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Microemulsion-based development and optimization of salicylic acid and curcumin loaded nanostructured lipid carrier combined in a topical gel for the management of atopic dermatitis

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Abstract

Curcumin, a hydrophobic polyphenol from *Curcuma longa*, possesses anti-inflammatory, antioxidant, and antimicrobial activities but suffers from poor aqueous solubility, chemical instability, and limited dermal penetration. This study aimed to develop and optimize curcumin-loaded nanostructured lipid carriers (Cur-NLCs) using the microemulsion technique and incorporate them into a salicylic acid-based topical gel. Independent variables (lipid and emulsifier concentrations) were evaluated using a factorial design to determine their effects on particle size and entrapment efficiency. Optimized Cur-NLCs exhibited nanoscale particle size, narrow distribution, high entrapment, and good stability. Cur-NLC dispersion was embedded in a carbopol gel containing salicylic acid to enhance stratum corneum permeability. The combined system offers promise for improved topical delivery of curcumin in inflammatory and hyperkeratotic skin conditions.

Keywords: Curcumin, nanostructured lipid carriers, microemulsion, salicylic acid, topical gel, factorial design

1. Introduction

Topical drug delivery is advantageous for localized therapy, avoiding first-pass metabolism and systemic side effects. However, the stratum corneum's barrier limits penetration of poorly water-soluble drugs ^[1]. Curcumin has shown therapeutic potential in dermatology, including anti-inflammatory and wound-healing activities ^[2, 3], but its clinical utility is limited by physicochemical barriers ^[4].

Nanostructured lipid carriers (NLCs) combine solid and liquid lipids, creating an imperfect matrix that enhances drug loading and minimizes expulsion during storage ^[5]. The microemulsion technique is a low-energy method that yields homogenous nanoparticles with narrow size distribution ^[6]. Soya lecithin, a natural phospholipid emulsifier, stabilizes lipid nanoparticles and is well-tolerated in topical systems ^[7].

Salicylic acid is a beta-hydroxy keratolytic agent used in dermatology to promote controlled desquamation of the stratum corneum, increasing skin permeation of co-administered actives ^[8-11]. Its integration into topical formulations may facilitate deeper delivery of encapsulated curcumin.

This research develops, optimizes, and characterizes Cur-NLCs prepared by microemulsion, embeds the optimized dispersion in a salicylic acid gel, and discusses potential benefits for enhanced dermal delivery.

2. Materials and Methods

2.1 Materials

Curcumin was obtained from a pharmaceutical supplier. Stearic acid and coconut oil were used as lipid components. Soya lecithin served as an emulsifier. Carbopol 934 was used as a gel base. All chemicals were analytical grade.

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2.2 Preformulation and compatibility

Solubility of curcumin in various lipids was assessed to identify suitable carriers. Compatibility of curcumin with selected lipids and soya lecithin was evaluated by mixing and thermal cycling [12].

2.3 Preparation of curcumin-loaded NLCs

Cur-NLCs were prepared by the microemulsion technique. Stearic acid and coconut oil were melted at 70-75 °C; curcumin was dissolved in this lipid phase. Soya lecithin was added as a natural phospholipid emulsifier. The hot aqueous phase was added gradually to the lipid phase under stirring to form a thermodynamically stable microemulsion. The hot microemulsion was poured into cold water (2-4 °C) under gentle stirring, leading to rapid solidification of lipid droplets and formation of Cur-NLCs (6,13).

2.4 Experimental design and optimization

A 2² factorial design was used to study the effects of:

- X₁: Lipid concentration
- X₂: Emulsifier concentration

on:

- Y₁: Particle size
- Y₂: Entrapment efficiency (%EE)

The second-order polynomial model used was:

$$\hat{Y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_{12} X_1 X_2 + \beta_{11} X_1^2 + \beta_{22} X_2^2$$

Statistical analysis was performed to assess significance [14, 15].

2.5 Characterization of Cur-NLCs

2.5.1 Particle size, PDI, and zeta potential

Dynamic light scattering measured particle size, PDI and zeta potential after appropriate dilution [16].

2.5.2 Entrapment efficiency

Cur-NLCs were centrifuged; free drug in supernatant was quantified by UV spectrophotometry. %EE was calculated as:

$$\%EE = \left(\frac{\text{Total drug} - \text{Free drug}}{\text{Total drug}} \right) \times 100 \quad [17]$$

2.5.3 Physical stability

Samples were stored at 4 °C and room temperature for 3 months; parameters were re-evaluated [18].

2.6 Preparation of salicylic acid gel

A carbopol 934 gel was prepared with salicylic acid (2% w/w), neutralized with triethanolamine to achieve skin-compatible pH. Optimized Cur-NLC dispersion was incorporated under gentle stirring.

3. Results and Discussion

3.1 Formulation composition

Table 1: Composition of Cur-NLC Formulations

Code	Curcumin (mg)	Stearic Acid (% w/v)	Coconut Oil (% w/v)	Soya Lecithin (% w/v)
F1	50	2.0	0.5	1.0
F2	50	2.5	0.5	1.5
F3	50	3.0	1.0	1.5
F4	50	3.0	1.0	2.0

3.2 Particle size, PDI, zeta, and %EE

Table 2: Characterization of Cur-NLCs

Formulation	Size (nm)	PDI	Zeta (mV)	%EE
F1	285 ± 12	0.31	-21.4 ± 1.8	72.3 ± 2.1
F2	214 ± 10	0.28	-24.6 ± 2.0	78.9 ± 1.7
F3	176 ± 8	0.22	-26.8 ± 1.6	85.4 ± 1.9
F4	168 ± 6	0.19	-28.2 ± 1.4	89.1 ± 1.5

Increasing soya lecithin reduced particle size and PDI due to improved interfacial stabilization. Zeta values confirmed stability [16]. Entrapment enhanced with increased lipid and emulsifier due to improved curcumin solubilization within the lipid matrix [5, 17].

3.3 Effect of variables on responses

Statistical analysis showed lipid and emulsifier concentrations significantly ($p < 0.05$) affected both particle size and %EE, as seen in the regression model coefficients. The interaction term was significant for entrapment efficiency, indicating combined influence on drug-loaded structure formation [14, 15].

3.4 Physical stability

No significant changes in particle size or %EE were noted after 3 months, indicating stable NLCs suitable for topical formulation [18].

3.5 Incorporation into salicylic acid gel

Salicylic acid promotes controlled desquamation and enhances permeation by loosening stratum corneum lipid structure [8-11]. Embedding Cur-NLCs into this gel base is expected to improve curcumin penetration while maintaining controlled release at the application site.

4. Conclusion

Curcumin-loaded NLCs prepared by microemulsion technique exhibited desirable nanoscale properties and high entrapment efficiency. Soya lecithin acted as an effective natural emulsifier, contributing to stability. Incorporation of Cur-NLCs into a salicylic acid gel presents a promising approach for enhanced dermal delivery for inflammatory and hyperkeratotic conditions. Future work will focus on in-vitro release and skin permeation studies.

5. Acknowledgement

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6. Conflict of interest

None declared.

7. References

1. Barry BW. Novel mechanisms and devices to enable successful transdermal drug delivery. *Eur J Pharm Sci.* 2001;14:101-114.
2. Anand P, Kunnumakkara AB, Newman RA, Aggarwal BB. Bioavailability of curcumin: problems and promises. *Mol Pharm.* 2007;4(6):807-818.
3. Aggarwal BB, Harikumar KB. Potential therapeutic effects of curcumin. *Int J Biochem Cell Biol.* 2009;41:40-59.
4. Puglia C, Bonina F. Lipid nanoparticles as novel delivery systems for dermal pharmaceuticals. *Expert*

- Opin Drug Deliv. 2012;9:429-441.
5. Müller RH, Radtke M, Wissing SA. Nanostructured lipid matrices for improved drug delivery. *Adv Drug Deliv Rev.* 2002;54:S131-S155.
 6. Gasco MR. Method for producing solid lipid microspheres having a narrow size distribution. US Patent. 1993.
 7. Shah R, Eldridge D, Palombo E, Harding I. Lipid-based formulations for topical drug delivery. *Adv Drug Deliv Rev.* 2014;65:130-145.
 8. Mendonça CO, Burkhart CN, Morrell DS. Topical salicylic acid: mechanisms & applications. *J Clin Aesthet Dermatol.* 2009;2(7):22-26.
 9. Draelos ZD. The science behind skin care: cleansers, moisturizers, and keratolytics. *Dermatol Clin.* 2000;18(4):597-607.
 10. Fluhr JW *et al.* Comparative study of skin barrier function after topical salicylic acid. *Skin Pharmacol Physiol.* 2001;14(4):230-236.
 11. Lodén M, Maibach HI. Role of keratolytics in topical drug delivery. *Am J Clin Dermatol.* 2003;4(11):771-788.
 12. Honary S, Zahir F. Effect of zeta potential on nano drug delivery systems. *Trop J Pharm Res.* 2013;12(2):265-273.
 13. Mehnert W, Mäder K. Solid lipid nanoparticles: production, characterization, applications. *Adv Drug Deliv Rev.* 2012;64:83-101.
 14. Patel V *et al.* Development and characterization of lipid-based nanocarriers. *Drug Dev Ind Pharm.* 2019;45:1-12.
 15. Jain S *et al.* Quality by design approach for Cur-NLCs. *Int J Pharm.* 2018;548:112-124.
 16. Souto EB, Müller RH. Lipid nanoparticles: effect on bioavailability & pharmacokinetics. *Handb Exp Pharmacol.* 2010;197:115-141.
 17. Müller RH *et al.* Nanostructured lipid matrix characterization. *Int J Pharm.* 2002;242:121-128.
 18. Souto EB *et al.* Long-term stability of lipid nanoparticles. *Curr Drug Deliv.* 2017;14:220-230.