Pharmaciana
Vol.15, No.1, March 2025, Page. 10-18
ISSN: 2088 4559; e-ISSN: 2477 0256
DOI: 10.12928/pharmaciana.v15i1.30244

Antioxidant activity of silver nanoparticles synthesized using Tulak wood leaf extract *(schefflera elliptica harms)*

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Submitted: 17-10-2024 ***Reviewed: 27-12-2024*** ***Accepted: 21-02-2025***

ABSTRACT

Nanoparticles have been used in therapies applied to target specific parts. By delivering electrons to free radicals, silver nanoparticles (AgNPs) can reduce their activity and stop a chain reaction that would otherwise result in the creation of more free radicals. But the most common way to create silver nanoparticles is to use a variety of organic and inorganic reducing agents to chemically reduce silver precursors, usually silver salts. Various stabilizing or capping agents are frequently used to this process. Green synthesis and other ecologically friendly synthesis techniques are becoming more popular for producing metal nanoparticles that adhere to biodiversity principles. Accordingly, this study has determined that the tulak tree is a plant that effectively reduces green space. This study uses different concentrations of $AgNO_3$ solution at 1 mM and 2 mM. A Particle Size Analyzer's (PSA), The distribution of sizes of the artificially produced AgNPs was examined. The particles measuring between 1 and 100 nm made from the Tulak wood leaf extract with the corresponding $AgNO_3$ concentrations had average diameters of 88.2 nm and 16.9 nm. AgNPs were also shown to exist in a range of shapes, encompassing sphere, hexagonal, and triangular ones, according to Transmission Electron Microscopy (TEM) examination. Antioxidant qualities are displayed by AgNPs made with Tulak wood leaf extract. These antioxidant properties were assessed utilizing DPPH, which has 517 nm is the greatest absorption. Furthermore, the antioxidant activity's outcomes tests show that the AgNPs made using Tulak wood leaf extract biosynthesis have comparatively low antioxidant activity.

Keywords: silver nanoparticles, antioxidant, Tulak wood leave, green synthesis

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INTRODUCTION

In the development of nanoparticles (NPs), nanoparticles are defined as having at least one dimension of 100 nm, and they serve a number of functions, especially in the field of nanomedicine, which is a crucial aspect of nanoparticle technology (Thorley & Tetley, 2013). Drug delivery is the main application of NPs in nanomedicine. NPs are currently being used in cancer treatment, immunization, and focused therapeutic techniques, such as lung tissue therapies (Thorley & Tetley, 2013). Because of their great potential to meet the pressing need for new antibiotics in the realm of microbiology, nanoparticles (NPs) are increasingly being used. The pertinent literature has been added to by (Aruguete et al., 2013; Pelgrift & Friedman, 2013; Webster & Seil, 2012). Public health is seriously threatened by the rising incidence of infections and the effects that different medications have on the bacterial system. Among the many metal Nanoparticles, the medicinal qualities of (AuNP) and (AgNPs) have been widely studied (Loomba and Scarabelli, 2013). Interestingly, AgNPs have strong antibacterial and antifungal properties (Dos Santos et al., 2014). Usually, metallic NPs are chemically and even physically synthesised. Ongoing issues regarding the use of this method (Green Synthesis) have helped the exploration of environmentally friendly synthesis and the creation of metal NPs based on biodiversity (Nath & Banerjee, 2013). Utilization of this biodiversity towards environmentally friendly green reduction agents.

The teak wood plant, a member of the Araliaceae family and a potentially therapeutic plant, is used as the green-reducing agent in this study. Skin conditions are treated using the oil extracted from the seeds, the paste made from the combination of S. elliptical, turmeric, banana plant, and honey, which is useful for treating fractures (Sharief et al., 2005). The bark of the tree can traditionally be used to treat rheumatism and also as a tonic (Handa et al., 2006). The description *S. elliptica* that has been done by (Wiart, 2006) is as follows: A woody or shrubby climbing stem with a wide, spreading crown (Wiart, 2006).

There are many popular applications for silver nanoparticles. One of the applications is in the form of cosmetic products. This is based on the activity of silver nanoparticles as an antibacterial, anticancer, anti-inflammatory, Antioxidant, and others (Du et al., 2019). The review will concentrate on the production of (AgNPs) using bioreductants made from botanicals extract and the antioxidant characteristics of the silver nanoparticles made using these bioreductants.

Antioxidants are substances that can reduce free radicals. These substances are important to consume because they can prevent the occurrence of various degenerative diseases and cancer, Considering that based on data from WHO in 2018 showed quite a large number of cancer cases in Indonesia, namely 348,809 cases. Cancer cases in Indonesia are quite high, so preventive measures are needed. These preventive measures need to be taken so that the number of cancer cases in Indonesia does not increase. Antioxidants can be divided into two types based on their composition, namely organic and inorganic antioxidants. One example of an inorganic antioxidant is silver nanoparticles. Silver nanoparticles can reduce the activity of free radicals through the electrons on free radicals, so they can prevent the chain reaction of free radicals (Sayuti & Yenrina, 2015). From the explanation above, In this study, the antioxidant qualities of silver nanoparticles made with a bioreductant extract from Tulak wood leaves (*Schefflera elliptica*) were evaluated. Together with the bioreductant extract from Tulak wood leaves (*S. elliptica*), the results of this investigation could shed light on the antioxidant potential of silver nanoparticles.

MATERIALS AND METHOD

Materials

Tulak leaves from Bangli Regency in Bali Province constituted the materials used in this study. In particular, the Banjar Kembangsari area of Satara Village, Kintamani District, which is also in Bangli Regency, Bali Province, is where the Tulak leaves are used. Plant determination test carried out at the Indonesian Institute of Sciences (LIPI) Conservation Center Plants of the "Eka Raya" Botanical Garden, Candikuning, Baturiti District, Regency Tabanan, Bali. Determining a plant is giving a Latin name and tribe or naming the family of an organism using literature. Results Plant determination is known through test results reports, which state that The plant used in this research was tulak leaves (*Schefflera elliptica* (Blume) Harms), which belongs to the Araliaceae family.

Methods

Preparation of Tulak wood leaves

The Tulak wood's leaves are gathered and aerated to allow them to dry naturally at room temperature. Following the completion of the drying process, the leaves are broken up into smaller pieces and then blended to become a fine powder. The Tulak leaf powder is then put in a clean and secure place to prevent degradation.

Making Tulak wood leaf extract

After cooling, the Tulak wood leaf extract mixture was filtered to separate the filtrate. The following procedures are advised in order to prepare leaf extracts: To get rid of any debris, fresh leaves should be gathered and carefully cleaned two or three times. After that, the leaves need to be dried for seven days at 40±1°C in a hot air oven. The samples should be broken up into little pieces and powdered into a coarse powder after they have completely dried. To avoid moisture absorption and guarantee their preservation for later usage, the powdered leaves must be kept in airtight containers. Additionally, the dried leaves can be boiled in water between 60°C and 80°C for 20 to 30 minutes, after which the mixture is filtered to create an aqueous extract.

The resulting filtrate will be put in a sterile, airtight container intended for use as a bio-reductant—a material that undergoes oxidation itself and aids in the reduction of another material. The term "bio-reduction" describes a method that uses living things, such as bacteria, fungi, and plants, to aid in the manufacture of nanoparticles, especially (AgNPs).

Green synthesis of silver nanoparticles

40 milliliters of 1 millimeter and 2 millimeter ($AgNO_3$) solution were combined with 20 milliliters of Tulak leaf infusion. The combination underwent heating in a microwave for a length of 120 seconds following a 24-hour period of agitation at ambient temperature with a magnetic stirrer. A change in hue to a brownish-yellow in the fluid indicates the creation of silver nanoparticles (AgNPs). The filtrate from the Tulak wood leaf extract was then examined employing a UV-Vis spectrophotometer to verify that (AgNPs) were present.

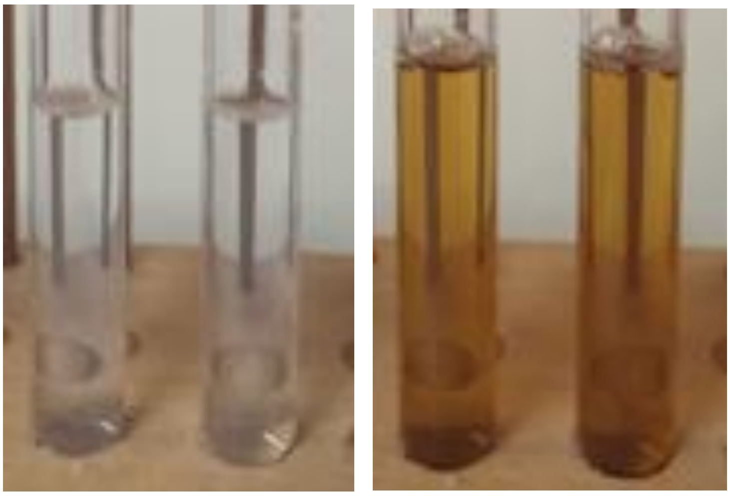
Determination of radical scavenging activity (DPPH)

With a few minor modifications, the combination underwent heating in a microwave for a length of 120 seconds following a 24-hour period of agitation at ambient temperature using a magnetic stirrer. A shift in hue to a brownish-yellow in the fluid indicates the creation of silver nanoparticles (AgNPs). The filtrate from the Tulak wood leaf extract was then examined using a UV-Vis spectrophotometer to verify that silver nanoparticles were present. These concentrations match the IC50 values. The values show the concentration of the fraction that exhibits 50% radical scavenging activity in relation to the control and are calculated using a linear regression equation. 4.0 military of ethanol and 1.0 military of Picrylhydrazyl were used to measure the absorbance of the control. Vitamins used in the second comparison are named antioxidants, such as those carried out by (Kikuzaki et al., 2002). The radical scavenging activity percentage is computed using a method that compares the absorbance of the control (A_0) with densitas optis measured in the presence of the test sample or reference substance (A_1).
Note: The absorbance of the control is indicated by Ao, whereas densitas optis recorded in the presence of the test sample or reference substance is represented by A1, which excludes the test sample. At wavelengths between 515 and 520 nm, the DPPH absorbance is measured.

RESULT AND DISCUSSION

Results of color changes in the silver nanoparticle synthesis process with Tulak wood leaf extract bioreductant

In this study, the synthesis of an $AgNO_3$ solution using was successfully achieved with the water extract of Tulak wood leaves. Figure 1 depicts the results of the procedure. The first color change was observed at 10 minutes, indicating that the synthesis of nanoparticles using tulak woods leaves had been formed. The results are consistent with previous studies on leaf-derived silver nanoparticles (Willian et al., 2020). There is a discernible change in color from clear to brownish yellow. This color change indicates that the metal nanoparticles' surface plasmon oscillations are being excited (Bakshi et al., 2015). The nanoparticle synthesis process stops when the color of the solution becomes constant; the color changes from clear, light yellow into brown because of surface plasmons such as the one shown in Figure 1.



(a) **(b)**

Figure 1. (a) $AgNO_3$ solution with concentrations of 1 and 2 mM (b) A silver nanoparticle was synthesized using a bioreductant derived from boiled Tulak wood leaf extract at $AgNO_3$ solution concentrations of 1 mM and 2 mM

UV-Vis Spectrophotometer test results

In this study, using a UV-Vis spectrophotometer, silver nanoparticles made using Tulak leaf extract as a bioreductant were examined. As shown in Figure 2, the concentration of AgNO3 solution varied between 1 mM and 2 mM during the investigation. Silver ion reduction from Ag+ to Ag0 is the main cause of the (SPR) peak shown in the spectrum analysis. As seen in Figure 2, after the synthesis had been running for 60 minutes, the reaction was clearly visible in, as seen from the appearance of the UV-Vis spectrum peak. The broad absorption peak appeared at a maximum λ of 432 nm. Averrhoa bilimbi Linn was used by the researchers in the study by (Isaac et al., 2013). According to Isaac et al. (2013), fruit extract showed a surface plasmon resonance peak at 440 nanometers. Furthermore, using fruit extract from *Prosopis farcta*, Salari et al., (2019) found that the SPR peak of (AgNPs) fell between 425 and 438 nm. The growth of silver nanoparticles can also be qualitatively observed from the shift of the SPR peak of silver nanoparticles. Plasmon area adjusts in particle size and even shape (Suárez-Cerda et al., 2015).

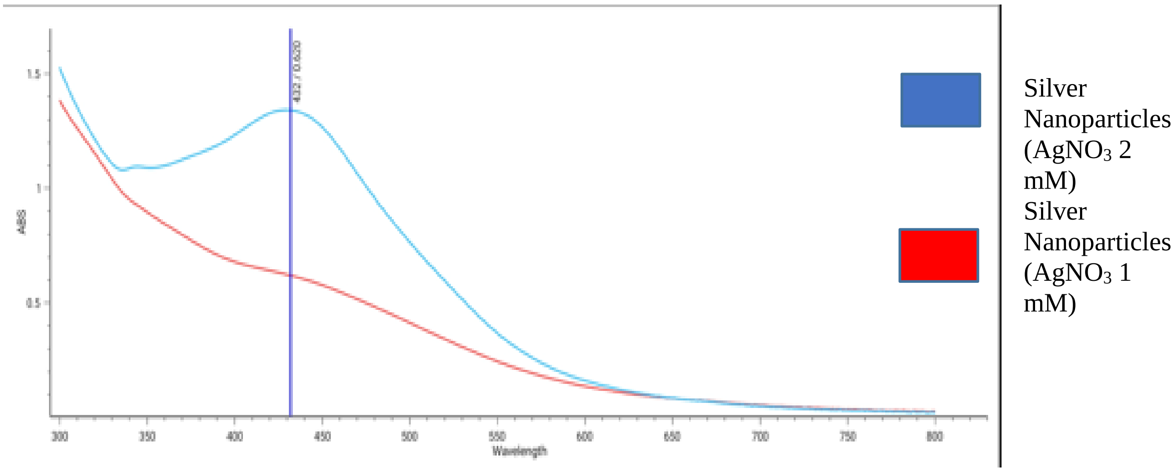


Figure 2. the absorbance spectra of silver nanoparticles made with different amounts of AgNO3 solution at 1 milimeter and 2 milimeter, utilizing tulak leaf extract as a bioreductant

Results of nanoparticle size distribution with PSA (Particle Size Analyzer)

Characterisation with PSA aims to see the distribution of nanoparticle size through the dynamin light catering test. The results of that can be shown in Figure 3 or 4. The particle size data obtained is a kind of 3 distribution, namely intensity, volume, and even quantity. After that, the sample's condition can be described (Nikmatin et al., 2011). The distribution of particle sizes is shown in Figure 3, with an average measurement of 88.2 nanometers and 16.9 nanometers.

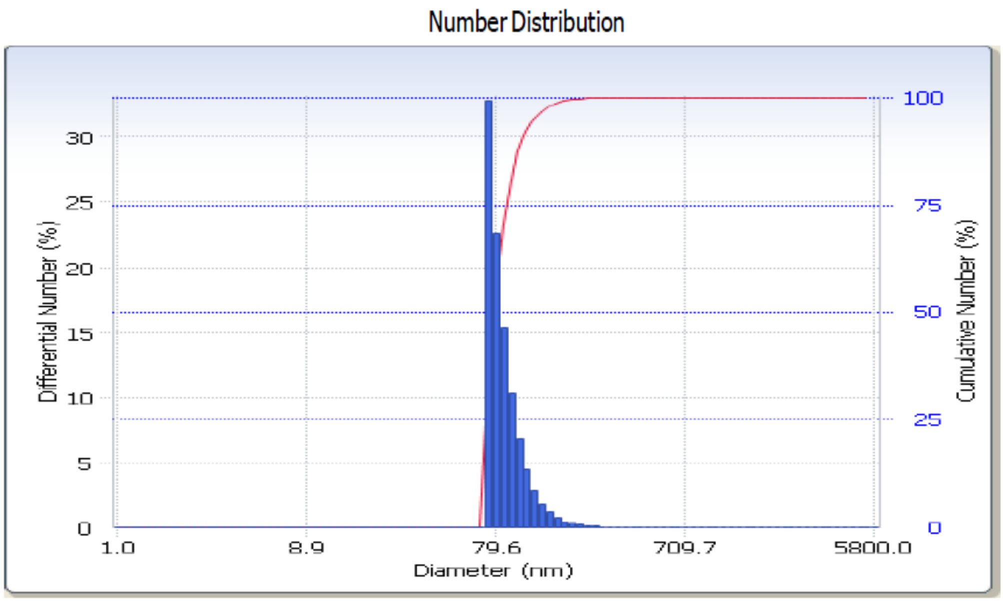


Figure 3. A bar chart showing the size distribution of silver nanoparticles made with a 1 mM AgNO3 solution and a bioreductant made from boiled Tulak wood leaf extract

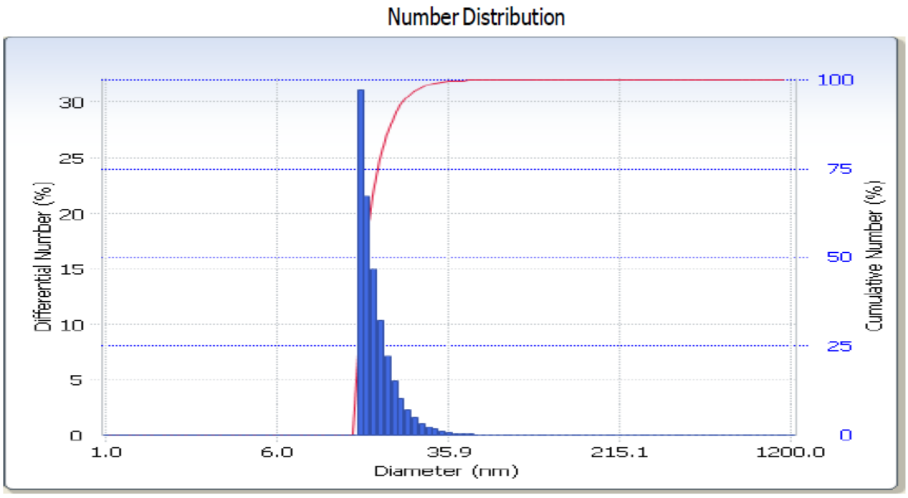
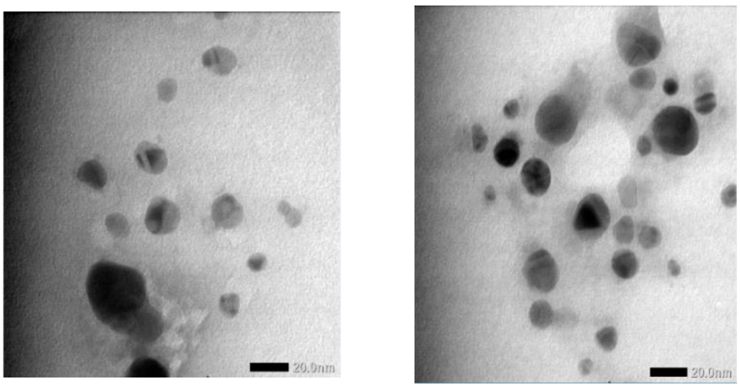


Figure 4. A bar chart showing the size distribution of silver nanoparticles made with a 2 mM AgNO3 solution and a bioreductant made from boiled Tulak wood leaf extract

Morphology of silver nanoparticles by transmission electron microscopy

The TEM images are a combination of silver nanoparticles with spherical, triangular, and even hexagonal shapes (Bhuvaneswari et al., 2017). A histogram showing the size distribution of silver nanoparticles made with a bioreductant made from boiled Tulak wood leaf extract and a 2 mM $AgNO_3$ solution. Different elements, even proteins, are included that are responsible for creating nanoparticles in all shapes.



(a) (b)

Figure 5. The morphology of silver nanoparticles produced with the bioreduction made from Tulak wood leaf extract was investigated at one-millimeter concentrations (a) and two millimeter (b) in silver nitrate solution

Antioxidant activity test of silver nanoparticles with bioreductant of Tulak wood leaf extract with variation of $AgNO_3$ solution concentration

Instead of using ascorbic acid as an antioxidant, the antioxidant qualities of the nanoparticles made with tulak leaf bioreductors were assessed in this study using a combined concentration of 1 or 2 mM AgNO3 solution. Where the test results can be shown in Table 1. Antioxidants are substances present in free radicals that prevent the body from disorders that lead to degeneration, such as cancer, caused by oxidative stress (Balashanmugam et al,. 2015). Phenolic substances, such as flavonoids and phenolic acids obtained from medicinal plants, serve to reduce reactive oxygen species (ROS) and provide hydrogen atoms to the plants (Labulo et al., 2022). According to the DPPH assay, the results of this investigation show that silver nanoparticles (AgNPs) have antioxidant qualities at all investigated concentrations (100–500 ppm). According to the data, the percentage of inhibition rose when both AgNPs and ascorbic acid concentrations increased (Table 1), ranging from 100 to 500 ppm for AgNPs and 1 to 5 ppm for ascorbic acid. The DPPH assay used the highest amounts of ascorbic acid and AgNPs. The determination results in IC_{50} of AgNPs 1, and AgNPs 2 were obtained at 935±0.21 ppm and 691± 0.22 ppm. If a chemical's IC50 value is less than 50, it is considered a very powerful antioxidant; if it is between 50 and 100, it is considered strong; if it is between 100 and 150, it is considered moderate; and if it is between 150 and 200, it is considered weak, and very weak if it is greater than 200, according to Molyneux (2004). This suggests that the antioxidant activity of the AgNPs is quite low. Its capacity to efficiently neutralize DPPH is demonstrated by the comparison with pure vitamin C. Interestingly, vitamin C has four hydroxyl groups (OH), which allow it to destroy free radicals by donating more hydrogen atoms. Apart from that, AgNPs are not a source of vitamin C. So, their antioxidant activity is much lower compared with vitamin C. Meanwhile, to determine the IC_{50} value compared to vitamin C. The results of determining the IC_{50} value compared to vitamin C were obtained at 4.11±0.03 ppm. Matter This shows that the comparison Vitamin C has very strong antioxidant activity. This difference in IC_{50} values can be caused by the number of metabolite compounds that have antioxidant activity and the concentration of $AgNO_3$ solution. The high polyphenol content of leaf extracts limited to AgNPs may be due to the increased amount of antioxidants (Moorthy et al., 2022). Silver Nanoparticles showed a wide range of antioxidant action in this study by significantly lowering reactive oxygen species (Berridge et al., 2005). The DPPH assay measures antioxidant activity and determines the antioxidants' capacity to scavenge free radicals by examining how they inhibit lipid oxidation, which leads to the scavenging of DPPH free radicals. Because of its quick analysis time—typically only a few minutes—this method has become more and more popular. The DPPH free radical has a UV–vis absorbance peak at 517 nm, interacts with hydrogen donors, and is remarkably persistent. The technique relies on antioxidants' capacity to scavenge DPPH, which causes the DPPH methanol solution to become decolorized after the reduction procedure (Baliyan et al., 2022).

Table 1. Percentage inhibition values and IC_{50} of silver nanoparticles and ascorbic acid

Sample	Concentration (ppm)	Inhibition ± SD in %	IC_{50}± SD value in ppm
1 mM silver nitrate nanoparticles of silver.	100	25.53±0.19	935.60±0.21
	200	27.63±0.20	
	300	30.78±0.18	
	400	35.67±0.19	
	500	37.23±0.17	
Two millimolar $AgNO_3$ nanoparticles of silver.	100	27.48±0.12	691.32±0.22
	200	29.89±0.14	
	300	33.08±0.10	
	400	40.16±0.11	
	500	42.57±0.11	
Ascorbic Acid	1	10.45±0.09	4.11±0.03
	2	27.63±0.10	
	3	37.05±0.12	
	4	50.34±0.11	
	5	61.58±0.12	

CONCLUSION

Tulak leaf extract has been effectively used to synthesize AgNPs, and the benefits of tulak leaves have been proven as a natural ingredient that acts as a silver bioreduction agent and a capping agent. Results of antioxidant activity tests on silver nanoparticles biosynthesis using teak wood leaf extract have very weak antioxidant activity (IC_{50}) values of AgNPs were 935.60±0.21 ppm and 691.32±0.22 ppm. Therefore, AgNPs are very important for biomedicine as an antioxidant in the pharmaceutical sector.

ACKNOWLEDGEMENT

The writers would like to express their profound gratitude to Universitas Bali Internasional and the academic and volunteer institutions that helped make this study a success.

REFERENCES

Aruguete, D. M., Kim, B., Hochella, M. F., Ma, Y., Cheng, Y., Hoegh, A., Liu, J., & Pruden, A. (2013). Antimicrobial nanotechnology: its potential for the effective management of microbial drug resistance and implications for research needs in microbial nanotoxicology. *Environ. Sci.: Processes Impacts*, *15*(1), 93–102. https://doi.org/10.1039/C2EM30692A

Bakshi, M., Ghosh, S., & Chaudhuri, P. (2015). Green synthesis, characterization and antimicrobial potential of sliver nanoparticles using three mangrove plants from Indian Sundarban. *BioNanoScience*, *5*(3), 162–170. https://doi.org/10.1007/s12668-015-0175-8

Balashanmugam, M., Cheong, Y. S., Hounslow, M. J., & Salman, A. D. (2015). Semi-solid paste binder dispersion in a moving powder bed. *Procedia Engineering*, *102*, 626–633. https://doi.org/10.1016/j.proeng.2015.01.151

Baliyan, S., Mukherjee, R., Priyadarshini, A., Vibhuti, A., Gupta, A., Pandey, R. P., & Chang, C.-M. (2022). Determination of antioxidants by DPPH radical scavenging activity and quantitative phytochemical analysis of ficus religiosa. *Molecules*, *27*(4), 1326. https://doi.org/10.3390/molecules27041326

Berridge, M. V., Herst, P. M., & Tan, A. S. (2005). *Tetrazolium dyes as tools in cell biology: New insights into their cellular reduction*, 11, 127–152. https://doi.org/10.1016/S1387-2656(05)11004-7

Bhuvaneswari, R., Xavier, R. J., & Arumugam, M. (2017). Facile synthesis of multifunctional silver nanoparticles using mangrove plant Excoecaria agallocha L. for its antibacterial, antioxidant and cytotoxic effects. *Journal of Parasitic Diseases*, *41*(1), 180–187. https://doi.org/10.1007/s12639-016-0773-6

Dos Santos, C. A., Seckler, M. M., Ingle, A. P., Gupta, I., Galdiero, S., Galdiero, M., Gade, A., & Rai, M. (2014). Silver nanoparticles: therapeutical uses, toxicity, and safety issues. *Journal of Pharmaceutical Sciences*, *103*(7), 1931–1944. https://doi.org/10.1002/jps.24001

Du, J., Hu, Z., Dong, W., Wang, Y., Wu, S., & Bai, Y. (2019). Biosynthesis of large-sized silver nanoparticles using Angelica keiskei extract and its antibacterial activity and mechanisms investigation. *Microchemical Journal*, *147*, 333–338. https://doi.org/10.1016/j.microc.2019.03.046

Handa, S. S., Rakesh, D. D., & Vasisht, K. (2006). *Compendium of medicinal and aromatic plants Asia, Vol. II.* United Nation Industrial Development Organisation and the International Centre for Science and High Technology.

Isaac, R. S. R., Sakthivel, G., & Murthy, C. (2013). Green synthesis of gold and silver nanoparticles using Averrhoa bilimbi fruit extract. *Journal of Nanotechnology*, *2013*, 1–6. https://doi.org/10.1155/2013/906592

Kikuzaki, H., Hisamoto, M., Hirose, K., Akiyama, K., & Taniguchi, H. (2002). Antioxidant properties of ferulic acid and its related compounds. *Journal of Agricultural and Food Chemistry*, *50*(7), 2161–2168. https://doi.org/10.1021/jf011348w

Labulo, A. H., David, O. A., & Terna, A. D. (2022). Green synthesis and characterization of silver nanoparticles using Morinda lucida leaf extract and evaluation of its antioxidant and antimicrobial activity. *Chemical Papers*, *76*(12), 7313–7325. https://doi.org/10.1007/s11696-022-02392-w

Loomba, L., & Scarabelli, T. (2013). Metallic nanoparticles and their medicinal potential. part I: gold and silver colloids. *Therapeutic Delivery*, *4*(7), 859–873. https://doi.org/10.4155/tde.13.55

Molyneux, P. (2003). The use of the stable free radical diphenyl picrylhydrazyl (DPPH) for estimating antioxidan activity. *Songklanakarin Journal of Science and Technology*, *26*(2), 211–219

Moorthy, K., Chang, K.-C., Yu, P.-J., Wu, W.-J., Liao, M.-Y., Huang, H.-C., Chien, H.-C., & Chiang, C.-K. (2022). Synergistic actions of phytonutrient capped nanosilver as a novel broad-spectrum antimicrobial agent: unveiling the antibacterial effectiveness and bactericidal mechanism. *New Journal of Chemistry*, *46*(32), 15301–15312. https://doi.org/10.1039/D2NJ02469A

Nath, D., & Banerjee, P. (2013). Green nanotechnology – a new hope for medical biology. *Environmental Toxicology and Pharmacology*, *36*(3), 997–1014. https://doi.org/10.1016/j.etap.2013.09.002

Nikmatin, S., Maddu, A., Mandang, T., & Purwanto, A. (2011). Analisa struktur mikro pemanfaatan limbah kulit rotan menjadi nanopartikel selulosa sebagai pengganti serat sintetis. *Jumal Biofisika*, *7*(1), 41–49.

Pelgrift, R. Y., & Friedman, A. J. (2013). Nanotechnology as a therapeutic tool to combat microbial resistance. *Advanced Drug Delivery Reviews*, *65*(13–14), 1803–1815. https://doi.org/10.1016/j.addr.2013.07.011

Salari, S., Bahabadi, S. E., Samzadeh-Kermani, A., & Yosefzaei, F. (2019). In-vitro evaluation of antioxidant and antibacterial potential of green synthesized silver nanoparticles using prosopis farcta fruit extract. *Iranian Journal of Pharmaceutical Research*, *18*(1), 430–455.

Sayuti, K., & Yenrina, R. (2015). *Antioksidan, alami dan sintetik*. Andalas University Press.

Sharief, M. U., Kumar, S., Diwakar, P. G., & Sharma, T. (2005). Traditional phytotherapy among Karens of Middle Andaman. *Traditional Phytotherapy among Karens of Middle Andaman*, *4*(4), 429–436.

Suárez-Cerda, J., Alonso-Nuñez, G., Espinoza-Gómez, H., & Flores-López, L. Z. (2015). Synthesis, kinetics and photocatalytic study of “ultra-small” Ag-NPs obtained by a green chemistry method using an extract of Rosa ‘Andeli’ double delight petals. *Journal of Colloid and Interface Science*, *458*, 169–177. https://doi.org/10.1016/j.jcis.2015.07.049

Thorley, A. J., & Tetley, T. D. (2013). New perspectives in nanomedicine. *Pharmacology & Therapeutics*, *140*(2), 176–185. https://doi.org/10.1016/j.pharmthera.2013.06.008

Webster, T. J., & Seil, I. (2012). Antimicrobial applications of nanotechnology: methods and literature. *International Journal of Nanomedicine*, 2767. https://doi.org/10.2147/IJN.S24805

Wiart, C. (2006). *Medicinal plants of the Asia-Pacific - drugs for the future?* World Scientific Publishing Co. Pte. Ltd. https://doi.org/10.1142/9789812707260

Willian, N., Syukri, Zulhadjri, Labanni, A., & Arief, S. (2020). Bio-friendly synthesis of silver nanoparticles using Mangrove Rhizophora stylosa leaf Aqueous extract and its antibacterial and antioxidant activity. *Rasayan Journal of Chemistry*, *13*(03), 1478–1485. https://doi.org/10.31788/RJC.2020.1335760