International Journal of Pharmaceutics and Drug Research
ISSN: 2347-6346
Available online at http://ijpdr.com

Review Article

ETHOSOMAL-BASED POLYHERBAL DRUG DELIVERY SYSTEMS FOR PSORIASIS MANAGEMENT: A COMPREHENSIVE REVIEW

Uma Shankar Joshi*, S. K. Gupta, Vivek Gupta, Jitendra Kumar Malik
P.K. University, Shivpuri (M.P.)

***Correspondence Info:**
Uma Shankar Joshi
P.K. University, Shivpuri (M.P.)
Email:
umapremjoshi@yahoo.co.in

***Article History:**

Received: 06/02/2026
Revised: 27/02/2026
Accepted: 15/03/2026

ABSTRACT

Psoriasis is a chronic autoimmune inflammatory skin disorder characterized by erythematous plaques, scaling, itching, and abnormal proliferation of keratinocytes. Conventional therapies used in psoriasis management often suffer from limitations such as poor skin penetration, systemic adverse effects, low patient compliance, and long-term toxicity. In recent years, vesicular drug delivery systems, particularly ethosomes, have emerged as promising carriers for enhanced topical and transdermal drug delivery. Ethosomes are soft, malleable phospholipid vesicles containing high concentrations of ethanol that improve drug permeation through the stratum corneum and facilitate deeper penetration into skin layers. Incorporation of polyherbal formulations into ethosomal systems offers synergistic therapeutic benefits due to the presence of multiple bioactive phytoconstituents such as flavonoids, alkaloids, terpenoids, tannins, phenolics, and glycosides possessing anti-inflammatory, antioxidant, antimicrobial, immunomodulatory, and wound-healing activities. Ethosomal-based polyherbal drug delivery systems enhance drug stability, bioavailability, controlled release, and targeted delivery while minimizing systemic toxicity and adverse effects. Phytochemical investigation plays a crucial role in identifying and standardizing the active constituents responsible for therapeutic efficacy. This review comprehensively discusses the pathophysiology of psoriasis, composition and mechanism of ethosomes, methods of preparation, characterization techniques, phytochemical evaluation, and recent advances in polyherbal ethosomal formulations for effective psoriasis management. The review highlights the significant potential of combining herbal therapeutics with ethosomal nanotechnology as a safer, efficient, and patient-friendly approach for psoriasis treatment.

Keywords: Psoriasis, Ethosomes, Polyherbal formulation, Vesicular drug delivery system, Phytochemical screening, Transdermal drug delivery.

INTRODUCTION

Overview of Psoriasis

Definition and Epidemiology

Psoriasis is a chronic, immune-mediated, inflammatory skin disorder characterized by excessive proliferation and abnormal differentiation of keratinocytes, leading to the formation of erythematous, scaly plaques on the skin (Orzan *et al.*, 2025). It is considered a multifactorial disease influenced by genetic predisposition, environmental triggers, and immune dysregulation (Javierre *et al.*, 2025). Psoriasis is non-contagious in nature but significantly affects the physical,

psychological, and social well-being of patients (Hepat *et al.,* 2023). The disease commonly affects the elbows, knees, scalp, lower back, and nails, although any part of the body may be involved (Unissa *et al.,* 2019). The prevalence of psoriasis varies geographically and ethnically, affecting approximately 2–3% of the global population. It can occur at any age, but two peak incidences are generally observed: one between 15–30 years and another between 50–60 years of age. Factors such as stress, infections, trauma, smoking, alcohol consumption, obesity, and certain medications are known to trigger or aggravate the disease (Mehrmal *et al.,* 2021).

Pathophysiology of Psoriasis

The pathophysiology of psoriasis involves a complex interplay between the immune system, genetic susceptibility, and environmental factors (Yamanaka *et al.*, 2021). Psoriasis is primarily mediated by T-lymphocytes and dendritic cells, which release pro-inflammatory cytokines such as tumor necrosis factor-alpha (TNF-α), interleukin-17 (IL-17), interleukin-23 (IL-23), and interleukin-22 (IL-22) (Singh *et al.*, 2022). These cytokines stimulate rapid proliferation and impaired differentiation of keratinocytes in the epidermis (Feliciani *et al.*, 1996). Normally, keratinocyte turnover occurs over approximately 28 days; however, in psoriatic skin, this process is accelerated to 3–5 days, resulting in the accumulation of immature skin cells on the surface. Angiogenesis and infiltration of inflammatory cells further contribute to erythema and plaque formation (Lee *et al.*, 2021). Genetic factors also play a crucial role, with several susceptibility genes, particularly PSORS1 located on chromosome 6, being associated with disease development. Environmental triggers activate immune responses in genetically predisposed individuals, thereby initiating or exacerbating the disease process.

Clinical Manifestations and Types

Psoriasis presents with well-defined, raised, erythematous plaques covered by silvery-white scales that may crack, bleed, or cause itching and discomfort (Kuchekar *et al.,* 2011). The severity of symptoms varies from mild localized lesions to extensive body surface involvement. In some patients, nail changes such as pitting, discoloration, and onycholysis may occur, while others may develop psoriatic arthritis characterized by joint pain, swelling, and stiffness. Several clinical types of psoriasis have been identified based on lesion morphology and distribution (Raychaudhuri *et al.,* 2014). Plaque psoriasis, also known as psoriasis vulgaris, is the most common form and accounts for nearly 80–90% of cases. Guttate psoriasis appears as small drop-like lesions and is often associated with streptococcal infections. Pustular psoriasis is characterized by sterile pustules and may be localized or generalized. Erythrodermic psoriasis is a severe and potentially life-threatening form involving widespread redness and scaling of the skin. Inverse psoriasis affects skin folds such as the axillae and groin, while nail psoriasis predominantly involves the fingernails and toenails (Haneke, 2017).

Challenges in Conventional Psoriasis Therapy

Conventional therapies for psoriasis include topical corticosteroids, vitamin D analogues, retinoids, coal tar preparations, systemic agents such as methotrexate and cyclosporine,

phototherapy, and biologic therapies (Mahajan, 2016). Although these treatments provide symptomatic relief, they are often associated with several limitations and adverse effects. Long-term use of topical corticosteroids may lead to skin atrophy, irritation, pigmentation changes, and tachyphylaxis. Systemic therapies can cause hepatotoxicity, nephrotoxicity, immunosuppression, and other serious complications, thereby limiting their prolonged use. Biologic therapies, although highly effective, are expensive and may increase the risk of infections and immune-related disorders (Waldron *et al.,* 2022). Another major challenge is the poor penetration of therapeutic agents through the stratum corneum, which reduces drug bioavailability at the target site. Frequent dosing, poor patient compliance, relapse after discontinuation of therapy, and variability in therapeutic response further complicate psoriasis management. These limitations have encouraged researchers to explore novel drug delivery systems, particularly herbal and vesicular approaches such as ethosomes, to improve therapeutic efficacy, enhance skin penetration, reduce side effects, and achieve sustained drug release in psoriasis treatment (Pandey, 2020).

Herbal Medicines in Psoriasis Management

Role of Medicinal Plants in Skin Disorders

Medicinal plants have been widely used since ancient times for the treatment of various skin disorders due to their therapeutic efficacy, natural origin, and comparatively fewer side effects (Ahuja *et al.,* 2021). Herbal medicines contain a variety of bioactive phytoconstituents such as flavonoids, alkaloids, tannins, terpenoids, glycosides, phenolic compounds, and saponins that exhibit anti-inflammatory, antioxidant, antimicrobial, immunomodulatory, and wound-healing properties (Sarwar *et al.,* 2021; Yatoo *et al.,* 2018). In dermatological conditions like psoriasis, medicinal plants help reduce erythema, scaling, itching, and inflammation by modulating inflammatory mediators and promoting skin regeneration. Herbal formulations are generally considered safer for long-term use compared to synthetic drugs, which often produce adverse effects after prolonged therapy (Moreira *et al.,* 2014). In addition, plant-based therapies improve skin hydration, maintain skin barrier integrity, and protect against oxidative stress, which plays a significant role in the pathogenesis of psoriasis. Due to these beneficial effects, medicinal plants have gained considerable attention as alternative and complementary therapies for chronic inflammatory skin diseases.

Polyherbal Approach and Synergistic Effects

The polyherbal approach involves the combination of two or more medicinal plant extracts in a single formulation to achieve enhanced therapeutic efficacy (Rajini *et al.,* 2023). This concept is based on the principle of synergism, where the combined activity of multiple herbs produces a greater pharmacological effect than individual herbs alone. In psoriasis management, polyherbal formulations provide multi-targeted action by simultaneously reducing inflammation, suppressing abnormal keratinocyte proliferation, combating microbial infections, and promoting tissue repair (Yadav *et al.,* 2024). The presence of diverse phytoconstituents in polyherbal systems helps

improve bioavailability, minimize toxicity, and reduce the required therapeutic dose (Rana *et al.,* 2024). Furthermore, one herb may enhance the activity or stability of another herb, thereby improving overall therapeutic outcomes. Polyherbal formulations also offer broader pharmacological actions, including antioxidant, antiproliferative, immunomodulatory, and anti-allergic effects, which are beneficial in controlling the complex pathophysiology of psoriasis. Due to these advantages, polyherbal therapies are increasingly being explored in the development of advanced topical drug delivery systems such as ethosomes, liposomes, and nanocarriers for effective psoriasis treatment (Dadwal *et al.,* 2018).

Commonly Used Anti-Psoriatic Herbs

Several medicinal plants have demonstrated promising anti-psoriatic potential due to their anti-inflammatory, antioxidant, and immunomodulatory activities (Rios *et al.*, 2019). *Aloe vera* is commonly used for its soothing, moisturizing, and wound-healing properties and has shown effectiveness in reducing scaling and erythema in psoriatic lesions (Chelu *et al.,* 2023). *Curcuma longa* (Turmeric) contains curcumin, which inhibits inflammatory cytokines and suppresses keratinocyte proliferation (Razavi *et al.*, 2021). *Azadirachta indica* (Neem) possesses antimicrobial, anti-inflammatory, and antioxidant properties that help in reducing skin irritation and inflammation. *Calendula officinalis* exhibits wound-healing and anti-inflammatory effects, while *Mahonia aquifolium* has been reported to reduce excessive skin cell proliferation. *Nigella sativa* (Black seed) contains thymoquinone, which demonstrates immunomodulatory and antioxidant activities beneficial in psoriasis. Other important medicinal plants include *Cassia tora*, *Wrightia tinctoria*, *Ocimum sanctum* (Tulsi), *Tinospora cordifolia*, and *Psoralea corylifolia*, which have traditionally been used in herbal medicine for treating chronic skin disorders. These herbs may be utilized individually or in combination to enhance therapeutic effectiveness in psoriasis management.

Phytoconstituents Responsible for Anti-Psoriatic Activity

The anti-psoriatic activity of medicinal plants is mainly attributed to the presence of various phytoconstituents that act through multiple pharmacological mechanisms (Aneja *et al.*, 2023). Flavonoids such as quercetin, kaempferol, and rutin exhibit potent antioxidant and anti-inflammatory properties by scavenging free radicals and inhibiting inflammatory mediators. Polyphenols and phenolic acids help reduce oxidative stress and suppress cytokine production involved in psoriasis progression (Liu *et al.,* 2023). Terpenoids and triterpenes possess antiproliferative and immunomodulatory activities that regulate abnormal keratinocyte growth. Alkaloids and glycosides contribute to antimicrobial and anti-inflammatory effects, while tannins provide protective and astringent actions on damaged skin tissues. Curcumin, thymoquinone, aloe-emodin, psoralen, and berberine are some important bioactive compounds reported to exhibit significant anti-psoriatic activity through inhibition of inflammatory pathways such as TNF-α, IL-17, IL-23, and NF-κB signaling. These phytoconstituents also aid in restoring normal skin architecture and improving skin

barrier function (Romes *et al.*, 2023). Due to their multi-mechanistic actions and safety profile, phytoconstituents derived from medicinal plants are considered promising candidates for incorporation into novel vesicular drug delivery systems for enhanced psoriasis therapy.

Phytochemical Investigation of Polyherbal Formulations

Extraction Methods

Extraction is an important step in the preparation of polyherbal formulations because it helps isolate therapeutically active phytoconstituents from crude plant materials (Mondal *et al.*, 2026). The efficiency of extraction depends on several factors such as solvent type, extraction technique, temperature, duration, and nature of phytochemicals present in the plant material. Commonly used extraction methods include maceration, infusion, decoction, percolation, Soxhlet extraction, reflux extraction, ultrasound-assisted extraction, and microwave-assisted extraction (Kalaskar *et al.*, 2025). Polar solvents such as water, methanol, ethanol, and hydroalcoholic mixtures are generally preferred for extracting flavonoids, glycosides, tannins, and phenolic compounds, whereas non-polar solvents like petroleum ether and chloroform are used for lipophilic constituents. Among these methods, hydroalcoholic extraction is widely employed in polyherbal formulations due to its ability to extract both hydrophilic and lipophilic phytoconstituents efficiently. The obtained extracts are concentrated using rotary evaporators or vacuum drying techniques and stored under suitable conditions for further phytochemical and pharmacological investigations. Proper extraction methods are essential for obtaining maximum yield and maintaining the stability and therapeutic activity of herbal constituents (Khan and Dashti, 2023).

Preliminary Phytochemical Screening

Preliminary phytochemical screening is carried out to identify the major classes of secondary metabolites present in herbal extracts (Geetha and Geetha, 2014). This qualitative analysis helps determine the therapeutic potential of polyherbal formulations and provides information regarding the presence of bioactive compounds responsible for pharmacological activity (Kumar *et al.*, 2023). Various standard chemical tests are performed for the detection of alkaloids, flavonoids, glycosides, tannins, saponins, phenols, steroids, terpenoids, carbohydrates, proteins, and fixed oils. Wagner's, Mayer's, and Dragendorff's tests are commonly used for alkaloids, while ferric chloride and lead acetate tests are employed for phenolic compounds and flavonoids. Foam tests are used for saponins, and Liebermann–Burchard reaction is used for steroids and terpenoids. The results of phytochemical screening provide a scientific basis for selecting herbal extracts with potential anti-inflammatory, antioxidant, antimicrobial, and immunomodulatory activities useful in psoriasis management. Furthermore, phytochemical screening assists in quality control and ensures consistency in herbal formulations.

Identification of Bioactive Constituents

Identification and characterization of bioactive constituents are essential for understanding the therapeutic efficacy of polyherbal formulations (Anwar *et al.*, 2022). Advanced analytical and spectroscopic

techniques are employed for the isolation and identification of active phytochemicals present in herbal extracts. Thin Layer Chromatography (TLC) and High-Performance Thin Layer Chromatography (HPTLC) are commonly used for fingerprint profiling and detection of phytoconstituents (Ram *et al.,* 2011). High-Performance Liquid Chromatography (HPLC), Gas Chromatography-Mass Spectrometry (GC-MS), and Liquid Chromatography-Mass Spectrometry (LC-MS) are widely utilized for qualitative and quantitative analysis of active compounds. Spectroscopic techniques such as Fourier Transform Infrared Spectroscopy (FTIR), Nuclear Magnetic Resonance (NMR), and UV-Visible spectroscopy help determine structural and functional characteristics of phytochemicals (Patle *et al.,* 2020). Identification of compounds such as curcumin, quercetin, berberine, aloe-emodin, thymoquinone, psoralen, and catechins is particularly important because these constituents exhibit potent anti-inflammatory, antioxidant, and anti-psoriatic activities. Accurate identification of bioactive compounds supports the development of effective and reproducible polyherbal drug delivery systems.

Standardization of Herbal Formulations

Standardization of herbal formulations is a crucial process to ensure the quality, safety, efficacy, and reproducibility of polyherbal products (Santosh and Jyotiram, 2016). Herbal formulations often exhibit variability due to differences in plant species, geographical conditions, harvesting time, processing methods, and storage conditions. Therefore, standardization helps maintain batch-to-batch consistency and therapeutic reliability. The process includes evaluation of organoleptic properties, physicochemical parameters, phytochemical analysis, microbial load, ash values, extractive values, moisture content, and determination of active marker compounds. Chromatographic fingerprinting techniques such as HPTLC and HPLC are commonly used for establishing standard profiles of herbal formulations (Bārzdiņa *et al.,* 2022). In addition, stability studies and assessment of heavy metals, pesticide residues, and microbial contamination are important to ensure product safety. Standardization also involves evaluating pharmacological activity and ensuring compliance with regulatory guidelines for herbal medicines. Properly standardized polyherbal formulations provide improved therapeutic outcomes and facilitate their incorporation into advanced drug delivery systems such as ethosomes for effective psoriasis management (Modi *et al.,* 2025).

Novel Drug Delivery Systems for Psoriasis

Need for Advanced Topical Delivery

Psoriasis is a chronic inflammatory skin disorder that requires prolonged treatment for effective management (Smith and Barker, 2006). Conventional topical formulations such as creams, ointments, gels, and lotions often show limited therapeutic efficacy due to poor penetration of drugs through the stratum corneum, which acts as the primary barrier of the skin. Frequent application, poor patient compliance, local irritation, and inadequate drug concentration at the target site further limit the effectiveness of traditional therapies. In addition, systemic administration of anti-psoriatic drugs may lead to severe adverse effects including hepatotoxicity, nephrotoxicity, immunosuppression, and

gastrointestinal disturbances. Therefore, there is a growing need for advanced topical drug delivery systems capable of improving skin penetration, enhancing drug retention within skin layers, reducing systemic absorption, and providing sustained drug release (Ali *et al.*, 2015). Novel drug delivery systems have gained significant attention because they improve therapeutic efficacy while minimizing side effects and improving patient compliance.

Vesicular Drug Delivery Systems

Vesicular drug delivery systems are advanced carriers composed of lipid bilayers capable of encapsulating both hydrophilic and lipophilic drugs (Jain *et al.*, 2014). These systems include liposomes, niosomes, transferosomes, ethosomes, phytosomes, and invasomes. Vesicular carriers enhance drug permeation through the skin by interacting with skin lipids and facilitating transport across the stratum corneum (Cevc, 1996). Their ability to improve bioavailability, prolong drug release, and protect encapsulated drugs from degradation makes them highly suitable for dermatological applications. In psoriasis treatment, vesicular systems help deliver therapeutic agents directly to inflamed skin tissues, thereby improving localized action and reducing systemic toxicity. Among various vesicular systems, ethosomes have emerged as one of the most promising carriers due to their superior deformability and enhanced skin penetration properties (Paiva-Santos *et al.*, 2021).

Advantages over Conventional Formulations

Novel vesicular drug delivery systems provide several advantages over conventional topical formulations (Jadhav *et al.*, 2012). These carriers enhance drug permeation through the skin barrier and increase drug retention in deeper skin layers. They offer controlled and sustained drug release, which reduces dosing frequency and improves patient compliance. Vesicular systems also minimize systemic side effects by targeting drugs directly to affected skin tissues. The encapsulation of active compounds protects them from chemical and enzymatic degradation, thereby improving stability and therapeutic efficacy. Furthermore, these formulations can accommodate both hydrophilic and lipophilic drugs and improve the solubility of poorly water-soluble compounds (McCrary *et al.*, 2013). Their biocompatibility, biodegradability, and ability to enhance therapeutic outcomes make vesicular systems highly suitable for psoriasis management.

Ethosomes

Definition and Structure

Ethosomes are soft, malleable, and ultra-deformable vesicular carriers composed mainly of phospholipids, ethanol in relatively high concentration, and water (Shelke *et al.*, 2015). They are considered modified liposomes with improved transdermal penetration ability due to the presence of ethanol. Ethosomes possess a lipid bilayer structure surrounding an aqueous core in which hydrophilic drugs can be entrapped, while lipophilic drugs are incorporated within the lipid bilayer (Abdallah *et al.*, 2025). The presence of ethanol imparts flexibility and fluidity to the vesicular membrane, enabling ethosomes to penetrate efficiently through the stratum corneum and reach deeper skin layers. Due to their unique structure and enhanced permeation capability, ethosomes have become promising carriers for topical and

transdermal drug delivery applications (Nainwal *et al.,* 2019).

Composition of Ethosomes

Ethosomal formulations mainly consist of phospholipids, ethanol, water, and active pharmaceutical ingredients. Phospholipids such as phosphatidylcholine, soya phosphatidylcholine, and lecithin form the vesicular bilayer structure (Paiva-Santos *et al.,* 2021). Ethanol is the key component responsible for enhancing vesicle flexibility and skin permeation. Generally, ethanol concentration ranges from 20–45%, depending on the formulation requirements. Polyols such as propylene glycol or polyethylene glycol may also be added to improve vesicle stability and skin hydration. Herbal extracts or active phytoconstituents intended for psoriasis treatment are incorporated into the ethosomal vesicles according to their solubility characteristics (Touitou *et al.,* 2000). The careful selection and optimization of formulation components are essential for achieving stable vesicles with high drug entrapment and efficient skin delivery.

Mechanism of Skin Penetration

Ethosomes enhance drug penetration through a synergistic mechanism involving ethanol and phospholipids (Verma and Fahr, 2004). Ethanol interacts with the lipid molecules of the stratum corneum, causing fluidization and disruption of the tightly packed lipid structure, thereby increasing skin permeability. Simultaneously, the flexible ethosomal vesicles penetrate through the disturbed skin barrier and deliver the encapsulated drug into deeper epidermal and dermal layers. The deformable nature of ethosomes allows them to squeeze through intercellular spaces smaller than their own diameter without rupturing. This mechanism improves drug accumulation at the target site and enhances therapeutic efficacy in psoriasis treatment. Ethosomes can also facilitate systemic absorption when required, making them suitable for both local and transdermal drug delivery applications (Jafari *et al.,* 2023).

Advantages and Limitations of Ethosomes

Ethosomes offer several advantages including enhanced skin permeation, improved drug bioavailability, controlled drug release, and better drug retention within skin tissues (Garg *et al.,* 2017). They are capable of encapsulating both hydrophilic and lipophilic drugs and improve the stability of incorporated phytoconstituents. Ethosomal systems are non-invasive, biocompatible, and suitable for long-term topical therapy. They also reduce systemic side effects and improve patient compliance due to reduced dosing frequency. However, ethosomes also possess certain limitations (Mbah *et al.,* 2014). High ethanol concentration may occasionally cause skin irritation or dryness in sensitive individuals. Vesicle aggregation, leakage of entrapped drug, and physical instability during storage are additional challenges associated with ethosomal formulations. Moreover, large-scale manufacturing and long-term stability remain important concerns that require further optimization and research.

Preparation Methods of Ethosomal Systems

Cold Method

The cold method is one of the most commonly used techniques for preparing ethosomal vesicles (Maestrelli *et al.,* 2009). In this method, phospholipids and other lipid components are dissolved in ethanol with

continuous stirring at room temperature. Polyols such as propylene glycol may also be added during this stage. Water is heated separately to the same temperature as the organic phase and then slowly added to the ethanolic lipid mixture under continuous stirring. The resulting dispersion forms ethosomal vesicles spontaneously. The prepared formulation may be subjected to sonication or extrusion to reduce vesicle size and achieve uniform distribution. This method is simple, convenient, and widely employed for the preparation of herbal ethosomal formulations.

Hot Method

In the hot method, phospholipids are dispersed in water and heated to a temperature of approximately 40°C until a colloidal solution is formed. Ethanol and polyols are heated separately to the same temperature and then added gradually to the aqueous phase under continuous stirring. The drug or herbal extract is dissolved in either the aqueous or alcoholic phase depending on its solubility characteristics. The final ethosomal dispersion is obtained after continuous mixing and may be sonicated to reduce vesicle size. This method is suitable for temperature-stable compounds and provides relatively uniform vesicles (Supraja and Sailaja, 2017).

Thin Film Hydration Method

The thin film hydration method involves dissolving phospholipids and other lipid components in organic solvents such as chloroform and methanol. The solvent is removed using a rotary vacuum evaporator to form a thin lipid film on the walls of a round-bottom flask. The dried lipid film is then hydrated using an aqueous ethanolic solution containing the drug or herbal extract under continuous agitation. Hydration results in the formation of multilamellar vesicles, which may be reduced in size using sonication or extrusion techniques. This method is commonly employed when precise control over vesicle characteristics is required (Thabet *et al.,* 2022).

Ethanol Injection Method

In the ethanol injection method, phospholipids and drug are dissolved in ethanol and injected slowly into an aqueous phase under continuous stirring. Upon contact with water, spontaneous vesicle formation occurs due to rapid diffusion of ethanol. The resulting ethosomal dispersion is stirred continuously to ensure uniformity and may undergo sonication for size reduction. This method is simple, reproducible, and suitable for large-scale preparation of ethosomal formulations (Shaker *et al.,* 2017).

Characterization of Ethosomal Formulations

Vesicle Size and Polydispersity Index

Vesicle size and polydispersity index (PDI) are important parameters influencing skin penetration, drug release, and formulation stability (Danaei *et al.,* 2018). Dynamic light scattering techniques using a zetasizer are commonly employed for determining vesicle size distribution and PDI. Smaller vesicles generally exhibit better skin penetration, while low PDI values indicate uniform vesicle distribution and formulation homogeneity.

Zeta Potential

Zeta potential measures the surface charge of ethosomal vesicles and provides information regarding formulation stability. High positive or negative zeta potential values prevent vesicle aggregation due to electrostatic repulsion and improve storage stability. Zeta

potential is commonly measured using electrophoretic light scattering techniques (Midekessa *et al.,* 2018).

Entrapment Efficiency

Entrapment efficiency indicates the percentage of drug successfully incorporated within ethosomal vesicles. It is generally determined by centrifugation or ultracentrifugation methods, where free drug is separated from entrapped drug. High entrapment efficiency is desirable for effective therapeutic action and sustained drug release (Iizhar *et al.,* 2016).

Morphology Studies (SEM/TEM)

Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) are used to study the morphology, surface characteristics, and structural integrity of ethosomal vesicles. These techniques help confirm vesicle shape, size, and lamellarity. Ethosomes generally appear as spherical or nearly spherical vesicles under microscopic observation (Hussain *et al.,* 2023).

Drug Content

Drug content analysis determines the amount of active constituent present in the ethosomal formulation (Fathalla *et al.,* 2020). The formulation is lysed using suitable solvents, and drug concentration is measured using analytical techniques such as UV-Visible spectroscopy or High-Performance Liquid Chromatography (HPLC).

***In-vitro* Drug Release Studies**

In-vitro drug release studies are performed to evaluate the release profile of drugs from ethosomal formulations (David *et al.,* 2013). Franz diffusion cells with synthetic or biological membranes are commonly used for this purpose. These studies provide information regarding release kinetics, permeation behavior, and sustained release characteristics of the formulation.

Stability Studies

Stability studies are conducted to evaluate the physical, chemical, and microbiological stability of ethosomal formulations during storage. Parameters such as vesicle size, zeta potential, entrapment efficiency, drug content, and appearance are monitored under different storage conditions. Stability studies help determine the shelf life and suitability of the formulation for long-term use (Ghimire *et al.,* 2020).

Incorporation of Polyherbal Extracts into Ethosomes

Selection of Herbal Extracts

Selection of suitable herbal extracts is an important step in the development of polyherbal ethosomal formulations for psoriasis management (Yadav *et al.,* 2024). Herbs possessing anti-inflammatory, antioxidant, antiproliferative, antimicrobial, and immunomodulatory activities are generally preferred. The compatibility, therapeutic efficacy, and safety profile of herbal extracts must be carefully evaluated before incorporation into ethosomal systems.

Compatibility Studies

Compatibility studies are carried out to evaluate interactions between herbal extracts and formulation excipients (Bhope *et al.,* 2011). Techniques such as Fourier Transform Infrared Spectroscopy (FTIR), Differential Scanning Calorimetry (DSC), and X-ray diffraction studies are commonly employed to detect possible chemical interactions or incompatibilities. These studies ensure formulation stability and preservation of therapeutic activity.

Optimization of Formulation Variables

Optimization of formulation variables is essential for achieving stable ethosomal vesicles with desired physicochemical characteristics and therapeutic efficacy (El-Hashemy, 2022). Variables such as phospholipid concentration, ethanol concentration, hydration medium, sonication time, and drug-to-lipid ratio significantly influence vesicle size, entrapment efficiency, zeta potential, and drug release behavior. Experimental design approaches such as factorial design and Box–Behnken design are often employed for systematic optimization of ethosomal formulations.

Mechanism of Ethosomal Drug Delivery in Psoriasis

Ethosomal drug delivery systems enhance the penetration of therapeutic agents through the skin by utilizing the synergistic action of phospholipid vesicles and high concentrations of ethanol (Touitou *et al.,* 200). In psoriasis, the stratum corneum acts as a major barrier that restricts the penetration of drugs into deeper skin layers. Ethanol present in ethosomes disrupts and fluidizes the lipid arrangement of the stratum corneum, thereby increasing skin permeability. Simultaneously, the flexible and deformable ethosomal vesicles penetrate through the intercellular lipid pathways and deliver the encapsulated drug into the epidermis and dermis. The phospholipid bilayer of ethosomes can fuse with skin lipids, facilitating enhanced retention of therapeutic agents within inflamed psoriatic tissues. This targeted and sustained delivery improves local drug concentration at the affected site while minimizing systemic absorption and adverse effects. In the management of psoriasis, ethosomal formulations can effectively deliver herbal phytoconstituents possessing anti-inflammatory, antioxidant, antiproliferative, and immunomodulatory properties, thereby reducing erythema, scaling, itching, and plaque formation (Khan *et al.,* 2021).

Therapeutic Potential of Ethosomal Polyherbal Systems

Ethosomal polyherbal systems have emerged as promising carriers for the effective management of psoriasis due to their ability to combine the therapeutic advantages of herbal medicines with advanced vesicular drug delivery technology (Detholia *et al.,* 2024). Polyherbal formulations provide synergistic pharmacological effects because multiple medicinal plants contribute different bioactive compounds acting through diverse mechanisms. When incorporated into ethosomes, these phytoconstituents exhibit enhanced skin permeation, improved stability, and prolonged retention in the target tissues. Ethosomal polyherbal systems can effectively suppress inflammatory mediators such as TNF-α, IL-17, IL-22, and IL-23 involved in psoriasis pathogenesis. In addition, antioxidant phytochemicals reduce oxidative stress and protect skin cells from further damage. Herbal compounds with antiproliferative activity help regulate abnormal keratinocyte proliferation, while antimicrobial constituents reduce secondary skin infections commonly associated with psoriatic lesions. These systems also improve patient compliance by reducing dosing frequency and minimizing local irritation and systemic toxicity. Due to their biocompatibility, controlled release properties, and enhanced therapeutic efficacy,

ethosomal polyherbal systems are considered a valuable approach for topical psoriasis therapy (Salgaonkar *et al.*, 2024).

Recent Research and Advances in Ethosomal Herbal Formulations

Recent advancements in nanotechnology and vesicular drug delivery systems have significantly improved the development of ethosomal herbal formulations for dermatological applications (Fatima and Kaur, 2016). Researchers have successfully incorporated various herbal extracts and phytoconstituents such as curcumin, aloe vera, neem, resveratrol, quercetin, and thymoquinone into ethosomal carriers to enhance their skin permeation and therapeutic efficacy (Agrawal *et al.*, 2024). Studies have demonstrated that ethosomal formulations improve drug entrapment efficiency, increase transdermal flux, and provide sustained drug release compared to conventional topical formulations. Modern formulation approaches such as nanoethosomes, transethosomes, and dual-loaded vesicular systems are being investigated to achieve superior penetration and targeted delivery. Advanced optimization techniques including Box–Behnken design and factorial design are frequently used to optimize formulation variables and improve stability characteristics. In addition, recent research focuses on combining herbal extracts with biocompatible polymers and hydrogels to develop hybrid delivery systems with improved retention and therapeutic outcomes. The integration of advanced analytical techniques such as HPLC, FTIR, TEM, and confocal microscopy has further contributed to the precise characterization and quality evaluation of ethosomal herbal formulations (Dave *et al.*, 2020). These advancements indicate the growing potential of ethosomal systems as effective carriers for herbal anti-psoriatic therapy.

Safety, Toxicity, and Regulatory Considerations

Although ethosomal herbal formulations are generally considered safer than conventional systemic therapies, proper evaluation of safety and toxicity remains essential before clinical application (Abdulbaqi *et al.*, 2016). Herbal extracts may contain multiple phytoconstituents capable of causing allergic reactions, skin irritation, or hypersensitivity in sensitive individuals. Therefore, dermatological safety studies such as skin irritation tests, patch tests, and histopathological evaluations are necessary to ensure formulation safety. The ethanol content present in ethosomes may occasionally cause dryness or mild irritation upon prolonged application, particularly in damaged or sensitive skin. Toxicological assessment of herbal extracts, excipients, and vesicular components is important to establish their safety profile for long-term use. In addition, microbial contamination, heavy metals, pesticide residues, and batch-to-batch variation in herbal formulations must be carefully monitored through standardization and quality control procedures. Regulatory approval of herbal nanocarrier systems requires comprehensive evaluation of formulation quality, efficacy, stability, and toxicity according to guidelines established by regulatory authorities such as WHO, FDA, and national pharmacopeial standards. The development of standardized protocols and regulatory frameworks for herbal nanotechnology-based products remains a

major requirement for their successful commercialization.

Challenges and Future Perspectives

Despite the promising therapeutic potential of ethosomal polyherbal systems, several challenges still limit their widespread clinical application (Mahomoodally *et al.,* 2021). One of the major concerns is the physical and chemical instability of ethosomal formulations during long-term storage, including vesicle aggregation, drug leakage, and changes in vesicle size. Standardization of herbal extracts is another important challenge due to variability in phytochemical composition caused by differences in geographical source, cultivation conditions, harvesting time, and extraction methods. Large-scale industrial production and reproducibility of ethosomal formulations also require further optimization (Basak and Das, 2025). In addition, limited clinical studies and insufficient long-term safety data restrict their acceptance in mainstream medical practice. The high cost of advanced analytical instruments and formulation technologies may further hinder commercial development.

Future research should focus on improving the stability, scalability, and targeting efficiency of ethosomal systems using advanced nanotechnological approaches. The incorporation of novel biodegradable polymers, bioadhesive gels, and stimuli-responsive carriers may further enhance therapeutic outcomes. Clinical trials evaluating the efficacy and safety of ethosomal polyherbal formulations in psoriasis patients are necessary to establish their therapeutic potential. Personalized medicine approaches, artificial intelligence-based formulation optimization, and combination therapy strategies may also contribute to the future development of effective anti-psoriatic delivery systems. With continued advancements in herbal nanotechnology, ethosomal polyherbal formulations are expected to emerge as highly efficient, safer, and patient-friendly alternatives for psoriasis management.

CONCLUSION

Psoriasis is a chronic inflammatory skin disorder that significantly affects the quality of life of patients and requires long-term therapeutic management. Conventional treatment approaches often suffer from limitations such as poor skin penetration, systemic side effects, frequent dosing, and reduced patient compliance. Herbal medicines have gained considerable attention due to their anti-inflammatory, antioxidant, immunomodulatory, and antiproliferative properties, which are beneficial in psoriasis treatment. The incorporation of herbal extracts into advanced vesicular carriers such as ethosomes offers a promising strategy for enhancing skin permeation, improving drug retention, and achieving sustained therapeutic action. Ethosomal systems possess unique deformability and penetration-enhancing properties that enable efficient delivery of phytoconstituents into deeper skin layers. Polyherbal ethosomal formulations further provide synergistic therapeutic benefits and reduced toxicity compared to synthetic therapies. Although challenges related to stability, standardization, large-scale production, and regulatory approval still exist, recent advances in nanotechnology and herbal drug delivery systems have opened new possibilities for effective psoriasis management. Therefore, ethosomal-based

polyherbal drug delivery systems represent a promising and innovative approach for developing safer, more effective, and patient-compliant therapies for psoriasis.

DECLARATION OF INTEREST

The authors declare no conflicts of interests. The authors alone are responsible for the content and writing of this article.

REFERENCES

- Orzan, O. A., Tutunaru, C. V., & Ianoși, S. L. (2025). Understanding the intricate pathophysiology of psoriasis and related skin disorders. *International Journal of Molecular Sciences, 26*(2), 749.
- Javierre, B. M., Hernando, H., & Ballestar, E. (2011). Environmental triggers and epigenetic deregulation in autoimmune disease. *Discovery Medicine, 12*(67), 535–545.
- Hepat, A., Chakole, S., & Rannaware, A. (2023). Psychological well-being of adult psoriasis patients: A narrative review. *Cureus, 15*(4).
- Mehrmal, S., Uppal, P., Nedley, N., Giesey, R. L., & Delost, G. R. (2021). The global, regional, and national burden of psoriasis in 195 countries and territories, 1990 to 2017: A systematic analysis from the Global Burden of Disease Study 2017. *Journal of the American Academy of Dermatology, 84*(1), 46–52.
- Unissa, R., Kumar, P. M., Pasha, M., Begum, S., & Maheswari, B. (2019). Psoriasis: A comprehensive review. *Asian Journal of Research in Pharmaceutical Science, 9*(1), 29–38.
- Yamanaka, K., Yamamoto, O., & Honda, T. (2021). Pathophysiology of psoriasis: A review. *The Journal of Dermatology, 48*(6), 722–731.
- Singh, S., Ramani, P., Jayakumar, N. D., Pannu, S. J., Sharma, R. K., & Gill, S. S. (2022). Role of pro-inflammatory and anti-inflammatory cytokines in pathophysiology of psoriasis. *Current Oral Health Reports, 9*(4), 132–145.
- Feliciani, C., Gupta, A. K., & Saucier, D. N. (1996). Keratinocytes and cytokine/growth factors. *Critical Reviews in Oral Biology & Medicine, 7*(4), 300–318.
- Lee, H. J., Hong, Y. J., & Kim, M. (2021). Angiogenesis in chronic inflammatory skin disorders. *International Journal of Molecular Sciences, 22*(21), 12035.
- Kuchekar, A. B., Pujari, R. R., Kuchekar, S. B., Dhole, S. N., Mule, P. M., & Vidyapeeth, B. W. (2011). Psoriasis: A comprehensive review. *International Journal of Pharma and Life Sciences, 2*(6), 857–877.
- Raychaudhuri, S. K., Maverakis, E., & Raychaudhuri, S. P. (2014). Diagnosis and classification of psoriasis. *Autoimmunity Reviews, 13*(4–5), 490–495.
- Haneke, E. (2017). Nail psoriasis: Clinical features, pathogenesis, differential diagnoses, and management. *Psoriasis: Targets and Therapy, 7*, 51–63.
- Mahajan, V. K. (2016). Psoriasis treatment: Unconventional and non-standard modalities in the era of biologics. *World Journal of Dermatology, 5*(1), 17–51.

- Waldron, J. L., Schworer, S. A., & Kwan, M. (2022). Hypersensitivity and immune-related adverse events in biologic therapy. *Clinical Reviews in Allergy & Immunology, 62*(3), 413–431.
- Pandey, K. (2020). An overview on promising nanotechnological approaches for the treatment of psoriasis. *Recent Patents on Nanotechnology, 14*(2), 102–118.
- Ahuja, A., Gupta, J., & Gupta, R. (2021). Miracles of herbal phytomedicines in treatment of skin disorders: Natural healthcare perspective. *Infectious Disorders - Drug Targets, 21*(3), 328–338.
- Sarwar, R., Maisam, M., Khan, M. W., Xue, Y., & Hassan, S. (2025). Bioactive compounds in herbal remedies. In *Herbal pharmacopeia* (pp. 89–121). CRC Press.
- Yatoo, M. I., Gopalakrishnan, A., Saxena, A., Parray, O. R., Tufani, N. A., Chakraborty, S., Tiwari, R., Dhama, K., & Iqbal, H. M. N. (2018). Anti-inflammatory drugs and herbs with special emphasis on herbal medicines for countering inflammatory diseases and disorders: A review. *Recent Patents on Inflammation & Allergy Drug Discovery, 12*(1), 39–58.
- Moreira, D. D., Teixeira, S. S., Monteiro, M. H., De-Oliveira, A. C., & Paumgartten, F. J. (2014). Traditional use and safety of herbal medicines. *Revista Brasileira de Farmacognosia, 24*(2), 248–257.
- Rajini, P. S., & Muralidhara, M. (2023). Therapeutic efficacy of ayurvedic polyherbal formulations (PHF): Interactive mechanisms and broad-spectrum activities against neurological disorders. In *Ayurvedic herbal preparations in neurological disorders* (pp. 89–111).
- Yadav, T., Yadav, H. K., Raizaday, A., & Alam, M. S. (2024). The treatment of psoriasis via herbal formulation and nano-polyherbal formulation: A new approach. *BioImpacts, 15*, 30341.
- Rana, N., Gupta, P., Singh, H., & Nagarajan, K. (2024). Role of bioactive compounds, novel drug delivery systems, and polyherbal formulations in the management of rheumatoid arthritis. *Combinatorial Chemistry & High Throughput Screening, 27*(3), 353–385.
- Dadwal, A., Mishra, N., & Narang, R. K. (2018). Novel topical nanocarriers for treatment of psoriasis: An overview. *Current Pharmaceutical Design, 24*(33), 3934–3950.
- Ríos, J. L., Schinella, G. R., & Andújar, I. (2019). Antipsoriatic medicinal plants: From traditional use to clinic. In *Ethnobotany* (pp. 158–186). CRC Press.
- Chelu, M., Musuc, A. M., Popa, M., & Calderon Moreno, J. (2023). Aloe vera-based hydrogels for wound healing: Properties and therapeutic effects. *Gels, 9*(7), 539.
- Razavi, B. M., Ghasemzadeh Rahbardar, M., & Hosseinzadeh, H. (2021). A review of therapeutic

potentials of turmeric (*Curcuma longa*) and its active constituent, curcumin, on inflammatory disorders, pain, and their related patents. *Phytotherapy Research, 35*(12), 6489–6513.

- Aneja, S., Mittal, A., Dhiman, N., & Agarwal, G. (2023). A review on phytoconstituents for the treatment of psoriasis. *Pharmacognosy Reviews, 17*(34).
- Liu, H. M., Cheng, M. Y., Xun, M. H., Zhao, Z. W., Zhang, Y., Tang, W., Cheng, J., Ni, J., & Wang, W. (2023). Possible mechanisms of oxidative stress-induced skin cellular senescence, inflammation, and cancer and the therapeutic potential of plant polyphenols. *International Journal of Molecular Sciences, 24*(4), 3755.
- Romes, N. B., Abdul Wahab, R., & Abdul Hamid, M. (2021). The role of bioactive phytoconstituents-loaded nanoemulsions for skin improvement: A review. *Biotechnology & Biotechnological Equipment, 35*(1), 711–730.
- Mondal, S., Das, M., Debnath, S., Sarkar, B. K., & Babu, G. (2026). An overview of extraction, isolation and characterization techniques of phytocompounds from medicinal plants. *Natural Product Research, 40*(7), 1939–1961.
- Kalaskar, M., Yele, S. U., Ayyanar, M., Gurav, N., Beldar, V., & Surana, S. J. (2025). Methods of extraction. In *Pharmacognosy and phytochemistry: Principles, techniques, and clinical applications* (pp. 121–142).
- Khan, M. S., & Dashti, M. G. (2023). Optimizing extraction techniques for maximized bioactive compound yield in medicinal herbs. *Australian Herbal Insight, 6*(1), 1–10.
- Geetha, T. S., & Geetha, N. (2014). Phytochemical screening, quantitative analysis of primary and secondary metabolites of *Cymbopogan citratus* (DC.) Stapf leaves from Kodaikanal Hills, Tamil Nadu. *International Journal of PharmTech Research, 6*(2), 521–529.
- Kumar, R. A., Kumar, D. S., & Suresh, D. (2023). Polyherbal formulation: A promising approach for determining pharmacological activities and therapeutic uses. *AIJR Publisher Life Sciences, 8*(4), 1–8.
- Anwar, S., Kausar, M. A., Parveen, K., Zahra, A., Ali, A., Badraoui, R., Snoussi, M., Siddiqui, W. A., & Saeed, M. (2022). Polyherbal formulation: The studies towards identification of composition and their biological activities. *Journal of King Saud University - Science, 34*(7), 102256.
- Ram, M., Abdin, M. Z., Khan, M. A., & Jha, P. (2011). HPTLC fingerprint analysis: A quality control for authentication of herbal phytochemicals. In *High-performance thin-layer chromatography (HPTLC)* (pp. 105–116). Springer.
- Patle, T. K., Shrivas, K., Kurrey, R., Upadhyay, S., Jangde, R., & Chauhan, R. (2020). Phytochemical screening and determination of phenolics and flavonoids in *Dillenia pentagyna* using

UV–Vis and FTIR spectroscopy. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, *242*, 118717.

- Santosh, J., & Jyotiram, S. (2016). Standardization of poly-herbal formulations: A comprehensive review. *Research Journal of Pharmacognosy and Phytochemistry, 8*(2), 85–89.
- Bārzdiņa, A., Paulausks, A., Bandere, D., & Brangule, A. (2022). The potential use of herbal fingerprints by means of HPLC and TLC for characterization and identification of herbal extracts and the distinction of Latvian native medicinal plants. *Molecules, 27*(8), 2555.
- Modi, C., Prajapati, B. G., Kapoor, D. U., & Mehta, A. (2025). Transfersomes and ethosomes for psoriasis: A review of novel vesicular drug delivery systems. *Biomedical Materials & Devices*, 1–5.
- Smith, C. H., & Barker, J. N. (2006). Psoriasis and its management. *BMJ, 333*(7564), 380–384.
- Ali, S., Shabbir, M., & Shahid, N. (2015). The structure of skin and transdermal drug delivery system: A review. *Research Journal of Pharmacy and Technology, 8*(2), 103–109.
- Jain, S., Jain, V., & Mahajan, S. C. (2014). Lipid based vesicular drug delivery systems. *Advances in Pharmaceutics, 2014*, 574673.
- Cevc, G. (1996). Transfersomes, liposomes and other lipid suspensions on the skin: Permeation enhancement, vesicle penetration, and transdermal drug delivery. *Critical Reviews in Therapeutic Drug Carrier Systems, 13*(3–4), 257–388.
- Paiva-Santos, A. C., Silva, A. L., Guerra, C., Peixoto, D., Pereira-Silva, M., Zeinali, M., Mascarenhas-Melo, F., Castro, R., & Veiga, F. (2021). Ethosomes as nanocarriers for the development of skin delivery formulations. *Pharmaceutical Research, 38*(6), 947–970.
- Jadhav, S. M., Morey, P., Karpe, M. M., & Kadam, V. (2012). Novel vesicular system: An overview. *Journal of Applied Pharmaceutical Science, 2*, 193–202.
- McCrary, P. D., Beasley, P. A., Gurau, G., Narita, A., Barber, P. S., Cojocaru, O. A., & Rogers, R. D. (2013). Drug specific tuning of an ionic liquid's hydrophilic–lipophilic balance to improve water solubility of poorly soluble active pharmaceutical ingredients. *New Journal of Chemistry, 37*(7), 2196–2202.
- Shelke, S., Shahi, S., Kale, S., Patil, V., & Deshpande, D. (2015). Ethosomes: A novel deformable carrier. *World Journal of Pharmaceutical Sciences*, 1830–1839.
- Abdallah, M. H., Shahien, M. M., El-Horany, H. E., & Ahmed, E. H. (2025). Modified phospholipid vesicular gel for transdermal drug delivery: The influence of glycerin and/or ethanol on their lipid bilayer fluidity and penetration characteristics. *Gels, 11*(5), 358.

- Nainwal, N., Jawla, S., Singh, R., & Saharan, V. A. (2019). Transdermal applications of ethosomes: A detailed review. *Journal of Liposome Research, 29*(2), 103–113.
- Paiva-Santos, A. C., Silva, A. L., Guerra, C., Peixoto, D., Pereira-Silva, M., Zeinali, M., Mascarenhas-Melo, F., Castro, R., & Veiga, F. (2021). Ethosomes as nanocarriers for the development of skin delivery formulations. *Pharmaceutical Research, 38*(6), 947–970.
- Touitou, E., Dayan, N., Bergelson, L., Godin, B., & Eliaz, M. (2000). Ethosomes—Novel vesicular carriers for enhanced delivery: Characterization and skin penetration properties. *Journal of Controlled Release, 65*(3), 403–418.
- Verma, D. D., & Fahr, A. (2004). Synergistic penetration enhancement effect of ethanol and phospholipids on the topical delivery of cyclosporin A. *Journal of Controlled Release, 97*(1), 55–66.
- Jafari, A., Daneshamouz, S., Ghasemiyeh, P., & Mohammadi-Samani, S. (2023). Ethosomes as dermal/transdermal drug delivery systems: Applications, preparation and characterization. *Journal of Liposome Research, 33*(1), 34–52.
- Garg, V., Singh, H., Bimbrawh, S., Kumar Singh, S., Gulati, M., Vaidya, Y., & Kaur, P. (2017). Ethosomes and transfersomes: Principles, perspectives and practices. *Current Drug Delivery, 14*(5), 613–633.
- Mbah, C. C., Builders, P. F., & Attama, A. A. (2014). Nanovesicular carriers as alternative drug delivery systems: Ethosomes in focus. *Expert Opinion on Drug Delivery, 11*(1), 45–59.
- Maestrelli, F., Capasso, G., González-Rodríguez, M. L., Rabasco, A. M., Ghelardini, C., & Mura, P. (2009). Effect of preparation technique on the properties and in vivo efficacy of benzocaine-loaded ethosomes. *Journal of Liposome Research, 19*(4), 253–260.
- Supraja, R., & Sailaja, A. K. (2017). Formulation of mefenamic acid loaded ethosomal gel by hot and cold methods. *Nano Biomedicine and Engineering, 9*(1), 27–35.
- Thabet, Y., Elsabahy, M., & Eissa, N. G. (2022). Methods for preparation of niosomes: A focus on thin-film hydration method. *Methods, 199*, 9–15.
- Shaker, S., Gardouh, A. R., & Ghorab, M. M. (2017). Factors affecting liposomes particle size prepared by ethanol injection method. *Research in Pharmaceutical Sciences, 12*(5), 346–352.
- Danaei, M. R., Dehghankhold, M., Ataei, S., Hasanzadeh Davarani, F., Javanmard, R., Dokhani, A., Khorasani, S., & Mozafari, M. Y. (2018). Impact of particle size and polydispersity index on the clinical applications of lipidic nanocarrier systems. *Pharmaceutics, 10*(2), 57.
- Midekessa, G., Godakumara, K., Ord, J., Viil, J., Lattekivi, F., Dissanayake,

K., Kopanchuk, S., Rinken, A., Andronowska, A., Bhattacharjee, S., & Rinken, T. (2020). Zeta potential of extracellular vesicles: Toward understanding the attributes that determine colloidal stability. *ACS Omega, 5*(27), 16701–16710.

- Iizhar, S. A., Syed, I. A., Satar, R., & Ansari, S. A. (2016). In vitro assessment of pharmaceutical potential of ethosomes entrapped with terbinafine hydrochloride. *Journal of Advanced Research, 7*(3), 453–461.
- Hussain, A., Altamimi, M. A., Afzal, O., Altamimi, A. S., Ramzan, M., & Khuroo, T. (2023). Mechanistic study of vesicular ethosomes and elastic liposomes on permeation profiles of acyclovir across artificial membrane, human cultured EpiDerm, and rat skin: In vitro–ex vivo study. *Pharmaceutics, 15*(9), 2189.
- Fathalla, D., Youssef, E. M., & Soliman, G. M. (2020). Liposomal and ethosomal gels for the topical delivery of anthralin: Preparation, comparative evaluation and clinical assessment in psoriatic patients. *Pharmaceutics, 12*(5), 446.
- David, S. R., Hui, M. S., Pin, C. F., Ci, F. Y., & Rajabalaya, R. (2013). Formulation and in vitro evaluation of ethosomes as vesicular carrier for enhanced topical delivery of isotretinoin. *International Journal of Drug Delivery, 5*(1), 28–34.
- Ghimire, P., Shrestha, A. C., & Pandey, S. (2020). Guidelines on stability studies of pharmaceutical products and shelf life estimation. *International Journal of Advanced Pharmacy and Biotechnology, 6*(1), 15–23.
- Yadav, T., Yadav, H. K., Raizaday, A., & Alam, M. S. (2024). The treatment of psoriasis via herbal formulation and nano-polyherbal formulation: A new approach. *BioImpacts, 15*, 30341.
- Bhope, S. G., Nagore, D. H., Kuber, V. V., Gupta, P. K., & Patil, M. J. (2011). Design and development of a stable polyherbal formulation based on the results of compatibility studies. *Pharmacognosy Research, 3*(2), 122–127.
- El-Hashemy, H. A. (2022). Design, formulation and optimization of topical ethosomes using full factorial design: In-vitro and ex-vivo characterization. *Journal of Liposome Research, 32*(1), 74–82.
- Touitou, E., Godin, B., & Weiss, C. (2000). Enhanced delivery of drugs into and across the skin by ethosomal carriers. *Drug Development Research, 50*(3–4), 406–415.
- Khan, A., Qadir, A., Ali, F., & Aqil, M. (2021). Phytoconstituents based nanomedicines for the management of psoriasis. *Journal of Drug Delivery Science and Technology, 64*, 102663.
- Detholia, K., Prajapati, H. A., Patel, J. S., Panchal, N. C., Pal, V. S., & Patel, A. P. (2024). Innovative approaches in psoriasis management: Integration of novel drug delivery systems, herbal medicine, and lifestyle modifications. *International Journal of Scientific*

Research in Engineering and Management, 8, 1–3.

- Salgaonkar, S. P., Purewal, J. S., Doshi, G. M., Fernandes, T., Gharat, S., & Sawarkar, S. P. (2024). New insights in psoriasis management using herbal drug nanocarriers. *Current Pharmaceutical Design, 30*(32), 2550–2561.
- Fatima, Z., & Kaur, C. D. (2016). A review on potential of novel vesicular carriers for carrying herbal drugs in the treatment of dermatological disorders. *Journal of Atoms and Molecules, 6*(3), 987–999.
- Agrawal, R., Jurel, P., Deshmukh, R., Harwansh, R. K., Garg, A., Kumar, A., Singh, S., Guru, A., Kumar, A., & Kumarasamy, V. (2024). Emerging trends in the treatment of skin disorders by herbal drugs: Traditional and nanotechnological approach. *Pharmaceutics, 16*(7), 869.
- Dave, V., Bhardwaj, N., Gupta, N., & Tak, K. (2020). Herbal ethosomal gel containing luliconazole for productive relevance in the field of biomedicine. *3 Biotech, 10*(3), 97.
- Abdulbaqi, I. M., Darwis, Y., Khan, N. A., Assi, R. A., & Khan, A. A. (2016). Ethosomal nanocarriers: The impact of constituents and formulation techniques on ethosomal properties, in vivo studies, and clinical trials. *International Journal of Nanomedicine, 11*, 2279–2304.
- Mahomoodally, M. F., Sadeer, N., Edoo, M., & Venugopala, K. N. (2021). The potential application of novel drug delivery systems for phytopharmaceuticals and natural extracts—Current status and future perspectives. *Mini Reviews in Medicinal Chemistry, 21*(18), 2731–2746.
- Basak, S., & Das, T. K. (2025). Liposome-based drug delivery systems: From laboratory research to industrial production instruments and challenges. *ChemEngineering, 9*(3), 56.