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Green Synthesis Of Silver Nanoparticles Of Leaf Extract Of Senduduk Bulu (*Clidemia Hirta* (L) D.Don) And Exploration Of The Antibacterial Activity

Dias Wahyu Arvian[1*], Ismi Rahmawati[2] , Endang Diyah Ikasari[3]

[1,2)] Faculty Of Pharmacy, Universitas Setia Budi, Surakarta, Indonesia
[3)] Faculty Of Pharmacy, Sekolah Tinggi Ilmu Farmasi, Semarang, Indonesia

e-mail:
[1)] diasarvian@gmail.com

ABSTRACT

Senduduk bulu is a type of weed whose presence is not expected by farmers because it disturbs cultivated plants. Senduduk bulu wild plant contains secondary metabolite compounds which used natural reducing agent on synthesis of silver nanoparticles (AgNPs). This research determine the optimum extract concentration and temperature in the process synthesis of silver nanoparticle, characteristics of silver nanoparticles and antibacterial activity of silver nanoparticles against *S.aureus* and *E.coli*. Synthesis of silver nanoparticles senduduk bulu leaf using variations extract concentration and temperature variations. The characteristics of silver nanoparticles senduduk bulu leaf were carried out using a UV-Vis Spectrophotometry, Particle Size Analyzer (PSA) and Scanning Electron Microscopy – Energy Dispersive X-Ray Spectroscopy (SEM-EDS). Antibacterial activity testing used the disc diffusion method. The results of research showed the silver nanoparticles of senduduk bulu leaf were successfully synthesized under optimal conditions an extract concentration of 1% and temperature of 60ºC indicated the colloid color changing to brown and maximum wavelength value of 413 nm with absorbance value of 2.9987. The size of colloidal AgNPs of senduduk bulu leaf was 59.2 ± 1.03 nm; zeta potential value -39.3±0.509 mV. The morphology of the AgNPs of senduduk bulu non uniform shape, the crystal size distribution is 50 – 230 nm with an average of 136 nm. Feathered AgNPs had antibacterial activity against *S.aureus* of 14.1 ± 0.3 mm and *E. coli* of 13.5 ± 0.2 mm.

Keywords: Green Synthesis, Silver Nanoparticle, Senduduk Bulu Leaf, *Staphylococcus aureus* and *Escherichia coli*.

INTRODUCTION

The nanotechnology field including the silver nanoparticles, that is currently quite interesting to be improved in research. The silver nanoparticles are known for having the antifungal, antiviral also the antibacterial as the silver ions poisoning viruses, bacterial cells also another *eukaryotic microorganisms* (Nilavukkarasi et al., 2020). The silver nanoparticles synthesized through physical and chemical methods, however these methods are environemntally unfriendly and expensive. The green syntheis is a syntehsizing nanoparticles method which utilizes biologicall aspects such as the plant extracts use (Kumar et al., 2020). Nanoparticles biosythesis using plants as the bioreducers have become the environmentally, friendly, simple and easy procurable methods in Indonesia due to the reducing agents in plants presence (Rahim et al., 2020). Several previous studies extensively utilized plants in silver nanoparticles green synthesis (AgNPs) and knows could reducing agents from Ag^+ to Ag (Ahmed et al., 2016 ; Moosa et al., 2015). The *A.rotundum* l, *F.vulgaris* Bernh, and *F.angulate* Boiss extracts as the silver nanoparticles syntheiszed proved to possess the ability to inhibit the bacteria *P.aeruginosa* and *S.aureus* (Hemlata et al., 2020).

The synthesis selected source is senduduk bulu especially the leaves. The distribution in Indonesia is widespread and easilt found in several regions of the country. This plant recognized solely as the invasive species, the spread would disrupt the another plants habitats. Meanwhile, in several regions in Indonesia such in North Sumatra where this plant used for the wound healing. Moreover, this plant also used in Brazil and Malaysia to heal the skin infections and diarrhea. Fadhli et al., (2020) the senduduk bulu contains tannin, phenol, flavonoid, and steroid compounds. Moreover, another researcher have stated the senduduk bulu extract leaves could inhibit the *Pseudomonas aeruginosa, E.coli* and *S.aureus* growth (Lopez et al., 2016).

The phenolic compounds presence and tannins in the hairy beggarticks plant ensures the OH groups in these compounds would reduce and stabilize the formed silver nanoparticles (Kumar et al., 2020). The hairy beggarticks leaf was chosen as the biosynthesis source due to the active component content as the secondary metabolites in the plant playing a role in the synthesizing nanoparticles process with its ability reducing metal salts (Dewi et al., 2019). This study was conducted to analyze the extract concentration and the optimum temperature in the silver nanoparticles synthesis process, to identify the silver nanoparticles characteristics, and to determine the antibacterial silver nanoparticles activity from the leaves of hairy melastoma against *S.aureus* dan *E.coli*.

RESEARCH METHODS

Tools And Materials

This study using several tools such as the a set of maceration, evaporator, Sterling Bidwell, oven, inkubator, autoklaf, UV-Vis Spectrophotometer (Shimadzu UV-1800), Scanning Electron Microscopy (Phenom ProX), Particle Size Analyzer (Horiba SZ-100). The materials used were senduduk bulu leaves, silver nitrate AgNO3 (Merck), etanol 96%, Escherichia coli ATCC 25422, Staphylococcus aureus ATCC 25423, media Nutrient Agar (NA), Vogel Jhonson Agar (VJA), Endo Agar (EA), Brain Heart Infusion (BHI), and Mueller Hinton Agar (MHA).

Methodology contains analysis about Data, Source of Data, Research Model, and Hypothesis Formulation (if quantitative research). Also state the hypothetical relationships (hypothesis creation starts from the variables that influence the variables that are influenced).

RESEARCH PROCEDURE

Simplicia Powder Process

Wet sorting of 5 kg of Senduduk bulu leaves was carried out to be used as a sample. The leaves are dried using an oven at a temperature of 40ºC. The dried leaves are then ground and sieved with a mesh size of 40 to collect fine powder.

Extraction

Extraction was processed by maceration with 96% ethanol solvent. The 1kg powdered senduduk bulu leaves is placed in a container and put in 96% ethanol. The first immersion is 6 hours while occasionally stirred, then left in 16 hours. Filtration is carried out to separate macerate from pulp. Extraction carried out by repeating using the same type of solvent at least once, with a half of the solvent volume in the initial extraction. Then the filtrate concentrated using vacuum rotary evaporator at 40ºC, and subsequently evaporated using a water bath until the hairy senduduk bulu leaves is thick extract obtained (Zhang et al., 2018).

Loss on Drying Determination

The powder was weighed to be 2 grams on a moisture balance, then heat the sample at 105ºC and let it finished, then record the results displayed on the moisture balance (Ulfah et al., 2020).

The Extract Water Content Determination Using Distilation Method

The water content determined using the toluene distillation method. The toluene 150 ml prepared and then saturated with 10 ml of aquadest, shaken and allowed to separate, then the water layer is discarded. The 20 grams of extract of hairy leaf senduduk bulu and put it in a round-bottomed flask. Add toluene into the round-bottomed flask and heat it for 15 minutes. All distilled water, the cooling part is rinsed using toluene then continued distillation for 5 minutes. Read the volume of water and toluene separately then calculate the water content using the formula % v/b (FHI, 2017).

The Specific Extract Determination

The specific extract type can be determined by diluting 5% extract using ethanol and using a calibrated pycnometer. The pycnometer is calibrated by determining the empty pycnometer and the water weight which heated to 25°C. Then filled pycnometer with the extract and placed in a 25°C (Lestari, 2021).

The Chemical Compounds Identification in the Senduduk Bulu Plant Leaves

This identification aims to analyze the chemical compounds accuracy present in the senduduk bulu plant leaves. Identification is carried out on saponins, tannins, flavonoids, steroids, and triterpenoids (Cyril et al., 2019).

Green Synthesis of Silver Nanoparticles (AgNPs)

Nanoparticle silver synthesis from the Senduduk Bulu plant leaves was conducted from several previous studies which been modified. The synthesis was carried out by varying the Senduduk Bulu extract concentration and the synthesis temperature to obtain the best composition in the synthesis process. The synthesis of silver nanoparticles begins with the preparation of a 1 mM $AgNO_3$ solution (Ethiraj et al., 2016) (Nakkala et al., 2017) Prepare extracts with several concentration variations (0.25%; 0.5% and 1%) (Naveed et al., 2022), where the 5 ml of every extract concentration was added to 50 ml of 1 mM AgNO3 solution as the homogeneous mixture. The Senduduk Bulu leaf extract mixture and 1 mM AgNO3 was heated with stirring using a Hot Plate Stirrer at each synthesis temperature (40°C, 50°C, 60°C, and 70°C) for 60 minutes. The silver nanoparticles formation indicated by a color change from yellow to red. (Dewi et al., 2019). Then measured using a UV-Vis spectrophotometer and the result in peak wavelength form in 400-450 nm which indicates the characteristic absorption of SPR (Surface Plasmon Resonance) from silver nanoparticles. The optimum concentration composition determination and temperature variations in silver nanoparticles synthesis process from senduduk bulu leaf extract can be observed from the several form spectra data from the wavelength and absorbance.

The Silver Nanoparticles Antibacterial Testing Activity

Testing the antibacterial activity against *S.aureus* and *E.coli* bacteria. The selected method is the disc diffusion method. This method utilizes paper discs as carriers of the substance being tested. The positive controls used are vancomycin for *S.aureus*, chloramphenicol for *E.coli* and the negative control is aquadest. The substance to be tested is prepared in a series of predetermined concentrations. Next, place the disc paper on a petri dish containing MHA media and inoculated with test bacteria. Then, incubate the dish at a temperature of 37°C for 18-24 hours, subsequently observe and measure the inhibition diameter. The region which is not inhabited by bacteria around the disc, indicating that silver nanoparticles (AgNPs) from the synthesis of the extract of the leaf of senduduk bulu have inhibitory effects on the bacteria *S.aureus* and *E.coli*.

Data Analysis

The antibacterial test data of silver nanoparticles from the hairy beggar-ticks leaves against *S. aureus* also *E. coli*, presented with the inhibition values zone diameters analyzed using the SPSS. The initial statistical analysis involved to examine whether the obtained data were normally distributed or not, using the Shapiro-Wilk test. If the data yielded a p-value < 0.05, then it considered non-normally distributed, and subsequent non-parametric tests conducted. The data obtained is $p > 0.05$, means that the data is normally distributed, thus proceeding with the Analysis of Variance test. Subsequently, Post Hoc test conducted to determine significant differences between each treatment.

RESULT AND DISCUSSION

Senduduk Bulu leaves 5 kg were dried in an oven at 40 ^{o}C. The result obtained was 1.8 kg of dried leaves with 36% yield. It was different with Diana, (2022) The fresh *Melastoma malabatricum* plant leaves are cut into small pieces and then dried using an oven to obtain 8.185% yield. The drying loss of the Melastoma malabatricum leaf powder is 8.1%, indicating the maximum compounds which evaporate during drying is 8.1%. It was different with (Aqila et al., 2022) The powdered simplicia drying loss was 8.665%. The drying loss simplicia of the hairy senduduk bulu (*Clidemia hirta*) results and the melastoma (*Melastoma malabatricum*) show slightly different outcomes, as both plants belong to the same Melastomataceae family.

One kilogram of powder macerated obtained an 152 g extract with 15.2% yield. A similar study using 96% ethanol as a solvent obtained a yield of 17.7% for the Senduduk leaf extract (*Melastoma malabatricum*) (Aqila et al., 2022), 10 % (Marlina, 2020) and 11,3% (Sapitri et al., 2020). According to Junedi et al., (2023) Clidemia hirta leaf extract using 70% ethanol solvent yielded in 25.34%. Lohvina et al., (2022) The extraction yield will increase as the the solvent polarity used increases.

The water content of the extract was obtained with an average of 8.83%, which is stated to still fall within the permissible range of extract water content. The allowable range for the water content of thick extract is between 5% and 30%. Meanwhile, liquid extract is >30% and for dry extract <5%. The water content determination related to the extract purity as low as the water content allows the extract to be free from contamination by mold and microorganisme (Komala & Haryoto, 2021).

The specific extract gravity obtained from the Senduduk Bulu plant leaves was found in 1.057 g/mL. It shows mass per unit volume and provides a boundary between liquid extract and concentrated extract. Specific gravity also indicates the connection with the substance purity determined by its specific gravity (Maryam et al., 2020).

To determine the chemical compounds in the extract, a color reaction test is conducted using test tubes, according to observing any changes. Positive results are indicated by the characteristic features of each compound tested. The identification results obtained are shown in table I.

Table 1. The Phytochemical Screening Result of The Extract.

Chemical Compound	Appearance	Result	Reference
Flavonoid	Reddish-orange color	Reddish-orange color	(Cyril et al., 2019)
Saponin	Foam	Foam	(Cyril et al., 2019)
Tannin	Dark green color	Dark green color	(Cyril et al., 2019)
Steroid or triterpenoid	Steroid :Blue-green color Triterpenoid : brown or violet	Blue-green color (Steroid)	(Loka et al, 2017)

The synthesis AgNPs results shown in table 1, where after mixing undergo a color change due to the presence of a bioreducer from several secondary metabolite compounds capable of reducing Ag+ ions to Ag^{o} ions. Electrons are donated from Ag+ ions to Ag^{o} ions so that the extract of senduduk bulu is oxidized, then reduced Ag ions are observed by the eye with a yellowish-brown color (Khan et al., 2018). The nanoparticles formation indicated by a color change in the solution. The color appearance due to AgNPs colloid has the characteristic could absorb light in the

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visible region at a wavelength 400-480 nm, that perceived by the eye as a yellowish-brown color (Afriani et al., 2022).

A **B** **C**

Figure 1. Physical appearances of $AgNO_3$ 1 mM solution (A), 1% extract (B) & AgNPs senduduk bulu (C)

The silver nanoparticles formation could observed by maximum wavelength measuring value using a UV-Vis spectrophotometer instrument (Vanlalveni et al., 2021). The UV-Vis spectrum of the silver nanoparticles (AgNPs) senduduk bulu leaves can be seen in figure 2.

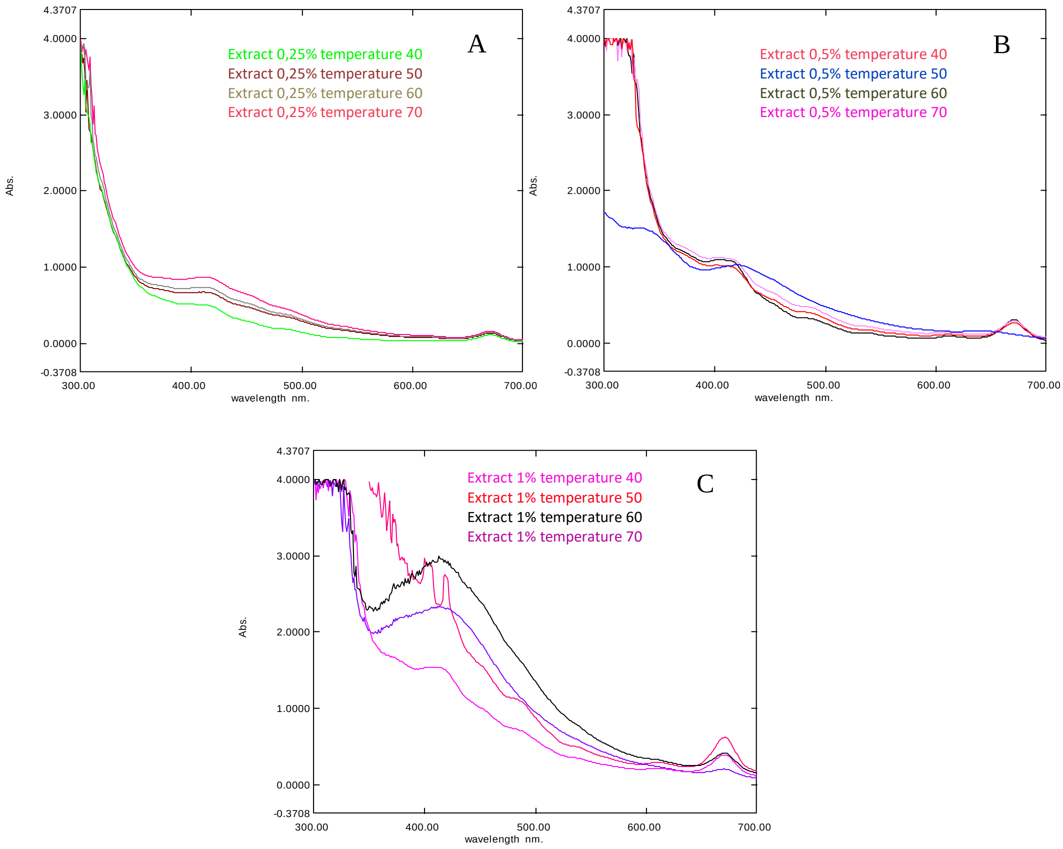

Figure 2. UV-Vis Spectrum temperature variations and 0,25% extract (A), UV-Vis Spectrum temperature variations and 0,5% extract (B) & UV-Vis Spectrum temperature variations and 1% extract

According to figure 2, it can be seen that there is an absorbance absorption development with increasing extract concentration. That the higher the extract concentration used will be the greater the absorbance value. The reducing agents increasing concentration able to increase the absorbance due to the increasing number of nanoparticles formed (Gusrizal et al, 2016). Increasing the extract concentration increase the rate of reduction of Ag^{+} ions to Ag^{-} (Gomathi et al., 2020). The formation of silver nanoparticles senduduk bulu leaves was demonstrated in the wavelength range of 400-450 nm from all extract concentrations. There is no significant difference in wavelength from small to large concentration variations. Therefore, the silver nanoparticles senduduk bulu leaves obtained tend to be stable (Taba et al. 2019).

The temperature variation effect also affects the absorbance value due to heating. In addition, the higher the temperature used at the time of synthesis of silver nanoparticles will accelerate the synthesis time and accelerate the reaction of Ag^{+} to Ag^{0}. During the heating process there will be interaction among particles in the solution causing the reaction which been formed to be more (Ahmed & Mustafa, 2020). In figure 2, shows the 1% extract at 70 ^{o}C, the absorbance value and wavelength have decreased, this decrease is likely due to the secondary damage metabolite compounds in the senduduk bulu leaf extract due to damage too high a temperature resulting in silver ion bioreductor agents being reduced. Matin et al., (2019) this shows that the silver nanoparticles formed are still unstable due to the concentration of the extract and the synthesis temperature is too high. In addition, very high temperatures will accelerate the reaction of silver nanoparticle formation, causing agglomeration to be faster as well (Stavinskaya et al., 2019). From the observations, it shows the optimum silver nanoparticles synthesis composition of senduduk bulu leaf extract is 1% Extract and 60 ^{o}C with a wavelength 413 nm absorption and 2.9987 absorbance.

The collection and purification of silver nanoparticles senduduk bulu colloids of optimum composition (extract 1% temperature 70ºC) is carried out using the centrifugation. The results obtained in the form of silver nanoparticle powder with a distinctive shiny black silver as much as 7.5 mg.

The nanoparticle measurements results using PSA in Figure 3 show the silver nanoparticles were obtained with 59.2±1.03 nm average size. It shows the particle size obtained falls within the nanoparticle size scale. In the resulting nano-size scale proves that leaf extract senduduk bulu has the potential as a reducing agent for nanoparticle synthesis. Where the size range of metal nanoparticles is 1-100 nm (Yaqoob et al., 2020).

The analysis silver nanoparticles senduduk bulu leaves obtained with 59.2±1.03 nm average. It shows the particle size obtained by silver nanoparticles leaves senduduk feathers in the nanoparticle size scale. The nanoscale size proves that the leaf extract senduduk bulu has the potential as a reducing agent in the synthesis of nanoparticles. Where the size range of metal nanoparticles is 1-100 nm.

In Figure 3 shows the Polydispersity Index (PI) value on silver nanoparticles obtained senduduk bulu leaves an average of 0.387 ±0.008 and is monodisperse. So, the silver nanoparticles of leaf senduduk feathers have good particle size uniformity. In addition the size of the nanoparticles is <150 nm and the PI 0,3 range is sufficient to be absorbed by the cell (Cervantes et al., 2019).

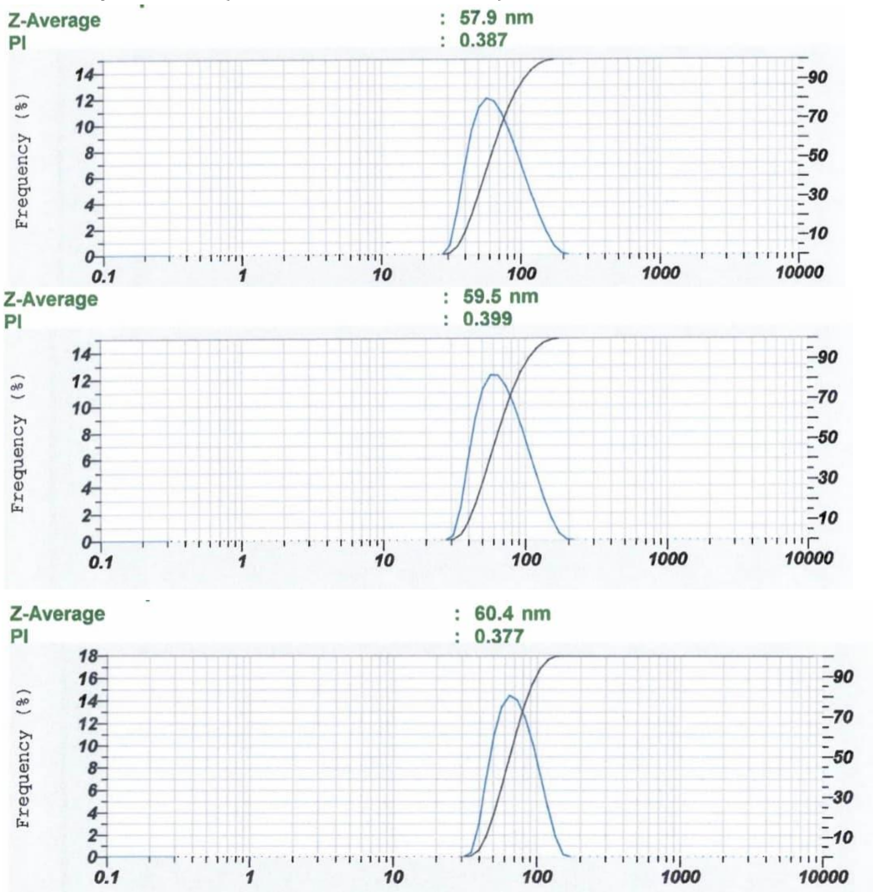

Figure 3. Particle size observation AgNPs using PSA.

Figure 4 shows the potential silver nanoparticles (AgNPs) zeta value obtained after 3 repetitions is negative with an average of - 39.3 mV, meaning AgNPs leaves senduduk bulu have good stability (Ahn et al., 2019).

Zeta Potential (Mean) : -39.1 mV
Electrophoretic Mobility Mean : -0.000302 cm^2/Vs

Zeta Potential (Mean) : -40.0 mV
Electrophoretic Mobility Mean : -0.000309 cm^2/Vs

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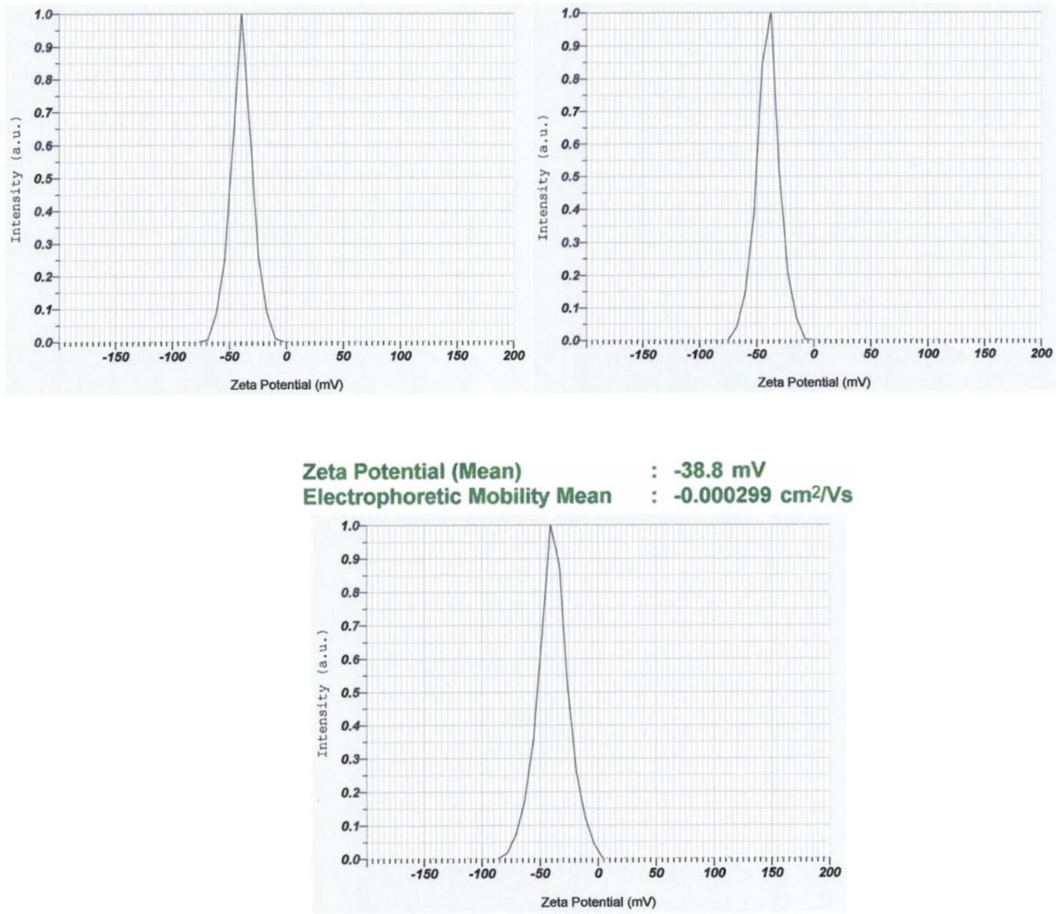
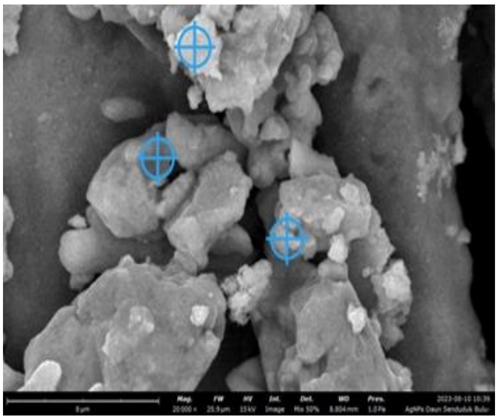
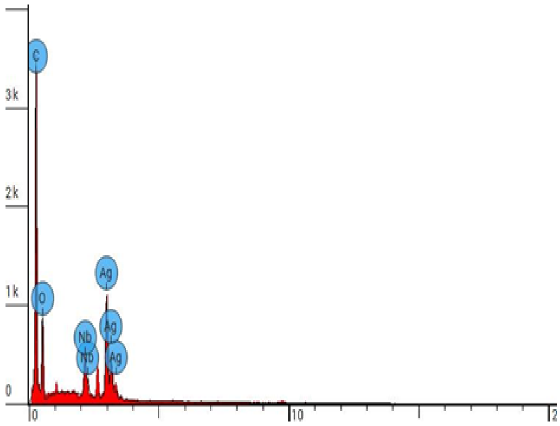


Figure 4. Potential zeta value result observation.

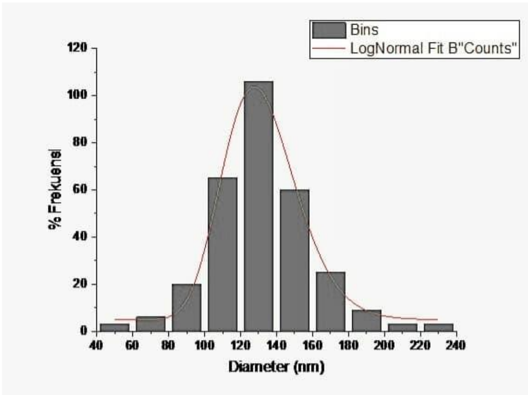
The morphology of AgNPs particles obtained is not uniform, some are box-shaped and tend to cluster. Observation of particle size distribution was done using imageJ-win32 software. From the observation of 300 points obtained particle size distribution senduduk feather leaves with 50-230 nm with 136 nm average. Obtained the smallest particle 50 nm with % frequency 3 and the largest size of 230 nm with % frequency 3. While the highest frequency % with a particle size of 130 nm. Different particle sizes are caused by the tendency particles to agglomerate so that the particles tend to clump together when the process of preparing test samples is carried out (Hemlata et al., 2020). The results of the analysis showed a high peak sharpness intensity in the typical silver optical absorption area shown at 3 keV. The result of SEM-EDS analysis can be seen in Figure 5.



(A)



(B)



(C)

Figure 5. AgNPs Morphology (A), AgNPs Atomic Composition Spectrum (B) & AgNPs Particle Size Distribution (C).

Based on table II, the chemical AgNPs composition percentage senduduk bulu leaves shows that silver (Ag) has the highest composition with a concentration of 37.688%. In addition, there are also compounds of carbon atoms (C) and oxygen (O) which are organic compounds that play an important role in the reduction and stability process of AgNPs in synthesis (Hemlata et al. 2020). While other concentrations measured in the sample are Niobium atom compounds (Nb) referred to as impurities that may be contained in the leaf extract senduduk fur, besides niobium atom (Nb) is a compound of the decay of heavy metal elements and one of the biomass contained in plants (Oliveira et al., 2023)

Table 2. The chemical silver nanoparticles composition of senduduk bulu leaf.

Element Number	Element	Atomic ratio (%)	Relative amount (%)
6	Carbon (C)	64.124	35.377
8	Oxygen (O)	26.528	19.497
41	Niobium (Nb)	1.743	7.437
47	Silver (Ag)	7.605	37.688

Silver nanoparticles (AgNPs) which obtained then tested for antibacterial activity against bacteria *S.aureus* and *E.Coli*. This test was conducted using AgNPs solution, $AgNO_3$ 1 mM, 1% Extract of senduduk bulu leaves and positive control chloramphenicol and vancomycin comparator and negative control of aquadest. The results obtained from testing the antibacterial activity of AgNPs senduduk bulu in the form of inhibition diameter are shown in the table III.

The table III shows the antibacterial activity result of silver nanoparticles senduduk bulu leaves (AgNPs), $AgNO_3$ 1 mM and extract 1% senduduk bulu leaves have the ability to inhibit the growth of *S.aureus* and *E.Coli*. Silver nanoparticles (AgNPs) have the greatest inhibitory power against *S.aureus* is with a diameter of 14.1°±0.3 mm. While $AgNO_3$ 1 mM and extract 1% each have an inhibition zone with an average of 9.7±0.1mm and 8.1±0.3mm. As a positive control vancomysin has an inhibition zone of 17.1°±0.1 mm and aquadest has no inhibition against *S.aureus*. Silver nanoparticles (AgNPs) also have the largest inhibitory diameter against *E.coli* that is with an average yield of 13.5±0.2 mm. While $AgNO_3$ 1 mM has an average inhibitory power of 8.6±0.2 mm and extract 1% an average of 7.5±0.2 mm. Chloramphenicol as a positive control has an inhibitory 24.06±0.1 mm zone against *E.Coli*. As negative control aquadest did not show no formation of inhibitory zones, the inhibitory zones were formed correctly derived from silver nanoparticles, 1% Extract and AgNO3 1 mM that is not affected by the solvent.

Table 3. Inhibition diameters for antibacterial activity test by diffusion test.

Sample	Inhibition diameter (mm) *S.aureus*			Mean±SD	Inhibition diameter (mm) *E.coli*			Mean±SD
	1	2	3		1	2	3	
AgNPs	14.4	14.1	13.8	14.1±0.3	13.3	13.7	13.5	13.5±0.2
$AgNO_3$ 1 mM	9.9	9.6	9.8	9.7±0.1	8.6	8.8	8.4	8.6±0.2
Extract 1%	8.4	8.1	7.8	8.1±0.3	7.6	7.3	7.8	7.5±0.2
Control (+)	17.1	17.1	17.3	17.1±0.1	24	24.2	24	24.06±0.1
Control (-)	0	0	0	0	0	0	0	0

Based on the table, the truth test is carried out by one-way Anova test. The analysis showed that the inhibitory diameter of AgNPs, $AgNO_3$ and extract were significantly different. In addition, the AgNPs leaves senduduk bulu have the best effectiveness in inhibiting bacterial growth. This occurs due to the influence of AgNPs which results in leakage of membrane proteins and bacterial reducing genes that can increase the permeability of bacterial cell membrane *S.aureus* and *E.coli*, resulting in leakage of plasma membrane that is high enough to cause damage to bacteria that make bacterial structures rot and cause death (Gomaa, 2017). The smaller particle size will generally have greater antibacterial activity when compared to larger particles. Particles with small sizes are also able to cross the cell membrane barrier, encourage free radicals, damage cell respiration and bacterial cell membrane permeability resulting in bacterial lysis or death (Liu et al., 2022).

In addition, AgNPs leaves senduduk bulu have a potential zeta value of -3 mV. The zeta potential AgNPs value leaf senduduk bulu also describes the electrostatic interaction between particles with opposite charges that will cause a stronger pull on the bacterial cell wall, causing the bacterial cell wall to rupture (Bruna et al., 2021). Silver nanoparticles (AgNPs) senduduk bulu leaves characterized known to contain silver metal compounds, Ag atoms work by releasing Ag^+ ions that will interact with bacterial DNA so as to inhibit replication and Ag^+ ions induce ROS production to damage DNA, RNA and bacterial proteins. The crystal morphology of silver nanoparticles (AgNPs) may also affect antibacterial activity. Particles that have a rectangular shape are known to have better antibacterial activity than the spherical shape (Sayed et al., 2022).

Based on the results shows that AgNPs senduduk bulu leaf has a larger diameter in inhibition against bacteria. Similar with Fatihin et al., (2016) and Dewi et al., (2019) AgNPs has a larger inhibitory zone against *S.aureus* compared to *E.coli*. The formation of different inhibition zones between Gram-positive and Gram-negative bacteria because there are differences in the arrangement of the cell wall. Gram-positive bacteria have a wider cell wall than Gram-negative bacteria. However, Gram-negative bacteria have an outer membrane that is outside the peptidoglycan layer that is not found in Gram-positive bacteria. The outer membrane acts as a selective permeability barrier to protect bacteria from harmful agents such as drugs, toxins, degradative enzymes and other antibacterial agents. Structure and chemical composition of the outer membrane of cell *E.coli* is known to have an asymmetric lipid bilayer. The inner layer contains tightly arranged phospholipid chains, while the outer layer consists of lipopolysaccharide molecules. The lipopolysaccharide layer on the outer membrane plays an important role in providing a selective permeability barrier for *E.coli* and other Gram-negative bacteria (Das et al., 2017).

CONCLUSION

Based on the results of the study, it can be concluded that the senduduk bulu leaves ethanol extract has the ability to reduce $AgNO_3$ into silver nanoparticles. The extract concentration of 1% and the temperature of 60° C is the optimal composition required for the synthesis of silver nanoparticles leaves senduduk bulu. Colloidal AgNPs leaves senduduk bulu have a size of 59.2±1.03 nm, the average value of the polydispersity index of 0.387±0.008, the potential zeta value of -39.3±-0.509. Silver nanoparticles (AgNPs) of senduduk bulu leaves have antibacterial activity with inhibitory diameter of 14.1±0.3 mm for *S. aureus* and 13.5±0.2 mm for *E.coli.*

DECLARATION OF COMPETING INTEREST

We as authors declare that this research was conducted without any commercial or financial relationships that could potentially give rise to conflicts or particular interests.

REFERENCE

Afriani, F., Susanti, S., Ramadhani, F., Soraya, M., & Evi.J, E. . (2022). Green-Synthesis Of Silver Nanoparticles Based On Bioreductor Key Orange Extract As Antibacterial. *Konstan - Jurnal Fisika Dan Pendidikan Fisika*, *7*(1), 12–17. https://doi.org/10.20414/konstan.v7i01.101

Ahmed, R. H., & Mustafa, D. E. (2020). Green synthesis of silver nanoparticles mediated by traditionally used medicinal plants in Sudan. *International Nano Letters*, *10*(1), 1–14. https://doi.org/10.1007/s40089-019-00291-9

Ahmed, S., Ahmad, M., Swami, B. L., & Ikram, S. (2016). A review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: A green expertise. *Journal of Advanced Research*, *7*(1), 17–28. https://doi.org/10.1016/j.jare.2015.02.007

Ahn, E. Y., Jin, H., & Park, Y. (2019). Assessing the antioxidant, cytotoxic, apoptotic and wound healing properties of silver nanoparticles green-synthesized by plant extracts. *Materials Science and Engineering C*, *101*(March), 204–216. https://doi.org/10.1016/j.msec.2019.03.095

Aqila Dliya Zhafira, Indra Topik Maulana, & Livia Syafnir. (2022). Uji Aktivitas Antifungi Ekstrak Daun Senduduk (Melastoma malabathricum (Linn.)) terhadap Jamur Candida albicans Penyebab Sariawan (Stomatitis Aphtosa Rekuren). *Bandung Conference Series: Pharmacy*, *2*(2), 65–73. https://doi.org/10.29313/bcsp.v2i2.3357

Bruna, T., Maldonado-Bravo, F., Jara, P., & Caro, N. (2021). Silver nanoparticles and their antibacterial applications. *International Journal of Molecular Sciences*, *22*(13). https://doi.org/10.3390/ijms22137202

Cervantes, B., Arana, L., Murillo-Cuesta, S., Bruno, M., Alkorta, I., & Varela-Nieto, I. (2019). Solid lipid nanoparticles loaded with glucocorticoids protect auditory cells from cisplatin-induced ototoxicity. *Journal of Clinical Medicine*, *8*(9), 1–17. https://doi.org/10.3390/jcm8091464

Cyril, N., George, J. B., Joseph, L., Raghavamenon, A. C., & Sylas, V. P. (2019). Assessment of antioxidant, antibacterial and anti-proliferative (lung cancer cell line A549) activities of green synthesized silver nanoparticles from Derris trifoliata. *Toxicology Research*, *8*(2), 297–308. https://doi.org/10.1039/C8TX00323H

Das, B., Dash, S. K., Mandal, D., Ghosh, T., Chattopadhyay, S., Tripathy, S., … Roy, S. (2017). Green synthesized silver nanoparticles destroy multidrug resistant bacteria via reactive oxygen species mediated membrane damage. *Arabian Journal of Chemistry*, *10*(6), 862–876. https://doi.org/10.1016/j.arabjc.2015.08.008

Dewi, K. T. A., Kartini, Sukweenadhi, J., & Avanti, C. (2019). Karakter Fisik dan Aktivitas Antibakteri Nanopartikel Perak Hasil Green Synthesis Menggunakan Ekstrak Air Daun Sendok (Plantago major L.). *Pharmaceutical Sciences and Research*, *6*(2), 69–81. https://doi.org/10.7454/psr.v6i2.4220

Diana, Y. (2022). Antibacterial Activity Test of the Ethanol in Leaves Extract of Senduduk (Melastoma malabathricum L.) Against Escherichia coli and

Staphylococcus aureus. *Jurnal Pembelajaran Dan Biologi Nukleus*, *6*(2), 139–152. https://doi.org/10.36987/jpbn.v6i2.1766

Ethiraj, A. S., Jayanthi, S., Ramalingam, C., & Banerjee, C. (2016). Control of size and antimicrobial activity of green synthesized silver nanoparticles. *Materials Letters*, *185*, 526–529. https://doi.org/10.1016/j.matlet.2016.07.114

Fadhli, H., Ikhtiarudin, I., & Lestari, P. (2020). Isolasi dan Uji Aktivitas Antioksidan Ekstrak Metanol Dari Buah Senduduk Bulu (Clidemia hirta (L.) D. Don). *Pharmacon: Jurnal Farmasi Indonesia*, *17*(2), 92–100. https://doi.org/10.23917/pharmacon.v17i2.9846

Fatihin, S., Hajono, & Kusuma, S. B. W. (2016). SINTESIS NANOPARTIKEL PERAKMENGGUNAKAN BIOREDUKTOR EKSTRAK BUAH JAMBU BIJI MERAH (Psidium guajava L.). *Indonesian Journal of Chemical Science*, *5*(3), 174–177. Retrieved from http://journal.unnes.ac.id/sju/index.php/ijcs

Gomaa, E. Z. (2017). Silver nanoparticles as an antimicrobial agent: A case study on Staphylococcus aureus and escherichia coli as models for gram-positive and gram-negative bacteria. *Journal of General and Applied Microbiology*, *63*(1), 36–43. https://doi.org/10.2323/jgam.2016.07.004

Gomathi, M., Prakasam, A., Rajkumar, P. V., Rajeshkumar, S., Chandrasekaran, R., & Anbarasan, P. M. (2020). Green synthesis of silver nanoparticles using Gymnema sylvestre leaf extract and evaluation of its antibacterial activity. *South African Journal of Chemical Engineering*, *32*(November 2019), 1–4. https://doi.org/10.1016/j.sajce.2019.11.005

Gusrizal, G., Santosa, S. J., Kunarti, E. S., & Rusdiarso, B. (2016). Dual function of p-hydroxy benzoic acid as reducing and capping agent in rapid and simple formation of stable silver nanoparticles. *International Journal of ChemTech Research*, *9*(9), 472–482.

Hemlata, Meena, P. R., Singh, A. P., & Tejavath, K. K. (2020). Biosynthesis of Silver Nanoparticles Using Cucumis prophetarum Aqueous Leaf Extract and Their Antibacterial and Antiproliferative Activity against Cancer Cell Lines. *ACS Omega*, *5*(10), 5520–5528. https://doi.org/10.1021/acsomega.0c00155

Junedi, S., Nurwijayanto, A., Simamora, D. D., Palimbongan, A. M., & Arsiningtyas, I. S. (2023). Potential Extracts of Melastomataceae Species from Mount Merapi National Park as Sunprotection Material with Antioxidation and Antiglycation Activities. *Tropical Journal of Natural Product Research*, *7*(1), 2172–2177. https://doi.org/10.26538/tjnpr/v7i1.14

Khan, A. U., Yuan, Q., Khan, Z. U. H., Ahmad, A., Khan, F. U., Tahir, K., … Ullah, S. (2018). An eco-benign synthesis of AgNPs using aqueous extract of Longan fruit peel: Antiproliferative response against human breast cancer cell line MCF-7, antioxidant and photocatalytic deprivation of methylene blue. *Journal of Photochemistry and Photobiology B: Biology*, *183*(2), 367–373. https://doi.org/10.1016/j.jphotobiol.2018.05.007

Komala, A. M., & Haryoto, H. (2021). Tests of Ash Content, Moisture Content and Dry

Shrinkage of Ethanol Extracts of Capidada Leaves (Sonneratia alba) and Ketapang (Terminilia cattapa). *Journal of Nutraceuticals and Herbal Medicine*, *3*(1), 10–14. Retrieved from https://journals.ums.ac.id/index.php/jnhm/article/view/10549

Kumar, B., Smita, K., Cumbal, L., & Debut, A. (2020). Phytosynthesis of silver nanoparticles using andean cabbage: Structural characterization and its application. *Materials Today: Proceedings*, *21*, 2079–2086. https://doi.org/10.1016/j.matpr.2020.01.327

Lestari, L. (2021). Standardisasi Spesifik Dan Non Spesifik Ekstrak Etanol Labu Kuning (, *4*(January), 37–44.

Liu, T., Pang, Q., Mai, K., He, X., Xu, L., Zhou, F., & Liu, Y. (2022). Silver nanoparticle@carbon quantum dot composite as an antibacterial agent. *RSC Advances*, *12*(16), 9621–9627. https://doi.org/10.1039/d2ra00561a

Lohvina, H., Sándor, M., & Wink, M. (2022). Effect of ethanol solvents on total phenolic content and antioxidant properties of seed extracts of fenugreek (Trigonella foenum-graecum l.) varieties and determination of phenolic composition by hplc-esi-ms. *Diversity*, *14*(1). https://doi.org/10.3390/d14010007

Loka, W. P., Sumadja, W. A., & Resmi. (2017). SKRINING FITOKIMIA SENYAWA METABOLIT SEKUNDER DARI EKSTRAK ETANOL BUAH DELIMA (Punica granatum L.) DENGAN METODE UJI WARNA. *Journal of Chemical Information and Modeling*, *21*(2), 1689–1699. Retrieved from https://www.oecd.org/dac/accountable-effective-institutions/Governance Notebook 2.6 Smoke.pdf

Lopez, T., Corbin, C., Falguieres, A., Doussot, J., Montguillon, J., Hagège, D., … Lainé, É. (2016). Influence de la composition du milieu de culture sur la production de métabolites secondaires et les activités antioxydantes et antibactériennes des extraits produits í partir de cultures in vitro de Clidemia hirta L. *Comptes Rendus Chimie*, *19*(9), 1071–1076. https://doi.org/10.1016/j.crci.2016.03.012

Marlina, D. (2020). FORMULASI SEDIAAN GEL EKSTRAK ETANOL DAUN SENDUDUK (Melastoma malabathricum L.) TERHADAP UJI KESTABILAN FISIK DAN UJI AKTIVITAS ANTIBAKTERI PADA STAPHYLOCOCCUS AUREUS. *JPP (Jurnal Kesehatan Poltekkes Palembang)*, *15*(2), 88–93. https://doi.org/10.36086/jpp.v15i2.557

Maryam, F., Taebe, B., & Toding, D. P. (2020). Pengukuran Parameter Spesifik Dan Non Spesifik Ekstrak Etanol Daun Matoa (Pometia pinnata J.R & G.Forst). *Jurnal Mandala Pharmacon Indonesia*, *6*(1), 1–12. https://doi.org/10.35311/jmpi.v6i01.39

Matin, T. A. B., Ghasemi, N., Ghodrati, K., & Ramezani, M. (2019). Green synthesis and characterization of silver nanoparticles using Scrophularia Striata extract. *Eurasian Chemical Communications*, *1*(6), 494–506. https://doi.org/10.33945/SAMI/ECC.2019.6.1

Moosa, A., Mousa Ridha, A., Hameed Allawi, M., & Moosa, A. A. (2015). Green Synthesis of Silver Nanoparticles using Spent Tea Leaves Extract with Atomic Force Microscopy International Journal of Current Engineering and Technology Green Synthesis of Silver Nanoparticles using Spent Tea Leaves Extract with Atomic Force Micros. *3233| International Journal of Current Engineering and Technology*, *5*(5), 3233–3241. Retrieved from http://inpressco.com/category/ijcet

Nakkala, J. R., Mata, R., & Sadras, S. R. (2017). Green synthesized nano silver: Synthesis, physicochemical profiling, antibacterial, anticancer activities and biological in vivo toxicity. *Journal of Colloid and Interface Science*, *499*, 33–45. https://doi.org/10.1016/j.jcis.2017.03.090

Naveed, M., Bukhari, B., Aziz, T., Zaib, S., Mansoor, M. A., Khan, A. A., … Alhomrani, M. (2022). Green Synthesis of Silver Nanoparticles Using the Plant Extract of Acer oblongifolium and Study of Its Antibacterial and Antiproliferative Activity via Mathematical Approaches. *Molecules*, *27*(13), 1–15. https://doi.org/10.3390/molecules27134226

Nilavukkarasi, M., Vijayakumar, S., & Prathip Kumar, S. (2020). Biological synthesis and characterization of silver nanoparticles with Capparis zeylanica L. leaf extract for potent antimicrobial and anti proliferation efficiency. *Materials Science for Energy Technologies*, *3*, 371–376. https://doi.org/10.1016/j.mset.2020.02.008

Oliveira, L., Pereira, M., Pacheli Heitman, A., Filho, J., Oliveira, C., & Ziolek, M. (2023). Niobium: The Focus on Catalytic Application in the Conversion of Biomass and Biomass Derivatives. *Molecules*, *28*(4). https://doi.org/10.3390/molecules28041527

Rahim, D. M., Herawati, N., & Hasri. (2020). Sintesis Nanopartikel Perak Menggunakan Bioreduktor Ekstrak Daun Teh Hijau (Camellia Sinensis) dengan Iradiasi Microwave. *Journal Chemica*, *21*(1), 30–41.

RI, K. (2017). Farmakope Herbal Indonesia Edisi II. *Pills and the Public Purse*, 97–103. https://doi.org/10.2307/jj.2430657.12

Sayed, F. A. Z., Eissa, N. G., Shen, Y., Hunstad, D. A., Wooley, K. L., & Elsabahy, M. (2022). Morphologic design of nanostructures for enhanced antimicrobial activity. *Journal of Nanobiotechnology*, *20*(1), 1–18. https://doi.org/10.1186/s12951-022-01733-x

Stavinskaya, O., Laguta, I., Fesenko, T., & Krumova, M. (2019). EFFECT of temperature on green synthesis of silver nanoparticles using vitex agnus-castus extract. *Chemistry Journal of Moldova*, *14*(2), 117–121. https://doi.org/10.19261/cjm.2019.636

Taba, P., Parmitha, N. Y., & Kasim, S. (2019). Sintesis Nanopartikel Perak Menggunakan Ekstrak Daun Salam (Syzygium polyanthum) Sebagai Bioreduktor Dan Uji Aktivitasnya Sebagai Antioksidan. *Indo. J. Chem. Res.*, *7*(1), 51–60. https://doi.org/10.30598//ijcr.2019.7-ptb

Tri Aksari Dewi, K., Sukweenadhi, J., & Avanti, C. (2019). ARTICLE HISTORY Karakter Fisik dan Aktivitas Antibakteri Nanopartikel Perak Hasil Green Synthesis Menggunakan Ekstrak Air Daun Sendok (Plantago major L.) Physical Characteristics and Antibacterial Activity of Silver Nanoparticle from Green Synthesis Proce. *Pharmaceutical Sciences and Research*, *6*(2), 69–81.

Ulfah, M., Kurniawan, R. C., & Erny, M. (2020). STANDARDISASI PARAMETER NON

SPESIFIK DAN SPESIFIK EKSTRAK ETANOL DAUN JAMBLANG (Syzygium cumini (L .) Skeels), *17*(2), 35–43.

Vanlalveni, C., Lallianrawna, S., Biswas, A., Selvaraj, M., Changmai, B., & Rokhum, S. L. (2021). Green synthesis of silver nanoparticles using plant extracts and their antimicrobial activities: a review of recent literature. *RSC Advances*, *11*(5), 2804–2837. https://doi.org/10.1039/d0ra09941d

Yaqoob, A. A., Umar, K., & Ibrahim, M. N. M. (2020). Silver nanoparticles: various methods of synthesis, size affecting factors and their potential applications–a review. *Applied Nanoscience (Switzerland)*, *10*(5), 1369–1378. https://doi.org/10.1007/s13204-020-01318-w

Zhang, Q. W., Lin, L. G., & Ye, W. C. (2018). Techniques for extraction and isolation of natural products: A comprehensive review. *Chinese Medicine (United Kingdom)*, *13*(1), 1–26. https://doi.org/10.1186/s13020-018-0177-x