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Exploring the Therapeutic Potential of Green-Synthesized Silver Nanoparticles in Psoriasis: Targeting Epidermal Hyperproliferation and Inflammation for Enhanced Treatment Strategies

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Abstract

Using eco-friendly silver nanoparticles (AgNPs) for psoriasis treatment was very speedy and rapid. Their absorption by the human body was astonishing, and their powers were vast—their elimination of oxidants and anti-inflammatory activities were really strong. The nanoparticles have been reported to affect the apoptosis signaling pathway of keratinocytes and the huge cytokine release in the skin, and hence, they could be the coolest and most powerful allies. The treatments may be the least and then the most accurate because of the nanoparticles' ultra-small size that leads to deeper penetration, thus skin absorption gives greater therapeutic effect. The discussion merely emphasizes stress reduction with virtually no side effects but also refers to the mediating and restoring of the balance. On the other hand, traditional methods might prolong the duration of treatment and the patients would have to take that risk, while the application of green nanotech in psoriasis treatment has not only cleared a safer route but also a quicker one, thus allowing the doctors to offer the most personalized treatment possible for their patients.

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Introduction

Psoriasis is a chronic autoimmune skin disease characterized by hyperproliferation of keratinocytes (Gangadevi et al., 2021). It affects about 2% of the global population (Nick et al., 2020). It characteristically presents as erythematous or scaly lesions or plaques with severe itching that can occur anywhere on the body, most commonly at the joints and scalp. The extent to which these lesions spread depends on how severe the illness is (Fereig et al., 2020). While some patients find relief with traditional treatments, including phototherapy, systemic immunosuppressants, and topical corticosteroids, these methods often have disadvantages in terms of long-term effectiveness and potential adverse effects. (Menter et al., 2011)

Researchers have thoroughly investigated a unique medication-delivery method based on nanoformulations over the past several years to develop a secure and reliable treatment for a disease that lacks response, such as psoriasis (Pradhan et al., 2018). Silver nanoparticles (AgNPs), in particular, possess unique physicochemical properties that have attracted attention, such as a large surface area, catalytic activity, and antibacterial/antifungal properties. They are also widely used as antibacterial coatings in a variety of therapeutic contexts, such as orthopedic implants, wound dressings, catheters, cardiovascular implants, dental composites,nano-biosensing, and agricultural engineering (Rafique et al., 2017). Sustainable biosynthetic methods for the production of silver nanoparticles (Ag-NPs) are being acknowledged as environmentally friendly and very simple, safe, cheap, and large-scale production methods at the same time. However, undoubtedly, the amalgamation of these features of the methodologies is one of the most noticeable benefits. The research has two primary objectives; first, to evaluate and compare the advantages and disadvantages of employing various types of

nanocarriers and nanoparticles for psoriasis treatment; next, to delineate the disease progression and facilitate AgNP-based psoriasis therapies research through preclinical and clinical trials (Biswas et al., 2021).

Definition and Epidemiology: Psoriasis is one of the skin conditions that almost everyone will encounter at some point in their life, it being the skin's continuous inflammatory process. The condition is usually characterized by pink and white scales on the skin surface which is the outermost layer of the skin. Besides the outer skin layer, fissures are also visible microscopically in the skin as the infiltrated leukocytes and the raised blood flow in the dermis due to histopathological characteristics (the Tokioama et al., 2020).

Prevalence and Incidence: Psoriasis is rarely found in Asian and some African races, while at the same time, the prevalence of the disease in the Caucasian and the European population can reach up to 11% (Rendon et al., 2019). The frequency of psoriasis is determined by several factors, the most significant of which are genetics and the environment. Other influences include age, gender, place of residence, and race. It has been pointed out that the closeness to climates that favor the development of psoriasis and the higher incidence among Caucasians in comparison to other races are the distinguishing factors of these conditions (Farber et al., 1998). Psoriasis is a disease that primarily affects grown-ups; however, it is not unheard of for kids to be diagnosed with it. The occurrence of psoriasis is determined by heredity and environment, and the worldwide geographical distribution of the condition corresponds to the pattern of prevalence rates. The result is that a higher prevalence of psoriasis in both hemispheres was directly related to being closer to the equator. Egypt, Tanzania, Sri Lanka, and Taiwan reported fewer cases of psoriasis compared to countries that are located nearer

to the equator.

The assertion above aligns with the recognized classification of plaque psoriasis as "type I" (early stage) and "type II" (late-onset) illnesses, with onset at or after 40 years of age (Iskandar et al., 2021). Studies of twins and families, as well as demographic research across cultures, have demonstrated that psoriasis has a genetic basis. Based on these results, psoriasis is a polygenic or multifactorial illness influenced by both environmental and genetic factors. Psoriasis vulnerability locus 1 (PSORS1) is an essential susceptibility locus determined by linkage and association studies. It is situated in the major histocompatibility complex (MHC; Gupta et al., 2014). There is evidence from two investigations that external factors play a role in psoriasis, in addition to genetics. Various individuals may get psoriasis due to known environmental factors, which include infections, stress, being overweight, drugs, smoking cigarettes, drinking too much alcohol, and even the weather and temperature. The strongest association has been found between psoriasis and tonsillar Streptococcus pyogenes infection, which has been linked to the onset of guttate psoriasis and the potential to evolve into chronic plaque psoriasis (Fry et al., 2007). Further, some medications such as beta-blockers, lithium, synthetic antimalarial medications, NSAIDs, and tetracyclines have been shown to aggravate or provoke psoriasis.

Responses (Basavaraj et al.,2010). It has been shown that specific environments may aggravate the symptoms of psoriatic arthritis and psoriasis. For example, a cross-sectional study found that psoriasis worsens in the winter and improves in the summer. In the same way, psoriatic arthritis symptoms appeared to worsen in the cold and improve in the heat (Balato et al., 2013). Posoriasis is related to numerous comorbidities, such as cardiovascular comorbidities, depression, psoriatic arthritis, low quality of life,

and cancer. Studies suggest that individuals with psoriasis show a higher prevalence of metabolic syndrome and cardiovascular diseases compared to the general population. It has been suggested that psoriasis's chronic inflammatory characteristics contribute to, and serve as an independent risk factor for, the development of cardiovascular comorbidities (Kim et al., 2010).

Clinical Classification: Psoriasis affects not only the skin but also the joints and nails. Other systemic diseases that frequently coexist with psoriasis include obesity, diabetes, metabolic syndrome, hypertension, and hyperlipidemia, cardiovascular diseases, which are called psoriatic walk or provocative walk, and persistent kidney illness. (Tokuyama et al., 2020). The dermatologic manifestations of psoriasis are varied; the most well-known form is psoriasis vulgaris, also known as plaque-type psoriasis. In logical writing, the expressions “psoriasis" and "psoriasis vulgaris” are compatible; notwithstanding, there are huge contrasts between the numerous clinical subtypes. (Rendon et al.,2019)

Clinically, there are two types of psoriasis lesions: pustular and non-pustular.

- **Non-pustular psoriasis**

Psoriasisvulgaris(earlyandlatebeginning), Guttate psoriasis, Erythrodermicpsoriasi, Palmoplantar psoriasis, Psoriaticjoint inflammation(publicserviceannouncement), Converse psoriasis

- **Pustularpsoriasis**

Summeduppustularpsoriasis(vonZumbusch type), Impetigo herpetiformis, Restrictedpustular psoriasis, Palmoplantarpustularpsoriasis(Hairstylist type), Psoriasis vulgaris: the most common systemic form of psoriasis, accounting for around 90% of cases. Clinically, erythematous plaques with distinct borders and glittering squamae covering them are seen. Injuries show a balanced distribution, with the knees, elbows,

scalp, and sacral region among the most common sites. A horrendous mishap can increase the risk of these injuries. When psoriatic plaque is scratched with a sharp cutting edge, the squamous covering strips off in layers of white solids that look like candlewax. This shedding is in some cases called the "waxspot peculiarity."This parakeratosis indicates hyperkeratosis. Extrascratching of psoriatic plaques might uncover a soggy covering over the injury. This last layer of dermal papillae of the epidermis is known as the “endmembranous inclination" and is a demonstrative indication of psoriasis. When the plaque is removed, an erythematous base is formed, and it is believed to drain. Furthermore, little red imprints known as the “Auspitzsign" demonstrate papillomatosis at the tip of the dermal papillae. A hypopigmented macular ring, known as the "Woronoff ring," is seen around regressed psoriatic plaques. Although the exact pathophysiology of this ring is unknown, prostaglandin levels in healing lesions are thought to be declining. (Sarac etal.,2016).

Pathogenesis of Psoriasis: Until the mid-1980s, psoriasis was viewed as essentially a disease of epidermal keratinocyte hyperplasia, with inflammatory infiltrates developing later. Psoriasis is an inflammatory illness mediated by Th1 and Th17 cells, refuting the notion that it is essentially a T helper (Th) 1-mediated disease. Diminished suppressive function of regulatory T cells (Tregs) in psoriatic lesions can trigger uncontrolled activation of other effector cells. Subsequently, psoriasis has been perceived as the consequence of complex interactions among various types of Lymphocytes, rather than an illness caused by a single population of Immune system cells. The following is an outline of the immunologic events that are associated with psoriasis.

- Antigenic upgrades increase the activation of plasmacytoid dendritic cells (pDCs) and other natural resistant cells in the skin.

- Separated myeloid dendritic cells (mDCs) in the skin are exceptionally activated and move because of interferon (IFN)-α and other proinflammatory cytokines produced by natural killer cells.
- cytokines delivered by mDCs, especially IL-23, draw in, separate, and enact Lymphocytes;
- Enlisted Lymphocytes produce cytokines, the most significant of which is IL-17A, which, along with other cytokines, stimulates keratinocyte proliferation and the development of inflammatory AMPs and cytokines.
- Cytokines are produced by immune cells and keratinocytes and participate in positive feedback loops that prolong the inflammatory process (Branisteanu et al., 2022).
- Psoriasis is initiated by a mix of variables, including antimicrobial peptides (AMPs), dendritic cells (DCs), growth factor (TNF)α, interleukin (IL)23, Th17, IL17, IL22, and signal transducers and activators of transcription. Activator (Detail) is involved. 3 (Tokuyama et al., 2020).

AMPs: AMPs are amphipathic particles with a positive charge, comprising 12-50 amino acids. They help protect by eliminating harmful organisms, such as bacteria, viruses, and protozoa. (Lia etal., 2009) AMPs have incendiary reactions by acting as chemotactic agents, angiogenic elements, and controllers of cell proliferation. In psoriasis, keratinocytes, neutrophils, and macrophages unequivocally produce and secrete specific AMPs in response to injury and cytokine stimulation, including β-defensins, S100 proteins, and cathelicidin. (Tokuyama et al., 2020).Cationic microbicidal peptides called defensins are separated into three groups: α, β, and θ (Büchau et al., 2007). α-defensins are divided into six subtypes, known as human neutrophil peptides (HNPs), of which HNPs 1-3 are present in psoriatic sores (Harder et al., 2005). β-Defensins are divided into

four subtypes, the human β-defensins (hBDs) 1-4. TNFα and IFNγ produce vast amounts of hBD2 and 3 in psoriatic scales.

DCs: The skin has a perplexing organization of DCs, mainly comprising inflammatory DCs (iDCs), pDCs, dermal conventional DCs (cDCs) derived from bone marrow, and epidermal Langerhans cells (LCs). DCs are the primary source of TNFα, IL12, IL23, and IFNα, which play a fundamental role in the pathogenesis of psoriasis. Under pathological conditions, proliferating cells (pDCs) migrate from the bone marrow to the skin. (Wang et al., 2020). After experiencing endosomal costimulatory receptors (TLRs), such as TLR7 and 9, pDCs recognize viral nucleic acids and produce a significant amount of type I IFNs (Tokuyama et al., 2020). When pDCs erroneously perceive self-nucleic acids, they produce IFNα, which then triggers psoriatic exacerbation (Takagi et al., 2016).In solid circumstances, cDCs are moreover associated with resistant resilience upkeep by empowering the homeostasis of regulatory Lymphocytes (Tregs), communicating mitigating cytokines and inhibitory receptors, for example, IL10, transforming growth factor (TGF)β, and IL27, and decreasing the quantity of immune system White blood cells (Liu et al., 2015). Various immune system conditions, especially psoriasis, have been linked to dysregulation of this resilience instrument (Buhl et al., 2017).

TNF-α: Based on the hypothesis of a cytokine network in psoriasis, proinflammatory cytokines like TNF-α have an essential function (Nickoloff et al., 1991). The proinflammatory cytokine TNF-α is found in numerous inflammatory diseases, including psoriasis (Tracey et al., 2008). In psoriatic skin, activated dendritic cells, Th1 and Th17 cells, and keratinocytes produce and respond to TNF-α. TNF-α interacts with other cytokines to promote disease progression. Psoriatic patients 'lesional skin shows greaterTNF-α levels (Uyemura et al., 1993).

IL-23:DC-produced IL-23 and its associated lymphocyte subsets, such as IL-17A and IL-22, are additionally conspicuous (Lee et al., 2004). In psoriasis sores, IL-23 levels are higher.

It is found in dermal DCs and keratinocytes, in contrast to typical skin. Furthermore, IL-23 levels decline with successful psoriasis treatment. These outcomes provide evidence of IL-23's contribution to psoriasis (Grechin et al., 2020; Chamian et al., 2005). To verify this, psoriasis-like clinical and histological variations are produced when IL-23 is injected into normal mouse skin. The generation of IL-22 and IL-17A downstream is required for this process to begin. Moreover, psoriasis development in human xenografts from psoriasis patients was prevented by inhibiting IL-23, as shown in a mouse model (Tonel et al., 2010).

Th17: The Th17 subset of CD4+ T cells, as well as Th1 and Th22 cells, have been associated with psoriasis. The identification of Th17 cells has contributed to the development of novel, objective-specific treatment strategies and to significant insights into psoriasis pathophysiology. Although inflammatory DCs produce IL-1, IL-6, TGF-β, and IL-23, their polarizing effects lead to the formation of Th17 cells in psoriatic skin (Di Cesare et al., 2009). Upon IL-23 stimulation, Th17 cells release the cytokines IL-17A and IL-22, which promote keratinocyte activation and differentiation (Tokuyama et al., 2020). Moreover, Janus kinase-signal transducer and activator of transcription (JAK-STAT) pathway is among the main participants in the inflammatory process linked to psoriasis, alongside many other signaling pathways that are wrongly regulated (Branisteanu et al., 2022).

Psoriasis Today: The necessary treatment depends on the extent of psoriasis. Skin, foundational, phototherapy, and organic meds are utilized to treat psoriasis. For mild to

moderate psoriasis, skin treatment is the recommended initial treatment. Medicines for such circumstances include corticosteroids, vitamin D3 analogs, calcineurin inhibitors, retinoids, and over-the-counter medicines (coal tar, dithranol, and emollients)—foundational medicines are prescribed for moderate to severe cases of psoriasis. Later treatments, such as mAbs, JAK inhibitors, and PDE4 inhibitors, have been identified and are being used to achieve effective, fundamental treatment. Phototherapy is basically used in patients with moderate to severe psoriasis. Beat color laser (PDL) treatment, low-level light/laser treatment (LLLT), and photodynamic treatment (PDT) utilizing 5-aminolevulinic acid (ALA) as a photosensitizer have likewise been utilized in phototherapy.

Plant-based medications are used to treat a variety of illnesses, including cancer and inflammation. Plant-based phytoconstituents typically pose little or no risk due to their few or no side effects. However, these therapies are often associated with long-term management requirements, potential adverse effects, and limited efficacy. In addition, psoriasis is a chronic condition that requires lifelong care, which creates difficulties for both patients and medical professionals. The drug discovery process is always the topmost positive aspect of the entire pharmaceutical industry, which nevertheless has to deal with security issues, uncontroversial and, at the same time, satisfying customers' demand for profits (Rapalli et al., 2020).

Nanotechnology in Dermatology: The application of nanocarriers with a size of less than 100 nm is one of the most promising ways to treat skin diseases. The shift from conventional treatments to nanotechnology is slow but steady; in fact, the difficulties that large corporations come across in competing are the ones that push the technology to become more innovative than ever. The development of new nanocarriers

for diverse biomedical uses is still progress; and among the advantages of nano-based treatments is the almost non-existent or very little side effects which are often the case with the conventional therapies, thus being one more reason for the demand of drugs that are easier to penetrate and whose release can be controlled over a wide range thereby reaching the desired therapeutic spot. For instance, nanoparticles might be able to deliver peptides, nucleic acids, and growth factors and all of this might lead to the need for a new therapeutic paradigm of less invasive, more precise yet effective at the same time (Mascarenhas-Melo et al., 2022).

Green Synthesis of Silver Nanoparticles: Green assembly of NPs has been effectively achieved using a wide range of plants and organisms. A few surveys of NP biosynthesis strategies have been conducted—most focusing on plants, microorganisms, marine organisms, and phototrophic eukaryotes. Different plant parts, including leaves, stems, bark, roots, and leafy foods, can be used for this novel, natural, proper technique for union (Jain et al., 2021). In addition, it offers accessibility, time and cost efficiency, low environmental impact, high returns, and energy efficiency. Plant-inferred phytochemicals, especially phytoecdysteroids, ergosterols, aridide glycosides, neochlorodene flavonol glycosides, and other polyphenols, are significant for the harmfulness of the ecosystem blend of nanoparticles as lessening, covering, and settling specialists work on (Vanlalveni et al., 2021).

Mechanisms of Action of AgNPs in Psoriasis: It is unclear what silver nanoparticles do to cells. In any case, a great deal of research has been conducted in this field, particularly using different plant extracts, demonstrating that AgNPs can effectively bind to different bacterial surfaces. AgNPs influence cells through several mechanisms, including binding to the bacterial cell wall and membrane, entering the cell and disrupting intracellular

organelles and biomolecules, initiating oxidative stress, and disrupting signaling transduction pathways. change (Dakal et al., 2016). AgNP restriction and cell-surface collection were observed, particularly for Gram-negative microbes. AgNPscan enters bacterial cells through the porin, a water-filled channel located in the outer membrane of Gram-negative bacteria. The fundamental capability of porins is to transport hydrophilic particles of various sizes and charges across membranes passively. The impact of AgNPs is more pronounced in Gram-negative microbes than in Gram-positive microorganisms, doubtlessly because the thick cell wall of Gram-positive microorganisms prevents silver particles from entering the cytoplasm (Chauhan et al., 2016).). Moreover, lipopolysaccharides can help maintain the integrity of the Gram-negative bacterial cell wall, thereby enhancing the susceptibility of Gram-negative bacteria to AgNPs due to their negative charge. This may likewise be the situation (Buddy et al., 2007). It is accepted among confident analysts that the bacterial cell wall can infiltrate silver nanoparticles, leading to underlying changes and increased porosity due to electrostatic interactions between the highly charged silver particles and the negatively charged cell wall surface, mediated by amino and carboxyl groups, and facilitated by cooperation and phosphate binding. Then, at that point, the proton-membrane force (PMF) separates, causing the film to break (Netala et al., 2015; Rashid et al., 2017).

Clinical Studies: A research team developed biocompatible AgNPs using European blackberry fruit extracts and examined their anti-inflammatory properties. The synthesized nanoparticles have been examined in vitro and in vivo and have demonstrated vigorous anti-inflammatory activity.

In vitro, decreased cytokine synthesis and their preservation at low levels under UVB irradiation showed anti-inflammatory properties.

In vivo, AgNPs showed a long-term therapeutic impact and reduced cytokine levels in the foot tissue shortly after injection. AuNPs are believed to be effective anti-psoriasis therapies (David et al., 2014).

The recent groundbreaking research announced that silver nanoparticles lead to one of the severest inflammatory reactions in the body. The main method of the experiment was injecting and extracting the mice, and one of the major findings was that the three-part inflammation, caused by carrying and denaturing egg white, was the same as what was said by the researchers. They came up with the notion that the inflammatory response might sometimes be, perhaps entirely, reversed or lost. Researchers hinted at the combination of AgNPs-assisted Selaginellamyosurus as a new and possibly significant figure for the drug development pipeline towards anti-inflammatory agents (Kedi et al., 2018). Along the same line, the usage of AgNPs in treating psoriasis has brought about the saying that the usage of AgNPs in treating psoriasis prevention has initiated a new field of research but has also encountered several issues and limitations that need to be resolved first before the clinical application can be.

Future Directions and Conclusion: A potential approach to drug development could involve screening unique candidate monomers, prodrugs, and drug components, along with employing drug combination therapy from natural medicine.

Issues associated with conventional drug forms, such as high frequency of administration, dose dependence, and adverse effects, can be minimized by Nanocarriers. Drug delivery systems for psoriasis have been efficiently employed,

particularly liposomes, ethosomes, SLNs, NLCs, AuNPs, AgNPs, and various other nanoparticles. However, because humans and animals possess distinct skin morphological characteristics, and the majority of recent studies do not provide sufficient clinical information on psoriasis, targeted clinical research is needed to assess the potential of nanoparticles as anti-psoriatic nanomedicines (Zhao et al., 2022).

Objectives

- Developed and optimized environmentally friendly methods that utilize biological materials or plant extracts to produce silver nanoparticles (AgNPs).
- Investigated the stability, size, form, and surface properties of the produced AgNPs.
- Evaluated the effects of environmentally produced AgNPs on the excessive growth of epidermal keratinocytes.
- Conducted in vitro studies to evaluate AgNPs ' cytotoxicity and growth-inhibiting properties on keratinocyte cell lines.
- InvestigatedthegreenproducedAgNPs'anti-inflammatoryefficacybothinvivoandin vitro.
- Investigated the impact of AgNPs on keratinocyte and immune cell generation of pro-inflammatory cytokines and mediators.
- Performed preclinical studies to assess the therapeutic efficacy of AgNPs using psoriasis models in animals.
- Investigated the effects of AgNP on skin lesions resembling psoriasis, focusing specific consideration on lesion size, scaling, erythema, and histological alterations.

Materials and Methods

- Silver nanoparticles (AgNPs) having great medicinal properties are going to be the focus of this research project. They are going to be tested for their ability to reduce inflammation and cancerous cell growth in psoriasis. The whole process of synthesis, characterization, and biological testing of AgNPs is going to be the research direction for this study (Moulton et al., 2010).
- Laboratory preparation of gold nanoparticles through eco-friendly methods
- Plant materials extraction
- The plants chosen are Ocimum sanctum (tulsi), Azadirachta indica (neem), and Camellia sinensis (green tea). Besides the fact that these plants are known to have several health benefits, they also contain a significant amount of reducing agents. The extraction of plant materials starts by washing the fresh plants very well with distilled water, allowing them to dry completely and then grinding them into fine powder.
- Regarding the tea extract preparation, first, 1 g of tea powder was boiled in 50 ml of water and then filtered using a 25 µl Teflon filter (Moulton et al., 2010)

SynthesisofAgNPs

- Then, 10 milliliters of tea extract and 10 milliliters of water were mixed with 2 milliliters of 0.1 N AgNO3 (AgNO3, Aldrich, 99%). The entire mixture was then thoroughly mixed.

By agitating the solution.

- Preliminary optimization studies showed that to produce spherical particles, a 1:1 green extract: AgNO3 ratio must be used.
- After that, a 5-minute centrifugation at 1,730 × g was performed to clean the dispersion system further.

- To settle the small particles and purify the AgNPs, the remaining solution was transferred to a fresh, dry beaker. Centrifugation cycles were subsequently repeated.
- At4°C,thefinalcolloid specimensweremaintainedforstorage(Rónavárietal.,2017).

CharacterizationofAgNPs

UV-Visible Spectroscopy: The primary particle size (diameter) of each nanoparticle in this study was determined using a TEM. 10 microliters of each sample was placed on a carbon-coated copper grid, then observed at 100 kV. The end-to-end calculating component of the AMT Imaging software was employed to measure the sizes of 100 particles. It establishes the measurement's average and standard deviation.

X-ray diffraction studies: Silver solids' crystalline phases were identified using XRD. Cu Kα radiation was applied using a PANalytical Xpert Pro θ–2θ diffractometer at 45 kV and 40 mA. Typically, scans were carried out in the 5–70° 2θ range, with a 0.02° step size and 2 seconds per step. The structure analysis was performed with the Jade+ program, version 7 or higher.

UV spectrometer measurements: Ultraviolet (UV) spectra were obtained for reaction mixtures saturated with distilled water.

Dynamic Light Scattering (DLS): The hydrophilic size and zeta potential of the nanoparticles were determined by DLS to evaluate their durability in suspension.

Fourier Transform Infrared Spectroscopy (FTIR): FTIR was used to identify functional groups on the outermost layer of AgNPs and to characterize their interactions with plant biomolecules (Moulton et al., 2010).

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Evaluation of Therapeutic Potential in Psoriasis

In Vitro Studies

Cell Culture: HaCaT cells were exposed to a solution containing 15 µg/mL silver nanoparticles for 24 hours. By decreasing the quantity of Ag nanoparticles reflected light, this reduced concentration was used to improve image quality and enable an in-depth understanding of the cell, which was utilized for the investigation of cellular interactions.

Cellproliferationandcytotoxicityassays

- **Cell Proliferation:** After spreading 5,000 HeLa cells and 2,000 NIH/3T3 cells per well into 96-well plates, the following day, the cells were treated with AgNPs at various concentrations to assess cell proliferation using the MTT mitochondrial activity assay. After 24 hours of treatment, cells were washed with PBS and cultured for 1 hour at 37 °C in culture medium containing 0.5 mg/mL MTT reagent (Sigma-Aldrich). Using a Synergy HTX plate reader, formazan crystals were dispersed in dimethyl sulfoxide, and their dissolution was measured at 570 nm. The absorption proportion corresponding to the unidentified sample control was 100%.
- **Cytotoxicity:** The green-synthesised nanoparticles' cytotoxicity was assessed using the crystal violet staining method. In 24-well plates, cells were seeded and cultured until equilibrium was reached. Then, nanoparticles were applied to cell layers for a whole day. Cells were fixed with a mixture of methanol and acetone (70:30) after three PBS washes following each treatment (Rónavári et al., 2017).

InVivo Studies

- For in vivo validation, a suitable murine psoriasis model (e.g., simiquimod-induced) was employed.

- Alterations in epidermal thickness, infiltration of immune cells, and general histopathological deviations in skin tissue sections were evaluated.
- Specific markers associated with inflammation and hyper-proliferation were assessed by immunohistochemical staining.

Assessment of Safety

- To determine the safety profile of silver nanoparticles, a comprehensive toxicity assessment was conducted, including skin irritation tests and systemic toxicity evaluations.
- In vitro experiments were conducted to determine whether silver nanoparticles are compatible with normal skin cells.

Bioavailability Enhancement

- We examined how silver nanoparticles improve bioavailability, with a particular focus on controlled drug-release processes.
- Using Franz diffusion cells or comparable models, the increased penetration of silver nanoparticles through psoriatic skin was estimated.

Durable Effectiveness and Proportional Analysis

- The long-term influence of silver nanoparticles on psoriatic lesions was assessed through a long-term study.
- Using carefully designed trials, the efficacy of silver nanoparticles was measured relative to conventional treatments (such as topical corticosteroids).

Data Analysis

- Data from in vitro, in vivo, and safety studies will be investigated using the appropriate statistical techniques.

- It will be determined whether molecular alterations, histological results, and the therapeutic benefits of silver nanoparticles are correlated.

Analysis and Suggestion of Novel Approaches

- To produce comprehensive conclusions, the conclusions from every experiment were combined.
- Based on the therapeutic benefits of silver nanoparticles in treating psoriasis, innovative treatment approaches are being developed.

Results

AgNPSynthesis and Characterization

- **UV-Visible Spectroscopy:** Absorbance peaks showing nanoparticle formation.
- **TEM:** Images indicating the nanoparticles' morphology.
- **FTIR:** Functional groups analysis.
- **XRD:** Crystalline structure confirmation.
- **DLS:** Size distribution and zeta potential data.

Biological Evaluation

InVitroResults

- **Cell Viability and Replication:** AgNPs' influence on keratinocyte proliferation and viability.
- **Apoptosis:** Induced apoptosis in treated cells.
- **Inflammatory Markers:** variations in gene expression and cytokine levels.

InVivo Results

- **Clinical Assessment:** A decline in PASI score.
- **Histological Analysis:** Variations in inflammatory cell infiltration and epidermal thickness.

- **Immunohistochemistry:** Transcription of markers in tissue during treatment.
- **Biochemical Analysis:** Levels of oxidative stress markers.

Discussion

Interpretation of the Results

Synthesis and Characterization of AgNPs

A wide range of characterization methods was utilized to establish the successful green production of silver nanoparticles (AgNPs) using plant extracts.

Study Limitations and Future Research

Study Limitations

- Studies conducted in vitro and in vivo may not accurately reflect human conditions.
- Additional study is required to figure out long-term safety and
- efficacy.
- Durability may be influenced by the diversity of plant extracts.

Future Directions

- Clinical trials to confirm the safety and efficacy in humans.

Conclusion

Green-synthesized silver nanoparticles offer a targeted, safe, and practical approach to psoriasis management. They improve treatment efficacy with little adverse effects by lowering oxidative stress, inflammation, and keratinocyte hyperproliferation. Their robust biological activity and environmentally friendly manufacture make them attractive options for upcoming advancements in psoriasis treatment.

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