Proceedings Academic Universitas Jambi
Volume 1, Issue 2, November 2025

Sunscreen potential of green-synthesized ZnO nanoparticles from Sungkai leaf extract

Indri Maharini[1], Yuliawati[1], Puspa Dwi Pratiwi[1], Aulia Hafizhah Nugroho[1], Yulwilla Virginia[1], Adhyatmika[2], Sekar Ayu Pawestri [2]

[1] Pharmacy Study Program, Faculty of Medicine and Health Sciences, Universitas Jambi, Jambi, 36122 Indonesia
[2] Department of Pharmaceutics, Faculty of Pharmacy Universitas Gadjah Mada, Yogyakarta, 55281 Indonesia

*Coressponding Authors: indri.maharini@unja.ac.id

Abstract

Introduction: Zinc oxide (ZnO) nanoparticles synthesized through green routes have garnered considerable attention as sustainable alternatives for use in cosmetics and pharmaceuticals. The use of plant extracts as bioreductors offers an eco-friendly and non-toxic approach for nanoparticle production. In this study, ZnO nanoparticles were synthesized using the aqueous leaf extract of *Peronema canescens* Jack. (*Sungkai*) as a natural reducing and stabilizing agent. **Objective:** The research aimed to evaluate the sunscreen potential of the biosynthesized ZnO nanoparticles by determining their Sun Protection Factor (SPF) values. **Methods:** ZnO nanoparticles were synthesized via a green synthesis method employing Peronema canescens leaf extract as a bioreductor. The sunscreen activity was analyzed using a UV–Visible spectrophotometer across concentrations of 125, 250, 500, 750, and 1000 ppm. The SPF values were calculated based on absorbance measurements within the wavelength range of 290–320 nm, according to the Mansur equation. **Results:** The biosynthesized ZnO nanoparticles exhibited concentration-dependent photoprotective activity. The mean SPF values obtained were 0.89±0.002, 3.34±0.001, 6.57±0.002, 10.39±0.003, and 14.70±0.006 for concentrations of 125, 250, 500, 750, and 1000 ppm, respectively. These findings demonstrate that higher concentrations of ZnO nanoparticles enhance UV absorption capability and overall SPF value. **Conclusion:** Green-synthesized zinc oxide nanoparticles using Peronema canescens Jack. Leaf extract exhibited concentration-dependent sunscreen activity. The highest SPF value of 14.70 at 1000 ppm indicates moderate to high UV protection. These results suggest that biosynthesized ZnO nanoparticles are promising eco-friendly agents for natural sunscreen formulations.

Keywords: Zinc oxide nanoparticles, Peronema canescens Jack., green synthesis, SPF, sunscreen.

Cite This Article

Maharini, I., Yuliawati, Pratiwi, P. D., Nugroho, A. H., Virginia, Y., Adhyatmika, & Pawestri, S. A. (2025). Sunscreen potential of green-synthesized ZnO nanoparticles from Sungkai leaf extract. *Proceedings Academic Universitas Jambi, 1*(2). 679-684.

Editor

I Made Dwi Mertha Adnyana, M.Ked.Trop.

Article info

Received: October 04, 2025. Revised: October 05, 2025. Accepted: November 09, 2025

INTRODUCTION

Zinc oxide nanoparticles (ZnO NPs) are widely recognized as effective inorganic UV filters, providing broad-spectrum protection by absorbing and scattering both UVA and UVB radiation, while offering high photostability and good skin tolerability compared to several organic filters [1–3]. Recent advances indicate that reducing ZnO to the nanoscale enhances its optical properties (reducing whitening on the skin) and improves UV attenuation, making ZnO NPs attractive candidates for modern sunscreen formulations [4,5].

Concurrently, the green synthesis of metal oxide nanoparticles using plant extracts has gained attention as an eco-friendly and less toxic alternative to traditional chemical synthesis methods [6]. The phytochemical constituents of plants function as natural reducing and stabilizing agents, enabling the formation of ZnO nanoparticles with similar photoactive characteristics while reducing the use of harmful reagents and by-products [7]. Numerous recent reviews and experimental studies have reported reproducible green synthesis pathways for ZnO NPs and highlighted their potential in biomedical and photoprotective applications[1,8–11]. The extract of *Peronema canescens* Jack. Leaves (locally known as Sungkai) contain phenolics, flavonoids, and other bioactive constituents that can act as bioreductants and capping agents in nanoparticle biosynthesis[12]. Preliminary phytochemical and bioactivity studies suggest that this material is suitable for the production of green nanoparticles [13,14].

ZnO nanoparticles synthesized using plant extracts have demonstrated significant sunscreen activity. A study by Elbrolesy et al., (2023) reported that ZnO nanoparticles synthesized using tomato (*Solanum lycopersicum*) fruit extract exhibited an SPF value of 16.8, which falls within the moderate to high protection category. Similarly, Azeez et al., (2024) found that ZnO nanoparticles synthesized from *(Lepidium sativum L.* leaf extract showed good photoprotective activity. However, no studies have reported the sunscreen potential of ZnO nanoparticles synthesized using *Peronema canescens* Jack leaf extract.

This study investigates the sunscreen potential of ZnO nanoparticles synthesized using *Peronema canescens Jack* leaf extract, with SPF assessment conducted via UV-Vis spectrophotometric analysis. This research aims to evaluate whether biosynthesized ZnO NPs can serve as effective and eco-friendly active ingredients for natural sunscreen formulations.

METHODS

Study design and setting

This study was designed to evaluate the sunscreen potential (Sun Protection Factor, SPF) of zinc oxide nanoparticles (ZnO-NPs) synthesized via a green method using liquid extract of Sungkai (Peronema canescens Jack.) leaves as a natural bioreducing and stabilizing agent. An in vitro laboratory experimental approach with technical replication was employed to ensure the validity of the data. The research process consisted of several key stages, including the preparation of Sungkai leaf extract, biosynthesis of ZnO nanoparticles, and evaluation of sunscreen activity at various sample concentrations. Measurements were performed using a UV–Vis spectrophotometer to obtain absorbance data in the wavelength range of 290–320 nm, and the SPF values were subsequently calculated using the Mansur method. All measurement data were statistically analyzed to determine the UV protection capability.

Population, samples and sampling
The population in this experimental study consists of zinc oxide nanoparticle (ZnO-NP) powders synthesized through a green method using aqueous leaf extract of Peronema canescens (Sungkai) under the described laboratory conditions. The test samples consisted of five concentrations of ZnO nanoparticles—125, 250, 500, 750, and 1000 ppm—each tested in triplicate to ensure data reliability and accuracy. The concentration levels were selected using purposive sampling, based on preliminary study results and literature indicating that increasing the concentration of ZnO nanoparticles is associated with enhanced UV protection capability.

Instruments
The UV–Visible spectrophotometer (e.g., Shimadzu UV-1800, Japan) with a 1 cm quartz cuvette, and Glassware.

Procedure and data collection
One gram of ZnO nanoparticles was dispersed in 100 mL of absolute ethanol at room temperature. The UV–Visible spectrophotometer (e.g., Shimadzu UV-1800, Japan) was used to determine the absorbance of ZnO nanoparticle suspensions in the wavelength range of 290–320 nm for SPF calculation, following the Mansur method. The instrument was equipped with a 1 cm quartz cuvette, and all measurements were performed using ethanol as the solvent blank. Each sample was scanned in triplicate, and baseline correction was carried out before each run to eliminate background interference [17].

$$SPF = CF \sum_{290}^{320} A(\lambda) I(\lambda) EE(\lambda) \quad (1)$$

Statistical analysis
The data SPF were analyzed statistically using ANOVA to compare the SPF values at each concentration.

RESULTS
The results of the SPF test of ZnO nanoparticles at each concentration are presented in Table 1.

Table 1. SPF Values of ZnO nanoparticles at various concentrations

Concentration (ppm)	SPF
125	0.885±0.0018
250	3.34±0.001
500	6.566±0.002
750	10.387±0.0029
1000	14.698±0.006

DISCUSSION
This study aimed to evaluate the sunscreen activity of ZnO nanoparticles synthesized via a green method using Sungkai leaf extract. The obtained data showed an increase in SPF values corresponding to the increasing concentrations of ZnO nanoparticles (Table 1). At a concentration of 125 ppm, the SPF value was 0.885 ± 0.0018, indicating a very low level of UV protection. Increasing the concentration to 250 ppm resulted in a significant increase in SPF to 3.34 ± 0.001. The SPF continued to rise proportionally at 500 ppm (6.566±0.002), 750 ppm (10.387±0.0029), and up to 1000 ppm

(14.698±0.006). The One-Way ANOVA results indicated a p-value of 0.001, demonstrating that concentration variations had a significant impact on SPF values

These results indicate a positive correlation between the concentration of ZnO nanoparticles and their UV-protective capability. ZnO acts as a physical UV filter through absorption and reflection of UV rays. The higher the concentration of ZnO nanoparticles, the larger the surface area available for interaction with UV radiation, thereby enhancing their protective effectiveness [18,19]. The green synthesis method using Sungkai leaf extract is believed to provide a biologically derived coating on the nanoparticle surface, which can enhance stability and uniform dispersion in the test medium [20]. Additionally, Sungkai leaf extract contains active compounds, such as flavonoids and alkaloids, that can act as reducing and stabilizing agents in the synthesis of ZnO nanoparticles.

Previous studies also demonstrated that green-synthesized ZnO nanoparticles exhibit significant SPF activity. For example, Elbrolesy et al. (2023) reported that ZnO nanoparticles synthesized using tomato (Solanum lycopersicum) extract had an SPF value of 16.8, indicating their potential as an effective sunscreen agent [15]. However, for commercial applications requiring high sun protection (SPF ≥ 30), formulation optimization is necessary, such as increasing the ZnO nanoparticle concentration, combining with organic UV filters, or using stabilizing matrices to enhance nanoparticle dispersion in topical formulations. Overall, the results of this study demonstrate that ZnO nanoparticles synthesized using Sungkai leaf extract have potential as environmentally friendly sunscreen agents, with SPF activity that can be controlled by varying the concentration. Green synthesis not only reduces the use of hazardous chemicals but also contributes to improved nanoparticle biocompatibility.

CONCLUSIONS

The SPF of ZnO nanoparticles exhibited a concentration-dependent increase, indicating a strong positive correlation between nanoparticle concentration and UV-protective efficacy. ZnO nanoparticles synthesized via a green approach using Sungkai leaf extract demonstrate significant potential as active sunscreen agents, with their SPF performance effectively modulated through concentration adjustment.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

FUNDING

This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

ACKNOWLEDGMENT

The authors sincerely acknowledge the Lembaga Penelitian dan Pengabdian Kepada Masyarakat Universitas Jambi for the financial support provided under Research Grant No. 371/UN21.11/PT.01.05/SPK/2025.

DECLARATION OF ARTIFICIAL INTELLIGENCE USE

We hereby confirm that no artificial intelligence (AI) tools or methodologies were utilized at any stage of this study, including during data collection, analysis, visualization or manuscript preparation. All work presented in this study was conducted manually by the authors without the assistance of AI-based tools or systems.

REFERENCES

[1] El-Saadony M, Fang G, Yan S, Alkafaas S, El Nasharty M, Khedr S, et al. Green Synthesis of Zinc Oxide Nanoparticles: Preparation, Characterization, and Biomedical Applications - A Review. International Journal of Nanomedicine 2024;Volume 19:12889–937. https://doi.org/10.2147/IJN.S487188.

[2] Schneider SL, Lim HW. A review of inorganic <scp>UV</scp> filters zinc oxide and titanium dioxide. Photodermatology, Photoimmunology & Photomedicine 2019;35:442–6. https://doi.org/10.1111/phpp.12439.

[3] O'Keefe SJ, Feltis BN, Piva TJ, Turney TW, Wright PFA. ZnO nanoparticles and organic chemical UV-filters are equally well tolerated by human immune cells. Nanotoxicology 2016;10:1287–96. https://doi.org/10.1080/17435390.2016.1206148.

[4] Islam F, Shohag S, Uddin MdJ, Islam MdR, Nafady MH, Akter A, et al. Exploring the Journey of Zinc Oxide Nanoparticles (ZnO-NPs) toward Biomedical Applications. Materials 2022;15:2160. https://doi.org/10.3390/ma15062160.

[5] Khan AUH, Liu Y, Fang C, Naidu R, Shon HK, Rogers Z, et al. A comprehensive physicochemical characterization of zinc oxide nanoparticles extracted from sunscreens and wastewaters. Environmental Advances 2023;12:100381. https://doi.org/10.1016/j.envadv.2023.100381.

[6] Radulescu D-M, Surdu V-A, Ficai A, Ficai D, Grumezescu A-M, Andronescu E. Green Synthesis of Metal and Metal Oxide Nanoparticles: A Review of the Principles and Biomedical Applications. International Journal of Molecular Sciences 2023;24:15397. https://doi.org/10.3390/ijms242015397.

[7] Ashour M, Mansour AT, Abdelwahab AM, Alprol AE. Metal Oxide Nanoparticles' Green Synthesis by Plants: Prospects in Phyto- and Bioremediation and Photocatalytic Degradation of Organic Pollutants. Processes 2023;11:3356. https://doi.org/10.3390/pr11123356.

[8] Al-darwesh MY, Ibrahim SS, Mohammed MA. A review on plant extract mediated green synthesis of zinc oxide nanoparticles and their biomedical applications. Results in Chemistry 2024;7:101368. https://doi.org/10.1016/j.rechem.2024.101368.

[9] Swain M, Mishra D, Sahoo G. A review on green synthesis of ZnO nanoparticles. Discover Applied Sciences 2025;7:997. https://doi.org/10.1007/s42452-025-06957-8.

[10] Mutukwa D, Taziwa RT, Khotseng L. A Review of Plant-Mediated ZnO Nanoparticles for Photodegradation and Antibacterial Applications. Nanomaterials 2024;14:1182. https://doi.org/10.3390/nano14141182.

[11] Tiwari AK, Jha S, Tripathi SK, Shukla R, Awasthi RR, Bhardwaj AK, et al. Spectroscopic investigations of green synthesized zinc oxide nanoparticles (ZnO NPs): antioxidant and antibacterial activity. Discover Applied Sciences 2024;6:399. https://doi.org/10.1007/s42452-024-06049-z.

[12] Sudaryati NLG, Utomo B, Adnyana IMDM, Fauziyah S, Hari Sucipto T, et al. Phytochemical profiling, dengue antiviral properties, and cytotoxicity of novel Baper tea polyherbal infusion: Insights from in silico and in vitro studies. Salud, Ciencia y Tecnologia. 2025;5:1791. https://doi.org/10.56294/saludcyt20251791.

[13] Shalihin MI, Khatib A, Yusnaidar Y, Tarigan IL, Latief M. An in-vogue plant, Peronema canescens Jack: traditional uses and scientific evidence of its bioactivities. Discover Plants 2024;1. https://doi.org/10.1007/s44372-024-00048-5.

[14] Ahkam AH, Susilawati Y, Sumiwi SA. Peronema canescens as a Source of Immunomodulatory Agents: A New Opportunity and Perspective. Biology 2024;13:744. https://doi.org/10.3390/biology13090744.

[15] Elbrolesy A, Abdou Y, Elhussiny FA, Morsy R. Novel Green Synthesis of UV-Sunscreen ZnO Nanoparticles Using Solanum Lycopersicum Fruit Extract and Evaluation of Their Antibacterial and Anticancer Activity. Journal of Inorganic and Organometallic Polymers and Materials 2023;33:3750–9. https://doi.org/10.1007/s10904-023-02744-3.

[16] Azeez H, Gozeh B, Azeez H, Slewa L. The Effect of Green Synthesis ZnO NPs on Sun Protection Factor of Sunblock Lotion. Rafidain Journal of Science 2024;33:137–47. https://doi.org/10.33899/rjs.2024.185392.
[17] Wigati S, Maharini I. Formulation and In Vitro Evaluation of Sun Protection Factor of Dadap Serep (Erythrina Subumbrans (Haks.) Merr) Cream. repository.unja.ac.id; 2019.
[18] Irede EL, Awoyemi RF, Owolabi B, Aworinde OR, Kajola RO, Hazeez A, et al. Cutting-edge developments in zinc oxide nanoparticles: synthesis and applications for enhanced antimicrobial and UV protection in healthcare solutions. RSC Advances 2024;14:20992–1034. https://doi.org/10.1039/D4RA02452D.
[19] Sasani Ghamsari M, Alamdari S, Han W, Park H-H. Impact of nanostructured thin ZnO film in ultraviolet protection. International Journal of Nanomedicine 2016;Volume 12:207–16. https://doi.org/10.2147/IJN.S118637.
[20] Abdelbaky AS, Abd El-Mageed TA, Babalghith AO, Selim S, Mohamed AMHA. Green Synthesis and Characterization of ZnO Nanoparticles Using Pelargonium odoratissimum (L.) Aqueous Leaf Extract and Their Antioxidant, Antibacterial and Anti-inflammatory Activities. Antioxidants 2022;11:1444. https://doi.org/10.3390/antiox11081444.