Evaluation of *Aloe vera*–Turmeric Nano Gel for Psoriasis

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Abstract

Background: Psoriasis is a chronic immune-mediated inflammatory skin disorder characterized by excessive keratinocyte proliferation, erythema, scaling, and epidermal thickening. Conventional therapies are often associated with adverse effects and limited long-term compliance, necessitating the development of safer and more effective alternatives. The present study aimed to develop and evaluate an Aloe vera–Turmeric Nano Gel for the management of psoriasis.

Methods: Aloe vera gel and turmeric rhizome extracts were subjected to phytochemical screening and formulated into a nano gel using a nanoparticle-based delivery approach. The prepared formulation was evaluated for physicochemical properties, including pH, viscosity, spreadability, particle size, zeta potential, entrapment efficiency, and in vitro drug release. Anti-psoriatic activity was assessed in a psoriasis-induced rat model using clinical parameters such as erythema, scaling, skin thickness, and Psoriasis Severity Index (PSI). Histopathological examination of skin tissues was also performed.

Results: Phytochemical analysis confirmed the presence of flavonoids, phenolics, tannins, terpenoids, and other bioactive constituents. The nano gel exhibited satisfactory pharmaceutical properties with a particle size of 182.4 ± 8.6 nm, entrapment efficiency of 88.7 ± 2.1%, and sustained drug release over 24 h. Pharmacological evaluation demonstrated a significant reduction in erythema, scaling, skin thickness, and PSI compared with the psoriatic control group. Histopathological studies revealed restoration of normal epidermal architecture with marked reduction in hyperkeratosis, parakeratosis, and inflammatory cell infiltration.

Conclusion: The Aloe vera–Turmeric Nano Gel showed promising anti-psoriatic efficacy owing to its synergistic phytochemical activity and enhanced topical delivery. The formulation may serve as a potential herbal nanotherapeutic approach for the safe and effective management of psoriasis.

Keywords: Aloe vera, Turmeric, Nano Gel, Psoriasis, Anti-inflammatory Activity

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1. Introduction

Psoriasis is a chronic, immune-mediated inflammatory skin disorder characterized by erythematous, thickened, and scaly plaques resulting from excessive keratinocyte proliferation and dysregulated immune responses. The disease affects approximately 2–3% of the global population and significantly impairs quality of life due to persistent itching, pain, psychological distress, and social stigma [1,2]. The pathogenesis of psoriasis involves complex interactions between genetic susceptibility, environmental triggers, dendritic cells, T lymphocytes, and inflammatory cytokines, particularly the IL-23/IL-17/TNF-α signaling axis, which drives epidermal hyperplasia and chronic inflammation [3,4].

Conventional therapeutic approaches for psoriasis include topical corticosteroids, vitamin D analogues, calcineurin inhibitors, systemic immunosuppressants, phototherapy, and biological agents. Although these treatments can effectively control disease symptoms, long-term use is frequently associated with adverse effects such as skin atrophy, irritation, hepatotoxicity, nephrotoxicity, immunosuppression, and high treatment costs [5,6]. These limitations have stimulated growing interest in safer and more sustainable therapeutic alternatives derived from natural products.

Medicinal plants have gained considerable attention in dermatological research because of their broad spectrum of biological activities and favorable safety profiles. Among them, *Aloe vera* (*Aloe barbadensis* Miller) is widely recognized for its anti-inflammatory, antioxidant, wound-healing, moisturizing, and immunomodulatory properties. The therapeutic effects of *Aloe vera* are primarily attributed to its rich phytochemical composition, including polysaccharides, anthraquinones, flavonoids, vitamins, amino acids, and phenolic compounds [7]. Clinical and experimental investigations have demonstrated that *Aloe vera* can reduce erythema, scaling, and epidermal inflammation, making it a promising candidate for psoriasis management [8].

Similarly, turmeric (*Curcuma longa* L.) has been extensively investigated for its pharmacological potential. Curcumin, the principal bioactive constituent of turmeric, exhibits potent anti-inflammatory, antioxidant, antiproliferative, and immunomodulatory activities. Curcumin modulates several molecular targets implicated in psoriasis pathogenesis, including nuclear factor-kappa B (NF-κB), signal transducer and activator of transcription-3 (STAT3), mitogen-activated protein kinase (MAPK), and pro-inflammatory cytokines such as TNF-α, IL-17, and IL-23 [9,10]. Experimental studies have demonstrated that curcumin suppresses keratinocyte hyperproliferation, promotes apoptosis of activated inflammatory cells, and improves epidermal barrier function, thereby contributing to its anti-psoriatic effects [11].

Despite their promising therapeutic potential, both *Aloe vera* phytoconstituents and curcumin face formulation challenges, including limited skin penetration, poor aqueous solubility, instability, and reduced bioavailability following topical administration [12]. These limitations often restrict the achievement of optimal therapeutic concentrations within psoriatic lesions. Nanotechnology-based drug delivery systems have emerged as an effective strategy to overcome these barriers by enhancing drug solubility, stability, skin permeation, controlled release, and site-specific delivery [13].

Nanogels represent an advanced class of nanoscale hydrogel systems composed of crosslinked polymeric networks capable of encapsulating both hydrophilic and hydrophobic bioactive compounds. Owing to their high water content, biocompatibility, biodegradability, prolonged residence time, and excellent skin adherence, nanogels have gained increasing importance in topical drug delivery applications [14]. Recent investigations have demonstrated that curcumin-loaded nanogels significantly improve drug retention within skin layers, enhance anti-inflammatory activity, and increase therapeutic efficacy against psoriasis compared with conventional formulations [15].

The combination of *Aloe vera* and turmeric within a nanogel platform offers a promising synergistic approach for psoriasis treatment. *Aloe vera* can provide moisturizing, wound-healing, and anti-inflammatory benefits while enhancing patient acceptability, whereas curcumin can directly target inflammatory and proliferative pathways involved in disease progression. The incorporation of these phytoconstituents into a nano-sized gel system may further improve skin penetration, bioavailability, and localized therapeutic action while minimizing systemic exposure and adverse effects [16].

Therefore, the present study aims to develop and evaluate an *Aloe vera–Turmeric Nano Gel* and investigate its phytochemical characteristics, pharmaceutical properties, and pharmacological efficacy against psoriasis. The study is expected to provide scientific evidence supporting the development of a novel herbal nanotherapeutic system for the effective and safer management of psoriasis.

2. Materials and Methods

2.1 Materials

Fresh leaves of *Aloe vera* (*Aloe barbadensis* Miller) and rhizomes of *Curcuma longa* L. were procured from a local herbal supplier and authenticated by a qualified taxonomist. Carbopol 934, chitosan, sodium tripolyphosphate (TPP), Tween 80, ethanol,

methanol, and other analytical-grade chemicals were obtained from certified chemical suppliers. Retino-A cream was used as the standard anti-psoriatic formulation. All reagents employed in the study were of analytical grade and used without further purification [17].

2.2 Collection and Authentication of Plant Material

Healthy and disease-free *Aloe vera* leaves and turmeric rhizomes were collected and thoroughly washed with distilled water to remove adhering contaminants. The plant materials were authenticated by a botanist, and voucher specimens were deposited in the departmental herbarium for future reference. Authentication of medicinal plants is an essential prerequisite for ensuring reproducibility and quality control in phytopharmaceutical research [18].

2.3 Preparation of Aloe vera Extract

Fresh *Aloe vera* leaves were washed and carefully dissected to separate the outer rind from the inner mucilaginous gel. The gel was homogenized using a mechanical blender and filtered through muslin cloth to remove fibrous material. The filtrate was lyophilized to obtain a dry extract and stored at 4°C until further use. The extraction procedure was performed under controlled conditions to preserve thermolabile polysaccharides and bioactive constituents [19].

2.4 Preparation of Turmeric Extract

The collected turmeric rhizomes were shade-dried, pulverized, and sieved to obtain a coarse powder. Approximately 500 g of powdered material was subjected to Soxhlet extraction using 70% ethanol for 8–10 h. The extract was concentrated under reduced pressure using a rotary evaporator and further dried to obtain a semisolid mass. The dried extract was stored in airtight containers at refrigerated conditions for subsequent formulation studies [20].

2.5 Preliminary Phytochemical Screening

Qualitative phytochemical investigations were performed on both extracts to identify major classes of secondary metabolites. Standard phytochemical tests were conducted for alkaloids, flavonoids, phenolic compounds, tannins, glycosides, terpenoids, saponins, carbohydrates, and proteins according to established procedures. The presence or absence of characteristic color changes or precipitates was recorded [21].

2.6 Preparation of Curcumin-Loaded Nanoparticles

Curcumin-rich turmeric extract nanoparticles were prepared by ionic gelation using chitosan and sodium tripolyphosphate (TPP). Chitosan was dissolved in 1% acetic acid solution, whereas TPP was dissolved separately in distilled water. The turmeric extract was dispersed in the chitosan solution under continuous stirring. Subsequently, TPP solution was added dropwise under magnetic stirring to facilitate nanoparticle formation through electrostatic interactions. The resulting nanosuspension was stirred for 2 h and subjected to ultrasonication to obtain uniform nanoparticles [22].

2.7 Formulation of Aloe vera–Turmeric Nano Gel

The nano gel was prepared using Carbopol 934 as the gelling polymer. Carbopol was dispersed in distilled water and allowed to hydrate overnight. Aloe vera extract was incorporated into the hydrated gel base, followed by the addition of curcumin-loaded nanoparticles under continuous stirring. Tween 80 was employed as a stabilizer, and triethanolamine was added dropwise to adjust the pH to skin-compatible levels. The final formulation was homogenized until a smooth and uniform nano gel was obtained [23].

2.8 Pharmaceutical Evaluation of Nano Gel

2.8.1 Organoleptic Properties

The prepared formulation was evaluated for appearance, color, odor, homogeneity, consistency, and absence of phase separation through visual inspection [24].

2.8.2 Determination of pH

The pH of the nano gel was measured using a calibrated digital pH meter at room temperature. Measurements were performed in triplicate, and mean values were calculated [25].

2.8.3 Viscosity Measurement

Viscosity was determined using a Brookfield viscometer equipped with an appropriate spindle at controlled temperature conditions. Measurements were conducted in triplicate and expressed as centipoise (cP) [26].

2.8.4 Spreadability Study

Spreadability was evaluated using the parallel-plate method. A known quantity of gel was placed between two glass slides, and the time required for the upper slide to move a specified distance under a standard weight was recorded [27].

2.8.5 Particle Size and Polydispersity Index

Particle size distribution and polydispersity index (PDI) of the nanoparticles incorporated within the nano gel were determined using dynamic light scattering (DLS) analysis. Measurements were performed at 25°C after suitable dilution with distilled water [28].

2.8.6 Zeta Potential Analysis

The surface charge of nanoparticles was assessed using a zeta potential analyzer to evaluate colloidal stability. Samples were analyzed in triplicate, and mean values were recorded [29].

2.8.7 Entrapment Efficiency

Entrapment efficiency was determined by centrifugation of the nanoparticle dispersion. The amount of free curcumin in the supernatant was quantified spectrophotometrically, and entrapment efficiency was calculated using the standard equation [30].

2.8.8 In Vitro Drug Release Study

Drug release from the nano gel was evaluated using a Franz diffusion cell fitted with a cellulose acetate membrane. Phosphate buffer (pH 7.4) was employed as the receptor medium and maintained at 37 ± 0.5°C. Samples were collected at predetermined intervals and analyzed spectrophotometrically [31].

2.9 Acute Dermal Toxicity Study

Acute dermal toxicity of the formulated nano gel was assessed according to OECD Guideline 402. Healthy Wistar rats were observed for mortality, behavioral changes, skin irritation, erythema, edema, and other toxic manifestations for 14 days following topical application of the formulation [32].

2.10 Experimental Animals

Adult Wistar rats weighing 180–220 g were procured from a CPCSEA-registered animal facility. Animals were maintained under standard laboratory conditions (25 ± 2°C, relative humidity 55 ± 5%, and 12 h light-dark cycle) with free access to standard pellet diet and water. Experimental protocols were approved by the Institutional Animal Ethics Committee and conducted in accordance with CPCSEA guidelines [33].

2.11 Induction of Psoriasis

Psoriasis-like skin inflammation was induced using Complete Freund's Adjuvant (CFA) combined with topical formaldehyde application. The dorsal skin region was shaved prior to induction. Repeated exposure resulted in erythema, scaling, epidermal thickening, and inflammatory infiltration resembling psoriatic lesions [34].

2.12 Experimental Design

Animals were randomly divided into four groups (n = 6):

- Group I: Normal Control
- Group II: Psoriatic Control
- Group III: Standard Treatment (Retino-A Cream)
- Group IV: Aloe vera–Turmeric Nano Gel

Treatments were administered topically once daily for 21 consecutive days following psoriasis induction [35].

2.13 Evaluation of Anti-Psoriatic Activity

The severity of psoriasis was assessed periodically based on erythema, scaling, and skin thickness scores. The cumulative Psoriasis Severity Index (PSI) was calculated by summing individual parameter scores. Reduction in lesion severity was considered indicative of therapeutic efficacy [36].

2.14 Histopathological Examination

At the end of the experimental period, animals were sacrificed, and skin samples were excised from the treated area. Tissues were fixed in 10% neutral buffered formalin, processed using standard paraffin embedding techniques, sectioned at 5 µm thickness, and stained with hematoxylin and eosin (H&E). Histological examination was performed to assess epidermal thickness, hyperkeratosis, parakeratosis, acanthosis, and inflammatory cell infiltration [37].

2.15 Statistical Analysis

All experimental data were expressed as mean ± SEM. Statistical analysis was performed using one-way analysis of variance (ANOVA) followed by Tukey's post hoc test. Values of $p < 0.05$ were considered statistically significant [38].

3. Results

3.1 Preliminary Phytochemical Screening

Qualitative phytochemical analysis revealed the presence of several bioactive constituents in both extracts. Aloe vera extract showed the presence of polysaccharides, flavonoids, tannins, phenolic compounds, and saponins, whereas turmeric extract demonstrated the presence of curcuminoids, flavonoids, phenolics, terpenoids, and alkaloids. These phytoconstituents are known to exhibit anti-inflammatory, antioxidant, immunomodulatory, and wound-healing activities, which may contribute to the observed anti-psoriatic effects.

Table 1. Phytochemical Screening of Extracts

Phytoconstituent	Aloe vera	Turmeric
Alkaloids	–	+
Flavonoids	+	+
Phenolics	+	+
Tannins	+	+
Saponins	+	–
Terpenoids	+	+
Glycosides	+	+
Carbohydrates	+	+

(+ Present, – Absent)

3.2 Characterization of Aloe vera–Turmeric Nano Gel

The developed nano gel exhibited desirable pharmaceutical properties. The formulation was homogeneous with a smooth texture and showed no evidence of phase separation. The pH remained within the physiological skin range, minimizing the possibility of irritation. Nanoparticle size below 200 nm indicated efficient dermal penetration and improved drug localization within psoriatic lesions.

Table 2. Pharmaceutical Evaluation of Nano Gel

Parameter	Result
Appearance	Smooth, homogeneous
Color	Yellowish green
pH	6.48 ± 0.12
Viscosity (cP)	4725 ± 95
Spreadability (cm)	7.92 ± 0.28
Particle Size (nm)	182.4 ± 8.6
PDI	0.241 ± 0.03
Zeta Potential (mV)	-29.6 ± 1.8
Entrapment Efficiency (%)	88.7 ± 2.1
Drug Content (%)	96.4 ± 1.3

The negative zeta potential value indicated good colloidal stability, while high entrapment efficiency

suggested successful incorporation of curcumin within the nanoparticle matrix.

3.3 In Vitro Drug Release Study

The nano gel demonstrated sustained release behavior over 24 h. Initial burst release was attributed to surface-associated drug molecules, followed by controlled diffusion from the polymeric matrix.

Table 3. In Vitro Drug Release Profile

Time (h)	% Drug Released
1	18.4 ± 1.2
2	29.7 ± 1.5
4	44.8 ± 1.8
6	56.5 ± 2.1
8	67.3 ± 2.4
12	79.2 ± 2.7
24	92.8 ± 3.1

Sustained release is advantageous for psoriasis management because it prolongs drug residence time and reduces the frequency of application.

3.4 Anti-Psoriatic Activity

The psoriasis control group exhibited severe erythema, scaling, epidermal thickening, and inflammatory infiltration. Treatment with Aloe vera–Turmeric Nano Gel significantly reduced disease severity compared with untreated animals.

Table 4. Psoriasis Severity Index (PSI)

Group	Erythema	Scaling	Thickness	Total PSI
Normal Control	0.12 ± 0.05	0.15 ± 0.04	0.18 ± 0.06	0.45 ± 0.09
Psoriatic Control	3.85 ± 0.21	3.76 ± 0.18	3.92 ± 0.17	11.53 ± 0.43
Standard (Retino-A)	1.24 ± 0.11	1.17 ± 0.12	1.29 ± 0.09	3.70 ± 0.21***
Nano Gel	0.92 ± 0.08	0.84 ± 0.10	0.96 ± 0.08	2.72 ± 0.18***

***p < 0.001 compared with Psoriatic Control

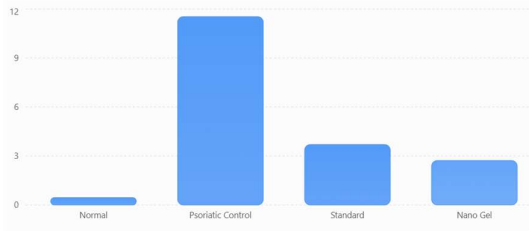

Figure1: Effect of Aloe vera–Turmeric Nano Gel on Psoriasis Severity Index (PSI) in Experimental Animals.

3.5 Reduction in Skin Thickness

Table 5. Epidermal Thickness

Group	Thickness (µm)
Normal Control	32.4 ± 3.1
Psoriatic Control	148.7 ± 8.6
Standard	58.2 ± 4.4***
Nano Gel	44.8 ± 3.7***

The nano gel markedly reduced epidermal hyperplasia, indicating suppression of keratinocyte over-proliferation.

3.6 Histopathological Findings

Histological examination of normal skin showed intact epidermal architecture and absence of inflammatory infiltration. The psoriasis control group demonstrated pronounced hyperkeratosis, parakeratosis, acanthosis, elongated rete ridges, and extensive infiltration of inflammatory cells. Treatment with Retino-A cream reduced epidermal thickening and inflammatory infiltration; however, mild hyperkeratosis persisted. The Aloe vera–Turmeric Nano Gel group exhibited near-normal skin architecture with substantial reduction in hyperkeratosis, restoration of epidermal thickness, and minimal inflammatory infiltration. These findings confirmed the therapeutic efficacy of the nano gel against psoriasis-like lesions.

4. Discussion

Psoriasis is a chronic inflammatory skin disorder characterized by excessive keratinocyte proliferation, epidermal hyperplasia, immune dysregulation, and increased production of pro-inflammatory cytokines. Despite the availability of numerous topical and systemic therapies, long-term management remains challenging because of adverse effects, poor patient compliance, and disease recurrence [39]. Consequently, there is increasing interest in the development of safer and more effective phytopharmaceutical formulations capable of targeting multiple pathogenic pathways simultaneously.

The present investigation successfully developed an Aloe vera–Turmeric Nano Gel and evaluated its phytochemical composition, pharmaceutical characteristics, and anti-psoriatic activity. Phytochemical screening confirmed the presence of flavonoids, phenolic compounds, terpenoids, tannins, glycosides, and polysaccharides, which have been extensively associated with antioxidant and anti-inflammatory activities [40]. These bioactive constituents are known to modulate inflammatory mediators, reduce oxidative stress, and promote tissue repair processes, thereby supporting their therapeutic relevance in psoriasis management.

Nanoformulation technology was employed to overcome the limitations associated with conventional herbal preparations, particularly poor skin penetration and inadequate bioavailability of curcumin. The prepared nano gel exhibited a particle size below 200 nm and a narrow polydispersity index, indicating uniform nanoparticle distribution. Nanocarriers of this size range have been reported to enhance epidermal penetration and improve retention of active compounds within inflamed skin tissues [41]. Furthermore, the observed zeta

potential value suggested adequate colloidal stability, minimizing nanoparticle aggregation during storage and application.

The sustained drug-release profile obtained in the present study demonstrated gradual release of active constituents over 24 h. Controlled release systems are particularly advantageous in psoriasis because they maintain therapeutic concentrations within skin lesions for prolonged periods while reducing application frequency [42]. Enhanced residence time of curcumin and Aloe vera phytoconstituents at the target site may contribute significantly to improved therapeutic efficacy and patient adherence.

The anti-psoriatic activity observed in this study was evidenced by significant reductions in erythema, scaling, skin thickness, and overall Psoriasis Severity Index (PSI). These findings are consistent with previous investigations demonstrating the beneficial effects of herbal nanocarriers in inflammatory skin diseases [43]. The substantial decrease in lesion severity suggests that the formulation effectively suppressed inflammatory cascades and normalized epidermal turnover.

Aloe vera is recognized for its wound-healing, moisturizing, antioxidant, and immunomodulatory properties. The polysaccharides present in Aloe vera, particularly acemannan, have been reported to stimulate fibroblast proliferation, collagen synthesis, and tissue regeneration while simultaneously reducing inflammatory responses [44]. Additionally, Aloe vera enhances skin hydration and barrier restoration, both of which are important therapeutic objectives in psoriatic skin.

Turmeric-derived curcumin has attracted considerable attention owing to its ability to modulate multiple molecular targets implicated in psoriasis pathogenesis. Curcumin inhibits activation of nuclear factor-kappa B (NF-κB), Janus kinase/signal transducer and activator of transcription (JAK/STAT) signaling, cyclooxygenase-2 (COX-2), and various pro-inflammatory cytokines including TNF-α, IL-17, IL-22, and IL-23 [45]. Through these mechanisms, curcumin suppresses inflammatory cell recruitment and keratinocyte hyperproliferation, resulting in attenuation of psoriatic lesions.

The superior therapeutic outcome observed in the nano gel-treated group compared with the standard treatment group may be attributed to the synergistic interaction between Aloe vera and curcumin. Synergistic phytotherapy involves the simultaneous modulation of multiple biological pathways, thereby producing enhanced therapeutic efficacy compared with individual agents [46]. Aloe vera primarily contributes moisturizing and tissue regenerative effects, whereas curcumin exerts potent anti-inflammatory and antiproliferative actions. The nano gel platform further facilitates co-delivery of these phytoconstituents to affected skin regions.

Histopathological findings strongly supported the clinical observations. The psoriatic control group exhibited characteristic pathological changes including hyperkeratosis, parakeratosis, acanthosis, elongated rete ridges, and inflammatory cell infiltration. These features closely resemble human psoriatic lesions and validate the effectiveness of the induction model [47]. In contrast, treatment with the Aloe vera–Turmeric Nano Gel resulted in substantial restoration of normal epidermal architecture, reduced inflammatory infiltration, and normalization of epidermal thickness.

Recent studies have highlighted the importance of oxidative stress in psoriasis progression. Excessive production of reactive oxygen species contributes to lipid peroxidation, cytokine release, and keratinocyte dysfunction [48]. Both Aloe vera and curcumin possess potent antioxidant properties capable of scavenging free radicals and enhancing endogenous antioxidant defense systems. Therefore, the therapeutic benefits observed in the present study may also involve mitigation of oxidative damage within psoriatic tissues.

The incorporation of herbal extracts into nanocarrier-based systems has emerged as a promising strategy in dermatological drug delivery. Nanogels combine the advantages of hydrogels and nanoparticles, providing enhanced drug loading, controlled release, improved penetration, and increased patient acceptability [49]. Such systems are particularly suitable for chronic skin disorders requiring long-term therapy and localized drug action.

Although the present study demonstrated encouraging outcomes, certain limitations should be acknowledged. Molecular biomarkers such as TNF-α, IL-17, IL-23, NF-κB, and oxidative stress markers were not quantified. Future investigations involving gene expression analysis, cytokine profiling, and pharmacokinetic studies would provide deeper insights into the underlying mechanisms responsible for the observed anti-psoriatic activity [50-69].

Overall, the findings suggest that the Aloe vera–Turmeric Nano Gel represents a promising phytopharmaceutical approach for psoriasis management. The combination of bioactive herbal constituents and nanotechnology-based delivery appears capable of enhancing therapeutic effectiveness while minimizing potential adverse effects associated with conventional therapies. Further preclinical and clinical studies are warranted to establish long-term safety, efficacy, and translational potential in human psoriasis treatment.

5. Conclusion

The Aloe vera–Turmeric Nano Gel developed in the present study demonstrated promising anti-psoriatic activity owing to its favorable phytochemical composition, suitable pharmaceutical characteristics, and enhanced skin delivery. The

formulation significantly reduced erythema, scaling, skin thickness, and overall Psoriasis Severity Index while restoring normal skin architecture in histopathological studies. The synergistic combination of Aloe vera and curcumin within a nanogel system offers a potential herbal alternative for the effective and safe management of psoriasis. Further clinical studies are recommended to validate its therapeutic efficacy and long-term safety.

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