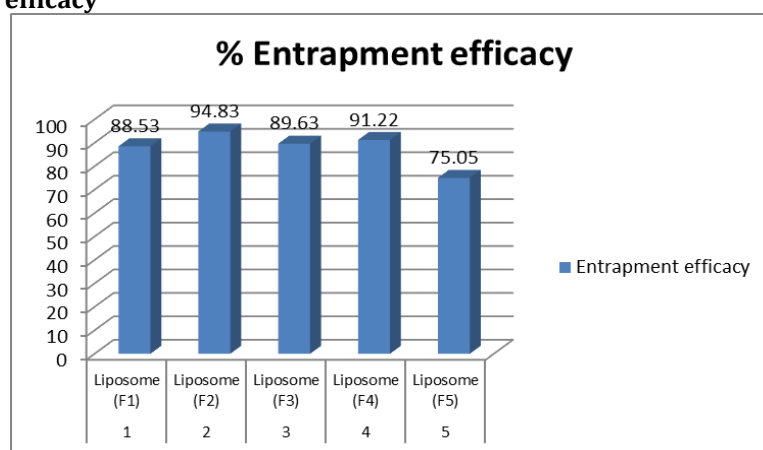


Graph 13: Zeta potential of Liposome (F5)



Graph 14: Graphical representation of Zeta potential.

3.2.4 % (EE) Entrapment efficacy



Graph 15: % Entrapment efficiency.

Table 8: Entrapment efficacy, Particle size and Zeta potential.

Formulations	Entrapment efficacy	Particle size (nm)	Zeta potential (mV)
Liposome (F1)	88.53	452.61	-34.0
Liposome (F2)	94.83	144.31	-57.8
Liposome (F3)	89.63	221.01	-31.6
Liposome (F4)	91.22	412.51	-54.4
Liposome (F5)	75.05	338.31	-41.7

3.2.5 Scanning electron microscope (SEM) of F2 Formulation

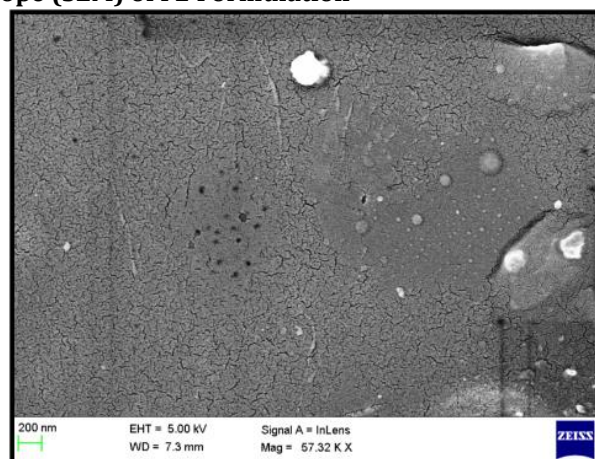


Figure 1: Scanning electron microscope (SEM).

3.3 Evaluation parameter of drug loaded liposome cream formulation

3.3.1 Physical appearance

Table 9: Physical appearance.

Parameter	Result
Colour	White to off-white
Odour	Characteristic or mild (non-offensive)
Appearance	Smooth, creamy, semi-solid
Homogeneity	Uniform, no phase separation

3.3.2 Viscosity, pH and Sped ability of Liposome cream

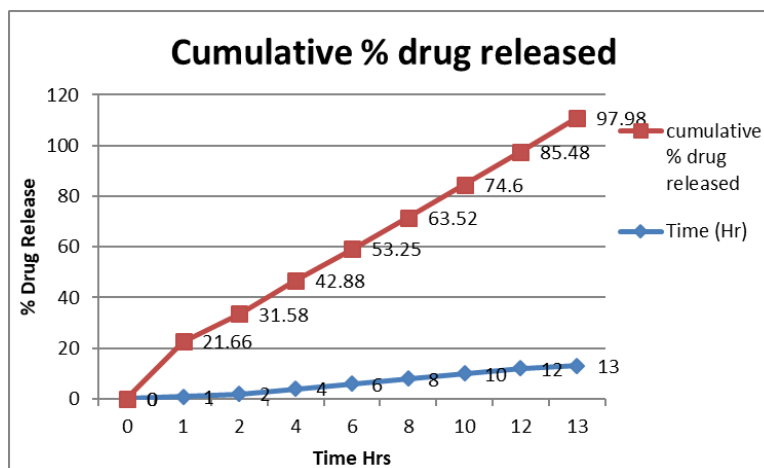
Table 10: Result of Viscosity, pH and Sped ability.

Formulation	Viscosity (Cps)	pH	Spreadability (g.cm/s)
Liposome cream	3562 cps	6.8	12.56 g-cm/sec

3.3.3 Release study

Table 11: *In Vitro* Drug Release Study.

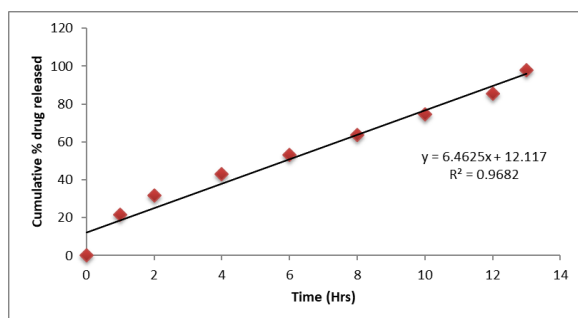
Time (Hr)	cumulative % drug released	% drug remaining	Square root time	log Cumu % drug remaining	log time	log Cumu % drug released
0	0	100	0.000	2.000	0.000	0.000
1	21.66	78.34	1.000	1.894	0.000	1.336
2	31.58	68.42	1.414	1.835	0.301	1.499
4	42.88	57.12	2.000	1.757	0.602	1.632
6	53.25	46.75	2.449	1.670	0.778	1.726
8	63.52	36.48	2.828	1.562	0.903	1.803
10	74.6	25.4	3.162	1.405	1.000	1.873
12	85.48	14.52	3.464	1.162	1.079	1.932
13	97.98	2.02	3.606	0.305	1.114	1.991



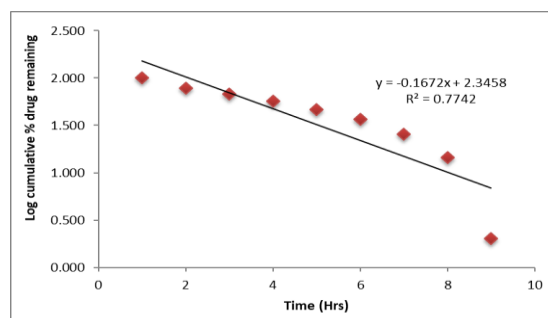
Graph 16: Cumulative Drug Release Study.

Table 12: Correlation value (R^2 value).

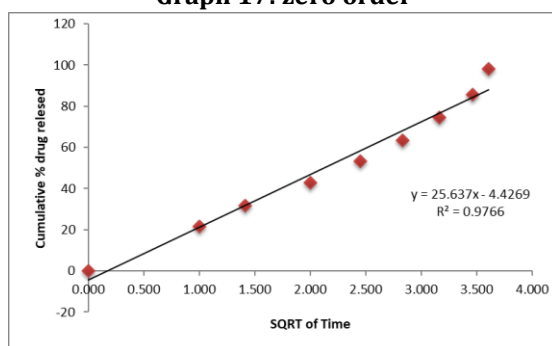
Formulation	Model	Kinetic parameter values
Liposome cream Formulation	Zero Order	$R^2 = 0.9682$
	First Order	$R^2 = 0.7742$
	Higuchi	$R^2 = 0.9766$
	Korsmeyerpeppas	$R^2 = 0.6343$



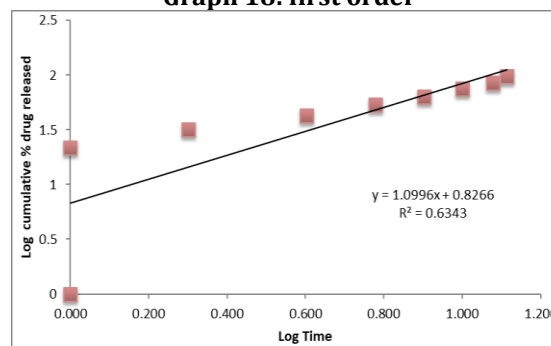
Graph 17: zero order



Graph 18: first order



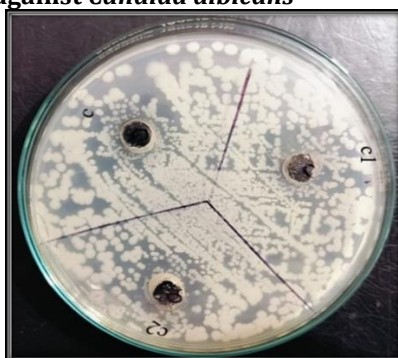
Graph 19: Higuchi



Graph 20: Korsmeyer peppas

3.4 Antifungal activity of Liposomal cream formulation

3.4.1 Antifungal activity of Formulation against *Candida albicans*

Figure 2: Antifungal activity against *Candida albicans*.Table 13: Anti antifungal activity of Formulation against *Candida albicans*.

Sample Name (mg/ml)	Zone of Inhibition (mm) of <i>Candida albicans</i>
C (control)	0 mm
Drug C1(1mg/ml)	11 mm
Formulation C2 (1mg/ml)	16 mm

4. DISCUSSION

The present study successfully developed and evaluated Sulconazole-loaded liposomal cream for improved topical antifungal therapy. Preformulation studies confirmed the identity, purity, and suitability of Sulconazole for formulation development. The drug showed poor aqueous solubility, supporting the use of a lipid-based delivery system. FTIR and UV studies confirmed drug integrity and provided a reliable method for quantitative analysis. Liposomes prepared by the thin-film hydration method showed satisfactory physicochemical characteristics. Among the formulations, F2 demonstrated the optimum properties, with a particle size of 144.31 nm, zeta potential

of -57.8 mV, and maximum entrapment efficiency of 94.83%. SEM confirmed predominantly spherical, smooth, and non-aggregated vesicles. The optimized liposomes were successfully incorporated into a cream base, producing a homogeneous formulation with suitable viscosity (3562 cps), pH (6.8), and spreadability (12.56 g/cm/s).

The liposomal cream exhibited sustained drug release, with approximately 98% Sulconazole released over 13 h. The release profile showed the best fit to the Higuchi model ($R^2 = 0.9766$), indicating predominantly diffusion-controlled drug release. Antifungal evaluation against

Candida albicans showed a greater zone of inhibition for the liposomal cream (16 mm) compared with the pure drug solution (11 mm), demonstrating enhanced antifungal activity. Overall, the optimized Sulconazole-loaded liposomal cream showed improved encapsulation, stability, sustained release, and antifungal efficacy, indicating its potential as an effective topical delivery system.

5. CONCLUSION

The present investigation successfully developed and evaluated a Sulconazole-loaded liposomal cream as a promising lipid-based vesicular system for topical antifungal therapy. The optimized formulation F2 exhibited desirable characteristics, including a nanosized particle size of 144.31 nm, high negative zeta potential of -57.8 mV, and excellent entrapment efficiency of 94.83%. SEM confirmed spherical and smooth vesicles with minimal aggregation. Incorporation of the optimized liposomes into the cream base produced a homogeneous formulation with suitable pH, viscosity, and spreadability. The formulation demonstrated sustained drug release, with approximately 98% drug release over 13 h, following predominantly Higuchi diffusion-controlled kinetics ($R^2 = 0.9766$). Furthermore, the optimized liposomal cream showed enhanced antifungal activity against *Candida albicans*, producing a 16 mm zone of inhibition compared with 11 mm for the pure drug solution. Overall, Sulconazole-loaded liposomal cream offers improved drug encapsulation, sustained release, and enhanced antifungal performance, indicating its potential as an effective topical delivery system for the treatment of superficial fungal infections. Further in vivo studies and long-term stability evaluation are recommended to establish its therapeutic potential and clinical applicability.

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