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Research Paper

Formulation And Evaluation of Polyherbal Nanoemulsion for Topical Treatment of Psoriasis

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ABSTRACT

Psoriasis is a Chronic and often disabling inflammatory skin disease affecting up to 2–5% of the world's population. Treatments currently used for topical psoriasis management have several limitations such as inadequate skin penetration, tachyphylaxis following repeated application, as well-documented systemic effects and toxicity. Objectives: In the wake of traditional and natural healing methods the current study aims at preparing and evaluating a polyherbal-based stable oil-in-water nanoemulsion incorporating Bakuchiol from Psoralea corylifolia, and oil of Neem from Azadirachta indica for the topical management of psoriasis. Methods: Based on a preestablished ratio range (1:1.8–3:10) five batches of nanoemulsion, F1 to F5 were prepared. These differed only in their oil: Smix ratio (Smix: Tween 80+PEG 400). Various batches of Smix were prepared by the low-energy method of Phase Inversion Temperature (PIT) for enhancing thebioadhesive properties to skin. All the polyherbal nanoemulsions thus obtained were evaluated on the basis of appearance, dilution test, pH determination, centrifugation studies, spreadability etc. Results: In respect of appearance all batches showed pale yellowish translucency (preferable in skin application). However F3 (1:2.99) exhibited the widest area of spreadability (7.8 ± 0.10 cm), pH (5.6 ± 0.04) nearest to normal skin pH, a negative dilution test, and absolute centrifugation stability. Conclusion: Topical application of psoralea oil and neem oil, both through altered chemical forms and optimal formulations, could potentially overcome the present shortcomings of corticosteroids, currently in wide use for management of various dermatoses, and achieve enhanced tolerability and optimal therapeutic index.

INTRODUCTION

1.1 Psoriasis: Disease Overview and Pathogenesis

Psoriasis is a chronic, slow-acting, relapsing, remitting and often disabling condition. It is a common skin disorder with a complicated

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autoimmune pathogenesis and definite genetic predisposition. Psoriasis is a worldwide health problem that affects 2–5% of the population across all ethnic groups. In India the prevalence has been reported to range from 0.44% to 2.8% [1, 2]. The commonest form of psoriasis (psoriasis vulgaris) accounts for about 90% of cases which is characterized by well demarcated, erythematous, silver-scaled plaques. There is significant increase in the epidermal cell turnover with the normal 28-day turnaround time being significantly shortened to 4–5 days in psoriasis.

The immunopathogenesis of psoriasis involves the dysregulation of the IL-23/Th17 axis. Environmental factors such as skin injury, microbial components, and stress can induce plasmacytoid dendritic cells (pDCs) to produce Type I interferons (IFNs) via the cathelicidin antimicrobial peptide, LL-37. In turn, activated myeloid dendritic cells (mDCs) induce production of IL-23, which drives naive CD4+ T cells (Th0 cells) to differentiate into pathogenic Th17 cells. Th17 cells produce IL-17A, IL-17F, IL-21 and IL-22 which induce keratinocyte hyperproliferation, impaired differentiation, angiogenesis and neutrophil influx into the skin in a self-sustaining process [4, 5].

Psoriasis is an inflammatory skin disease and simultaneously a systemic disease, linked to psoriatic arthritis (PsA; 30–40% of patients) and an increased risk for cardiovascular diseases and metabolic syndrome. Furthermore, psoriasis is frequently accompanied by substantial psychosocial burden. Its management thus demands a holistic approach to treat both skin and systemic inflammation.



Fig. 1: Representative clinical manifestation of psoriasis showing characteristic erythematous, scaly plaques on the back and legs.

1.2 Limitations of Current Therapies and Rationale for Herbal Approach

Available therapies for psoriasis are mainly classified based on the severity of the disease. For the patient with mild-to-moderate disease, topical corticosteroids and vitamin D analogues are first-line treatments that can be applied to the affected skin to reduce inflammation. However, prolonged use of topical corticosteroids can cause skin atrophy, tachyphylaxis, and telangiectasia. Over-the-counter topical corticosteroids have large molecular size and high polarity, which make them unable to penetrate the 10–20 µm thick stratum corneum to reach the pathogenic lesions at therapeutic concentrations. For patients with moderate-to-severe disease, treatment with systemic agents, such as methotrexate and cyclosporine, or biologic medications can be effective. However, systemic agents have serious side effects, such as nephrotoxicity and hepatotoxicity, and carry significant risks. Biologic medications also carry risks of immunosuppression and have high costs, limiting their use in developing countries.

Despite the advances made by the recent discoveries, the limitations of the current therapy have compelled us to revisit the plant-based alternatives as described in the traditional medicine system of Ayurveda. The two herbs Psoralea corylifolia (Babchi) and Azadirachta indica (Neem) have been used traditionally in the Ayurvedic system of medicine to treat cutaneous diseases including those with psoriasis-like skin features for thousands of years. The phytoconstituents of these herbs have been reported to possess anti-inflammatory, immunomodulatory, antioxidant, and antiproliferative activities through experimental studies performed in recent years. However, the most challenging issues that limit their clinical applications are their hydrophobic nature, poor aqueous solubility, and the inadequate skin permeability.

1.3 Nanoemulsions as an Advanced Topical Delivery Platform

These systems, known as nanoemulsions, are isotropic, kinetically stable colloidal systems (three-dimensional dispersion of two liquids) consisting of two immiscible liquids (i.e., oil and water) stabilized by surfactants and co-surfactants. The average diameter of the oil droplets in these systems ranges from 20 nm to 200 nm. In terms of advantages related to skin application, the systems include dramatically increased contact area, acceleration of dissolution and flux of drugs, very low interfacial tension (~10^{-2} to 10^{-3} mN/m), and enhanced skin permeation due to surfactant-mediated, reversible disruption of the ordered lipid (lamellar) matrix of the stratum corneum through transcellular, intercellular, or transfollicular routes. Another advantage of these systems is higher drug loading efficiency for lipophilic active ingredients compared with conventional systems (emulsions). For production of nanoemulsions, the PIT method is a simple procedure that exploits the temperature-dependent change in HLB (Hydrophilic-Lipophilic Balance) of non-ionic surfactants use to form oil-in-water (o/w) emulsions without the need for expensive high-pressure equipment.

The purpose of this study is to explore the potential of co-delivery of Bakuchiol and Neem oil through topical nanoemulsion for the treatment of psoriasis. The formulations were prepared by the PIT method and optimized. In this study, five batches of optimized nanoemulsions based on the obtained results were evaluated.

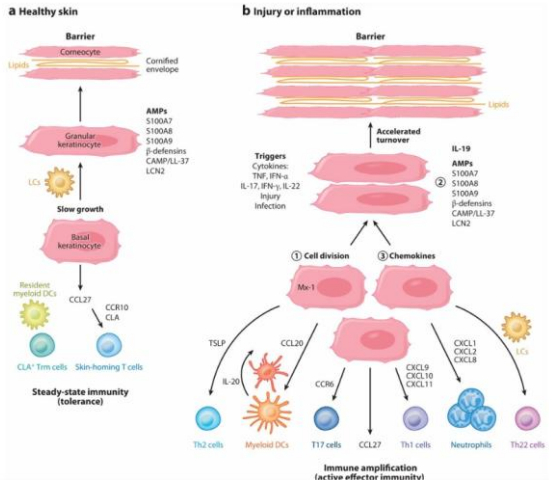


Fig. 2: Schematic representation of (a) healthy skin immunology and (b) psoriatic inflammation, highlighting the IL-23/Th17 axis, keratinocyte hyperproliferation, and relevant cytokine network.

2. LITERATURE REVIEW

2.1 Psoriasis Treatment Landscape

Management of psoriasis has been well studied and published in medical literature. In a recent review Rendon and Schäkel (2019) described the IL-23/Th17 pathway dysfunction in psoriasis and targeted therapeutic approaches. An earlier review by Griffiths and Barker in The Lancet presented first line management of psoriasis and outlined issues related to skin penetration of topical treatments. A review by Boehncke and Schön (2015) outlined limitations of current therapy leading to a rapid transition to more effective, although expensive, biologic agents. Psoriasis has been associated with a markedly increased risk of developing a myocardial infarction; thus safe long-term management is a medical necessity.

2.2 Herbal Actives: Bakuchiol and Neem

Chandra et al. (2021) concluded that in view of its anti-inflammatory and anti-proliferative effects on skin it is thus a good functional analogue of retinol for prevention and treatment of photoageing, that has a superior cosmeceutical profile in terms of tolerance. Dhaliwal et al. (2019) in their prospective randomized double-blind clinical study established that topical Bakuchiol is as effective as retinol for treating photoageing, with significantly less irritation, making it an ideal option for use on sensitive skin and even on psoriatic skin. Alzohairy (2016) in his article explained the therapeutic uses of the plant Azadirachta indica and its active metabolites nimbidin, nimbin and azadirachtin in treating inflammatory skin disorders including psoriasis. Koley and Mandal (2016) while reviewing on the medicinal importance of neem pointed out its immunomodulatory, antipruritic, antibacterial and antifungal properties that are beneficial in the present day scenario of pathogenesis of psoriasis. Tanwar (2023) emphasized that the emerging clinical benefits of polyherbal formulations is due to their ability to combat with various pathomechanisms involved in the psoriasis through a single formulation.

2.3 Nanoemulsions in Topical Therapy

The PIT method is being increasingly used for the preparation of stable O/W nanoemulsions for various applications. The method has gained popularity with respect to dermal applications. A comprehensive review on nanoemulsion and their applications as a novel drug delivery system were described by Singh and Meher (2017). Sonneville-Aubrun, Simonnet, and L'Alloret (2004) reported that nano-sized droplets possessed advantage over larger particles in terms of skin permeation and cosmetic acceptability. For the development of optimized nanoemulsion formulations, the effect of surfactant HLB values and phase inversion phenomena on final nanoemulsion droplet size were investigated by Gupta et al. (2016). Puglia et al. (2021) performed comparative drug deposition studies in skin models using topical anti-inflammatory nano-carriers and a conventional cream. Results from the studies showed that nano-carriers outperformed the performance of the traditional formulation. Golpashin et al. (2020) demonstrated that in comparison to conventional herbal emulsions, herbal nanoemulsions improved drug release of drug and permeation through skin in the treatment of psoriasis. The PIT method is an energy-efficient process for preparation of nanoemulsions that are easily scalable. The process does not require high-pressure homogenization devices as droplet size of 50–150 nm can be achieved (Khurana et al. 2013).

3. MATERIALS AND METHODS

3.1 Herbal Actives and Excipients

3.1.1 Bakuchiol (Psoralea corylifolia)

Bakuchiol is a meroterpene phenol isolated from the seeds of indigenous plant, Psoralea

corylifolia (Babchi, Fabaceae family) used in the management of psoriasis. It exerts its anti-psoriatic effect by suppressing pro-inflammatory cytokines TNF-α, IL- 6, IL- 8 and IFN-γ, stabilizing the pathologically accelerated turnover rate of keratinocytes; antioxidant by breaking the chain of free radical reactions; and inducing retinoid like gene expression profile in the skin devoid of risk of generating photosensitivity. Psoralea corylifolia is an annual herb indigenous to India, China and tropical Africa. It grows in dry areas; sandy loam soils of medium texture, moderately Coy; and full sun to partial shade; pH: 6.5–7.5. Bakuchiol oil (Pharma Grade), Psor P. corylifolia seed oil was obtained from the same supplier. The data recorded for this oil were confirmation of its chemical identity. It showed absorption maxima at 262nm (C=C or C□C) and 305nm (aromatic C□C); sharp absorption peak in the IR spectrum at 3200–3500 cm^{-1} (O–H) and a broad absorption at 1600–1640 cm·: (C=C). A medium sized absorption band was observed at 1150–1250 cm^{-1}. On TLC using petroleum ether : ethyl acetate (85:15 v/v), Rf of the oil was 0.45–0.55. Visualization was done using vanillin–H_2SO_4 spray.



Fig. 3: Psoralea corylifolia (Babchi) — plant source of Bakuchiol, showing characteristic leaves and seeds.

3.1.2 Neem Oil (Azadirachta indica)

Bio-active molecules of Neem oil, a well-known Ayurvedic dermatological preparation, act primarily through immobilization of inflammatory mediators. The bio-active molecules Nimbidin, Nimbin and Azadirachtin in Neem oil modulate immune response by inhibiting NF-κB to impede Th2-mediated inflammatory response and by modulating T-cells thereby reducing itching. These bioactive molecules prevent secondary infection in psoriasis by inhibiting prostaglandins thus exhibiting anti-inflammatory property and also provides relief from itching. Neem trees (Azadirachta indica) are common throughout India, almost drought hardy, evergreen trees that grow very fast and are found almost throughout the length and breadth of Gujarat and the Indian sub-continent. Neem oil (Pharma Grade) of authentic origin was received from a reliable supplier. Characterization of Neem oil was done by comparing the UV-Vis absorption spectrum with known spectrum. Characteristic FTIR Absorption peaks for Neem oil were obtained at 3200–3550 cm^{-1} (O–H stretch and at 1740 cm^{-1} for C=O ester in triglycerides. Absorption in the region of 2850–2950 cm^{-1} due to aliphatic C–H bonds of the alkyl chains of triglycerides was observed. Salkowski, Mayer's and Liebermann-Burchard tests were positive indicating the presence of triterpenes, steroids or triterpenoid saponins.



Fig. 4: Azadirachta indica (Neem) — showing characteristic leaves and seeds from which neem oil is extracted.

3.1.3 Excipients

Tween 80 (Polysorbate 80, HLB = 15, Pharmaceutical Grade) was used as a non-ionic surfactant. A mixture of PEG 400 (Polyethylene Glycol 400, Pharmaceutical Grade) and distilled water (USP/IP Grade) constituted the aqueous phase used as a co-surfactant, where it acts synergistically with Tween 80 to yield almost zero interfacial tension, and provides humectant and penetration enhancer properties.

3.2 Phytochemical Screening

Standard phytochemical screening tests were carried out for the two herbal active; Neem oil and Bakuchiol. These tests revealed the presence of many phyto-constituents from which most of the pharmacological activity of herbal active may stem. Tests carried out for Neem oil were; Mayer's test for alkaloids which was positive for Neem oil. Also the Froth test for saponins, Shinoda test for flavonoids were positive for Neem oil. Salkowski test for terpenoids and Liebermann-Burchard test for steroids were also positive. The test for tannins/phenolics carried out with Ferric chloride revealed positive result. For Bakuchiol, tests carried out for the presence of tannins/phenolics with Ferric chloride revealed dark blue- green colour due to presence of phenolic hydroxyl groups. The Salkowski test for terpenoids revealed reddish-brown colour due to classification of terpenoid. The test with alkaline reagent revealed intense yellow colour due to presence of co-occurring flavonoids.

3.3 Materials and Equipment

Table 1 lists the key chemical reagents used; Table 2 lists the instruments employed in the study.

Table 1: Key Chemical Reagents and Materials Used in the Study

Sr.	Chemical / Reagent	Grade	Purpose
1	Tween 80 (Polysorbate 80)	Pharma Grade	Surfactant in nanoemulsion formulation
2	PEG 400	Pharma Grade	Co-surfactant in nanoemulsion formulation
3	Neem Oil (Azadirachta indica)	Pharma Grade	Therapeutic oil phase
4	Bakuchiol Oil (Psoralea corylifolia)	Pharma Grade	Therapeutic oil phase
5	Distilled Water	USP/IP Grade	Aqueous phase; reagent preparation
6	Ferric Chloride ($FeCl_3$), 1%	AR Grade	Detection of phenolics/tannins
7	Mayer's Reagent	AR Grade	Detection of alkaloids (Neem)
8	Shinoda Reagent (Mg + HCl)	AR Grade	Detection of flavonoids
9	n-Hexane (BP 68–69°C)	AR/HPLC Grade	Soxhlet extraction of Neem oil
10	Ethanol (95%)	AR Grade	Soxhlet extraction of Bakuchiol

11	Methanol	HPLC Grade	UV-Vis spectrophotometry
12	Silica Gel (60–120 Mesh)	Chromatographic	Column chromatography for Bakuchiol
13	KBr (Potassium Bromide)	Spectroscopic	FTIR pellet preparation
14	Concentrated H_2SO_4	AR Grade	Salkowski & Liebermann-Burchard tests

Table 2: Instruments Used in the Study

Sr.	Instrument / Equipment	Application
1	Magnetic Stirrer with Hot Plate	PIT method heating; Smix preparation
2	Analytical Balance (0.0001 g precision)	Accurate weighing of excipients and actives
3	Digital Thermometer (−10°C to 150°C)	Temperature monitoring during PIT method
4	Centrifuge (5000–10,000 RPM)	Centrifugation stability tests
5	pH Meter with Calibration Buffers	Measurement of nanoemulsion pH
6	UV-Vis Spectrophotometer (200–800 nm)	Quantitative analysis of actives (planned)
7	FTIR Spectrophotometer (ATR/KBr)	Structural characterization; compatibility
8	DLS Particle Size Analyzer	Droplet size & PDI measurement (planned at SICART)
9	Zeta Potential Analyzer (ELS)	Surface charge measurement (planned at SICART)
10	Franz Diffusion Cell Assembly	In vitro drug release; ex vivo permeation (planned)
11	Soxhlet Extraction Apparatus	Extraction of Neem oil and Bakuchiol
12	Rotary Evaporator	Solvent recovery under reduced pressure

3.4 Nanoemulsion Formulation Design

The O/W nanoemulsion was made using a technique known as the Phase Inversion Temperature (PIT) method and by using a low-energy process for its formulation. The nanoemulsions of five batches (F1–F5) were prepared by altering the proportion of the oil phase (Neem oil + Bakuchiol) and the Smix (Tween 80 + PEG 400) while the amount of the aqueous phase was kept constant. Table 3 illustrates the five batches of nanoemulsions formulated varying the oil:Smix ratio ranging from 1:1 (F1) to 1:4.33 (F4) to achieve the optimum stable nanodroplets.

Table 3: Composition of Nanoemulsion Batches F1–F5 (per 50 mL batch). *F3 = Optimized batch

Ingredient	F1 (mL)	F2 (mL)	F3* (mL)	F4 (mL)	F5 (mL)
Neem Oil	4.00	3.00	2.50	2.00	2.50
Bakuchiol Oil	2.00	1.50	1.25	1.00	1.25
Tween 80	3.00	4.50	5.60	6.50	7.00
PEG 400	3.00	4.50	5.60	6.50	7.00

Distilled Water	38.00	36.50	35.05	34.00	32.25
Total Volume (mL)	50.00	50.00	50.00	50.00	50.00
Oil Phase (mL)	6.00	4.50	3.75	3.00	3.75
Smix (mL)	6.00	9.00	11.20	13.00	14.00
Oil:Smix Ratio	1:1	1:2	1:2.99	1:4.33	1:3.73

F1 (oil:Smix = 1:1) served as the negative control with insufficient surfactant coverage. F2 and F3 represented progressively optimized batches. F4 and F5 explored the effect of surfactant excess on formulation performance.

3.5 Preparation Procedure (PIT Method)

The procedure was employed for five consecutive batches, each being characterised by different amounts of test ingredients (tab. 3). All glass equipment (250 ml beakers, measuring cylinders, pipettes, pipette tips, test tubes) prior to the procedure was washed with a neutral detergent, rinsed with warm water and after that dried. Then the glassware was exposed to a sterilization cycle using a microwave oven. The procedure itself was conducted at room temperature (25 ± 2°C), at relative humidity of 60 ± 5 %.

Step 1: Smix preparation: 1:1 v/v mixture of Tween 80 and PEG 400 was mixed in a glass beaker and stirred at 300 RPM for 5 minutes to form a clear homogeneous solution referred to as Smix.

Step 2 — Oil Phase Preparation: Neem oil and Bakuchiol were mixed together and then incorporated into the complete Smix. The mixture was mixed at 400 RPM for 5 minutes until fully homogeneous.

Step 3 — Coarse Emulsion Formation: Once the mixture has reached a paste-like consistency, it is necessary to slowly mix in distilled water using a burette. The mixture should be at medium to high speed (around 400 RPM) and it should take roughly 5 minutes to reach a milky-white macro-emulsion. The mixture should be stirred for an additional 5 minutes.

Step 4 - PIT Heating Phase. The coarse emulsion was heated on a magnetic stirrer hot plate at 500 RPM and simultaneously its temperature was measured with a digital thermometer. The temperature at which the milky emulsion changed over to a translucent/optically clear, bicontinuous liquid is known as the Phase Inversion Temperature (PIT), which typically is in the range of 60 °C to 80 °C.

Step 5 — Shock Cooling (Nano-Formation): Immediately following the PIT observations, the beaker was quickly transferred to a pre-prepared ice bath at 0 °C. Stirring at 500 rpm for 5 min. caused the bicontinuous nanostructure to be ‘frozen’ into discrete O/W nanodroplets within thebeaker before coalescence could occur.

Step 6 - Packaging and Storage. The cooled nanoemulsion was filled into dark amber glass bottles with tight screw caps, labelled and stored at F1: room temperature (25°C) and F2-F5: refrigerator temperature (4°C).



Fig. 5: Visual comparison of Batch F1 (left, milky white macro-emulsion indicating phase instability) and Batch F3 (right, translucent nanoemulsion confirming successful nano-formation).

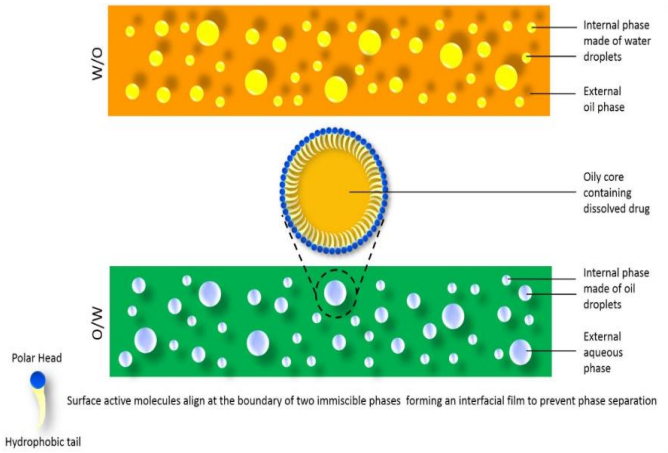


Fig. 6: Fig.6:Schematic representation of the O/W nanoemulsion structure selected for this formulation, showing oil droplets (internal phase) dispersed in the aqueous continuous phase, stabilized by the surfactant/co-surfactant interfacial film.

3.6 Evaluation Parameters

3.6.1 Physical Appearance

Visual inspection against both white and black backgrounds for colour, clarity, homogeneity and evidence of phase separation was recorded for each batch.

3.6.2 Dilution Test

Dilute the sample: Mix 1 mL of sample with 10 mL of sterile, distilled water. Invert gently 5 times. Observe the sample immediately and after 15 min for oil separation and phase miscibility. A uniform solution with no oil separation is an O/W type nanoemulsion.

3.6.3 pH Determination

pH measurement was performed on each sample using a calibrated pH meter (pH meter; Hanna) with pH 4.0 and 7.0 buffers at room temperature. pH values were determined in triplicate. pH was accepted within the range of 4.5–7.0; typical skin surface pH is approximately 5.5.

3.6.4 Centrifugation Test

10mL of each batch was held at room temperature for a minimum of 7 days and then stored at -20°C for a minimum of 30 days. Vials were removed from -20°C storage and then placed in a refrigerated centrifuge at 4°C and approximately

3000 RPM for 30 minutes. After centrifuge, the appearance of each tube was inspected for any visible creaming, cracking, or separation of phases. No change indicated physically stable product.

3.6.5 Spreadability Test

Methodology (Parallel Plate Method): Approximately 0.5g of nanoemulsion was placed on one half of the surface of two glass plates of size 10×10cm. A standard weight of 100g was placed on the top of both plates and pressed down for a period of time equal to one minute. The average diameter of spread (mean of two measurements at right angles to each other) was recorded. A larger diameter of spread indicates better spreadability and patient compliance.

4. RESULTS AND DISCUSSION

All the five batches of Neem–Bakuchiol nanoemulsion were evaluated for various physical, thermal and stability studies. All the studies were carried out in triplicate (n=3). The results obtained were presented as mean ± SD. The consolidated results of the various studies carried out for all the batches are presented in Table 4. Subsequently, the results for individual batches (F1–F5) are discussed.

Table 4: Consolidated Evaluation Results for All Batches (F1–F5). *F3 = Best batch

Batch	Appearance	Dilution Test	pH (Mean±SD)	Centrifuge Test	Spread Diam. (cm)
F1	Milky, Opaque	**FAIL**	6.2 ± 0.08	**FAIL**	4.2 ± 0.15
F2	Pale Yellow, Turbid	PASS	5.9 ± 0.06	PASS	6.1 ± 0.12
F3 (Best)	Pale Yellow, Clear	PASS	5.6 ± 0.04	PASS	7.8 ± 0.10
F4	Pale Yellow, Clear	PASS	5.7 ± 0.05	PASS	7.5 ± 0.11
F5	Pale Yellow, Turbid	PASS	5.8 ± 0.05	PASS	6.9 ± 0.13

4.1 Physical Appearance

Table 5 presents the physical appearance evaluation.

Table 5: Physical Appearance Evaluation of Batches F1–F5

Parameter	F1	F2	F3*	F4	F5
Appearance (Colour)	Milky White	Pale Yellow	Pale Yellowish	Pale Yellowish	Pale Yellow
Clarity	Opaque	Slightly Turbid	Translucent/Clear	Translucent	Slightly Turbid
Phase Separation	Present	Absent	Absent	Absent	Absent
Homogeneity	Non-uniform	Uniform	Uniform	Uniform	Uniform

Sample Batch F1 (oil:Smix = 1:1) was an opaque, milky white solution and showed visible phase separation. A 1:1 ratio of oil to Smix was found to be insufficient for surfactant coverage to generate

and stabilise nanodroplets. The literature typically indicates that a minimum 1:2 ratio of oil to surfactant is required for effective nanoemulsification using the PIT method.

Increasing Smix concentration from batch F2 to F5 resulted in increasingly clearer formulations with batch F3 achieving the best translucent/clear pale yellowish appearance. This was the expected optical signature for nanoemulsions below 200 nm, displaying a transparent appearance due to reduced light scattering as the droplet diameter approaches or is below the wavelength of visible light (400–700 nm). Similar clarity was achieved in batch F4 with an excess of surfactant. Batch F5 appeared to have re-entered oil droplet growth possibly due to surfactant micellar crowding at very high surfactant concentrations.

4.2 Dilution Test

The batch F1 failed the dilution test with the formation of visible oily layer which indicated the formation of non-emulsified W/O or unstable macroemulsion. On the other hand, batches F2–F5 passed the test with uniform mixing and homogeneous appearance and no oil separation, and thus these optimized batches formed O/W nanoemulsion. O/W nanoemulsions are miscible with the continuous aqueous phase and do not separate upon dilution. These characteristics make the O/W nanoemulsions ideal for topical application without any greasy residue.

4.3 pH Determination

All produced batches showed pH values within the acceptance limits of 4.5–7.0 and therefore showed skin compatibility. The batch F3 had the lowest pH of 5.6 ± 0.04 which was closest to the natural skin physiological pH (~5.5). Formulations prepared for the treatment of psoriasis should have a pH within 5.5–6.5, as psoriatic skin has a significantly elevated surface pH (~6.5–7.0) and acidic formulation helps to re-establish the acid mantle of skin, reduces the risk of pathogenic microbial colonisation and promotes the healing of epidermal barrier. It was observed that as the concentration of Smix increased from batch F1 to batch F3, the pH decreased from 6.2 to 5.6. This can be due to the slightly acidic nature of PEG 400 that helps in decreasing the pH at higher concentration of co-surfactant.

4.4 Centrifugation Test

Samples from batch F1 exhibited significant problems including creaming, cracking and a complete liquid-liquid phase separation at 3000 RPM. Batches F2–F5 did, however, resist centrifugation, retaining liquid-liquid homogeneity at accelerated stress equivalent to ~900 × g, and thus serve as a predictive accelerated stability test (AST) for these nanoemulsions. It is well established that samples which resist such a test will possess shelf-stability in excess of 6 months, and in many cases up to 2 years or more.

4.5 Spreadability

All tested formulations F1 to F5 showed a good spreadability and the spreadability increased with increasing Smix concentration from poor (4.2 ± 0.15 cm) over moderate (6.1 ± 0.12 cm) to good (7.8 ± 0.10 cm) at F3. Then the spreadability decreased for F4 (7.5 ± 0.11 cm) and F5 (6.9 ± 0.13 cm). The good spreadability of our formulations is very important for patient compliance, because for most psoriasis sufferer the skin areas, where they suffer from severe scaling, are elbows, knees or scalp. Thick hyperkeratotic plaques have to be uniformly coated with our formulation.

4.6 Selection of Optimum Batch (F3) and Evaluation Summary

The most optimum formulation through the evaluation of various parameters was observed to be Batch F3. This formulation comprised of Neem oil: Bakuchiol: Tween 80: PEG 400: Distilled Water in the proportion of 2.5: 1.25: 5.60: 5.60:

35.05 mL. The oil: Smix ratio was found to be 1: 2.99. Table 6 showed the complete formulation details of F3.

Table 6: Complete Evaluation Summary for Optimized Batch F3

Evaluation Test	Result / Observation	Criteria Met?
Physical Appearance	Pale yellowish, translucent, homogeneous	Yes
Phase Separation	Absent	Yes
Dilution Test (1:10 with water)	Uniform mixing; No oil separation	Yes
pH Determination	5.6 ± 0.04 (closest to skin pH 5.5)	Yes
Centrifugation (3000 RPM, 30 min)	No creaming, cracking, or phase separation	Yes
Spreadability	7.8 ± 0.10 cm (Good)	Yes

The oil:Smix ratio of F3 formulation was found to be approximately 1:3 which is in a good equilibrium state between sufficient amounts of Smix to ensure complete surface coverage of nanodroplets for prevention of coalescence, and avoiding excessive amounts of surfactant that increase the viscosity of oil-in-water formulation, and cause micelle-induced Ostwald ripening or reduced spreadability. The observed pH value of 5.6 ± 0.04 is the closest to skin physiological pH and is very suitable for comfortable application on psoriatic plaques. Furthermore, it possesses the superior spreadability on skin surface of 7.8 cm.

4.7 Synergistic Mechanism and Anti-Psoriatic Rationale

Both Bakuchiol and Neem oil were chosen as co-actives as they target different steps in the pathogenesis of psoriasis and have synergistic effects in treating the condition. Bakuchiol acts by inhibiting the later part of the IL-17 pathway and prevents keratinocyte hyperproliferation and scaling. Neem oil on the other hand targets the earlier step of immunological dysregulation and prevents Th1/Th17 imbalanced immune response by inhibiting NF-κB thereby preventing excessive expression of proinflammatory cytokines and also prevents T- cell activation. Both actives also have antimicrobial properties to prevent secondary infections caused by Staphylococcus aureus and Candida. The dual drug-dual target approach is known to result in synergistic effects as is typical of polyherbal formulations.

The nanoemulsion carrier enhances the anti-psoriatic activity of the lipophilic active agents by facilitating their deep penetration through the thickened hyperkeratotic stratum corneum of psoriatic plaques. The nano-sized droplet size (target <200 nm) offers both transcellular and transfollicular routes for drug delivery. The surfactant system Tween 80 + PEG 400 reversibly fluidizes the stratum corneum lipid, forming 'transient liquid structures' that form and revert to their original state within a short period of time.

CONCLUSION

Both Bakuchiol and Neem oil were chosen as co-actives as they target different steps in the pathogenesis of psoriasis and have synergistic effects in treating the condition. Bakuchiol acts by inhibiting the later part of the IL-17 pathway and prevents keratinocyte hyperproliferation and scaling. Neem oil on the other hand targets the

earlier step of immunological dysregulation and prevents Th1/Th17 imbalanced immune response by inhibiting NF-κB thereby preventing excessive expression of proinflammatory cytokines and also prevents T- cell activation. Both actives also have antimicrobial properties to prevent secondary infections caused by Staphylococcus aureus and Candida. The dual drug-dual target approach is known to result in synergistic effects as is typical of polyherbal formulations.

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Conflict of Interest

The authors declare no conflict of interest

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REFERENCES

1. Rendon, A., & Schäkel, K. (2019). Psoriasis Pathogenesis and Treatment. International Journal of Molecular Sciences, 20(6), 1475. https://doi.org/10.3390/ijms20061475
2. Tanwar, A. (2023). Natural Compounds in Psoriasis Management: A Review. Journal of Pharmacognosy, 10(9). https://pharmacognosyjournal.org/archives/2023/vol10/issue9/
3. Griffiths, C.E.M., & Barker, J.N.W.N. (2007). Pathogenesis and clinical features of psoriasis. The Lancet, 370(9583), 263–271. https://doi.org/10.1016/S0140-6736(07)61128-3
4. Nestle, F.O., Kaplan, D.H., & Barker, J. (2009). Psoriasis. New England Journal of Medicine, 361(5), 496–509. https://doi.org/10.1056/NEJMra0804595
5. Di Meglio, P., Villanova, F., & Nestle, F.O. (2014). Psoriasis. Cold Spring Harbor Perspectives in Medicine, 4(8), a015354. https://doi.org/10.1101/cshperspect.a015354
6. Gelfand, J.M., et al. (2006). Risk of myocardial infarction in patients with psoriasis. JAMA, 296(15), 1735–1741. https://doi.org/10.1001/jama.296.15.1735
7. Boehncke, W.H., & Schön, M.P. (2015). Psoriasis. The Lancet, 386(9997), 983–994. https://doi.org/10.1016/S0140-6736(14)61909-7
8. Gudjonsson, J.E., & Elder, J.T. (2007). Psoriasis: Epidemiology. Clinics in Dermatology, 25(6), 535–546. https://doi.org/10.1016/j.clindermatol.2007.08.007
9. Chandra, A., et al. (2021). Bakuchiol: A Retinol-like Functional Compound for Skin Anti-Aging and Psoriasis. Molecules, 26(15), 4671. https://doi.org/10.3390/molecules26154671

10. Dhaliwal, S., et al. (2019). Prospective, randomized, double-blind assessment of topical bakuchiol and retinol for facial photoageing. British Journal of Dermatology, 180(2), 289–296. https://doi.org/10.1111/bjd.16918
11. Alzohairy, M.A. (2016). Therapeutics role of Azadirachta indica (Neem) and their active constituents in diseases prevention and treatment. Evidence-Based Complementary and Alternative Medicine, 2016, 7382506. https://doi.org/10.1155/2016/7382506
12. Singh, Y., & Meher, J.G. (2017). Nanoemulsion: Concepts, development and applications in drug delivery. Journal of Controlled Release, 252, 28–49. https://doi.org/10.1016/j.jconrel.2017.03.008
13. Puglia, C., et al. (2021). Nanostructured lipid carriers and nanoemulsions for topical anti-inflammatory therapy. International Journal of Pharmaceutics, 606, 120916.
14. Sonneville-Aubrun, O., Simonnet, J.T., & L'Alloret, F. (2004). Nanoemulsions: A new vehicle for skincare products. Advances in Colloid and Interface Science, 108–109, 145–149. https://doi.org/10.1016/j.cis.2003.10.021
15. Khurana, S., et al. (2013). Formulation of nanoemulsions for topical application: A review. Drug Development Research, 74(7), 429–452.
16. Koley, S., & Mandal, S.C. (2016). Neem (Azadirachta indica): A Promising Medicinal Plant. International Journal of Pure and Applied Biosciences, 4(3), 225–233.
17. Gupta, A., et al. (2016). Nanoemulsions: Formation, properties and applications. Soft Matter, 12(11), 2826–2841. https://doi.org/10.1039/c5sm02958a
18. Golpashin, N., et al. (2020). Formulation and evaluation of herbal nanoemulsions for psoriasis treatment. Asian Journal of Pharmaceutics, 14(3), 230–238.
19. Kaul, S., et al. (2018). Neem: Present situation and future prospects. Journal of Pharmacognosy and Phytochemistry, 7(4), 1469–1478.

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