RESEARCH ARTICLE

Formulation, Development & Evaluation of *Mallotus philippensis* Extract Loaded NLCS based Nanogel for Psoriasis

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ABSTRACT

The current study's objective was to develop and evaluate the potential of Bergenin-loaded nanostructured lipid carriers (NLCs) as a novel topical therapeutic for psoriasis, obtained from *Mallotus philippensis*. NLCs loaded with Bergenin were created using a modified Hot-melt emulsification technique, and then Box-Behnken design optimization was performed. The Independent factors were concentration of solid lipid, the concentration of liquid lipid and the concentration of surfactant. Particle size, entrapment efficiency, and drug permeation percentage were the dependent variables. The Bergenin-nano-lipid carriers (NLCs) that has been optimized has a Particle size of 148 ± 0.37 nm, an %Entrapment efficiency of 93.44 ± 0.45%, and a drug permeation percentage was found to be 83.56 ± 0.137. and the zeta potential was - 0.0617 ± 5.53 mV and the polydispersity index (PDI) was 0.30 ± 0.03. Bergenin's existence within the NLCs was verified by FTIR. The outcomes show that Nanostructured lipid carriers have the ability to deliver Bergenin for topical psoriasis treatment.

Keywords: Psoriasis, NLCs, Bergenin, *Mallotus philippensis*, %Entrapment efficiency, Particle size, Polydispersity index, Zeta Potential.

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INTRODUCTION

Psoriasis is a skin condition marked by distinct, non-contagious patches of thickened skin, typically colored peach-pink or drab-red, and covered with silver-colored scales. These patches are a result of an autoimmune response, leading to inflammation and rapid skin cell growth which causes discomfort and itchiness.[1] Skin cells normally divide and regenerate in a regular cycle, but in psoriasis, the epidermis hyperproliferates, keratinocytes mature prematurely, and cornification is incomplete, with nuclei remaining in the stratum corneum, resulting in the creation of patches.[2]

About 2% of people suffer with psoriasis, a common and chronic skin disorder. Psoriasis is categorized by the National Organization for Rare Disorders (NORD) as a rare inflammatory recurrent chronic skin condition. First-line treatments are conventional topical medicines such as dithranols, corticosteroids, and vitamin D and its analogs.[3]

Epidemiological surveys reveal the global prevalence of psoriasis, with varying rates across different countries and age groups. In children, the prevalence is notably lower, such as 0% in Taiwan, 0.71% in Germany, and 2.1% in Italy. However, in adults, the prevalence is higher, with rates of 5.20% reported in France.[4] Psoriasis, is managed through various treatment modalities including topicals, systemics, phototherapy, combination therapies, herbal remedies, and emerging compounds. Among the topically applied medications are Vitamin D analogs like calcipotriol, corticosteroids, dithranol, and retinoids. In extreme situations, systemic medicines like cyclosporine and methotrexate are given. UV-B, Psoralen with UV therapy, and excimer laser treatments are all part of phototherapy.[5]

However, despite the array of treatment options, several issues persist. Effectiveness can be limited, and discomfort or adverse reactions may occur, potentially leading to organ damage or even carcinogenic effects. While current treatments provide symptomatic relief, they often fail to address the underlying causes of psoriasis.[6]

M. philippensis, a perennial shrub belonging to the Euphorbiaceae family, distributed across tropical and subtropical regions, particularly in the outer Himalayas. Its diverse chemical composition includes phenols, steroids, diterpenoids, flavonoids, coumarins, triterpenoids, cardenolides, and isocoumarins. Pharmacologically, it demonstrates antioxidant, antimicrobial, antiviral, cytotoxic, immunoregulatory, anti-inflammatory and anti-cancer properties.[7]

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Bergenin, a prominent compound derived from *M. philippensis*, possesses moderate antioxidant properties and is classified as a BCS class IV molecule. To overcome problems due to its low permeability and solubility, formulating Bergenin into nanoparticles or novel dosage forms can enhance its solubility, retention in skin layers, and release over time.[8] Topical administration of Bergenin offers advantages such as better patient compliance, site-specific drug delivery, and reduced adverse effects compared to oral administration.

Utilizing a core matrix made up of both liquid and solid lipids, nanostructured lipid carriers (NLCs) are an advanced class of drug delivery methods. NLCs have a number of benefits over typical carriers in drug delivery, such as increased solubility, better permeability and bioavailability, less adverse effects, longer half-lives, and tailored distribution to particular tissues.[9]

Since NLCs can be administered differently, with a focus on topical and parenteral routes and have gained lots of attention in recent years.[10] Figure 1 explains the **e**valuation of Lipid based nanoparticles

The development of NLCs aims to improve upon SLNs by offering enhanced drug loading capacity and improved stability. NLCs can accommodate higher drug payloads and exhibit greater stability during storage and transportation.[11]

Polymer nanoparticles (PNPs) play a crucial role in medication delivery by further enhancing drug stability and enabling controlled release. These nanoparticles can efficiently direct therapeutic delivery to specific targets, thereby enhancing the efficacy of drug therapy while minimizing systemic side effects. NLCs can be engineered to target specific tissues or organs, maximizing therapeutic effects while minimizing off-target effects.[12]

MATERIALS AND METHODS

Reagents

Reagents used in the study were: Bergenin Extract "Root Extract of Mallotus Philippensis" (Ambe NS Agro Products Pvt. Ltd. New Delhi, India, a WHO GMP, USFDA certified organic and botanical extract producer), Soy wax (BRM Herbals, Tilak bazar, New Delhi), Tamanu oil (Aromaaz International, Sahibabad, Ghaziabad, UP) and Tween 20(CDH).

Methods

Determination of Bergenin

The amount of Bergenin in the samples was determined using an HPLC technique. A wavelength of 265 nm was chosen for the detection. As the mobile phase, chloroform: methanol: acetic acid (8:1:1, v/v/v) was employed, while precoated HPLC silica gel plates served as the stationary phase.

Melting point is used to identify and characterize Bergenin. Additionally, it was examined at wavelengths between 200 and 400 nm using a UV-vis spectrophotometer.[13]

Calibration Curve

Firstly, 100 mL of standard solution of drug is prepared of concentrated 1-mg/mL. after that the running solution is prepared by taking 1-mL from standard solution and diluted up to 100 mL by the solvent. After the preparation of running solution, the serial dilution is made of concentrated 2 up to 10 µg/mL with using same solvent system. Then the absorbance of drug in each dilution is measured by using UV-spectrophotometer.[14]

Preparation of Bergenin-loaded NLCs

The Bergenin-loaded NLCs were fabricated through a modified Hot Melt Emulsification method. For both Blank and *M. philippensis* root extract entrapped NLCs, this process involved initially heating lipid fractions composed of tamanu oil (liquid lipid) and soy wax (solid lipid) to a temperature of 60 ± 2°C until they formed a homogeneous, transparent molten mixture. This molten lipid phase was then combined with the medication (M root extract) right before it hardened. To create a primary emulsion, an aqueous phase containing dispersed Tween 20 was simultaneously introduced, drop by drop, to the molten lipid mass at the same temperature. Subsequent steps included homogenization at 25000 rpm for 15 minutes, followed by sonication for 5 minutes at 80% amplitude for 6 cycles using Labsonic® M equipment, to achieve a nanoemulsion (Figure 2). In order to create NLCs, this nanoemulsion was quickly cooled in ice-cold water. The NLCs were then preserved at 4°C for additional analysis. Ultimately, the prepared NLCs were subjected to centrifuge for 30 minutes at the speed of 9000 rpm to separate and save the stable NLCs and discard the supernatant.[15]

Design of Experiment

In this study, NLCs were optimized using the Box Behnken design, which was carried out using Statease's Design Expert® 13 software. Three crucial parameters had to be manipulated in order to optimize the process: Concentrations of liquid lipid, solid lipids and surfactants.[16] A thorough analysis was conducted to determine how these independent variables affected the dependent variables, which included %drug permeation, entrapment efficiency, and particle size. A number of mathematical models, including 2F, quadratic, and linear models, were used to assess the optimization procedure. ANOVA was used as an extra tool to evaluate the overall

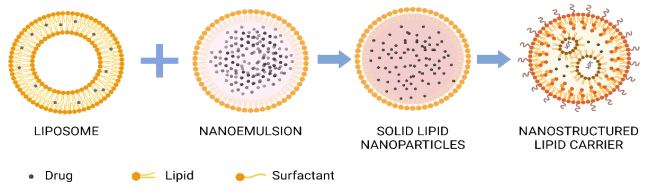

Figure 1: Evaluation of lipid based nanoparticles

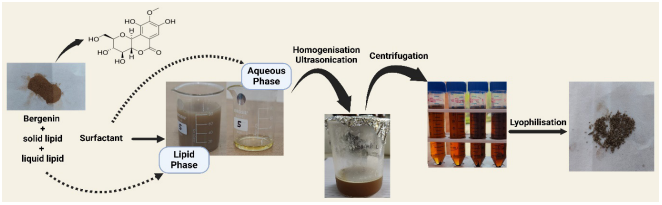

Figure 2: Preparation of NLCs

significance of the model. The polynomial equations produced by the software were used to assess the positive and negative effect of each factor on particle size, entrapment efficiency, and permeation studies. The validity of the method was verified by comparing actual and predicted values for each response. In addition, the p-values of regression coefficients were used to establish the significance of factors influencing the responses.

Drug and Excipient Compatibility Studies (FTIR)

FTIR spectra was taken with potassium bromide discs system, spectra were recorded in the 400 to 4000 cm^{-1} frequency range at a frequency of 4 cm^{-1}. The Bruler FT–IR instrument was used for the spectral analysis. 30 days were spent keeping the drug and excipients (1:1 w/w) at 402°C and 75% relative humidity. Drug, specific excipients, and mixtures of excipients and drug were crushed, mixed well with potassium bromide in a mortar for three to five minutes, and then compressed into discs using a hydraulic press operating at five tons of pressure for five minutes. The potassium bromide sample concentration needs to be between 0.2 and 1%. After the pellets were aimed toward the light, the spectrum was collected and analysed for any indications of interactions.[17]

Preparation of Nanogel

Carbopol solution was used as the gelling medium, and Bergenin was dispersed throughout the NLC formulation to create the Bergenin-loaded nanostructured lipid carrier (NLC) gel. The appropriate consistency of the gel was achieved by the use of carbopol as the gelling agent.

By altering the pH, the gel viscosity of formulation could be regulated. This had an impact on the network creation and swelling behavior of the polymer, which in turn changed the gel's rheological characteristics and consistency. Using this method guaranteed the creation of a gel with the best properties for use and drug administration.[18]

Entrapment Efficiency

Using the cool centrifugation process, an indirect technique was used to determine the EE% of Bergenin-NLCs. To separate the free medication, 10 mL of Bergenin-NLC was put in a centrifuge tube and centrifuged at 10,000 rpm for 30 minutes. The concentration was calculated using a UV spectrophotometer set to the Bergenin standard curve at a wavelength of 265 nm after that the supernatant was collected, filtered and diluted with phosphate buffer pH 7.4. A reference cuvette was filled with blank NLCs that were diluted the same. The equation used to calculate the EE% was:[19]

$$\text{EE}\,(\%) = \frac{Total\ drug - Free\ drug}{Total\ drug} \times 100$$

where the drug amount added is known as the total drug, and the amount of drug present in the supernatant is free drug.

Percentage Yield

The percentage yield was estimated by the division of weight of recovered NLCs by the weight of the drug and lipid utilized to produce nanoparticles.[20]

$$Percentage\ Yield = \frac{Weight\ of\ recovered\ NLC}{Theoretical\ weight\ (drug + lipid)} \times 100$$

Particle Size (PS), Zeta Potential (ZP) and Polydispersity (PDI)

PS, PDI, and ZP were measured on the generated BN-NLCs using a particle size analyzer (Malvern S90). Particle homogeneity can be assessed using the PDI value. A value of less than one is considered uniform. To make a cuvette for analysis, BN-NLC was dissolved in double-distilled water. The zeta potential was evaluated on the identical sample.[21]

XRD Analysis

Using a Bruke D2 Phase diffractometer, XRD analysis was utilized to evaluate the crystalline structure of Bergenin. In a 2θ angle setup, the sample was evaluated using CuKα radiation (λ = 1.54 Å). At a rate of 2°/min, the sample was scanned within the measurement range of 10° to 50°.[22]

SEM (Scanning Electron Microscopy)

An HRSEM was used to study the surface morphology of BN-NLCs. The drop cast method, which entailed depositing a drop on a carbon-coated grid and allowing it to cure at room temperature, was used to evaluate the generated NLCs' colloidal dispersion. Furthermore, the photo was taken at an accelerated voltage of 200 kV.[23]

Permeation Study

A 0.64 cm^2 diffusion area Franz-type diffusion cell was used for the permeation study. The magnetic stirrer-mounted diffusion cells were linked to a water bath set at 32 ± 0.1°C. 0.3 cc of BN-loaded NLC dispersion was administered.[24]

Drug Release Study

Using a dialysis bag that had been pre-soaked for 24 hours, the release of bergenin from the prepared and optimized formulation was conducted to determine the concentration of drug released from the NLCs in phosphate buffer saline (pH) solution. Pre-soaked dialysis bags (LA401-1MT Himedia) were used to assess the release profile. The BN-NLCs were placed into the dialysis bag. After that, the bag with the samples is filled with the dissolving medium (250 mL). The temperature was kept constant at 37°C and the stirring speed was 350 rpm. To maintain the sink state, 5 mL of release medium was gathered and replenished with an equivalent volume at prearranged intervals. After further diluting the sample, the amount of Bergenin present at various time intervals was measured using a UV spectrophotometer set to 265 nm. We performed each technique three times. To determine the release process, the data was fitted to several mathematical models.[25]

RESULTS AND DISCUSSION

Bergenin-Determination

Bergenin was found to have a melting point of 240°C. Bergenin diluted in ethanol has a UV-visible spectrum with a maximum at 265 nm.

HPLC report of bergenin was found satisfactory which shows that *M. philippensis* root extract contains 0.06378 mg bergenin in 1-mg of root extract.

Calibration Curve

Bergenin was found to be soluble in ethanol. The maximum absorbance was found to be at 265nm. The equation y = 0.0314x+0.0256 was determined, and it was discovered that the regression coefficient (R2) has a value of 0.9982. The calibration curve was plotted between concentration and absorbance.

Formulation development

NLCs were prepared using a significantly modified Hot-Melt Emulsification Method. In short, a clear molten mass was produced by heating lipid fractions made up of solid lipid (soy wax) and liquid lipid (tamanu oil) to a temperature of 60 ± 2°C. Melted lipid was cooled and then the medicine (M root extract) was added right before it solidified. In the meantime, a primary emulsion was prepared by slowly adding drops of the aqueous medium containing dispersed Tween 20 at 60 ± 2°C into the molten lipid mass.

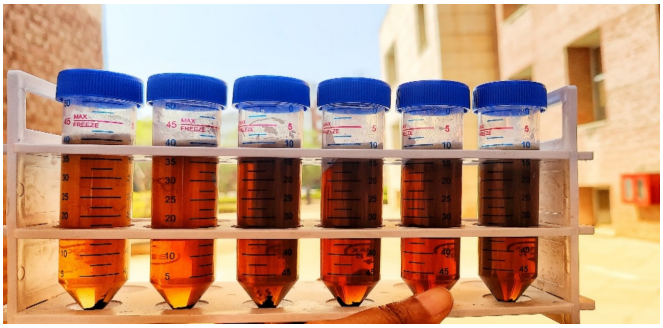

Figure 3: Physical appearance of prepared NLCs

The prepared emulsion was homogenized for 15 minutes at 25000 rpm, followed by 6 cycles of 5 minutes at 80% amplitude sonication to create a nano emulsion (Labsonic® M, Sartorius, Germany). After that, the nanoemulsion was formed by cooling it in ice-cold water and maintaining a 4°C temperature. The mixture was then subjected to centrifuge for 30 minutes at 9000 rpm. NLCs are formed. Physical appearance of prepared NLCs shown in Figure 3.

Preparation of Optimized Formulation Using Factorial Design

The effect of every independent variable on different answers was ascertained after careful investigation. The dependent responses of all 17 formulations were assessed, including mean particle size (nm) drug permeation and %entrapment efficiency.[26]

The values of the independent variables for each individual trial's dependent responses are shown in Table 1. 3D Surface plots of particle size, entrapment efficiency %drug permeation is shown in Figure 4.

Drug Excipient Compatibility Studies (FTIR)

FR spectra of Bergenin (Figure 5)

3414 = OH, 2922 = C-H stretch, 2866 = C-H stretch, 1635 = C=O stretch, 1458 = C=C stretch (aromatic), 1381 = C-O stretch, 1138 = C-O stretch, 1024 = C6H6OH779 = C_6H_6OH, 611 = C_6H_6OH.

FTIR spectra of Soy wax (Figure 6)

2920 = C-H stretch (CH2), 2852 = C-H stretch (CH2), 1735 = C=O stretch, 1463 = C=C stretch, 1381 = C-O stretch, 1178 = C-O stretch

Table 1: Runs designed by the software

	Independent Variables			*Dependent variable*		
Formulation	*Solid lipid (mg)*	*Liquid lipid (mL)*	*Tween20 (mL)*	*Particle size (nm)*	*Entrapment efficiency%*	*Drug permeation%*
1	300	0.3	1	148	93.44	83.56
2	450	0.3	0.75	179.48	92.75	80.87
3	450	0.1	0.5	179	91.005	76.21
4	600	0.3	1	210	90.009	80.75
5	600	0.3	0.5	180	87.16	82.14
6	450	0.5	1	158.1	93.43	84.83
7	600	0.5	0.75	187.32	90.45	82.35
8	450	0.3	0.75	172	89.5	80.75
9	300	0.5	0.75	174	93.06	80.56
10	300	0.1	0.75	160	91.3	85.66
11	450	0.5	0.5	179.21	90.11	80.77
12	450	0.3	0.75	158.79	90.75	83.89
13	450	0.1	1	202.37	90.07	84.87
14	450	0.3	0.75	192.85	88.08	81.88
15	300	0.3	0.5	187.73	87.39	81.98
16	450	0.3	0.75	185.85	89.99	84.97
17	600	0.1	0.75	190.59	87.45	80.87

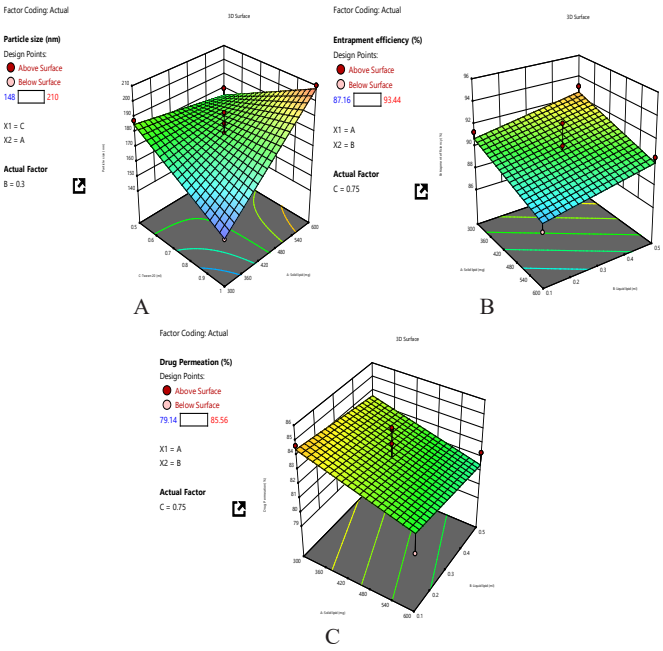

Figure 4: 3D Surface plots of A: Particle size, B: Entraptment efficiency% and C: %Drug permeation

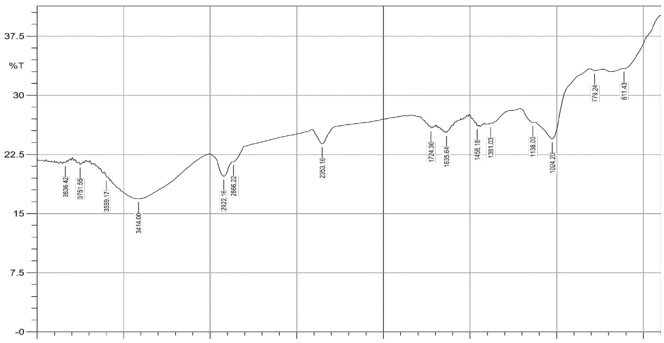

Figure 5: FTIR spectra of bergenin

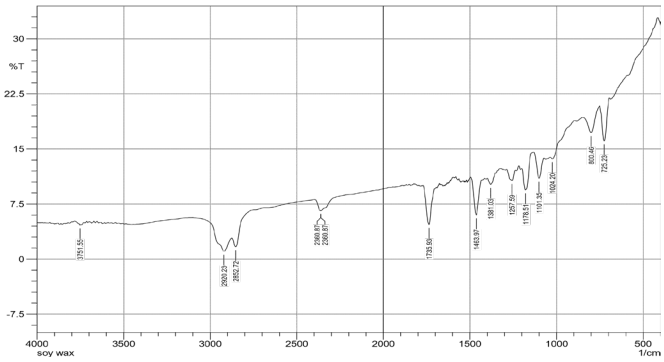

Figure 6: FTIR spectra of soy wax

FTIR spectra of Soy wax + Bergenin (Figure 7)

2924 = C-H stretch, 1735 = C=O stretch, 1458 = C=C stretch, 1384 = C-O stretch, 1170 = C-O stretch, 1029 = C6H6OH, 727 = C_6H_6OH

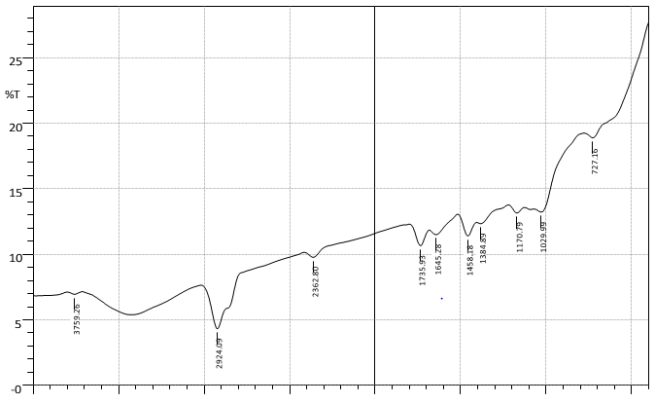

Figure 7: FTIR spectra of soy wax + Bergenin

To determine whether bergenin (BG) and the elements of the delivery system could interact in any way, FTIR analysis was carried out. Peaks at 2922 and 2866 cm^{-1} show C-H stretching vibrations, while the characteristic peaks at 3414 cm^{-1} in the BG spectrum belong to H-bonded O-H. Peaks at 1458 cm^{-1} indicate the aromatic C=C stretching of BG, whereas those at 1635 cm^{-1} show the C=O group. Furthermore, C-O bonds in BG are responsible for peaks at 1381 and 1138 cm^{-1}. Analyzing the FTIR spectra of NLCs loaded with BG reveals that almost all of the distinctive peaks of BG do not change, suggesting that the molecular structure of the loaded drug has not changed. In the FTIR analysis of the mixture of drug and excipients characteristic peaks of drug was found which indicates that no reaction happened between drug and excipients. FTIR analysis gives comprehensive data regarding the molecular constitution and structure of substances.[27]

Preparation of Nanogel

To create the nanogel for topical administration, NLC-F1 formulations with optimal physicochemical properties were chosen on the basis of particle size, entrapment effectiveness, and *in-vitro* release profiles of NLC dispersions. The lyophilized NLC powder was mixed into the gel, yielding a yellowish-brown drug-loaded NLC nanogel that was smooth and translucent. Every formulation was found to be homogeneous.

Entrapment Efficiency

The improved bergenin-NLC (F-1) has an entrapment efficiency of 93.44 ± 0.45%. The independent factors had a substantial effect on %EE; as liquid lipid (Tamanu oil) levels increased, so did the EE of bergenin-NLC. While an increase in solid lipid (soy wax) lowered entrapment efficiency. The efficacy of NLCs depends on percentage entrapment efficiency, The entrapment efficiency of NLCs determine the capacity of it to successfully encapsulate the active component.[28] The entrapment efficiency of bergenin-NLC ranged from 87.16 ± 0.26 to 93.44 ± 0.68, shown in Figure 8.

Percentage Yield

A low process loss was indicated by the optimized bergenin-NLC formulation %yield, which was found to be 77 ± 14%.

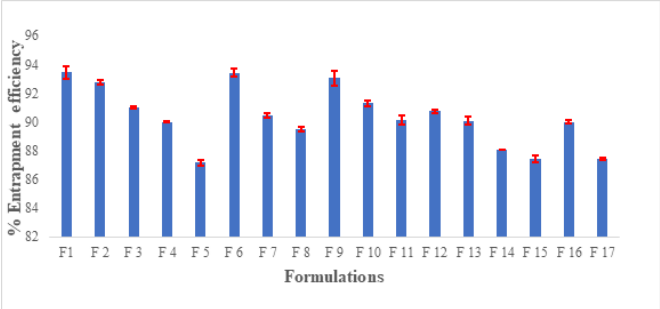

Figure 8: %Entrapment efficiency

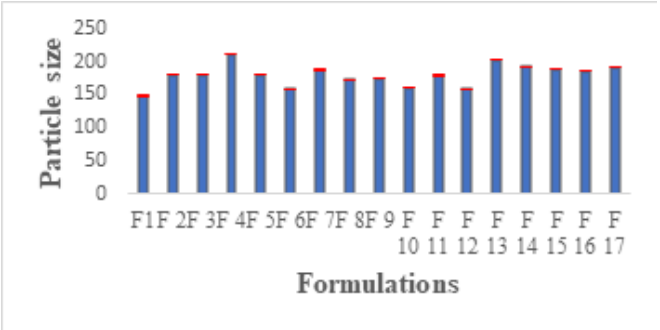

Figure 9: Particle size of all formulations

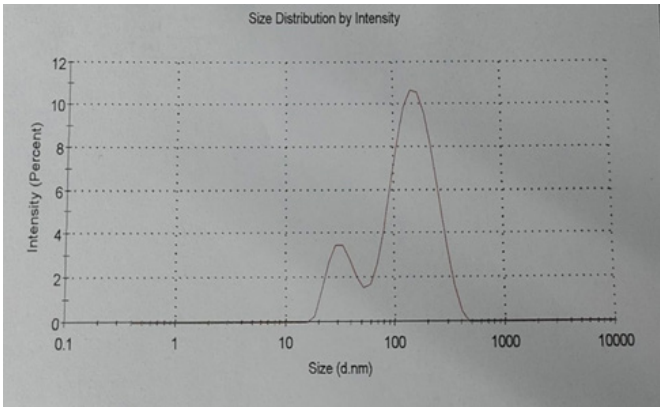

Figure 10: Particle size of optimized NLC

It may be impacted by the increase in soy wax (Solid lipid) concentration, leading to an enhanced practical yield.

Particle Size

To keep the formulations stable, the optimal formulation should have the smallest particle size and the lowest PDI. The stability and efficacy of NLCs are influenced by their polydispersity index and particle size. Figures 9 and 10 illustrates the particle size and PDI of formulated and optimized Bergenin-loaded NLCs. Readings were recorded in triplicate and presented as (n = 3, mean ± SD). Optimized NLCs had particle size of 148 ± 0.37 nm and a PDI of 0.30 ± 0.03.

Zeta Potential

The stability of nano-dispersions and the surface charge of the formulation are assessed by the zeta potential. High potential

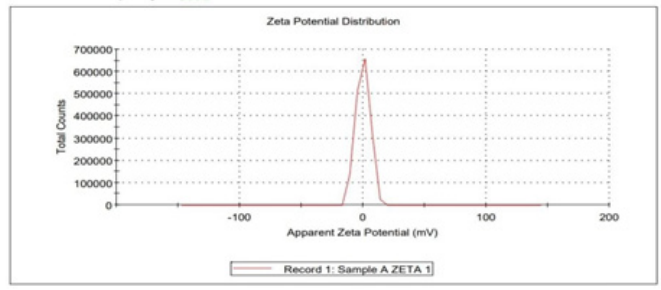

Figure 11: Zeta potential of optimized NLC formulation

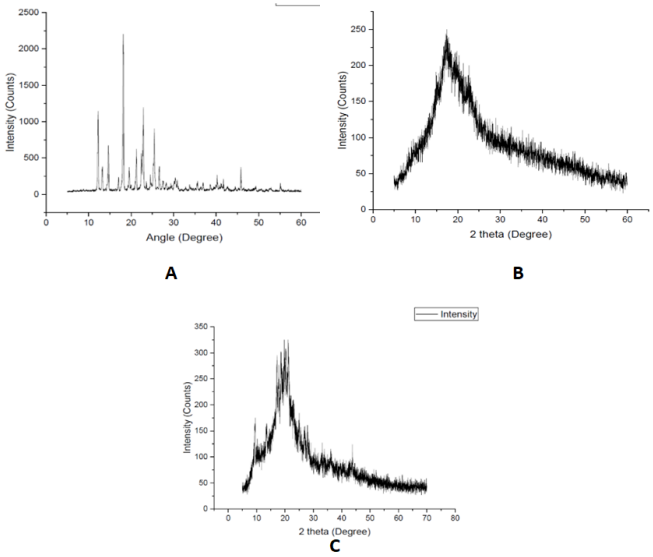

Figure 12: XRD data (XRD of (standard) Drug (A); XRD of (Extract) blank formulation(B); and XRD of NLCs formulation (C)

values (± 30 mV) are often optimal for creating a strong energy barrier between the particles and preventing them from coalescing. The improved nano-formulation's zeta potential value, as shown in Figure 11, was - 0.0617 ± 5.53.

X-Ray Diffraction Studies (XRD)

Through the use of X-ray powder diffraction, the crystal nature of the chosen drug was examined. An XRD result of standard bergenin, extract, and optimized formulation of NLCs is shown below Figure 12. The crystalline structure of pure bergenin accounts for its strong diffraction peaks. In the actual mixture, these peaks were also noticeable. Nonetheless, the optimized NLC formulation of the drug did not exhibit any peaks, suggesting that its crystalline form had been transformed into an amorphous form Figure 12. XRD analysis of the blank, drug and NLC formulation characteristic peaks depicted that bergenin is present in amorphous form in the prepared formulation. XRD analysis present data related to the crystallographic structure.[29, 30]

Figures 12 represent the X-ray diffraction patterns of drug, blank formulation, and NLCs formulation, the diffractogram of curve A displays sharp peaks at 2θ values of 12.26°, 14.70°, 18.18°, 22.88° and 25.48° for bergenin, which are absent in

the blank formulation (curve B) and NLCs formulation (curve C). These finding indicate amorphism of bergenin within the nanoparticles. Curve B of Figure 12 exhibits sharp peaks at 2θ values of 9.40°, 12.05°, 15.85°, 16.50°, 16.05°, 17.18°, 17.40°, 17.78°, 20.50°, 22.13°, 23.49° for blank formulation, while curve C shows sharp peaks at 2θ values of 9.40°, 12.11°, 13.61°, 14.95°, 16.49°, 17.21°, 18.65°, 20.31° for NLCs formulation. The XRD result demonstrates a distinct sharp peak on the 2θ scale, indicating its crystalline nature of drug. However, the intensity of these peaks declined or weaker peak intensities in the XRD pattern of bergenin loaded NLCs, suggesting that the integration of bergenin with liquid and solid lipids led to the loss of its crystalline nature.

Scanning Electron Microscopy (SEM)

It depicts the morphology of precipitated NLC particles. Direct visual information regarding the form, surface properties, and size distribution of NLC particles can be obtained from SEM. Because SEM requires scanning the sample with a concentrated electron beam and detecting the reflected or secondary electrons, it is very helpful for evaluating the surface morphology of NLCs. SEM images shows that the prepared NLCs were spherical and uniformly distributed (Figure 13). The nanoparticles precipitated with PVA as a stabilizer were spherical and evenly dispersed.

Permeation Study

The %drug permeation of the optimized bergenin-NLC (F-1) was found to be 83.56 ± 0.137. The independent variables showed significant effect on %drug permeation, with increase

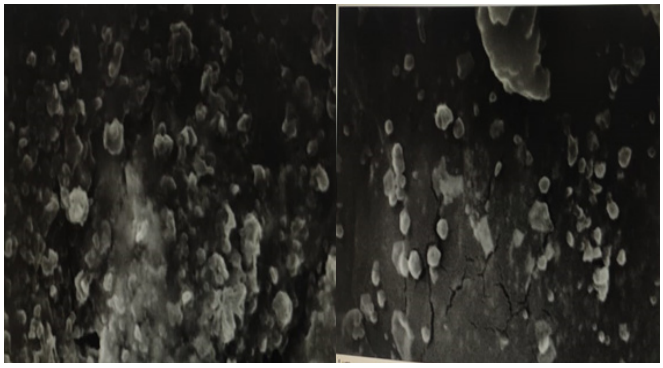

Figure 13: SEM image of optimized bergenin loaded NLC

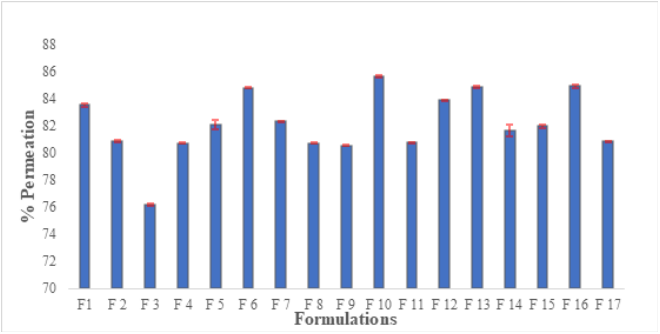

Figure 14: %Drug permeation of all formulations

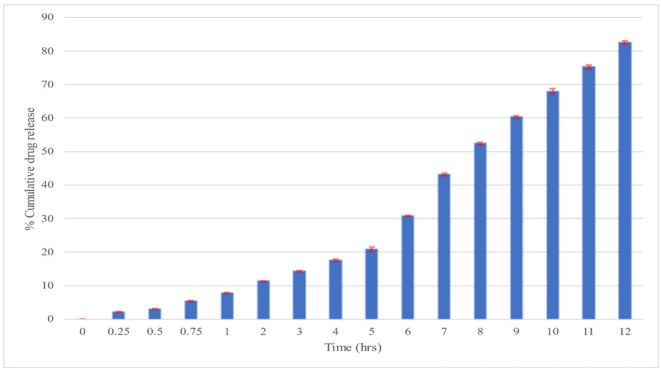

Figure 15: Drug Release of all formulations

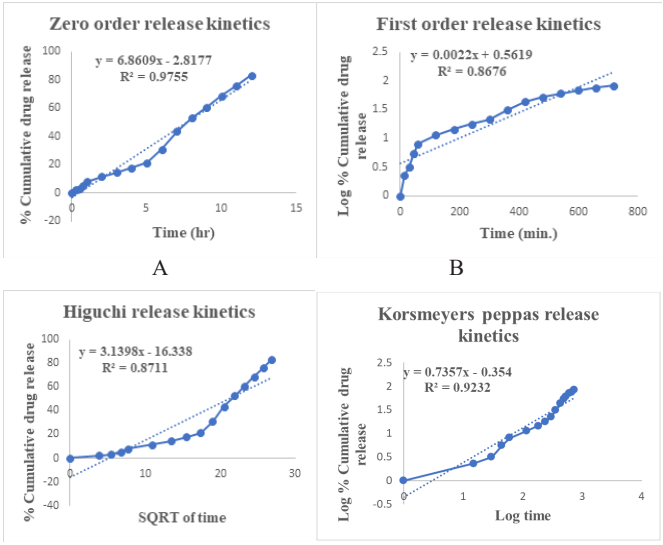

Figure 16: *In-vitro* release kinetics of (A) Zero order, (B)First order, (C) Higuchi, (D) Korsmeyers Peppas

in liquid lipid (Tamanu oil) increase in %drug permeation of bergenin-NLC is observed (Figure 14). While, increased in solid lipid (soy wax) decreased the %drug permeation. The %drug permeation of prepared bergenin-NLC ranged from 80.56 ± 0.045 to 85.66 ± 0.088.

Drug Release Study

The drug was integrated into the lipid matrix of lipid nanoparticle systems in either dissolved or dispersed form. As a result, a crucial regulating factor for the release of bergenin from NLCs is their solubility in the lipid matrix. A dialysis diffusion approach was used in in vitro release experiments to assess the release of bergenin from the NLC (F1).

In-vitro drug release was performed in phosphate buffer 7.4 at a temperature of 37°C for the optimized formulation (F1). Figure 15 shows sustained release of optimised formulation(F1). bergenin release from NLCs was observed to be 82.46% ± 0.01 in 12 hours.

Release Kinetics

Release kinetics of the optimised formulation was calculated and r^2 values were found to be 0.9755, 0.8676, 0.8711, and

0.9232 for zero order model, first order model, Higuchi model and korsmeyers peppas model respectively (Figure 16). The optimised formulation's release kinetic analysis shows that the Zero order model has a regression coefficient closer to one than other models. As a result, the improved formulation is best suited to the zero-order model.

CONCLUSION

This work suggests that the hot-melt emulsification approach might be used to successfully create the NLCs loaded with bergenin. NLCs exhibit high entrapment efficiency and drug release that lasts up to 12 hours. It was determined that the bergenin-loaded NLCs nanogel formulation is beneficial in treating psoriasis and can be used as a carrier with increased drug loading capacity. The current study highlights recent progress in using NLCs for anti-psoriatic medication. With significant advantages over first-generation systems, this innovative delivery method will be the most effective option for treating psoriasis in the future, offering a novel pathway for lipid-based carriers.

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