RESEARCH PAPER

PHYTOCHEMICAL AND PHARMACOLOGICAL INSIGHTS OF KIGELIA AFRICANA SEED OIL: PROSPECTS IN NANOEMULSION BASED PSORIASIS THERAPY

Kavita Pant[1], Sumit Durgapal[2*]

[1]Research Scholar, Department of Pharmaceutics, Uttaranchal Institute of Pharmaceutical Sciences, Uttaranchal University, Premnagar, Dehradun-248007, India.

[2]Professor, Department of Pharmaceutics, Uttaranchal Institute of Pharmaceutical Sciences, Uttaranchal University, Premnagar, Dehradun-248007, India.

***Corresponding author: Dr. Sumit Durgapal, Professor, Department of Pharmaceutics, Uttaranchal Institute of Pharmaceutical Sciences, Uttaranchal University, Premnagar, Dehradun-248007, India.**

Email: durgapalsumit1@gmail.com

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ABSTRACT

This review emphasizes the therapeutic promise of Kigelia africana seed oil and its phytochemical components in treating psoriasis, placing special focus on drug delivery systems based on nanoemulsions. Psoriasis is a long-lasting autoimmune inflammatory skin condition marked by red, scaly patches and related systemic issues, greatly impacting the quality of life for patients globally. Traditional treatments like topical corticosteroids, systemic medications, and phototherapy frequently lead to side effects, low patient adherence, and restricted therapeutic effectiveness. Consequently, urgently required are safer and more effective alternatives. Kigelia africana, often referred to as the sausage tree, has historically been utilized in African traditional medicine to address skin ailments, wounds, infections, inflammation, and cancers. The plant comprises various bioactive phytochemicals such as flavonoids, iridoids, naphthoquinones, sterols, tannins, fatty acids, and phenolic compounds demonstrate anti-inflammatory, antioxidant, antimicrobial, wound-healing, and immunomodulatory properties. These drug properties reinforce its possible function in easing psoriatic symptoms like redness, scaling, and increased epidermal proliferation. Experimental findings suggest that extracts from K. africana can reduce inflammatory mediators, nitric oxide synthesis, and oxidative stress mechanisms linked to psoriasis development. The review additionally addresses the growing importance of nanotechnology, especially nanoemulsions, in improving topical treatments for psoriasis. Nanoemulsion systems enhance drug solubility, skin absorption, bioavailability, and controlled release, all while reducing systemic toxicity and irritation. Different nano-formulations incorporating anti-psoriatic agents have shown better therapeutic results in animal studies by increasing skin retention and lowering inflammatory cytokine levels. In summary, the combination of Kigelia africana seed oil with nanoemulsion technology offers a potential approach for creating efficient, safer, and more user-friendly topical treatments for psoriasis, although additional clinical trials are needed to confirm their long-term effectiveness and safety.

Keywords: Kigelia Africana, nanoemulsions, psoriasis, naphthoquinones, immunomodulatory.

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1. INTRODUCTION

Psoriasis is a enduring, immune system disorder that effects billions globally. This disorder is marked by skin with scaly, reddish patches that could be throbbing, prickly, and defacing (1). This disease, which is not contagious, creates deposits and speeds up the rate at which skin cells divide. Psoriasis is a condition where healthy skin cells are mistakenly attacked by the immune system, resulting in inflammation and a variety of symptoms, influenced by both genetic predispositions and environmental triggers. (2). The enormous emotional, social, and financial burden of psoriasis led the WHO to classify it as a "painful, disfiguring, incapacitating, chronic, non-communicable illness for which there is no curative option and with a significant adverse effect on patients' quality of life" in 2014. (3)

(4). Psoriasis impacts both genders, with females experiencing a younger onset and those with a family history exhibiting it more frequently. The age at which onset occurs displays a bimodal pattern, with higher peaks at 30-39 years and 60-69 years for males, and a 10-year earlier onset for females (5) (6). Epidemiological studies reveal that Approximately 2% to 3% of people worldwide suffer from psoriasis, with regional variations in prevalence. Additionally, a geographical variance has been seen, with a higher occurrence in colder places. Although the illness can occur at any age, it usually does so in the second and third decades of life, peaking in the fourth and fifth (7).

(8). The different methods for treating psoriasis include light therapy, creams or pills, and a variety of biological drugs. (9). Topical treatments are the initial approach and the most effective medication method for managing psoriasis symptoms. Nevertheless, conventional topical treatments like gels and creams are ineffective, unattractive, and result in poor patient compliance, whereas systemic and phototherapy methods cause severe side effects. (10)

This review outlines the current information on phytochemistry, conventional uses, mechanism of psoriasis treatment and pharmacological importance of K. Africana with emphasis on nano-system and prospects in nano-emulsion based psoriasis therapy.

2. Methodology

In addition to Google Scholar, databases like Scopus, PubMed, Thomson Reuters, Mendeley, a Standard Scientific Information Directory (SID), HINARI Database, Springer & African Journals Online Database (AJOL) were investigated. Additionally reviewed were conference presentations, educational journal articles, student dissertations, institutional reports, and educational periodicals. Keywords utilized in iksearch engines included "Kigelia africana," "Kigelia pinnata," "phytochemicals," "conventional uses," "products of K. africana," "biological activity," "pharmacological potential," "psoriasis treatment mechanism," "nano-emulsion," "nano-system," and "Africa." However, alternative expressions indicating areas of interest were utilized. Throughout the complete search, keywords were utilized in different combinations, incorporating synonyms, substitute phrases, diverse spellings, associated words, and distinctions in word conclusions. Topics examined encompass: traditional healing, native wisdom, therapeutic flora, antifungal properties, antibacterial properties, antiplasmodial properties, pain-relieving effects, anti-inflammatory properties, antioxidants, cancer-fighting properties, toxicity, market products, Kigelia africana, plant science and ethnobotany, nanoemulsion, and more. The investigation took place over a span of five months and incorporated sources released up to January 2025. Mendeley, an online bibliographic database organizer, was used to compile pertinent records once all papers from these searches were examined. The two in vitro as well as in vivo studies were included. The authors collected and evaluated every document that met the review paper's inclusion requirements. The writers may have inadvertently overlooked some material, such as unreported student dissertations, proceedings from conferences, and dark literature, despite their best efforts to find all pertinent documents. In order to include this review, the following criteria were applied: (1) English-language papers, (2) primary and secondary literature that is published, (3) student theses that have been published, (4) articles from newspapers, and (5) reports of a technical nature.

3. Results and Discussion

An outline of the four subject areas covered in this part: (1) Psoriasis, (2) Causes and risk factors, (3) Pathogenesis and types of psoriasis, (4) K. Africana's morphological description; (5) ethnobotany in general; (6) phytochemical properties; (7) pharmacological activities; and (8) Mechanism of Kigelia Africana for Treating Psoriasis, and (9) prospects in nano-emulsion based psoriasis therapy.

Psoriasis

According to WHO, Psoriasis is classified under noncommunicable diseases (NCDs), this condition is characterized by chronic, painful, disfiguring, and debilitating symptoms without a known cure. It adversely affects patients' well-being. It can happen at any time, and is most prevalent in the 50 to 69 year-old demographic. The incidence of psoriasis varies from 0. 09% to 11. 4%, highlighting its significant health impact. Psoriasis affects the skin and nails, and is linked to multiple coexisting conditions. Skin lesions can be localized or widespread, often appearing symmetrically, with clear borders, and typically manifesting as red bumps or patches, often accompanied by white or silver scales. Injuries lead to irritation, burning sensations, and discomfort. Psoriatic arthritis, a chronic inflammatory arthritis that results in joint deformities and disability, can affect 1.3% to 34.7% of individuals with psoriasis. (11). As per

the current data of WHO, specifies a global prevalence of approximately 2-4% of psoriasis, affecting around 60 million people, with significant regional variations. Factors influencing these numbers include differences in socioeconomic status, healthcare access, age, ethnicity, and diagnostic methods. In India, plaque psoriasis prevalence was estimated at 0.4–2.8%, and approximately 8.7% of patients with plaque psoriasis have concomitant psoriatic arthritis (PsA). (12)

Causes and risk factors

The precise reason of psoriasis remains unclear, but studies suggest it is probably a mix of genetic and environmental influences as outlined in Table 1 and Table 2. Genetic differences have remained recognized that are linked to a higher danger of emerging psoriasis, especially genes that play a role in growth of skin cell and the body's defenses, as per the National Psoriasis Foundation **[R]**. These inherited elements play a role in body's defenses impairment & irregular skin cell growth seen in psoriasis (13).

Apart from hereditary factors, a number of environmental factors have been identified as probable causes of psoriasis development or exacerbation. Infections, especially those caused by streptococci, have remained recognized to provoke psoriasis warning sign in certain people. Some medicines, including lithium (used for mental health disorders), Beta-blockers (for heart issues) and antimalarial drugs have continued to be connected to the development or aggravation of psoriasis (14).

In susceptible individuals, physical damage to skin, like cuts, burns, or contaminations, can similarly trigger psoriasis. Stress is a recognized trigger, as numerous individuals indicate that their warning sign intensify throughout times of elevated trauma. A higher chance of acquiring psoriasis has also been linked to lifestyle factors like smoking and being overweight. (15) (16).

It remains crucial to understand that although these causes can lead to onset /aggravation of psoriasis, these do not impact every single person with condition uniformly (17).

Table 1: Factors responsible for causing Psoriasis

Cause	Details	References
Genetic predisposition	Variations in genes regulating skin cell growth and immune system function; linked to immune dysfunction and abnormal keratinocyte proliferation.	13
Infections	Streptococcal infections strongly associated with psoriasis onset, especially guttate psoriasis.	17, 14
Medications	Lithium, antimalarials, and beta-blockers can induce or worsen psoriasis.	14
Physical trauma (Koebner phenomenon)	Burns, cuts, and injuries can trigger new psoriatic lesions.	14
Stress	Psychological stress frequently triggers or worsens psoriasis; reported as a primary cause in guttate psoriasis (41% of cases).	18, 15

Table 2: Risk factors that contribute to psoriasis

Risk Factor	Specific Details	Ref.
The Family history	Individuals with psoriasis in their bloodline have higher susceptibility.	19
Obesity	Strongly associated with increased incidence and severity of psoriasis.	15
Smoking	Linked to higher risk and severity of psoriasis.	16
Environmental influences	General exposure to infections, drugs, or stress that increase susceptibility in predisposed individuals.	20, 16

PSORIASIS PATHOGENESIS

Psoriasis differs from other skin conditions in four ways: These four abnormal epidermal differentiation processes are indicative of acanthosis: (1) Vascular changes, such as dilated and twisted capillary blood vessels, cause redness or erythema; (2) polymorphonuclear leukocytes from dermal vessels infiltrate the epidermis, causing inflammation; (3) hyperproliferation of the keratinocytic layer; and (4) abnormal epidermal differentiation, where corneocytes maintain their ability to differentiate Figure (21), (22). Unlike the development of normal skin, psoriasis usually requires the stimulation of circulating immune cells and the signalling molecules they release, which promote hyperkeratosis and neovascularization in psoriatic skin (23) (24)

Pathophysiology

Psoriasis is an autoimmune condition lacking a clearly identified immunogen; however, its fundamental pathophysiology is thought to arise from excessive activation of certain components of the adaptive immune system. More specifically, it is caused by a mix of different cell types, including T cells, keratinocytes, and dendritic cells, which are all in a chronic inflammatory state due to cytokine production

[R]. Psoriasis can also result from genetic mutations and heredity, weather, infections, stress, and skin lesions. Figure 1 depicts the fundamental pathogenic processes associated with psoriasis. (25)

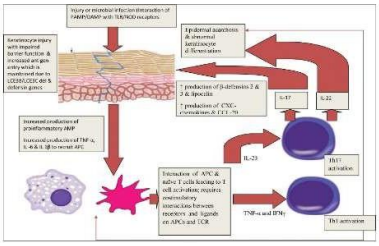

Figure 1: Events involved in pathophysiology of psoriasis [R]

Types

About 85–90% of people with psoriasis have psoriasis vulgaris, which is the most common phenotype (26). Although any area of the skin may be affected, the extensor surfaces of the knees and elbows, the sacral region, and the scalp are the most commonly affected. Furthermore, compared to the general population, psoriasis patients are more likely to suffer from a number of serious and chronic illnesses, such as arthritis, metabolic disorders, diabetes, cardiovascular diseases, hypertension, depression or anxiety, liver disease, Crohn's disease, lymphomas, or other cancers. Therefore, we suggest that cutaneous psoriasis and systemic psoriasis are two types of psoriasis. (Table 4). (26)

Cutaneous Psoriasis

Psoriasis vulgaris, or plaque psoriasis Plaque psoriasis often presents as distinct, scaly, erythematous regions (27). The areas usually affected are the lower body, knee joints, hair, and upper extremities. often afflicted with plaque psoriasis. Plaque psoriasis, the most prevalent kind of psoriasis, has been thoroughly investigated (28). The psoriatic area is one measure of psoriasis severity. severity index (PASI) (29) (30).

Guttate Psoriasis (GP)

GP occurs further frequently in offspring and teenagers than in grown-ups and is typically induced by a streptococcal infection. (31) (32).

Pustular Psoriasis

White, non-infectious pustules that can be localized or widespread are the hallmark of pustular psoriasis. A widespread case of superficial pustules with a crimson base is the typical appearance. The two forms of pustular psoriasis, localized pustular psoriasis (LPP) and generalized pustular psoriasis (GPP), are shown in Table 3. Localized pustular psoriasis includes both palmoplantar pustulosis (PPP) and acrodermatitis continuous of Hallopeau (ACH). (33).

Table 3: Clinical features of GPP and LPP

Type	Affected Area	Clinical Features	Common Triggers	Prognosis	References
Generalized Pustular Psoriasis (GPP)	Entire body	Painful, widespread pustules; systemic symptoms such as fever and chills	Streptococcal infections, stress, infections, certain drugs	Potentially life-threatening if untreated; mortality rate ~3.6%	61; 59;
LPP	Specific parts of body (palms, soles, etc.)	Localized patches of small pustules, usually without systemic symptoms	Streptococcal infections, stress, infections, certain drugs	Easier to manage with appropriate therapy; generally better prognosis	61; 59;

Generalized Pustular Psoriasis (GPP)

Extensive sterile pustules are the hallmark of GPP, a neutrophilic autoinflammatory skin disorder that can develop with or without a history of plaque psoriasis (34, 35). Systemic symptoms such as chills, high fever, exhaustion, appetite loss, nausea, and severe pain are common in acute GPP. (36) (37).

Pustulosis of Palm and Sole

Palmoplantar pustulosis is an uncommon, long-lasting, relapsing inflammatory condition that impacts the palms and/or soles, featuring sterile, symmetrically arranged, eruptive pustules on an erythemato-squamous base. Sure! Please provide the text you'd like me to paraphrase (38). Nails frequently show impact, exhibiting pitting, side grooves, longitudinal ridges, nail cloudiness, nail shedding, and empyema (39).

Acrodermatitis Continua of Hallopeau

It is an uncommon, non-infectious, visibly apparent pustule impacting the nail structure of one or several fingers (40). ACH presents as gentle pustules accompanied by redness beneath on the fingertip, and occasionally on the toes (41)

Erythrodermic Psoriasis (EP)

EP is a sporadic & serious form of psoriasis distinguished by extensive redness (usually affecting ninety percent or supplementary of

surface area of body), inflammation, itching, scaling, oozing sores, & either localized or widespread peeling. EP consistently exhibits systemic warning sign such as shivering, high temperature, shortage of water, swollen lymph nodes, gastrointestinal discomfort, and occasionally, high output cardiac failure & weight loss. (42) (43).

Inverse Psoriasis (IP)

IP is likewise referred to as flexural psoriasis. Lesions usually appear in form of smooth, soggy, scaly-free, deep-red spots in creases/ friction zones (44).

Systemic Psoriasis

Alongside psoriatic lesions, various systemic diseases may arise initially, at the same time, or subsequently. According to research, psoriasis is a serious systemic inflammatory disease with symptoms resembling those of other long-term inflammatory conditions (29, 45).

Psoriatic Arthritis

except psoriatic lesions, PsA can impact any joint within the frame, which includes massive joints (46) including elbows and knees, as well as small joints like arms and feet, together with the spine and sacroiliac joints (47). There are several subtypes of psoriatic arthritis, including the distal subtype, which affects the proximal and distal interphalangeal joints of the hands and feet; oligoarthritis, which affects no more than four joints; polyarthritis, which affects five or more joints; arthritis mutilans, which causes the finger bones to resorb and shorten; axial/ankylosing spondylitis; enthesitis; and dactylitis. (48)

Table 4: Difference between Cutaneous and Systemic Psoriasis

Aspect	Cutaneous Psoriasis	Systemic Psoriasis
Definition	Primarily affects skin and nails with localized or widespread lesions.	Involves skin plus systemic comorbidities (multisystem inflammatory disease).
Subtypes	- Plaque psoriasis (psoriasis vulgaris) - Guttate psoriasis - Pustular psoriasis (generalized & localized) - Erythrodermic psoriasis - Inverse psoriasis	- Psoriatic arthritis - Psoriasis with metabolic syndrome (49,50) - Psoriasis with cardiovascular disease (51) - Psoriasis with nephropathy (53) - Psoriasis with bowel disease (IBD) (55) - Psoriasis with brain/mental diseases (57) - Psoriasis with pulmonary disease (58) - Psoriasis with liver disease (59) - Psoriasis with uveitis (60) - Psoriasis with lupus erythematosus (61) - Psoriasis with malignancy (62)
Clinical Manifestations	- Erythematous scaly plaques- Nail changes: pitting, onycholysis- Scalp involvement- Koebner phenomenon (lesions at trauma site)- Variable severity (mild, moderate, severe based on PASI, BSA, IGA)	- Arthritis (joint pain, deformity, enthesitis, dactylitis)- Obesity, insulin resistance, hypertension- Cardiovascular risks (MI, stroke, atherosclerosis) (52)- Kidney dysfunction (proteinuria, CKD) (54)- IBD (Crohn's, ulcerative colitis (56))- Depression, anxiety, suicidal ideation- COPD, interstitial lung disease- NAFLD, liver fibrosis- Uveitis (eye pain, blurred vision)- SLE association- Increased risk of malignancies
Severity Assessment	Based on: - PASI (erythema, scaling, induration, % BSA)- BSA involvement- IGA (investigator's global assessment)	Based on systemic involvement (scoring criteria include arthritis, metabolic syndrome, cardiovascular disease, renal disease, IBD, CNS, pulmonary, hepatic, ocular, autoimmune

Figure 2: *Kigelia africana* (Lam.) showing fruit, flower, whole plant.

		overlap, malignancies).
Stages	- Progressive: new lesions appear- Stationary: stable plaques- Regressive: flattening, post-inflammatory changes	Progression determined by development of systemic comorbidities over time.
Systemic Symptoms	Usually absent; occasionally mild systemic signs (e.g., fever in erythrodermic/pustular psoriasis).	Prominent systemic symptoms depending on comorbidity: fever, malaise, metabolic changes, organ dysfunction.
Complications	Local discomfort, itching, cosmetic impact, secondary infection risk.	Disability (arthritis), increased cardiovascular morbidity, renal failure, depression, malignancy risk.
Therapeutic Focus	- Mild: topical therapy, phototherapy- Moderate–severe: systemic agents (methotrexate, cyclosporine, retinoids) or biologics	- Requires multidisciplinary care- Biologics (anti-TNF, anti-IL-17, anti-IL-23) targeting both cutaneous lesions and systemic inflammation- Tailored treatment per comorbidity (e.g., CV, renal, IBD).

Kigelia Africana

South, Central, and West Africa are home to the African plant Kigelia africana (Lam.) Benth., which is a member of the Bignoniaceae family. The 20-meter-long K. africana tree can be either deciduous or evergreen, depending on the amount of rainfall in any region of the world (figure 2). K. africana is often called the sausage or cucumber tree because of its enormous fruit that resembles a sausage or cucumber. Around the world, different portions of K. africana have been utilized for a variety of therapeutic uses. K. africana is commonly referred to as Balmkheera in India. "Balamkheera jo bana de pet ko heera" is a well-known catchphrase used for K. africana in several districts of Uttar Pradesh, India. In Africa, K. africana is used externally as a remedy despite the fact that its unripe fruits are poisonous. (63)

Taxonomy Botanical classification:
Kingdom: Plantae,
Division: Magnoliophyta,
Class: Dicotyledons,
Order: Scrophulariales
Family: Bignoniaceae,
Genus: Kigelia,
Species: pinnata (Lam.) Benth. (64)
Vernacular names:
English: Sausage Tree, Cucumber Tree,

Hindi: Balamkheera, jhar fanus
Kannada: Aanethoradu Kaayi, Mara Sowthae,
Malayalam: Shiva Kundalam,
Telugu: Kijili, Ngamalle. (65)

Traditional Medicinal Properties

In countryside communities of African, K. africana has been utilized in traditional medicine for a long time, particularly for treating sickle cell anaemia, digestive issues, respiratory, and epilepsy, liver disease, cancer of skin, diabetes, as well as heart and nutritional disorders (66) (67) (68). In traditional medicine preparations, fruits are most normally used plant part, surveyed by roots, bark of stem, & leaves (69) (70). Folkloric indication
indicates that fruits and stem bark are better acknowledged for their pharmacological applications compared to leaves (71) (72). Venereal illnesses are typically managed with extracts of K. africana, often combined with palm wine for mouth treatment (73). The unripe fruit serves as a wound dressing and for treating hemorrhages and rheumatism in central Africa (74) (75) (76). The pulp of fruit is non-edible & poisonous & nnmay have intoxicating or laxative

effects. Fruits may only be eaten once they have been dried, roasted, or fermented (70). In South Africa, the seeds are also pulverized and used as balms to cure fungal infections, diabetes, pneumonia, malaria, eczema, and lower back discomfort, or they are toasted and eaten (72). The fruit is valued for its qualities as an aphrodisiac, a disinfectant, a therapy for skin conditions, and a cure for gynaecological problems (77).

The leaves are used for back pain (75), while leaves hot infusions treat stomach ulcers and jaundice (72). Leaves and bark of stem have remained utilized to address dysentery, constipation, high temperatures, in addition to induce abortion. Leaves are utilized for creating a tonic that promotes better health and development.

Extracts from bark of stem created via traditional African herbal practitioners can be effectively utilized to address infections related to cancer, especially in melanoma and various skin tumours (72), and can serve as treatment for gonorrhoea & syphilis (74). Decoction of bark of stem is utilized as aphrodisiac & for treating kidney ailments, watery stools, coughing, and inflammation (Table 5). Shona use bark of stem/root in powder or infusion form meant for ulcers treatment, like beverage, or for pneumonia treatment, and as a gargle for tooth pain (75). The bark is also used non-medicinally to create a potion for witch confessions that is ingested (72).

Table 5: Traditional uses of Kigelia Africana

Traditional use / ailment	Plant part used	Area / people (typical reports)	Pharmacological activity (reported / relevant lab evidence)	Reference (author, year)
Skin complaints: wounds, ulcers, abscesses, eczema, psoriasis, topical cancers	Fruit (pulp/extract), bark, leaves — applied topically (poultice, wash, ointment)	Widely reported across Africa (Southern, West, East Africa; many local communities).	Antimicrobial (antibacterial, antifungal), anti-inflammatory, wound-healing; some cytotoxic/anticancer activity in vitro.	Agyare et al., 2013; Nabatanzi et al., 2020; PROTA / Burkill (see sources). (PMC)
Dermal infections / mycoses (ringworm, athlete's foot, boils)	Bark and fruit preparations (washes, pastes)	West&Central Africa and Southern Africa (market and traditional healer reports)	Antifungal &antibacterial activity demonstrated in extracts.	PROTA (Burkill), UsefulTropicalPlants. (Prota)
Wound healing / topical antiseptic	Leaf, stem-bark, root, fruit (dressings, ointments)	Multiple African countries (ethnobotanical surveys)	Antioxidant, antimicrobial, and enhanced wound-healing seen in animal/in vitro studies.	Agyare et al., 2013; Agyare et al. (Adv Pharmacol Sci 2013). (PMC)
Venereal / genito-urinary infections (syphilis, gonorrhoea)	Bark, roots, fruit (decoctions, macerates; sometimes mixed with palm wine)	West and Central Africa (traditional formulations cited)	Antimicrobial activity supports traditional use against some pathogens (in vitro).	PROTA / Burkill. (Prota)
Gastrointestinal complaints: dysentery, diarrhoea, worms (vermifuge)	Fruit (ripe/unripe), roots, bark (decoction, enema, oral)	Reported across West, Central&Southern Africa	Antimicrobial and antidiarrhoeal effects shown in some animal studies; traditional anthelmintic claims reported.	MDPI review (Nabatanzi et al., 2020); Useful Tropical Plants. (MDPI)
Respiratory illnesses (cough, pneumonia)	Bark, roots (infusion, decoction) — e.g., Shona people use bark/root for pneumonia	Southern Africa (Shona and other groups)	Anti-inflammatory and antimicrobial activities reported in extracts (supports use in respiratory infections).	Pooley (cited in NTBG/other reviews); MDPI review (Nabatanzi et al., 2020). (National Tropical Botanical Garden)
Gynaecological uses (mastitis, promote/reduce breast swelling, contraceptive/abortifacient use reported)	Roots, fruits, bark (pessaries, decoctions)	Various African communities (ethnobotanical records)	Some experimental evidence for hormonal/anti-inflammatory effects; safety/toxicity not fully established.	PROTA; MDPI review.

Aphrodisiac / fertility / sexual disorders	Fruit (small amount of unripe fruit chewed), leaves, roots	Reported in multiple regions (traditional reports)	Some experimental/animal studies hint at reproductive effects; clinical evidence limited.	PROTA; regional ethnobotanical reviews. (Prota)
Traditional/commercial skin cosmetic products (anti-aging, creams for psoriasis, eczema)	Fruit extracts formulated topically	Commercial products (based on traditional use) and marketplaces across Africa&internationally	Antioxidant and anti-inflammatory activities documented; some topical formulations tested clinically for skin complaints.	Nabatanzi et al., 2020; Useful Tropical Plants. (MDPI)
Ethnoveterinary uses (mastitis, retained placenta, dermal infections)	Fruit and other parts	Rural/traditional livestock systems in Africa	Antimicrobial, anti-inflammatory properties reported in studies; ethnoveterinary use documented.	MDPI review; PROTA. (MDPI)
venereal diseases	Bark (stem bark)	Nsukka, Nigeria	Treatment of venereal diseases (macerated with palm wine and taken orally)	Walt, j.m. and Breyer-Bradwijk, M.G., 1962 the medicinal and poisonous plants 0f southernand easytern Africa, livingstone, London, 52
Cancer	Stem bark	Togo	Prescription against cancer (combined with *Xylopia aethiopica*)	Gill, L.S., 1992. Ethomedical uses of plants in Nigeria. Uniben Press. 143.
	Fruit pulp	Various African regions	Treatment of dysentery, ringworm, tape-worm, post-partum hemorrhage, malaria, diabetes, pneumonia, toothache	Gill, L.S., 1992. Ethomedical uses of plants in Nigeria. Uniben Press. 143.
Topical fungal infections	Leaves &Fruits	Traditional African medicine	Local application for fungal infections (ringworm, mycosis, athlete's foot)	Gill, L.S., 1992. Ethomedical uses of plants in Nigeria. Uniben Press. 143.
Washing fungal infestations	Stem bark (macerated water)	Traditional African practice	Washing fungal infestations (ringworm, mycosis, athlete's foot)	Gill, L.S., 1992. Ethomedical uses of plants in Nigeria. Uniben Press. 143.
antimicrobial use	Stem bark extract / cream	African traditional and orthodox medicine	Broad-spectrum antimicrobial use, treatment of microbial infections	Gill, L.S., 1992. Ethomedical uses of plants in Nigeria. Uniben Press. 143.
Skin diseases	General (fruits, bark, leaves)	Traditional African medicine	Skin ailments: boils, psoriasis, eczema, sunburn, chafing, itchy scalp, nappy rash	Gill, L.S., 1992. Ethomedical uses of plants in Nigeria. Uniben Press. 143.
Malignancies	Stem bark& other plant parts	African traditional and orthodox medicine	Treatment of malignant neoplasms, skin melanoma, tumors, breast cancer	Gill, L.S., 1992. Ethomedical uses of plants in Nigeria. Uniben Press. 143.

Phytochemistry of *kigelia Africana*

The many medicinal applications of Kigelia africana are facilitated by the presence of secondary metabolites in different parts of the plant. Naphtha quinones, iridoids, sterols, coumarins, flavonoids, and alkaloids are some of these compounds. Gas chromatography,

ultraviolet spectroscopy, infrared spectroscopy, nuclear magnetic resonance, and other spectroscopic techniques like mass spectrometry or gas chromatography-mass spectrometry have all been used to characterize and identify the structures
of isolated substances. The pharmacological
properties of Kigelia africana have validated its use in traditional African medicine (78).

The non-terpenes hexadecanoic acid, ethyl limonene, and the monoterpene α-pinene are the main constituents of leaf and floral oils (79). Flavonoids, alkaloids, carbohydrates, tannins, glycosides, phenols, sterols, and saponins have all been found in analyses of K. africana fruit extracts (ethanol, hexane, ethyl acetate, butanol, and water) (80, 81).

Kigelinone, vernolic acid, kigelin, luteolin, 6-hydroxy luteolin, and a number of iridoid derivatives are extracted from roots, wood, and leaves (82,83). The main iridoids found in the root and stem bark, such as specioside, verminoside (84), minecoside, and norviburtinal, have been identified as catalpol derivatives esterified with phenylpropanoic acid derivatives at C-6 (Houghton, 2002).

Tannins have been found in varying amounts in the leaf and stem bark of K. africana, along with steroids, saponins, glycosides, and carbohydrates. Flavonoids were discovered in leaves (Agyare et al., 2013). Along with calcium and potassium (Njogu et al., 2018), leaf extracts also yielded significant amounts of vitamins C, B1, and B3, as well as fatty acids including elaidic acid, elaidoic acid, stearic acid, palmitic (cetylic) acid, trans-phytol, and β-tocopherol (Atolani et al., 2013). In ethanolic twig extracts, Khan and associates found iridoid, 7-hydroxy eucommiol, rehmaglutin, 7-hydroxy viteoid II, leonuride, catalpol, specioside, verminoside, shoreaphenol, 4-hydroxy cinnamic acid, and caffeic acid (Khan et al., 2012). The iridoids jiofuran, jioglutolide, 1-dehydroxy-3,4-dihydroaucubigenin, des-p-hydroxybenzoyl kisasagenol B, ajugol, verminoside, 6-transcaffeoyl ajugol, and 7-hydroxy viteoid II, 7-hydroxy eucommic acid, 7-hydroxy-10-deoxyeucommiol, and 10-deoxyeucommiol were extracted using methanol(Goudaetal.,2003). According to Chivandi and associates, K. africana seeds are high in protein, lipids, phosphorus, and energy. Essential fatty acids (EFAs) like linoleic, α-linolenic, cis-11,14,17-eicosatrienoic, and γ-linolenic acids can be found in the oil extracted from the seeds, which also contains oleic acid. As a result, the seed has great potential as a nutritional source of protein, energy, and n3-polyunsaturated fatty acids (PUFAs). As a result, the seed may also be utilized economically as a source of oil (Chivandi et al., 2011). Palmitic acid has been detected in the stem bark and fruits of K. africana (Grace et al., 2002). Additionally, several solvent extracts of K. africana fruits have been reported to include trace elements such as Zn, Cu, Ni, Fe, Co, Cd, Pb, Mn, and Cr (Table 6). (Fagbohun and others, 2020a)**able 6:**

Chemical constituents present in different parts of *Kigelia africana*

Category of Constituent	**Chemical Constituent(s)**	**Plant Part Used**	**Plant Extract**	**Medicinal Uses / Pharmacological Activity**	**Solubility of Constituent**	**Full Reference**
Fatty acids, monoterpenes	Hexadecanoid acid, ethyl limonene, α-pinene	Leaves, Flowers	Essential oils	Antimicrobial, fragrance	Fatty acids: lipophilic (hexane, chloroform); monoterpenes: volatile oils	Asekun et al., 2007
Flavonoids, alkaloids, tannins, glycosides, phenols, sterols, saponins	Multiple (unspecified)	Fruits	Ethanol, hexane, ethyl acetate, butanol, aqueous extracts	Antioxidant, antimicrobial; free radical scavenging	Flavonoids, glycosides, tannins: polar solvents (methanol, ethanol, aqueous); sterols: nonpolar solvents	Azu et al., 2010; Fagbohun et al., 2020a
Iridoids, flavonoids	Kigelinone, vernolic acid, kigelin, luteolin, 6-hydroxy luteolin	Root, Wood, Leaves	Methanol, ethanol	Anti-inflammatory, antioxidant, antimicrobial	`1	`````````` `````````` ``````````

Iridoid glycosides	Specioside, vermicosidE, minecoside, norviburtinal	Root, Stembark	Methanol	Antimicrobial, cytotoxic, anti-inflammatory	Water-soluble glycosides, methanol/ethanol soluble	Houghton, 2002; Picerno et al., 2005; Saini et al., 2019
Steroids, naphthoquinones	Stigmasterol, β-sitosterol, lapachol, 6-methoxymellein, kigelin	Roots	Benzene	Antimicrobial, anticancer	Steroids: lipophilic (chloroform, hexane); naphthoquinones: ethanol, chloroform	Govindachari et al., 1971; Khan & Mlungwana, 1999
Naphthoquinones, lignans	Kigelinone, kigeliol, lapachol, dehydro-α-lapachone	Wood	Benzene	Antimicrobial, anticancer	Nonpolar solvents (chloroform, benzene, ether)	Inoue et al., 1981
Aromatic monoterpenes	Pinnatal, isopinnatal, kigelinol, isokigelinol	Whole plant	Ethanol	Antimicrobial, antiplasmodial	Volatile, soluble in ethanol/organic solvents	Akunyili &Houghton, 1993; Weiss et al., 2000
Polyphenols, steroids	Tannins, steroids, saponins, glycosides, carbo	Leaves, Stembark	Methanol, ethanol	Antimicrobial, antioxidant, antidiarrheal	Tannins: water/alcohol soluble; steroids: nonpo	Agyare et al., 2013
	hydrates				lar solvents	
Vitamins&minerals	Vitamin C, B1, B3, Ca, K	Leaves	Ethanol, aqueous	Nutritional, antioxidant, tonic	Vitamins: water-soluble (C, B); minerals: water-soluble salts	Njogu et al., 2018
Fatty acids, Vitamin E	Elaidic acid, stearic acid, palmitic acid, trans-phytol, β-tocopherol	Leaves	Ethanolic	Antioxidant, hepatoprotective	Fatty acids: lipophilic (ether, hexane); tocopherol: lipid-soluble	Atolani et al., 2013
Iridoids, phenolic acids	7-hydroxy eucommiol, rehmaglutin, leonuride, catalpol, specioside, vermicosidE, caffeic acid	Twigs	Ethanolic	Antioxidant, antimicrobial, anti-inflammatory	Iridoids: ethanol, water; phenolic acids: water, ethanol	Khan et al., 2012
Iridoids	Jiofuran, jioglutolide, ajugol, vermicosidE,	Fruits	Methanol	Antioxidant, antimicrobial	Polar solvents (methanol, ethanol, water)	Gouda et al., 2003

	hydroxy-eucommic acid derivatives					
Essential fatty acids (PUFAs)	Oleic acid, linoleic acid, α-linolenic acid, γ-linolenic acid, eicosatrienoic acid	Seeds	Seed oil	Nutritional supplement, anti-inflammatory	Lipid-soluble, nonpolar solvents (ether, chloroform, hexane)	Chivandi et al., 2011
Fatty acids	Palmitic acid	Stem bark, Fruits	Ethanolic, aqueous	Antibacterial, metabolic	Nonpolar solvents (ether, hexane, chloroform)	Grace et al., 2002
Trace elements	Zn, Cu, Ni, Fe, Co, Cd, Pb, Mn, Cr	Fruits	Various solvent extracts	Nutritional, toxicological	Water-soluble salts	Fagbohun et al., 2020a
Long-chain hydrocarbons	Hentriacontane (C31H64)	Leaves (cuticular wax)	Hexane	Antioxidant, antibacterial	Nonpolar solvents (hexane, benzene)	Atolani et al., 2009
Phenolics, triterpenoids	p-coumaric acid, caffeic acid, oleanolic acid, lapachol, kigelinol	Stem bark	Butanol, methanol	Anti-amoebic, antibacterial, anti-inflammatory	Phenolic acids: polar solvents; triterpenoids: nonpolar	Sidjui et al., 2014; Bharti et al., 2006
Phenylpropanoids&naphthoquinones	Lapachol, dehydro-α-lapachone, eugenol, bufexamac	Fruits, Stem bark	Ethyl acetate, methanol, aqueous	Antibacterial, antifungal	Soluble in ethanol, chloroform, ethyl acetate	Houghton, 2002; Arkhipov et al., 2014; Fagbohun et al., 2021
Flavonoids, iridoids	Verminoside, specioside	Fruits, Stem bark	Methanol, aqueous	Anti-inflammatory (NO, cytokine suppression)	Water/alcohol soluble	Picerno et al., 2005; Nabatanzi et al., 2020
General phytochemicals	Tannins, flavonoids, saponins, glycosides	Leaves, Bark, Fruits	Methanol, aqueous, ethanol	Antibacterial (broad-spectrum)	Tannins: water/alcohol; flavonoids: ethanol/methanol	Agyare et al., 2013; Hussain et al., 2016
Mixed phytochemicals	Phenolics, fatty acids, iridoids	Fruits, Leaves	Aqueous, ethyl acetate	Antidiabetic, hypoglycemic	Phenolics: polar; fatty acids: nonpolar	Fagbohun et al., 2020b; Njogu, 2018
Iridoids (verminoside)	Verminoside	Stem bark, Fruits	Butanol	Anti-amoebic (Entamoeba histolytica inhibition)	Water/alcohol soluble	Bharti et al., 2006

Mechanism of Kigelia Africana for Treating Psoriasis

Kigelia africana likely exerts its anti-psoriatic effects through anti-inflammatory, antioxidant mechanisms and wound-healing properties, supported by its rich phytochemical profile, including bioactive compounds like, flavonoids, naphthoquinones, and sterols and phenolic acids. These compounds can inhibit inflammation, (85) scavenge free radicals, and promote tissue regeneration (86), which helps to reduce the thickness and scaling associated with psoriasis. While studies show a reduction in psoriatic symptoms in animal models, its observed effects on inflammation and skin healing in general support its traditional use. The plant helps reduce inflammation and promotes tissue repair, which could address symptoms of psoriasis like redness, scaling, and skin damage. However, more clinical research is needed to fully understand its precise actions in humans. Significant analgesic and anti-inflammatory actions have been demonstrated by K. Africana aqueous extract, which also inhibits NO release and iNOS expression (87). **PROSPECTS IN NANOEMUSLION BASED TREATEMENT FOR PSORIASIS**

Nanoemulsion (NE) is a kinetically stable mixture consisting of oil & water, alleviated by emulsifying agent, with droplet sizes between approximately 20–200 nm. NE provides adaptable formulations for both lipophilic and hydrophilic medications by enhancing their solubility and permeability, thus boosting their bioavailability. They exhibit significantly greater kinetic stability against gravitational separation and aggregation compared to other emulsions. The large positive interfacial tension between the oil and water phases causes thermodynamic instability (88). They seem transparent because minimal scattering of visible light occurs, owing to the smaller droplet size of nanoemulsions relative to the wavelength of visible light. All these attributes depend on factors like composition, pressure, temperature, and the methods of preparation. Additionally, the characteristics of the dispersed phase, dispersion medium, surfactant, and cosurfactant significantly influence the stability of nanoemulsions (89). Consequently, there is a significant opportunity to create nanoemulsions with adjustable characteristics and desired droplet dimensions aimed at diverse applications (90) (91)

Utilizing nanoemulsion as a delivery system for anti-psoriatic medications offers benefits since it eliminates intrinsic issues such as creaming, flocculation, sedimentation, or coalescence, which are typically seen in macroemulsions (92). Concerning topical application, nanoemulsions are non-irritating to the skin, exhibit excellent permeation ability, and possess a high capacity for drug loading (93). Selecting appropriate oils and surfactants is crucial in the formulation of an ideal nanoemulsion. Table 7 below discusses several nano-emulsion formulations.

Overall, a topical method tends to be a fewer intrusive approach that might garner great adherence beginning from patients, & as this article focuses on psoriasis, which is a skin condition. Nanosystems represent an advancement over microsystems since the nano-strategy enhances the effectiveness of drug action. Nanosystems exist in various forms, including nanoemulsions, biopolymeric nanoparticles, liposomes, polymeric micelles, dendrimers, and quantum dots (94). Reducing the particle size enhances bioavailability, which consequently lowers the quantity of drug required for administration to patient. It would lower likelihood of toxin accumulation in body, that consequently aids in mitigating potential negative side effects. Lowering the dosage decreases the need for excessive manufacturing throughout the supply chain while still meeting the needs of target audience. The nano-sizing of colloidal system aids in compatibility of poorly soluble formulations. (95) (96)

In research by Rajitha et al., 2019, a topical nanoemulsion incorporating methotrexate and Chaulmoogra oil was developed for psoriasis treatment, demonstrating optimum properties for effective topical methotrexate delivery, with enhanced skin absorption and retaining, offering potential substitute to methotrexate tablets (97). The anti-psoriatic investigations conducted in animals on imiquimod psoriatic model demonstrated enhanced anti-psoriatic effectiveness, showcasing efficient skin retention and reduced serum and tissue accumulation relative to orally taken methotrexate tablets. (98).

Table 7: Nano emulsion formulation for psoriasis treatment

Sr. No.	Active agents	phases	Surfactant / Co-surfactant& Gel Base etc.	Particle Size (nm) / PDI / Zeta Potential	Entrapment /Efficiency	Key Outcomes in Psoriasis Model	Reference
1	Tacrolimus + Fish Oil or Linseed Oil	Oil	Tween 80 + Transcutol-P as surfactant / co-surfactant; converted into nanoemulsion gel using **1% Carbopol-934** gel base	Droplet size< 130 nm; narrow PDI; high transmittance (>95%)		Compared to marketed ointment, higher skin permeation, better retention (~1.5-fold), and significantly better anti-psoriatic activity in mice	99

						(imiquimod model) with reduction in pro-inflammatory cytokines (TNF-α, IL-6)	
2	Cyclosporine loaded into nano-colloidal carrier; oil phase: mixture of Virgin Coconut Oil + Nutmeg Oil (15-20 %)		Surfactant: Tween 80; gelling: Xanthan gum (0.75%); water; (Optimum formulations with ~15-20 % oil, ~15% surfactant etc.)	Oil phase 15-20%; particle size in these nanoemulsions ~100-200 nm (approx range for the studied formulations)		Good biocompatibility, increased hydration of stratum corneum, reduced irritancy; shows potential as topical delivery to limit systemic toxicity; favorable rheological and skin barrier properties	100
3	Methotrexate loaded into nanoemulsion gel; oil phase: Olive Oil	Oil	Converted into a nanoemulsion gel (neg) using olive oil, Tween-80, PEG-400; gel base	Particle size **202.6 ± 11.59 nm**, PDI **0.233 ± 0.01**,	entrapment efficiency 76.57 ± 2.48%; ~72.47% cumulative	In imiquimod-induced psoriasis-like rat model: PASI (Psoriasis Area&Severity Index) decreas	101
			(nanoemulsion gel)		release at pH 5.5 after 20 h.	e similar or better than oral methotrexate; improved skin permeation, retention; good safety.	
4	Methotrexate; oil phase: Neem oil		Formulated as a nanoemulsion (NE) with neem oil, Tween-80 (surfactant), ethanol (co-surfactant) etc.	Particle size ~ 30.69 nm, PDI ~ 0.65,	entrapment efficiency ~ **76.57%**; release ~72.47% at pH 5.5 after 20 h.	Ex vivo (rabbit skin) permeation and retention studies; suggests potential for psoriasis therapy by improving topical delivery and potentially reducing recurrence.	102
5	Tacrolimus + Kalonji oil (Nigella sativa oil)		Nanoemulsion gel with Kalonji oil as functional excipient, surfactant system (Tween etc.), gel base etc.	Droplet size 93.37 ± 2.58 nm, PDI 0.330 ± 0.025; biphasic sustained release; dermal bioavailability ~4.33-fold increase vs control; good		In vivo psoriasis model in BALB/c mice: significant reduction in serum cytokines; improved psoriatic condition vs	103

				spreadability & viscosity.		marketed ointment (Tacroz Forte).	
6	**Curcumin**; % 5 and 10 curcumin nanoemulsion / nanoemulgelrxtqqqq		Carbopol-loaded nanoemulsion / nanoemulgel; comparison with ointment & standard corticosteroid (triamcinolone acetonide)	10% formulation showed statistically significant improvements; histopathology: normalized epidermal thickness, decreased mitotic activity; details of size etc in full paper.		Rat model of psoriasis induced by complete Freund's adjuvant & formaldehyde; 10% formulation (nanoemulsion) significantly improved skin health (erythema, scaling, thickness), though did not outperform standard corticosteroid completely.	104
7.	**Curcumin-loaded nanoemulsions** decorated with cell-penetrating peptide (CPP)		Nanoemulsion embedded in oligopeptide hydrogel (Cur-CNEs/Gel) with CPP	Enhanced skin penetration; significant inhibition of cytokines TNF-α, IL-17, IL-6, IL-23;		IMQ-induced psoriasis in mice; Cur-CNEs/Gel had strongest inhibition of inflam	105
				decoration; gel base etc.		histo/immuno-staining shows reduced inflammation; size etc favorable (but size specifics likely in full text)	matory markers; alleviation of psoriatic symptoms; prolonged retention etc.	
8	Co-delivery of **Imiquimod** + **Curcumin** by nanoemugel (i.e., nanoemulsion + gel)		Nanoemugel prepared via low-energy emulsification; Tween-20 stabilizer etc.	The formulation improved topical delivery; reduced psoriasis-like lesions in skin models; better tolerability; details of size etc are in full paper.		Psoriasis-like skin lesions in animal model; combinatorial delivery improved efficacy and reduced adverse skin reactions from imiquimod.	106

List of Patents for nano-based psoriasis treatment

Psoriasis diagnostic and treatment device patents show a thorough progress from conventional methods toward accuracy, intelligence, and customization. A notable increase in patent filings each year reflects the rapid breakthroughs in psoriasis diagnostic technologies, highlighting the necessity of assessing technical advancement in the face of persistent problems such repeating modest improvements. For instance, a lot of recent patents concentrate on minor modifications to current phototherapy techniques (such adjusting UV light settings) or AI-based diagnostic systems that have trouble increasing accuracy past a certain point (107). Table 8 in below content lists various patents for treatment of nano-based psoriasis.

Table 8: List of Patents for nano-based psoriasis treatment

S. No.	Patent Title / Desc	Patent Number / Publication ID	Nanotechnology Used	Therapeutic Approach /	Assignee / Applicant	Year	Remarks / Application Area	Reference / Source

	ription			Mechanism				
1	V-9302 nanoparticles for treating psoriasis	CN113712938A	Biological nanoparticles (120–250 nm)	Nanoparticles deliver V-9302 to inhibit IL-23/IL-17 inflammatory axis	Chinese inventors	2021	Nano-targeted antifungal and anti-inflammatory therapy for psoriasis	Google Patents – CN113712938A (108)
2	Liposomal topical formulations for dermatological disorders	WO2019/084503A1	Liposomes	Controlled release, enhanced dermal penetration	Novan, Inc.	2019	Topical nano-liposomal formulation for psoriasis&eczema	WIPO – WO2019/084503A1 (109)
3	Liposomal spherical nucleic acid (L-SNA) targeting IL-17 receptor	WO2017/193087A1	Liposomal spherical nucleic acids	Gene silencing of IL-17R via antisense oligos	Exicure, Inc. / Northwestern University	2017	Nucleic acid-based nanotherapy for psoriasis	WIPO – WO2017/193087A1 (110)
4	Spherical nucleic acid-based constructs	US10894963B2	Spherical nucleic acids (SNA)	Oligonucleotide-functionalized nanoparticles	Northwestern University	2021	Foundational patent for skin-targeted SNA	Google Patents – US10894963B2 (111)
5	Nanoparticle-mediated delivery of siRNA	US9617544B2	Self-assembled nanoparticles (SSNPs)	siRNA delivery targeting TNF-α for immune modulation	Massachusetts Institute of Technology (MIT)	2017	RNA interference nanotherapy for inflammatory diseases	Google Patents – US9617544B2 (112)
6	Nanoparticle-based therapy of inflammatory disorders	WO2020/120787A1	Polymeric/lipid nanoparticles	Controlled release of anti-inflammatory compounds	Nanotherapy Biotech Ltd.	2020	Broad claims including psoriasis and other autoimmune disorders	WIPO – WO2020/120787A1 (113)
7	Lipid-polymer hybrid nanoparticles of hydrophobic drug molecules	US2021/0369631A1	Lipid–polymer hybrid nanoparticles	Enhances solubility and topical delivery of hydrophobic drugs	University of South Florida (example)	2021	Suitable for topical psoriasis drug delivery	Google Patents – US2021/0369631A1 (114)
8	Gold nanoparticle / peptide-conjugated compositions	WO2017/064687A1	Gold nanoparticles conjugated with peptides	Anti-inflammatory and antimicrobial mechanism	Amrita Therapeutics Ltd.	2017	Topical gold NP formulation for skin inflammation	WIPO – WO2017/064687A1 (115)

9	Gold nanocrystals for medical treatment	JP7014851B2	Gold nanocrystals	Modulate IL-6 and MIF cytokines	Japanese inventors	2020	Anti-inflammatory nanogold platform applicable to psoriasis	Google Patents – JP7014851B2 (116)
10	Topical compositions for treating psoriasis (nano variants)	US11679115B2	Liposomal/nanoemulsion formulations	Controlled release topical formulation	Bristol Myers Squibb / similar pharma	2023	Modern nano-enabled topical psoriasis treatment	Google Patents – US11679115B2 (117)

MAJOR NANO-TECHNOLOGICAL APPROACHES FOR TREATING PSORIASIS

Nanotechnology presents a hopeful solution to these issues by allowing for targeted drug delivery, improved therapeutic effectiveness, and diminished systemic toxicity (118). Nanocarriers represent a category of advanced methods measuring under 100 nm and have been explored for addressing skin disorders. The application of nanotechnology is generating significant interest and providing many benefits when contrasted with traditional formulations. (119). Topical and systemic methods offer efficient management of different disease types, yet exhibit several side effects and toxicity. Because of their unique characteristics, a variety of nanotechnology-based colloidal carriers, such as vesicular and particulate systems like liposomes, transfersomes, niosomes, ethosomes, solid lipid nanoparticles, microspheres, micelles, dendrimers (figure 3), etc., are widely used for psoriasis prevention and management, as explained in Table 9 and figure 4. Nanotechnological techniques can be applied topically, dermally, transdermally, or systemically, either alone or in combination. (120)

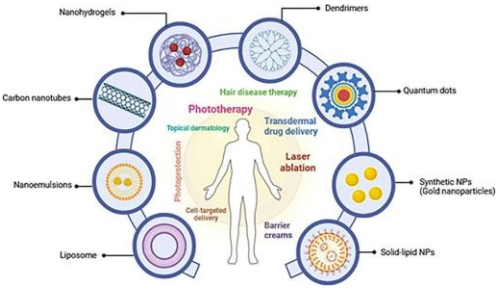

Figure 3: Nano carriers involved in psoriasis treatment

Lipid-based nanocarriers

Vesicular systems

Liposomes (LIPs): LIPs are tiny sacs, either single lamellar or many lamellar, formed from phospholipids, fat, and long-chain FAs. This nano-arrangement features a core of sacs encased in a water-soluble setting, while space between phospholipids layers contains lipophilic layer (121). LIPs have been specifically developed to manage inflammatory conditions, such as psoriasis, due to their hydrating features, aimed at enhancing drug delivery (122).

Niosomes*:* Non-ionized surfactants, fats such as cholesterol /+zand other lipids hydrate to form niosomes (NIOs). NIOs are divided into three types based on their potential to contain hydrophilic or hydrophobic drugs: unilamellar vesicles that are small (SUV, size 0.025–0.05 millimeter), multilamellar vesicles (MLV, size 0.05 millimeter), and huge unilamellar vesicles (LUV, size 0.10 millimeter). Like LIPs, NIOs can be administered in a number of ways, including topically. These might improve drug release & absorption through integumentary. It would not need different storing conditions since these are recyclable, biocompatible, & osmotically active as well (123). NIOs offer greater stability, decreased transepidermal water loss, and a more affordable price. Nonetheless, they exhibit reduced skin permeation when compared to liposomes and face challenges during large-scale manufacturing (124).

Transfersomes*:* Transfersomes (TRAs) are nanocarriers containing water-based core surrounded by surfactants & lipids, which could deform quite readily. Their most impressive benefit is capacity to pass via smaller openings because of its flexibility. Electrostatic and hydrophobic interactions aid in retaining drugs within double layered membrane in case these are lipophilic or in their water-based core whether they are water soluble (125)

Ethosomes: Ethosomes (ETOs) consist primarily of phospholipids, aqueous layer&, and ethanol. Dimensions of such nano-systems could vary from thirty nanometer to micrometers. Due to their high flexibility, they may also be referred to as elastic vesicles, and formulations based on

TRAs are capable of penetrating pores smaller than their diameter (126). They can encapsulate pharmacological molecules with a variety of physicochemical characteristics that are hydrophilic, lipophilic, or amphiphilic (Rohilla et al. 2014a). Increased patient adherence, better medication penetration, the use of non-toxic raw materials, and a simple drug delivery mechanism are the main advantages of these carrier systems (Rohilla et al. 2014b). As a result, several applications in the pharmaceutical, biotechnology, veterinary, cosmetic, and nutraceutical industries have shown these carrier systems to be suitable (127).

Polymeric-based nanocarriers

Nanospheres (NSs): NSs are elements smaller than one micrometer that features matrix classification comprising polymer background in which drug is evenly dispersed. The polymers used may be biodegradable or non-biodegradable. NSs offer greater stability and increased solubility along with enhanced drug release control and improved absorption (128).

Nanocapsules (NCs): NCs are smaller particles less than one micrometer and are colloid shaped in size; however, contrasting NSs, NCs contains reservoir arrangement in which a polymeric membrane encases the drug core. Their popularity has increased because of their outstanding ability to permeate the skin. They protect the medication from deterioration and are regarded as outstanding materials for skin-related uses (129). Suspensions of NCs containing a lipid core were produced to assess the stability and safety of NCs loaded with dithranol. NCs consist of a polymeric shell encasing a lipophilic core and are primarily utilized for the incorporation of hydrophobic compounds. Dithranol is a medication utilized for psoriasis, acting on inflammation and proliferation phases; however, it is highly reactive to light, leading to tissue injury and significant skin irritation.

Metal-based nanoparticles: Nanoparticles with metal base had garnered significant attention in delivery of drug for skin disorders because of their small dimensions, ease of alteration, & elevated interactions with human cells. These have attracted significant interest primarily for their role in tumor treatment, but also lately for their use as anti-inflammatory agents in managing skin diseases (130).

Gold nanoparticles: Gold nanoparticles (AuNPs) exhibit low toxicity and are inert, rendering them advantageous for drug delivery applications. Their popularity among scientists is increasing because of their benefits, including a greater surface area, reduced size, and anti-inflammatory properties.

In this setting, AuNPs with MTX were created for the treatment of psoriasis. Sodium 3-mercapto-1-propane sulfonate was utilized to enhance distribution & stability, along with hydrophilic layer for stabilizing AuNPs. Furthermore, existence of thiol-based layer aided in stabilizing formulation while enhancing MTX activity retention. However, outcomes proved to be successful, demonstrating that therapy using MTX in conjunction with AuNPs was more potent than MTX alone. It was correspondingly noted that it might serve as harmless, non-toxic, & effective topical treatment selection for psoriasis. (131)

Silver nanoparticles*:* AgNPs are primarily utilized in diagnosis and therapy of cancer; nonetheless, they have likewise been effectively researched as potential drugs for psoriasis alternatives for psoriasis treatment. The anti-inflammatory properties were investigated by creating AgNPs infused with blackberry fruit extract to evaluate the efficacy in lesions caused by psoriasis. They carry out a cream formulation that combines petrolatum, oil of vaseline, and cetyl alcohol with a hydrophilic surfactant and incorporates AgNPs into water phase. The AgNPs enhance buildup of extracts in swollen skin, making anti-inflammatory properties a promising strategy for psoriasis treatment, as they reduce edema and decrease cytokine levels (132)

Dendrimers

According to Sharma et al. (2014c), dendrimers are three-dimensional macromolecular structural categories (linear, crosslinked, and branched) with an initiator core, multiple branching components, and different functional terminal groups. In addition to being connected to surface functions, drug molecules can be included within dendrimers. Dendrimers present several benefits compared to other polymers, including lower likelihood of absorption by reticuloendothelial system, ability to target specific locations in human being, consistent PK behaviour, & offering wide range of structures at a decreased production cost (132).

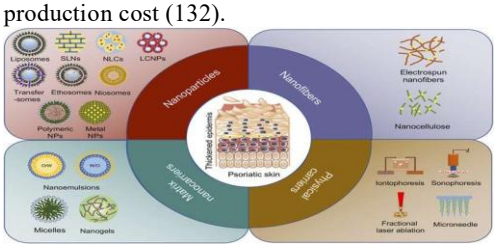

Figure 4: Approaches for treatment of psoriasis

Table 9: Major Nano-Technological Approaches for Treating Psoriasis

Nanocarrier Category	Sub-type	Composition / Structure	Size (when given)	Drug Loading Ability	Key Features / Advantages	Limitations / Challenges	References
Lipid-based Nan	Liposomes (LIPs)	Phospholipids, cholesterol	Not specified	Hydrophilic (core)&lipophilic	Hydrating; enhance skin penetrati	Lower stability than	(121), (122)

ocarriers		, long-chain fatty acids; unilamellar or multilamellar vesicles		(bilayers)	on&permeation; suitable for inflammatory diseases like psoriasis; biocompatible	niosomes; may require special storage	
	Niosomes (NIOs)	Non-ionic surfactants + cholesterol + lipids	SUV: 0.025 – 0.05 µm; MLV: 0.05 µm; LUV: 0.10 µm	Hydrophilic and hydrophobic	Enhanced drug release; improved skin permeation; biodegradable; biocompatible; osmotically active; no special storage; low cost; higher stability &lower TEWL	Lower skin permeation vs. liposomes; scale-up challenges	(123), (124)
	Transfersomes (TRAs)	Lipid + surfactant-based ultradeformable vesicles with aqueous core	Not specified	Hydrophilic (core)&lipophilic (bilayer)	Highly deformable; penetrate pores smaller than their diameter; flexible; improved transdermal delivery	Stability issues depending on surfactant content	(125)
	Ethosomes (ETOs)	Phospholipids + high alcohol content + water	30 nm – microns	Hydrophilic, lipophilic&amphiphilic	Highly flexible; enhanced drug permeation; non-toxic; simple formulation; high patient compliance; suitable for pharma, cosmetic, nutraceutical applications	Alcohol content may irritate sensitive skin	(126), (127)
Polymeric-based Nanocarriers	Nanospheres (NSs)	Polymer matrix system (biodegradable or non-biodegradable)	< 1 µm	Drug dispersed homogeneously in polymer matrix	High stability; improved solubility; controlled drug release; enhanced absorption	Drug leakage difficult to control; polymer toxicity depends on type	(128)
	Nanocapsules (NCs)	Reservoir system: drug core enclosed by polymeric membrane; may have lipid core inside	< 1 µm	Best for hydrophobic drugs	Excellent skin permeation; protects drug from degradation; suitable for dermatology; good for unstable drugs (e.g., dithranol)	Polymer wall may limit release; sensitive to light for some drugs	(129)
Metal-based Nanoparticles	Gold nanoparticles (AuNPs)	Metallic gold core with stabilizing ligands such as Na-3MP	Nano-scale (not specified)	Hydrophobic or hydrophilic depending on surface functionalization	Inert, low toxicity; strong anti-inflammatory effects; large surface area; improved MTX	Costly; risk of aggregation if not stabilized	(131)

		S & hydrophilic layer			stability &retention; more effective than MTX alone; safe for topical psoriasis	properly	
	Silver nanoparticles (Ag NPs)	Metallic silver nanoparticles; incorporated into creams with petrolatum, vaseline oil, cetyl alcohol, hydrophilic surfactants	Nano-scale	Hydrophilic&bioactive plant extracts	Strong anti-inflammatory effects; enhance accumulation of actives in inflamed skin; reduce edema & cytokine levels; potential antipsoriatic therapy	Cytotoxic at high doses; formulation-dependent stability	(132)
Dendrimers	Various generations of 3D branched dendritic polymers	Branched macromolecules with initiator core, branching units, multiple terminal groups	Not specified	Drug can be loaded inside or attached to terminal groups	Site-specific targeting; easy modification; reduced RES uptake; reproducible pharmacokinetics; high structural versatility; cost-effective	Complex synthesis at higher generations; toxicity varies by surface groups	Sharma et al. (2014c), (127)

Future Prospectives of Nanotechnological approaches

Nanotechnology stands out as a highly promising field with numerous possibilities and significant potential to enhance innovative treatment options. Nonetheless, there remain numerous uncertainties associated with it and risks that need to be addressed. Although significant research is ongoing and notable findings have surfaced about the use of nanotechnology in treating skin conditions, a lot remains to be explored. Recent findings regarding the pathogenesis and treatment of psoriasis have positively influenced the condition; however, it remains quite ambiguous and challenging, necessitating continual updates in therapeutic approaches (133). In the future, a more accurate view of the actual effects of these nanocarriers is essential, necessitating a shift from preclinical research to clinical testing. Despite the considerable positive impacts of nanocarriers evidenced by numerous studies conducted over the years, this clinical advancement presents a crucial hurdle for the widespread introduction of nano-formulations in the market and their application in clinical settings (134). An additional intriguing future challenge will be identifying the optimal nanocarrier for every psoriasis type to enhance the advantages of nanotechnology. In other words, considering the various features each nanocarrier presents and the specific active ingredient intended for incorporation, which nanocarrier would provide the greatest advantage for the different forms of psoriasis? Moreover, large-scale production presents another challenge because of its increased expense and the challenges in ensuring reproducibility. However, significant research is still required, but it can be confidently stated that nano-based carriers present a promising alternative to traditional treatment and enhance safety and effectiveness in managing psoriasis (135).

Conclusion

All things considered, research on herbal nano-formulations for the treatment of psoriasis is promising and could provide a safe and efficient substitute or supplement to traditional therapies. Natural remedies are beneficial for treating psoriasis, especially when combined with modern drug delivery methods that have the fewest adverse effects. Nonetheless, there are some problems that must be resolved. There is much opportunity for disagreement when it comes to safety. Psoriasis lesions differ significantly from typical skin lesions in terms of drug absorption, accumulation, and circulation. A innovative drug delivery system's distribution capability, efficacy, and safety must be carefully assessed in order to have a more significant therapeutic impact. Up until now, the majority of natural psoriasis treatments have relied on a single natural component. Therefore, more complex illnesses like mild or severe psoriasis can be treated with the synergistic effects of

natural products and other biologic treatments, but the combined mechanisms of action need to be carefully studied. The current state of knowledge on the phytochemical and pharmacological insights of Kigelia Africana seed oil for the development of nano-emulsion-based therapy for the treatment of psoriasis is summarized in this review article, along with their future prospects.

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