

การประเมินฤทธิ์ต้านอนุมูลอิสระและฤทธิ์ปกป้องผิวของสารสกัด สมุนไพรเดี่ยวและชนิดผสมเพื่อการประยุกต์ใช้เป็นยาทาภายนอก สำหรับโรคสะเก็ดเงิน

ชลดา จัดประกอบ^{1*}, อรุณรัตน์ แซ่ฮู้², ชยานนท์ เชาวนัญญิกุล²

¹ สาขาวิชาเภสัชศาสตร์บัณฑิต คณะเภสัชศาสตร์ วิทยาลัยนครราชสีมา นครราชสีมา

² สาขาวิชาการแพทย์แผนไทยบัณฑิต วิทยาลัยเฮลท์แอนด์เวลเนส
มหาวิทยาลัยธุรกิจบัณฑิต, กรุงเทพมหานคร

*Corresponding author email: chonlada.jud@nmc.ac.th

ได้รับบทความ: 4 กุมภาพันธ์ 2569

ได้รับบทความแก้ไข: 9 มีนาคม 2569

ยอมรับตีพิมพ์: 22 มีนาคม 2569

บทคัดย่อ

โรคสะเก็ดเงินเป็นโรคผิวหนังอักเสบเรื้อรังที่มีลักษณะเด่นคือการอักเสบอย่างต่อเนื่อง การเพิ่มจำนวนของเซลล์เคราติโนไซต์อย่างผิดปกติ และความไม่สมดุลของระบบภูมิคุ้มกัน โดยภาวะเครียดออกซิเดชันจากการสะสมของอนุมูลอิสระมีบทบาทสำคัญต่อการเกิดและการดำเนินของโรค ดังนั้น การพัฒนาสารออกฤทธิ์ที่มีคุณสมบัติต้านอนุมูลอิสระและสามารถปกป้องเซลล์ผิวหนังจึงเป็นแนวทางที่มีศักยภาพในการสนับสนุนการรักษาโรคสะเก็ดเงิน สมุนไพรไทยหลายชนิดได้รับรายงานว่ามียฤทธิ์ต้านอนุมูลอิสระและต้านการอักเสบ อย่างไรก็ตาม การศึกษาฤทธิ์ของสารสกัดในรูปแบบผสมยังมีข้อมูลจำกัด การศึกษานี้จึงมีวัตถุประสงค์เพื่อประเมินฤทธิ์ต้านอนุมูลอิสระและศักยภาพในการปกป้องเซลล์ผิวหนังของสารสกัดเอทานอลจาก ขมิ้นชัน (*Curcuma longa*), บัวบก (*Centella asiatica*) และ ฟ้าทะลายโจร (*Andrographis paniculata*) ทั้งในรูปแบบสารสกัดเดี่ยวและสารสกัดผสม ผลการวิเคราะห์พบว่าสารสกัดขมิ้นชันมีปริมาณสารฟีนอลิกรวมสูงที่สุดในกลุ่มสารสกัดเดี่ยว (TPC = 215.4 ± 6.8 mg GAE/g extract) และมีฤทธิ์ต้านอนุมูลอิสระสูงที่สุด โดยมีค่า DPPH IC₅₀ = 42.6 ± 2.1 µg/mL อย่างไรก็ตาม สารสกัดผสมโดยเฉพาะตำรับที่ประกอบด้วยสมุนไพรทั้งสามชนิด แสดงฤทธิ์ต้านอนุมูลอิสระสูงที่สุดใน

ทุกการทดสอบ โดยมี TPC = 362.7 ± 9.5 mg GAE/g extract, DPPH IC₅₀ = 21.8 ± 1.3 µg/mL, FRAP = 271.3 ± 10.4 mg AAE/g extract และ ABTS = 2.31 ± 0.09 mmol Trolox/g extract ผลการทดสอบในเซลล์ผิวหนังมนุษย์สายพันธุ์ HaCaT พบว่าสารสกัดผสมสามารถลดการสะสมของอนุมูลอิสระภายในเซลล์ได้อย่างมีนัยสำคัญ โดยลดระดับ ROS เหลือ $38.7 \pm 3.1\%$ ของกลุ่มควบคุม ภายใต้สภาวะเครียดออกซิเดชัน ขณะที่การทดสอบความเป็นพิษต่อเซลล์ด้วยวิธี MTT assay แสดงให้เห็นว่าสารสกัดทั้งหมดไม่มีความเป็นพิษต่อเซลล์ โดยมีความมีชีวิตของเซลล์มากกว่า 85% ในทุกกลุ่มทดลอง ผลการศึกษานี้บ่งชี้ว่าสารสกัดผสมจากสมุนไพรทั้งสามชนิดมีฤทธิ์เสริมกัน (synergistic effect) ในการต้านอนุมูลอิสระและปกป้องเซลล์ผิวหนัง จึงมีศักยภาพในการพัฒนาเป็นตำรับยาใช้เฉพาะที่สำหรับการรักษาโรคสะเก็ดเงินในอนาคต

คำสำคัญ: สะเก็ดเงิน/ ขมิ้นชัน/ บัวบก/ ฟ้าทะลายโจร/ ฤทธิ์ต้านอนุมูลอิสระ

Evaluation of Antioxidant and Skin-Protective Effects of Single and Combined Herbal Extracts for Potential Topical Application in Psoriasis

Chonlada Judprakob^{1*}, Arunrat Saeou², Chayanon Chaowuttikul²

¹ Pharmacy Program, Faculty of Pharmacy,
Nakhonratchasime College, Nakhonratchasima

² Thai Traditional Medicine Program, College of Health and Wellness,
Dhurakij Pundit University, Bangkok

*Corresponding author email: Chonlada.jud@nmc.ac.th

Received: 4 February 2026

Revised: 9 March 2026

Accepted: 22 March 2026

Abstract

Psoriasis is a chronic inflammatory skin disease characterized by persistent inflammation, abnormal keratinocyte proliferation, and immune dysregulation. Oxidative stress caused by excessive production of reactive oxygen species (ROS) plays a key role in the pathogenesis and progression of psoriasis. Therefore, bioactive compounds with antioxidant properties capable of protecting skin cells may represent a promising approach for psoriasis management. This study aimed to evaluate the antioxidant activity and cytoprotective effects of ethanolic extracts from *Curcuma longa*, *Centella asiatica*, and *Andrographis paniculata*, both individually and in combination, as a potential strategy for developing topical formulations for psoriasis. Antioxidant activity was assessed using total phenolic content (TPC), DPPH, FRAP, and ABTS assays, while intracellular ROS inhibition and cytotoxicity were evaluated in HaCaT keratinocyte cells. Among individual extracts, *C. longa* showed the highest phenolic content (215.4 ± 6.8 mg GAE/g extract) and the

strongest antioxidant activity (DPPH IC₅₀ = 42.6 ± 2.1 µg/mL). However, the combined extracts demonstrated enhanced antioxidant capacity. The triple combination exhibited the highest activity with TPC of 362.7 ± 9.5 mg GAE/g extract, DPPH IC₅₀ of 21.8 ± 1.3 µg/mL, FRAP of 271.3 ± 10.4 mg AAE/g extract, and ABTS of 2.31 ± 0.09 mmol Trolox/g extract. In HaCaT cells, the combined extracts significantly reduced intracellular ROS levels to 38.7 ± 3.1% of the control, without cytotoxicity (cell viability >85%). These findings suggest a synergistic antioxidant and cytoprotective effect of the combined herbal extracts, supporting their potential for the development of topical formulations for psoriasis treatment.

Keywords: Psoriasis/ Curcuma Longa/ Centella Asiatica/
Addrographis Paniculata/ Total Phenolic Content/
Antioxidant Activity

Introduction

Psoriasis is a chronic immune-mediated inflammatory skin disorder characterized by excessive keratinocyte proliferation, epidermal hyperplasia, and dysregulated immune responses. Its pathogenesis involves complex interactions between keratinocytes and immune cells, mediated by pro-inflammatory cytokines such as tumor necrosis factor- α (TNF- α), interleukin-6 (IL-6), and interleukin-8 (IL-8). In addition to immune dysregulation, oxidative stress plays a pivotal role in amplifying inflammatory signaling pathways, promoting keratinocyte hyperproliferation, and impairing skin barrier integrity, thereby contributing to disease severity and chronicity [1,2].

Current therapeutic strategies for psoriasis include topical corticosteroids, vitamin D analogues, systemic immunosuppressive agents, and biologic therapies targeting specific inflammatory mediators. Although these interventions demonstrate clinical efficacy, their long-term use is often limited by adverse effects, high treatment costs, and reduced patient adherence. Consequently, increasing attention has been directed toward alternative or complementary therapeutic approaches derived from natural products, particularly those possessing antioxidant and skin-protective properties. Such strategies may mitigate oxidative stress-induced skin damage and promote epidermal barrier restoration while offering more favorable safety profiles [3,11].

Thai medicinal plants have gained considerable scientific interest as sources of bioactive compounds with potential therapeutic applications in inflammatory skin disorders. Among these, *Curcuma longa* (turmeric), *Centella asiatica* (gotu kola), and *Andrographis paniculata* (king of bitters) are widely used in traditional medicine and have been extensively investigated for pharmacological activities relevant to psoriasis. These plants are rich in secondary metabolites, including polyphenols, triterpenoids, and diterpenoid lactones, which exhibit antioxidant, cytoprotective, and immunomodulatory effects on skin cells.

The rhizomes of *Curcuma longa* are a major source of curcuminoids, particularly curcumin, a compound with well-established antioxidant and anti-inflammatory properties. Curcumin has been shown to modulate oxidative stress and inflammatory signaling pathways by inhibiting the activation of nuclear factor kappa B (NF- κ B) and signal transducer and activator of transcription 3 (STAT3), leading to reduced production of pro-inflammatory cytokines. These mechanisms underlie its protective effects in inflammatory skin conditions, and recent studies have highlighted the potential of curcumin-based formulations as complementary agents in psoriasis management [7].

Centella asiatica contains triterpenoid saponins, including asiaticoside, madecassoside, asiatic acid, and madecassic acid, which are associated with antioxidant, anti-inflammatory, and skin barrier-enhancing activities. These compounds have been reported to promote keratinocyte viability, attenuate oxidative stress, and support epidermal repair processes. Moreover, ethanolic extracts of *C. asiatica* have demonstrated the ability to alleviate psoriasis-like inflammation through modulation of the JAK/STAT3 signaling pathway and suppression of pro-inflammatory cytokine expression in keratinocytes [8].

Andrographis paniculata is a rich source of diterpenoid lactones, particularly andrographolide, which exhibits potent antioxidant and immunomodulatory activities. Andrographolide has been shown to suppress oxidative stress, inhibit the production of inflammatory mediators, and protect skin cells from inflammation-induced injury. Emerging evidence also suggests its role in enhancing skin barrier function, supporting its potential application in the management of inflammatory skin disorders, including psoriasis [14].

From a pharmacological perspective, ethanolic extraction is an effective method for isolating phenolic compounds, flavonoids, and other bioactive constituents responsible for antioxidant activity. Total phenolic content has been reported to correlate strongly with free radical scavenging capacity and cellular protection against oxidative stress. Furthermore, combinations of herbal extracts may exert additive or synergistic effects by concurrently targeting multiple pathogenic mechanisms, such as oxidative

stress and keratinocyte damage, which is particularly relevant in multifactorial diseases such as psoriasis.

Despite accumulating evidence supporting the pharmacological activities of individual Thai medicinal plants, comparative studies evaluating the antioxidant and skin-protective effects of single and combined ethanolic herbal extracts in psoriasis-relevant *in vitro* models remain limited. Therefore, the present study aims to evaluate the total phenolic content, antioxidant activity, and cytotoxicity of ethanolic extracts of *Curcuma longa*, *Centella asiatica*, and *Andrographis paniculata*, both individually and in combination, using human keratinocyte (HaCaT) cells. The findings are expected to provide scientific evidence supporting the development of these herbal extracts as potential topical agents for psoriasis.

Materials and Methods

1. Plant Materials and Ethanolic Extraction

Dried rhizomes of *Curcuma longa*, aerial parts of *Centella asiatica*, and aerial parts of *Andrographis paniculata* were finely pulverized using a mechanical grinder. Each powdered plant material was extracted with 95% (v/v) ethanol by maceration at room temperature for 72 h with occasional agitation. The resulting extracts were filtered through Whatman No. 1 filter paper and concentrated under reduced pressure using a rotary evaporator. The dried crude extracts were stored at -20°C until further analysis. Combined herbal extracts were prepared by mixing equal weights of the individual ethanolic extracts immediately prior to biological and chemical evaluations.

2. Total Phenolic Content

Total phenolic content (TPC) was quantified using the Folin–Ciocalteu colorimetric method. Briefly, 20 μL of each extract solution was mixed with Folin–Ciocalteu reagent followed by sodium carbonate solution in a 96-well microplate. The reaction mixtures were incubated at room temperature in the dark for an appropriate period, and absorbance was measured at 765 nm using a microplate reader. Gallic acid was used to construct the standard calibration

curve, and TPC values were expressed as milligrams of gallic acid equivalents (GAE) per gram of extract [1].

3. Antioxidant Activity Assays

3.1 DPPH Radical Scavenging Assay

The free radical scavenging activity of the extracts was evaluated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay in a microplate format. DPPH solution was mixed with extract solutions at various concentrations and incubated in the dark at room temperature. Absorbance was measured at 517 nm, with ascorbic acid serving as the positive control. The percentage of DPPH radical scavenging activity was calculated relative to the control group [6].

3.2 Ferric Reducing Antioxidant Power (FRAP) Assay

Ferric reducing antioxidant power (FRAP) was assessed using a modified microplate-based method based on the reduction of ferric (Fe^{3+}) ions to ferrous (Fe^{2+}) ions. The FRAP reagent was freshly prepared prior to use, and absorbance was measured at 593 nm. Antioxidant capacity was calculated using a ferrous sulfate standard curve and expressed as micromoles of Fe^{2+} equivalents per gram of extract [1].

3.3 ABTS Radical Cation Scavenging Assay

The 2,2'-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid) radical cation ($\text{ABTS}^{\bullet+}$) was generated by reacting ABTS with potassium persulfate and incubating the mixture in the dark. The working $\text{ABTS}^{\bullet+}$ solution was adjusted to a defined absorbance prior to reaction with extract samples. After incubation, absorbance was measured at 734 nm. Trolox was used as the reference antioxidant, and results were expressed relative to the Trolox standard [12].

3.4 Intracellular Reactive Oxygen Species (ROS) Assay

Human keratinocyte (HaCaT) cells were cultured under standard cell culture conditions. Intracellular reactive oxygen species (ROS)

levels were determined using the dichlorodihydrofluorescein diacetate (DCFH-DA) fluorescent probe following pretreatment with herbal extracts and subsequent induction of oxidative stress. Fluorescence intensity was measured using a microplate reader and expressed relative to untreated control cells [4].

4. Cytotoxicity Assay

The cytotoxic effects of individual and combined herbal extracts were evaluated in HaCaT cells using the MTT assay. Following treatment with the extracts for a specified incubation period, MTT solution was added and incubated to allow the formation of formazan crystals. The crystals were subsequently dissolved using an appropriate solubilizing agent, and absorbance was measured at 570 nm. Cell viability was calculated as a percentage relative to untreated control cells [9].

5. Statistical Analysis

All experiments were performed in triplicate and the results are expressed as mean $\pm$ standard deviation (SD). Statistical differences among groups were analyzed using one-way analysis of variance (one-way ANOVA). When significant differences were detected, pairwise comparisons between groups were performed using Tukey's multiple comparison post hoc test. Differences were considered statistically significant at $p < 0.05$. Statistical analyses were carried out using SPSS software (Version 26.0, IBM Corp., Armonk, NY, USA).

Results

1. Total Phenolic Content

The total phenolic content (TPC) of individual and combined herbal ethanolic extracts is presented in Table 1. Statistically significant differences in TPC were observed among all tested samples ($p < 0.05$). Among the individual extracts, *Curcuma longa* (CL) exhibited the highest phenolic

content, followed by *Andrographis paniculata* (AP) and *Centella asiatica* (CA). All combined formulations demonstrated significantly higher TPC values than their corresponding single extracts ($p < 0.05$), indicating an additive effect on phenolic enrichment. Notably, the triple combination of CL, CA, and AP exhibited the highest TPC and differed significantly from all other treatment groups.

2. Antioxidant Activities

2.1 DPPH Radical Scavenging Activity

The DPPH radical scavenging activity, expressed as IC_{50} values, is summarized in Table 1. Ascorbic acid, used as a reference antioxidant, exhibited the lowest IC_{50} value. Among the individual herbal extracts, CL demonstrated significantly stronger radical scavenging activity compared with CA and AP ($p < 0.05$). All combined extracts exhibited significantly lower IC_{50} values than the individual extracts, reflecting enhanced free radical scavenging capacity. The triple combination displayed the strongest DPPH scavenging activity among the herbal formulations and differed significantly from all single and dual combinations.

2.2 Ferric Reducing Antioxidant Power (FRAP)

Ferric reducing antioxidant power (FRAP), expressed as ascorbic acid equivalents (AAE), showed significant variation among the tested samples ($p < 0.05$). Ascorbic acid demonstrated the highest ferric reducing capacity. Among the herbal formulations, all combined extracts exhibited significantly higher FRAP values than the individual extracts. The triple combination showed the greatest reducing power among the herbal samples and was significantly different from all single-extract groups.

2.3 ABTS Radical Cation Scavenging Activity

ABTS radical scavenging activity, expressed as Trolox equivalent antioxidant capacity (TEAC), is presented in Table 1. Trolox exhibited the highest scavenging activity. Significant differences were observed among the herbal extracts ($p < 0.05$). Combined formulations consistently showed higher

ABTS scavenging activity than individual extracts, with the triple combination demonstrating the strongest activity among all herbal samples.

2.4 Intracellular Reactive Oxygen Species (ROS) Inhibition in HaCaT Cells

The effects of herbal extracts on intracellular ROS production in HaCaT cells are shown in Table 1. Induction of oxidative stress markedly increased intracellular ROS levels compared with untreated control cells. N-acetylcysteine (NAC), used as a positive control, significantly reduced ROS production ($p < 0.05$). All herbal extracts significantly attenuated intracellular ROS levels relative to the oxidative stress control ($p < 0.05$). Combined extracts demonstrated significantly greater ROS inhibition than individual extracts, with the triple combination exhibiting the most pronounced inhibitory effect.

3. Cytotoxicity Assessment in HaCaT Cells

The cytotoxicity of individual and combined herbal extracts was evaluated using the MTT assay. No significant cytotoxic effects were observed in HaCaT cells treated with any extract at the tested concentrations. Cell viability remained above 85% in all treatment groups, with no statistically significant differences compared with the untreated control ($p > 0.05$), indicating acceptable cellular compatibility of all formulations.

Table 1. Total phenolic content, antioxidant activities, intracellular ROS inhibition, and cytotoxicity of individual and combined herbal extracts (n=3)

Sample	TPC (mg GAE/g extract)	DPPH IC ₅₀ (µg/mL)	FRAP (mg AAE/g extract)	ABTS (mmol Trolox/g extract)	ROS (% of control)	Cell viability (%)
Control	–	–	–	–	100.0 ± 4.2 ^a	100.0 ± 3.6 ^a
Ascorbic acid	–	12.4 ± 0.8 ^a	412.6 ± 12.8 ^a	–	–	–
Trolox	–	–	–	3.05 ± 0.11 ^a	–	–
NAC	–	–	–	–	29.4 ± 2.6 ^a	–
CL	215.4 ± 6.8 ^c	42.6 ± 2.1 ^c	168.4 ± 6.9 ^c	1.42 ± 0.06 ^c	63.8 ± 3.5 ^c	91.4 ± 4.2 ^a
CA	128.9 ± 5.1 ^e	78.3 ± 3.4 ^e	102.7 ± 5.4 ^e	0.96 ± 0.05 ^e	71.6 ± 4.1 ^e	94.8 ± 3.9 ^a
AP	176.3 ± 4.7 ^d	55.7 ± 2.6 ^d	139.6 ± 6.1 ^d	1.18 ± 0.07 ^d	66.9 ± 3.8 ^d	89.6 ± 4.5 ^a
CL + CA	289.6 ± 7.2 ^b	31.2 ± 1.8 ^b	214.8 ± 8.7 ^b	1.87 ± 0.08 ^b	48.2 ± 3.2 ^b	90.2 ± 3.8 ^a
CL + AP	312.4 ± 8.1 ^b	27.6 ± 1.5 ^b	236.9 ± 9.3 ^b	2.03 ± 0.09 ^b	44.6 ± 2.9 ^b	88.9 ± 4.1 ^a
CA + AP	271.8 ± 6.5 ^b	34.9 ± 2.0 ^b	201.5 ± 7.8 ^b	1.75 ± 0.07 ^b	51.7 ± 3.4 ^b	92.1 ± 3.6 ^a
CL + CA + AP	362.7 ± 9.5 ^a	21.8 ± 1.3 ^b	271.3 ± 10.4 ^b	2.31 ± 0.09 ^b	38.7 ± 3.1 ^b	87.5 ± 4.0 ^a

Values are expressed as mean ± SD (n = 3). Different superscript letters within the same column indicate statistically significant differences ($p < 0.05$).

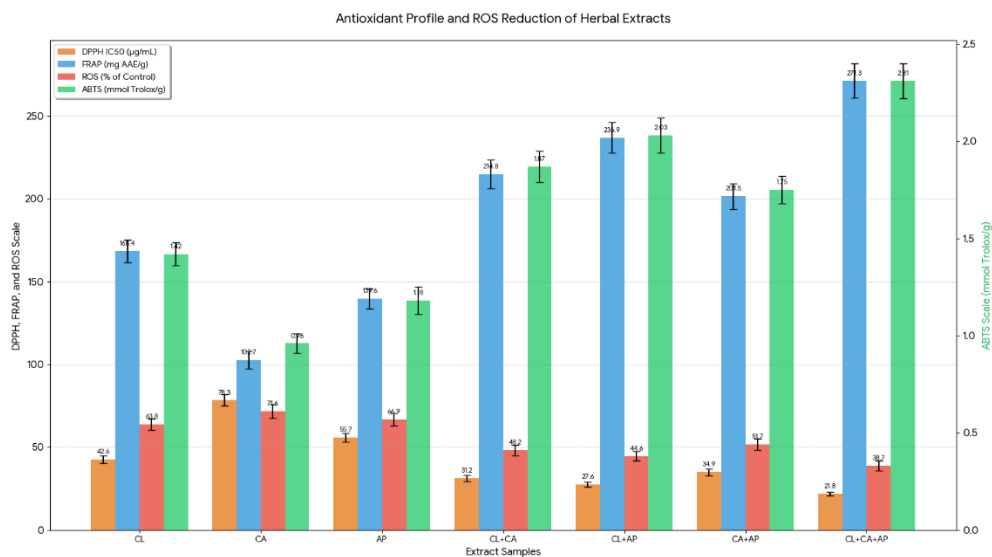


Figure 1 Comparative Antioxidant Profiles and Intracellular ROS Reduction of Single and Combined Herbal Extracts.

Discussion

Psoriasis is a chronic immune-mediated inflammatory skin disorder characterized by keratinocyte hyperproliferation, epidermal thickening, and sustained activation of inflammatory signaling pathways. Beyond immune dysregulation, oxidative stress has been increasingly recognized as a critical contributor to psoriasis pathogenesis. Elevated levels of reactive oxygen species (ROS) have been reported in psoriatic lesions as well as in the systemic circulation of affected patients, where they promote keratinocyte dysfunction, amplify pro-inflammatory cytokine production, and activate redox-sensitive signaling pathways, including nuclear factor kappa B (NF- κ B) and Janus kinase/signal transducer and activator of transcription 3 (JAK/STAT3) [2,5]. Accordingly, therapeutic strategies targeting oxidative stress represent a rational and complementary approach to conventional psoriasis management.

In the present study, ethanolic extracts of *C. longa*, *C. asiatica*, and *A. paniculata* both individually and in combination, were systematically evaluated for their antioxidant properties and cellular protective effects relevant to psoriasis. All tested extracts exhibited measurable antioxidant

activity, as demonstrated by total phenolic content determination and multiple in vitro antioxidant assays. These findings are consistent with previous reports indicating that polyphenol-rich plant extracts possess substantial radical scavenging and reducing capacities, which are critical for mitigating oxidative stress-mediated cellular damage [5,6].

Among the individual extracts, *C. longa* demonstrated superior antioxidant activity compared with *C. asiatica* and *A. paniculata*. This observation is likely attributable to its high content of curcuminoids, particularly curcumin, which has been extensively reported to exert potent antioxidant and anti-inflammatory effects through inhibition of NF- κ B, STAT3, and downstream pro-inflammatory mediators implicated in psoriasis pathophysiology [7]. In addition, experimental studies have demonstrated that curcumin can attenuate psoriasis-like inflammation by suppressing IL-6/STAT3 signaling and reducing the expression of inflammatory cytokines in keratinocytes and immune cells [15]. These mechanisms further support the strong antioxidant and anti-inflammatory activity observed for *C. longa* extract in the present study.

Nevertheless, despite the notable activity of single extracts, combined formulations consistently exhibited enhanced antioxidant performance across all assays, suggesting additive or complementary interactions among their bioactive constituents. Notably, the triple combination of *C. longa*, *C. asiatica*, and *A. paniculata* exhibited the highest total phenolic content and the strongest antioxidant activity in DPPH, FRAP, and ABTS assays. These chemical antioxidant findings were further supported by cellular evidence, as the combined extract markedly suppressed intracellular ROS generation in HaCaT keratinocytes exposed to oxidative stress. Given that excessive ROS accumulation in keratinocytes contributes to aberrant proliferation and sustained inflammatory signaling in psoriasis, effective ROS suppression by the combined formulation may have direct relevance to disease modulation [2,6].

The superior performance of the triple-herb formulation may be mechanistically explained by the complementary pharmacological actions of its major phytochemical constituents. Curcuminoids from *C. longa* primarily

target oxidative stress and inflammatory transcription factors, whereas triterpenoid saponins from *C. asiatica*, including asiaticoside and madecassoside, have been reported to enhance skin barrier integrity, regulate keratinocyte proliferation, and suppress inflammatory signaling pathways such as JAK/STAT3 and MAPK pathways [8]. In parallel, andrographolide from *A. paniculata* contributes additional immunomodulatory and antioxidant effects, including suppression of ROS-mediated inflammatory responses and inhibition of NF- κ B signaling in skin cells [14,16]. The convergence of these mechanisms is particularly advantageous for psoriasis, a multifactorial disease involving oxidative stress, immune activation, and keratinocyte dysregulation.

Importantly, none of the tested extracts, including the combined formulations, induced significant cytotoxicity in HaCaT cells at biologically active concentrations. This favorable safety profile is a critical consideration for topical applications, as long-term treatment is often required in psoriasis management. The observed cellular compatibility supports the feasibility of further formulation development using these herbal extracts, particularly for topical dosage forms such as creams, gels, or hydrogels. Moreover, antioxidant-based topical interventions have been increasingly explored as adjunctive strategies to alleviate oxidative stress and inflammation in psoriatic skin [3].

Furthermore, the enhanced biological activity observed in the combined extract may also reflect a synergistic interaction among phytochemicals present in the three medicinal plants. Herbal combinations are increasingly recognized for their potential to exert multi-target therapeutic effects through the simultaneous modulation of several molecular pathways involved in disease pathogenesis. In the context of psoriasis, where oxidative stress, immune activation, and keratinocyte dysregulation interact in a complex pathogenic network, multi-component phytochemical mixtures may provide broader pharmacological coverage compared with single-compound approaches. Previous studies have suggested that plant-derived polyphenols, terpenoids, and diterpenoids can act cooperatively to enhance antioxidant capacity, regulate inflammatory signaling pathways, and improve cellular resilience against oxidative damage [17]. Therefore, the combined use of *C.*

longa, *C. asiatica*, and *A. paniculata* may offer a complementary and multi-target strategy for modulating key pathogenic processes involved in psoriasis.

Conclusion

This study systematically evaluated the antioxidant and cellular protective effects of ethanolic extracts from *Curcuma longa*, *Centella asiatica*, and *Andrographis paniculata*, both individually and in combination, using psoriasis-relevant in vitro models. Although all extracts exhibited measurable antioxidant activity, the combined formulations consistently demonstrated superior efficacy compared with the individual extracts. Notably, the triple-herb combination exhibited the highest total phenolic content, the strongest antioxidant capacity, and the most effective suppression of intracellular reactive oxygen species (ROS) in HaCaT keratinocytes, without inducing cytotoxic effects.

Oxidative stress is recognized as a key contributor to the pathophysiology of psoriasis, where excessive ROS generation promotes keratinocyte hyperproliferation, dysregulated differentiation, and activation of pro-inflammatory signaling pathways such as NF- κ B, MAPK, and STAT3. These molecular events subsequently amplify cytokine production and sustain the chronic inflammatory environment characteristic of psoriatic lesions. In addition, oxidative damage has been implicated in the disruption of epidermal barrier integrity, which further aggravates immune activation and disease persistence. Therefore, interventions capable of reducing oxidative stress may play a critical role in modulating both keratinocyte dysfunction and inflammatory cascades associated with psoriasis.

The pronounced antioxidant activity and ROS-suppressive effects observed with the combined herbal extracts suggest a synergistic interaction among phytochemicals present in *C. longa*, *C. asiatica*, and *A. paniculata*. Such synergism may contribute not only to the attenuation of oxidative stress but also potentially to downstream modulation of inflammatory signaling and improvement of skin barrier homeostasis. Collectively, these findings highlight the potential relevance of multi-herbal antioxidant formulations as supportive

therapeutic approaches for psoriasis and other chronic inflammatory dermatoses characterized by oxidative imbalance and persistent inflammation.

Overall, the combined ethanolic extract of *C. longa*, *C. asiatica*, and *A. paniculata* represents a promising candidate for further development as a topical preparation for psoriasis management. Future studies focusing on the modulation of inflammatory mediators, restoration of epidermal barrier function, and optimization of topical delivery systems are warranted to further substantiate its therapeutic potential and translational applicability.

Reference

1. Ainsworth EA, Gillespie KM. Estimation of total phenolic content and other oxidation substrates in plant tissues using Folin–Ciocalteu reagent. *Nat Protoc.* 2007;2(4):875–7. doi: 10.1038/nprot.2007.102. PMID: 17446889.
2. Ahmad Jamil H, Abdul Karim N. Unraveling mitochondrial reactive oxygen species involvement in psoriasis: the promise of antioxidant therapies. *Antioxidants (Basel).* 2024 Oct 11;13(10):1222. doi: 10.3390/antiox13101222. PMID: 39456475.
3. Boehncke WH, Schön MP. Psoriasis. *Lancet.* 2015 Sep 5;386(9997):983–94. doi: 10.1016/S0140-6736(14)61909-7. PMID: 26025581.
4. Boulebd H, Pereira DM. Examination of the antioxidant activity of psoralidin: computational mechanistic study and impact on the ROS level in human keratinocytes. *J Org Chem.* 2023 May 5;88(9):5745–51. doi: 10.1021/acs.joc.3c00193. PMID: 37074959.
5. Dobrică EC, Cozma MA, Găman MA, Voiculescu VM, Găman AM. The involvement of oxidative stress in psoriasis: a systematic review. *Antioxidants (Basel).* 2022 Jan 29;11(2):282. doi: 10.3390/antiox11020282. PMID: 35204165.
6. Grasso F, Martínez MMA, Turrini F, Méndez Paz D, Vázquez Sobrado R, Orlandi V, et al. Antioxidant marine hydrolysates isolated from tuna mixed byproducts: an example of fishery side streams upcycling. *Antioxidants*

- (Basel). 2024 Aug 19;13(8):1011. doi: 10.3390/antiox13081011. PMID: 39199255.
7. Kantasa T, Yeerong K, Klinjan P, Na Takuathung M, Settakorn K, Chuamanochan M, et al. Therapeutic potential of curcumin and novel formulations in psoriasis treatment: evidence and future prospects. *Drug Des Devel Ther*. 2025 Jun 25;19:5387–414. doi: 10.2147/DDDT.S520555. PMID: 40589446.
 8. Lin P, Shi HY, Lu YY, Lin J. Centella asiatica alleviates psoriasis through JAK/STAT3-mediated inflammation: an in vitro and in vivo study. *J Ethnopharmacol*. 2023 Dec 5;317: Article 116746. doi: 10.1016/j.jep.2023.116746.
 9. Mosmann T. Rapid colorimetric assay for cellular growth and survival: application to proliferation and cytotoxicity assays. *J Immunol Methods*. 1983 Dec 16;65(1–2):55–63. doi: 10.1016/0022-1759(83)90303-4. PMID: 6606682.
 10. Mussard E, Jousselin S, Cesaro A, Legrain B, Lespessailles E, Esteve E, et al. Andrographis paniculata and its bioactive diterpenoids against inflammation and oxidative stress in keratinocytes. *Antioxidants (Basel)*. 2020 Jun 17;9(6): Article 530. doi: 10.3390/antiox9060530. PMID: 32560449.
 11. Wu JJ, Kavanaugh A, Lebwohl MG, Gniadecki R, Merola JF. Psoriasis and metabolic syndrome: implications for the management and treatment of psoriasis. *J Eur Acad Dermatol Venereol*. 2022 Jun;36(6):797–806. doi: 10.1111/jdv.18044. PMID: 35238067.
 12. Rumpf J, Burger R, Schulze M. Statistical evaluation of DPPH, ABTS, FRAP, and Folin–Ciocalteu assays to assess the antioxidant capacity of lignins. *Int J Biol Macromol*. 2023 Apr 1;233:123470. doi: 10.1016/j.ijbiomac.2023.123470. PMID: 36736974.
 13. Zhou Y, Man XY. The epidermal immune microenvironment plays a central role in the pathogenesis of psoriasis. *Curr Opin Immunol*. 2025 Dec;97: Article 102674. doi: 10.1016/j.coi.2024.102674. PMID: 41072151.

14. Xu H, Lan S, Lin S, Wang A, Luo Y, Wang J, et al. Exploring the active constituents of *Andrographis paniculata* in protecting the skin barrier and the synergistic effects with collagen XVII. *Antioxidants* (Basel). 2025 Jan 20;14(1):118. doi: 10.3390/antiox14010118. PMID: 39857452.
15. Cai Z, Zeng Y, Liu Z, Zhu R, Wang W. Curcumin alleviates epidermal psoriasis-like dermatitis and IL-6/STAT3 pathway of mice. *Clin Cosmet Investig Dermatol*. 2023 Sep 1;16:2399–408. doi: 10.2147/CCID.S423922. PMID: 37675183.
16. Dai Y, Chen SR, Chai L, Zhao J, Wang Y, Wang Y. Overview of pharmacological activities of *Andrographis paniculata* and its major compound andrographolide. *Crit Rev Food Sci Nutr*. 2019;59(sup1):S17–29. doi: 10.1080/10408398.2018.1501657. PMID: 30040451.
17. Shi Y, Liu J, Guan S, Wang S, Yu C, Yu Y, et al. Syn-COM: A multi-level predictive synergy framework for innovative drug combinations. *Pharmaceutics* (Basel). 2024 Sep 18;17(9): Article 1230. doi: 10.3390/ph17091230.