

PREPARATION AND EVALUATION OF GLYCEROSOMAL CREAM FORMULATION CONTAINING MINOCYCLINE AND NIACINAMIDE FOR ENHANCING ITS STABILITY AS WELL AS BIOAVAILABILITY

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Abstract

The present study aimed to develop and evaluate a glycosomal cream formulation containing Minocycline and Niacinamide to enhance their stability and bioavailability for topical dermatological applications. Glycosomes were prepared using the thin-film hydration method by varying phospholipid concentrations while maintaining constant amounts of cholesterol, glycerol, and active ingredients. The prepared formulations were characterized for entrapment efficiency and zeta potential. Among the formulations, F5 exhibited the highest entrapment efficiency (94.44%) and zeta potential (58.1 mV), indicating superior drug loading and vesicular stability. The optimized glycosomal formulation was incorporated into a cream base and evaluated for physical appearance, pH, viscosity, spreadability, in vitro drug release, and stability. The cream showed a smooth texture, homogeneous appearance, absence of phase separation, and a skin-compatible pH of 6.2. The viscosity and spreadability were found to be 3025 cP and 15.45 g·cm/sec, respectively, indicating suitable rheological properties for topical application. In vitro drug release studies demonstrated sustained release behavior with 92.33% cumulative drug release over 14 hours. Release kinetic analysis revealed that the formulation followed zero-order kinetics ($R^2 = 0.950$), indicating controlled and prolonged drug release. Stability studies conducted under long-term and accelerated storage conditions for 90 days showed no significant changes in pH or viscosity, confirming the stability of the formulation. The findings suggest that the developed glycosomal cream is a promising topical drug delivery system capable of enhancing the stability, bioavailability, and therapeutic efficacy of Minocycline and Niacinamide for dermatological applications.

Introduction

Acne vulgaris is one of the most prevalent chronic inflammatory skin disorders affecting adolescents and adults worldwide. It is characterized by the formation of comedones, papules, pustules, nodules, and cysts resulting from increased sebum production, follicular hyperkeratinization, colonization of *Cutibacterium acnes* (formerly *Propionibacterium acnes*), and inflammation (Alsaadoon et al., 2024).

Although acne is not a life-threatening condition, it can significantly affect quality of life, self-esteem, and psychological well-being. The increasing prevalence of acne and the limitations associated with conventional therapies have stimulated the development of novel topical drug delivery systems capable of improving therapeutic outcomes (Nandy et al., 2024).

Minocycline is a semi-synthetic tetracycline antibiotic widely used in the management of

moderate to severe acne vulgaris due to its potent antibacterial and anti-inflammatory properties. It inhibits bacterial protein synthesis and reduces the proliferation of *C. acnes*, thereby decreasing inflammatory lesions (Ochsendorf, 2010).

However, oral administration of minocycline is often associated with adverse effects such as gastrointestinal disturbances, dizziness, pigmentation changes, and the development of antibiotic resistance. Topical administration offers a safer alternative, but the drug's limited skin penetration and stability issues may reduce its therapeutic effectiveness (Martins et al., 2021).

Niacinamide (nicotinamide), a water-soluble form of vitamin B3, has gained considerable attention in dermatological therapy because of its anti-inflammatory, antioxidant, sebostatic, and skin barrier-enhancing properties. Niacinamide has been shown to reduce sebum production, improve epidermal barrier function, decrease inflammation, and enhance skin hydration. Furthermore, it helps reduce post-inflammatory hyperpigmentation and improves overall skin appearance (Camillo et al., 2025).

The combination of minocycline and niacinamide may provide synergistic

therapeutic benefits by simultaneously targeting microbial growth, inflammation, and skin barrier dysfunction associated with acne and other dermatological disorders (Niedźwiedzka et al., 2024).

Despite their therapeutic potential, conventional creams and gels containing minocycline and niacinamide often exhibit limited skin permeation, poor retention at the target site, and reduced stability. These challenges may lead to suboptimal drug delivery and decreased clinical efficacy. Therefore, the development of advanced vesicular delivery systems has emerged as a promising strategy to overcome these limitations and improve topical drug performance (Prajapati et al., 2025).

Glycosomes are modified liposomal vesicles containing phospholipids and high concentrations of glycerol. The incorporation of glycerol increases vesicle flexibility, enhances skin hydration, improves drug entrapment efficiency, and promotes deeper penetration into skin layers. Glycosomes possess superior stability compared with conventional liposomes and can effectively deliver both hydrophilic and lipophilic drugs through the stratum corneum. Additionally, glycerol acts as a humectant that improves skin moisturization

and contributes to enhanced drug permeation (Gupta et al., 2020).

The incorporation of minocycline and niacinamide into a glycosomal delivery system may improve drug stability, increase dermal bioavailability, prolong retention at the site of action, and provide sustained therapeutic effects. Such a delivery system has the potential to enhance treatment efficacy while minimizing systemic exposure and associated adverse effects (Ong and Goh, 2024).

Therefore, the present study was undertaken to prepare and evaluate a glycosomal cream formulation containing minocycline and niacinamide for enhancing their stability and bioavailability. The developed glycosomes were characterized for vesicle size, zeta potential, entrapment efficiency, and morphological properties, followed by incorporation into a cream base and evaluation of physicochemical characteristics, drug release behavior, and stability. The study aims to establish an effective and stable topical delivery system for improved dermatological therapy.

Material and Methods

Material

Minocycline and Niacinamide were used as the active pharmaceutical ingredients in the formulation. Cholesterol and glycerol were

employed for the preparation and stabilization of glycosomal vesicles. Stearic acid, cetyl alcohol, liquid paraffin, Tween 80, and Span 60 were utilized in the development of the cream base to provide emulsification, consistency, and stability. Propylene glycol was used as a solvent and penetration enhancer, while methylparaben and propylparaben served as preservatives to prevent microbial contamination. Phosphate buffer (pH 6.8) was used as the hydration medium during glycosome preparation. Chloroform and ethanol were employed as organic solvents for dissolving lipids and active ingredients during vesicle formation. Distilled water was used as the aqueous phase, and triethanolamine was added for pH adjustment and stabilization of the cream formulation. All chemicals and reagents used in the study were of analytical or pharmaceutical grade and were procured from reputed Indian manufacturers.

Methods

Preparation of Minocycline and Niacinamide Loaded Glycosomes

Drug-loaded glycosomes were prepared using the thin-film hydration technique. Briefly, phospholipid (10–50 mg) and cholesterol (40 mg) were accurately weighed and dissolved together with Minocycline (4.0%) and Niacinamide

(6.0%) in a methanol mixture (10:10 mL) in a round-bottom flask. The mixture was stirred at 40°C until a clear homogeneous solution was obtained. Organic solvents were removed under reduced pressure using a rotary evaporator to produce a thin lipid film on the inner wall of the flask. The resulting film was further dried under vacuum overnight to ensure complete solvent removal.

The dried lipid film was hydrated with 15 mL phosphate-buffered saline (PBS, pH 6.8) containing 10% v/v glycerol at 40°C under continuous stirring for 1 h to obtain

multilamellar glycosomal vesicles. The vesicle dispersion was subsequently subjected to probe sonication to reduce particle size and obtain a uniform distribution. Unentrapped drug was removed by centrifugation at 1500 rpm for 10 min at 4°C. The prepared glycosomes were lyophilized and stored at 4°C until further use. Five formulations (GS1–GS5) were prepared by varying phospholipid concentration while maintaining constant amounts of cholesterol, glycerol, hydration medium, and solvent system (Moolakkadath et al., 2020).

Table 1: Composition of Drug-Loaded Glycosomes

F. Code	Minocycline (%)	Niacinamide (%)	Phospholipid (mg)	Cholesterol (mg)	Glycerol (% v/v)	PBS (mL, pH 6.8)	Solvent (Methanol: Chloroform mL)
GS1	4.0	6.0	10	40	10	15	10:10
GS2	4.0	6.0	20	40	10	15	10:10
GS3	4.0	6.0	30	40	10	15	10:10
GS4	4.0	6.0	40	40	10	15	10:10
GS5	4.0	6.0	50	40	10	15	10:10

Characterization of Drug-Loaded Glycosomes

Physical Appearance

The prepared glycosomal formulations were visually inspected for color, homogeneity, clarity, consistency, aggregation, precipitation, and phase

separation. Lyophilized samples were also evaluated for powder appearance, color uniformity, and ease of redispersion (Rani et al., 2021).

Vesicle Size and Polydispersity Index

The average vesicle size and polydispersity index (PDI) of glycosomal formulations were determined by Dynamic Light Scattering (DLS) using a particle size analyzer. Samples were diluted appropriately with distilled water before analysis. Results were expressed as mean vesicle diameter (nm) and PDI (Salem et al., 2018).

Zeta Potential Measurement

The surface charge of glycosomal vesicles was determined using a Zetasizer Nano instrument. Samples were diluted with distilled water and analyzed at room temperature. The zeta potential values were recorded in millivolts (mV) to assess colloidal stability (Gupta et al., 2020).

Entrapment Efficiency

Entrapment efficiency was determined by centrifuging the glycosomal dispersion to separate free drug from vesicle-associated drug. The amount of untrapped drug present in the supernatant was quantified using UV-visible spectrophotometry (Naguib et al., 2020). Entrapment efficiency was calculated using the following equation:

$$\text{Entrapment Efficiency (\%)} = \left[\frac{\text{Total Drug} - \text{Free Drug}}{\text{Total Drug}} \right] \times 100$$

Scanning Electron Microscopy (SEM)

The morphology of optimized glycosomes was examined using scanning electron microscopy. Freeze-dried samples were mounted on aluminum stubs, sputter-coated with gold-palladium, and observed under SEM to evaluate vesicle shape, surface morphology, and structural integrity (Naguib et al., 2020).

Preparation of Glycosomal Cream

The cream base was prepared by the fusion method. Beeswax (4 g) and liquid paraffin (15 mL) were heated to 75°C to obtain the oil phase. In a separate beaker, borax (0.4 g) and methyl paraben (0.03 g) were dissolved in distilled water (70 mL) and heated to the same temperature to prepare the aqueous phase.

The aqueous phase was gradually added to the oil phase with continuous stirring to obtain a smooth cream base. Subsequently, optimized Minocycline–Niacinamide loaded glycosomes (10 mL) were incorporated with gentle mixing. Lavender oil (3–4 drops) was added as a fragrance and the cream was stirred until cooled to room temperature. The final formulation was packed in airtight containers and stored at ambient conditions (Singh et al., 2024).

Table 2: Composition of Glycrosomal Cream Formulation

S. No.	Ingredient	Quantity	Function
1	Glycrosomes	10 mL	Active ingredient
2	Beeswax	4 g	Emulsifier and thickener
3	Liquid Paraffin	15 mL	Emollient
4	Methyl Paraben	0.03 g	Preservative
5	Lavender Oil	3–4 drops	Fragrance
6	Borax	0.4 g	Stabilizer
7	Distilled Water	q.s.	Vehicle

Evaluation of Glycrosomal Cream

Physical Evaluation

The prepared cream formulations were evaluated for color, texture, homogeneity, consistency, phase separation, odor, and overall appearance.

pH Determination

One gram of cream was dispersed in 10 mL distilled water and the pH was measured using a calibrated digital pH meter at room temperature (Salem et al., 2018).

Viscosity Measurement

The viscosity of the cream formulation was determined using a Brookfield viscometer equipped with an appropriate spindle at 50 rpm. Measurements were recorded in centipoise (cP) (Kharbanda et al., 2026).

Spreadability Study

Spreadability was determined by placing 1 g of cream between two glass slides and

applying a standard weight. The diameter of spreading was measured and expressed as an indicator of ease of application (Badawi et al., 2025).

In Vitro Drug Release Study

The in vitro release of Minocycline and Niacinamide from the glycrosomal cream was evaluated using the dialysis bag diffusion method. A known quantity of cream was placed in a pre-soaked dialysis membrane and immersed in 100 mL phosphate buffer (pH 7.4) maintained at $37 \pm 1^\circ\text{C}$ under continuous stirring at 100 rpm. Aliquots (2 mL) were withdrawn at predetermined intervals (0, 2, 3, 4, 5, 8, 11, 12, and 14 h) and replaced with fresh dissolution medium to maintain sink conditions. The collected samples were analyzed spectrophotometrically, and cumulative percentage drug release was

calculated. Drug release data were further fitted to various kinetic models to determine the release mechanism (Arora et al., 2020).

Stability Testing of Optimized Glycosome-Loaded Cream Formulation

The stability of the optimized glycosome-loaded cream formulation was evaluated under accelerated and ambient storage conditions in accordance with ICH guidelines to assess its physical and chemical stability. The formulation was packed in airtight containers and stored at $25 \pm 2^\circ\text{C}/60 \pm 5\% \text{ RH}$ (long-term condition) and $40 \pm 2^\circ\text{C}/70 \pm 5\% \text{ RH}$ (accelerated condition). Samples were withdrawn and evaluated at predetermined intervals of 0, 30, 45, 60, and 90 days. During the study, the formulation was assessed for changes in physical appearance, pH, and viscosity. Physical appearance was evaluated visually for any color change, phase separation, precipitation, or other signs of instability. The pH was determined using a calibrated digital pH meter after dispersing the cream in distilled water (1:10 w/v), while viscosity was measured using a Brookfield viscometer at room temperature. The obtained results were compared with the initial values recorded on day 0. Variations within ± 0.5 pH units and acceptable changes in physicochemical properties were considered

indicative of formulation stability throughout the storage period.

Results and Discussion

The present study was undertaken to develop a glycosomal cream formulation containing Minocycline and Niacinamide with the objective of enhancing drug stability, skin penetration, and bioavailability for topical dermatological applications. Glycosomes were prepared using the thin-film hydration method by varying the concentration of phospholipid while maintaining constant amounts of cholesterol, glycerol, drugs, hydration medium, and solvent system. The composition of the prepared glycosomal formulations (GS1–GS5) is presented in Table 1. Phospholipid serves as the primary structural component of glycosomes and plays a vital role in vesicle formation, encapsulation efficiency, and stability. Therefore, different phospholipid concentrations were investigated to optimize the formulation characteristics.

Cholesterol was incorporated into all formulations at a fixed concentration to improve membrane rigidity and reduce drug leakage from the vesicles. Glycerol was maintained at 10% v/v in all formulations because it acts as a membrane-fluidizing agent and enhances vesicle flexibility,

thereby improving skin permeation. The combination of Minocycline and Niacinamide was selected because of their complementary therapeutic actions. Minocycline exhibits potent antibacterial and anti-inflammatory properties, whereas Niacinamide improves skin barrier function, reduces inflammation, and promotes skin health. The glycosomal carrier system was designed to facilitate efficient delivery of these active agents into deeper layers of the skin.

After preparation of the glycosomal dispersion, the optimized formulation was incorporated into a cream base to improve patient acceptability and facilitate topical application. The composition of the glycosomal cream is shown in Table 2. Beeswax and liquid paraffin were employed as the major components of the cream base to provide suitable consistency, emollient properties, and structural stability. Borax acted as a stabilizer and emulsifying aid, while methyl paraben was included as a preservative to prevent microbial contamination during storage. Lavender oil was added to impart a pleasant fragrance and enhance the aesthetic appeal of the formulation. Distilled water served as the aqueous phase for the preparation of the cream.

The selected excipients contributed significantly to the quality and stability of the final cream formulation. Beeswax imparted the required viscosity and consistency, while liquid paraffin improved moisturization and spreadability. The incorporation of glycosomes into the cream matrix was achieved successfully without affecting the physical appearance or uniformity of the formulation. The cream base provided an effective vehicle for sustained release of the encapsulated drugs and improved retention on the skin surface.

The formulation strategy adopted in this study combined the advantages of glycosomal vesicles with those of a topical cream base. Glycosomes are known to enhance drug penetration through the stratum corneum due to their flexible vesicular structure and the presence of glycerol. This characteristic may lead to increased drug accumulation within the skin and improved therapeutic efficacy. The preparation process and incorporation of glycosomes into the cream base are illustrated schematically in Figure 1.

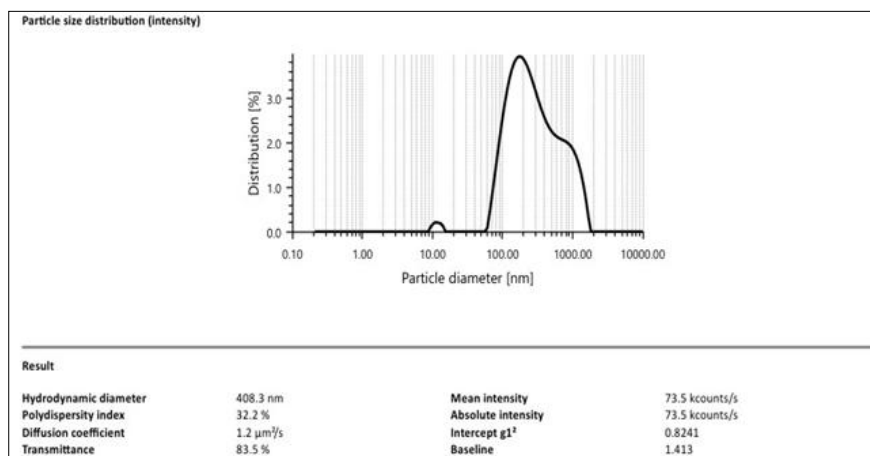
Overall, the formulation components presented in Table 1 and Table 2 were selected to develop a stable, effective, and patient-friendly topical delivery system. The developed glycosomal cream is expected

to provide enhanced skin penetration, prolonged drug retention, improved bioavailability, and superior therapeutic performance compared with conventional

topical formulations. The proposed mechanism of drug delivery from the glycosomal cream through the skin is illustrated in Figure 2.

Table 3: Particle Size of Glycosomal Formulations

S. No.	Formulation	Particle Size (nm)
1	Glycosome (F1)	752.1
2	Glycosome (F2)	472.4
3	Glycosome (F3)	724.0
4	Glycosome (F4)	805.5
5	Glycosome (F5)	408.3

**Figure 1: Graph of Particle size of glycosome optimized formulation (F5)****Table 4: Entrapment Efficiency of Glycosomal Formulations**

S. No.	Formulation	Entrapment Efficiency (%)
1	Glycosome (F1)	74.42
2	Glycosome (F2)	84.57
3	Glycosome (F3)	78.65
4	Glycosome (F4)	84.33
5	Glycosome (F5)	94.44

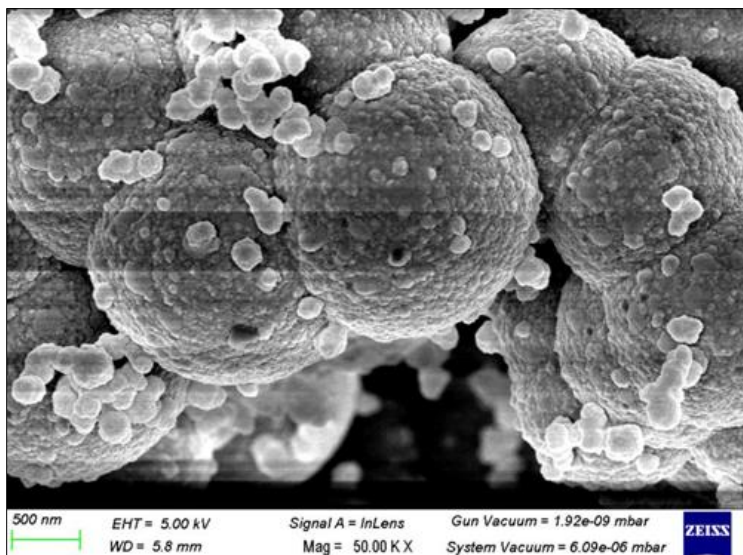


Figure 2: Scanning electron microscope (SEM)
Table 5: Zeta Potential of Glycosomal Formulations

S. No.	Formulation	Zeta Potential (mV)
1	Glycosome (F1)	34.0
2	Glycosome (F2)	52.6
3	Glycosome (F3)	40.7
4	Glycosome (F4)	40.6
5	Glycosome (F5)	58.1

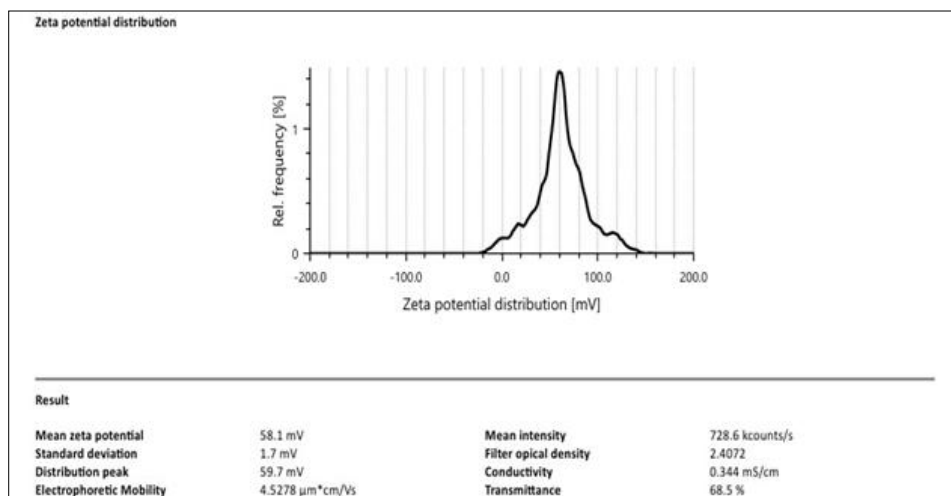


Figure 3: Zeta potential of optimized glycosome formulation (F5)

Table 6: Physical Evaluation of Glycosome Cream

Parameter	Observation / Result
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Color	Light yellow, uniform
Consistency / Texture	Smooth, creamy, easily spreadable, no grittiness or lumps
Homogeneity	Homogeneous, uniform distribution of glycosomes
Phase Separation	No creaming or layer formation observed
Odor / Fragrance	Pleasant lavender fragrance, uniform
Appearance after Storage	No significant change in color, texture, or homogeneity

Table 7: Physicochemical Evaluation of Optimized Glycosome Cream Formulation

S. No.	Formulation	pH	Viscosity (cP)	Spreadability (g·cm/sec)
1	Glycosome Cream	6.2	3025	15.45

Table 8: In Vitro Drug Release Profile of Glycosome Cream

Time (h)	Cumulative % Drug Released	% Drug Remaining
0	0.00	100.00
2	21.55	78.45
3	33.43	66.57
4	41.32	58.68
5	52.34	47.66
8	62.44	37.56
11	72.53	27.47
12	81.50	18.50
14	92.33	7.67

Table 9: Kinetic Modeling of Drug Release Data

Formulation	Release Model	R ² Value
Glycosome Cream	Zero Order	0.950
	First Order	0.908
	Higuchi	0.821
	Korsmeyer–Peppas	0.764

Table 10: Stability Study of Optimized Glycosome Cream

Time (Days)	25 ± 2°C / 60 ± 5% RH		40 ± 2°C / 70 ± 5% RH	
	pH	Viscosity (cP)	pH	Viscosity (cP)
0	6.2	3025	6.2	3025
30	6.2	3028	6.1	3026
45	6.1	3022	6.0	3024
60	6.1	3021	5.9	3017
90	6.0	3019	5.8	3015

Conclusion

The present study successfully developed a glycosomal cream containing Minocycline and Niacinamide for topical delivery. The optimized formulation exhibited high entrapment efficiency, good stability, suitable pH, viscosity, and spreadability, along with sustained drug release. Stability studies confirmed that the formulation remained stable under different storage conditions. The developed glycosomal cream shows promise as an effective topical drug delivery system with the potential to enhance skin penetration, bioavailability, and therapeutic efficacy of the incorporated drugs.

References

- Alsaadoon NS, Al-Refaie AM, Habashy AY. Acne vulgaris in adolescents: A comprehensive review. *Benha Journal of Applied Sciences*. 2024 Dec 31;9(12):5-13.
- Nandy P, Shrivastava T, Shrivastava Sr T. Exploring the multifaceted impact of acne on quality of life and well-being. *Cureus*. 2024 Jan 22;16(1).
- Ochsendorf F. Minocycline in acne vulgaris: benefits and risks. *American journal of clinical dermatology*. 2010 Oct;11(5):327-41.
- Martins AM, Marto JM, Johnson JL, Graber EM. A review of systemic minocycline side effects and topical minocycline as a safer alternative for treating acne and rosacea. *Antibiotics*. 2021 Jun 22;10(7):757.
- Camillo L, Zavattaro E, Savoia P. Nicotinamide: A multifaceted molecule in skin health and beyond. *Medicina*. 2025 Feb 1;61(2):254.
- Niedźwiedzka A, Micallef MP, Biazzo M, Podrini C. The role of the skin microbiome in acne: challenges and future therapeutic opportunities. *International journal of molecular sciences*. 2024 Oct 24;25(21):11422.
- Prajapati R, Vyas N, Luhana A, Solanki N, Patel RR, Patel H. Pharmaceutical Skin Care: Skin Structure, Barrier Function, and Advanced Drug Delivery Modes. *Journal of Drug Delivery & Therapeutics*. 2025 Sep 1;15(9).
- Gupta P, Mazumder R, Padhi S. Glycosomes: advanced liposomal drug delivery system. *Indian J. Pharm. Sci*. 2020 May 1;82(3):385-97.
- Ong RR, Goh CF. Niacinamide: a review on dermal delivery strategies and clinical evidence. *Drug delivery and translational research*. 2024 Dec;14(12):3512-48.

- Moolakkadath T, Aqil M, Ahad A, Imam SS, Praveen A, Sultana Y, Mujeeb M. Preparation and optimization of fisetin loaded glycerol based soft nanovesicles by Box-Behnken design. International journal of pharmaceutics. 2020 Mar 30;578:119125.
- Rani D, Sharma V, Manchanda R, Chaurasia H. Formulation, design and optimization of glycerosomes for topical delivery of minoxidil. Research Journal of Pharmacy and Technology. 2021 May 1;14(5):2367-74.
- Salem HF, Kharshoum RM, Sayed OM, Abdel Hakim LF. Formulation design and optimization of novel soft glycerosomes for enhanced topical delivery of celecoxib and cupferron by Box–Behnken statistical design. Drug development and industrial pharmacy. 2018 Nov 2;44(11):1871-84.
- Gupta P, Mazumder R, Padhi S, Gupta MP, Pharm M. Development of natamycin loaded glycerosomes— A novel approach to defend ophthalmic keratitis. Indian J Pharm Educ Res. 2020 Apr 1;54:s163-72.
- Naguib MJ, Salah S, Halim SA, Badr-Eldin SM. Investigating the potential of utilizing glycerosomes as a novel vesicular platform for enhancing intranasal delivery of lacidipine. International Journal of Pharmaceutics. 2020 May 30;582:119302.
- Singh R, Singh A, Srivastava D, Fatima Z, Prasad R. Crisaborole- Enthused Glycerosomal Gel for an Augmented Skin Permeation. Recent Advances in Drug Delivery and Formulation: Formerly Recent Patents on Drug Delivery & Formulation. 2024 Jun 1;18(2):120-30.
- Salem HF, Kharshoum RM, Sayed OM, Abdel Hakim LF. Formulation design and optimization of novel soft glycerosomes for enhanced topical delivery of celecoxib and cupferron by Box–Behnken statistical design. Drug development and industrial pharmacy. 2018 Nov 2;44(11):1871-84.
- Kharbanda J, Mazumder R, Dogra A, Singh N, Mishra R. Development and Therapeutic Evaluation of a Dual-loaded Glycerosomal Gel of Quercetin and Resveratrol in an

Arthritic Rat Model. Journal of Pharmaceutical Innovation. 2026 Aug;21(4):326.

- Badawi NM, Badie MA, Abdelrahman KA, Attia DA, Moussa YA. Development of novel cefoperazone-loaded glycosomes for enhanced wound healing and antibacterial efficacy: in vitro and in vivo assessments. Journal of Pharmaceutical Sciences. 2025 Sep 5:103982.
- Arora D, Khurana B, Nanda S. DoE directed optimization, development and evaluation of resveratrol loaded ultradeformable vesicular cream for topical antioxidant benefits. Drug Development and Industrial Pharmacy. 2020 Feb 1;46(2):227-35.