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GREEN SYNTHESIS OF SILVER NANOPARTICLES USING RUKU-RUKU LEAVES AS A BIOREDUCTANT

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ABSTRACT

Using ruku-ruku leaf extract (Ocimum tenuiflorum L) as a bioreductant and stabilizer, this study aims to synthesize silver nanoparticles (AgNPs) using an environmentally friendly method. The green synthesis method was chosen as an alternative to chemical method because it is simpler, less expensive and has the potential to reduce the use of hazardous chemicals. After the ruku-ruku leaves were extracted with the appropriate solvent, the extract was reacted with a silver nitrate ($AgNO_3$) solution under specific conditions. The color change observed in the solution indicated the formation of silver nanoparticles. Characterization was performed using a UV-VIS spectrophotometer, fourier transform infrared (FT-IR) spectroscopy and a particle size analyzer (PSA). UV-VIS spectrophotometery identified absorption peaks associated with the surface plasmon resonance of silver nanoparticles and FT-IR analysis identified the functional groups in the secondary metabolites of ruku-ruku leaves that are responsible for stabilizing the nanoparticles and reducing Ag^+ ions to Ag^0. PSA is used to measure the size distribution, average size and uniformity of the synthesized particles. Several factors, such as precursor concentration, extract volume ratio, pH, temperature and reaction time, can influence the formation and characteristics of nanoparticles. Bioactive compounds, particularly phenolics and flavonoids, are expected to effectively reduce silver ions. It is hoped that this research will yield stable nanometer-sized silver nanoparticles with a nearly uniform size distribution. Ruku-ruku leaves, as a bioreductant, can help develop sustainable methods for synthesizing nanomaterials. They can also be used in the fields of antibacterial applications, health, the environment and materials technology.

Keywords : *Green synthesis, nanopartikel perak, daun ruku-ruku, bioreduktor Ocimum Tenuiflorum L, UV-VIS, FT-IR dan Particle Size Analyzer (PSA)*

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I. INTRODUCTION

Silver nanoparticles (AgNPs) have attracted considerable attention due to their distinctive physicochemical properties, including high electrical conductivity, optical properties, catalytic activity, and broad-spectrum antimicrobial activity. At the nanoscale, the optical response of AgNPs is closely related to localized surface plasmon resonance (SPR), which arises from the collective oscillation of conduction electrons on the nanoparticle surface when interacting with electromagnetic radiation. The position, intensity, and bandwidth of the surface plasmon resonance (SPR) are influenced by several factors, including particle size, morphology, aggregation state, and the dielectric environment surrounding the nanoparticles. Therefore, UV–Vis spectroscopy and SPR analysis are commonly used to monitor the formation and optical characteristics of AgNPs (Vanlalveni et al., 2021). Recent studies have shown that AgNPs produced by plants generally exhibit characteristic SPR absorption in the visible light spectrum, with the exact wavelength depending on the size, shape, and surface conditions of the synthesized particles (Alharbi, 2022).

Conventional physical and chemical methods for synthesizing AgNPs can provide good control over particle characteristics; however, these methods may require high energy input, extreme reaction conditions, or chemical reducing agents and stabilizers that can produce undesirable environmental residues. Therefore, environmentally

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friendly synthesis utilizing biological resources is gaining increasing attention as an alternative approach because it can reduce the use of hazardous chemicals and utilize renewable biological materials. In particular, plant extracts contain various phytochemical compounds, such as phenolic compounds, flavonoids, terpenoids, alkaloids, proteins, and other reducing biomolecules, which can play a role in reducing Ag^+ ions to metallic Ag^0 while also contributing to the stabilization of the resulting nanoparticles (Dhaka et al., 2023). Therefore, plant-mediated synthesis is considered a relatively simple, economical, and environmentally friendly method for producing AgNPs, although reproducibility and control over particle size and stability remain significant challenges (Fahim et al., 2024).

Among various biological resources, plants belonging to the genus Ocimum have significant potential as bioreducing agents because their leaves contain a variety of secondary metabolites capable of contributing to the formation of nanoparticles. Phytochemical compounds found in Ocimum species—including phenolics, flavonoids, terpenoids, alkaloids, and other bioactive compounds—can act as reducing agents and stabilizers during the synthesis of metal nanoparticles (Singh, 2022). For example, green synthesis of AgNPs using *Ocimum americanum* leaf extract has been reported to produce spherical nanoparticles and a characteristic SPR band, while FTIR analysis indicated the involvement of functional groups originating from plant biomolecules in the reduction and surface stabilization of the nanoparticles. More recently, AgNPs synthesized using different *Ocimum* species have also demonstrated that phytochemicals present in the extracts can contribute simultaneously to the reduction of Ag^+ ions and stabilization of the formed AgNPs (Alex et al., 2024). These findings indicate that *Ocimum*-based plant extracts are promising candidates for developing environmentally friendly AgNP synthesis.

However, although biomolecules originating from plant extracts can act as natural capping agents, uncontrolled interactions among newly formed nanoparticles may lead to aggregation or agglomeration. Aggregation changes the effective particle size and size distribution and can consequently affect the optical, surface, and biological properties of AgNPs. In UV–Vis spectroscopy, aggregation may produce broadening or shifting of the SPR band because the optical response of the nanoparticles is sensitive to interparticle distance and the surrounding environment. Therefore, controlling nanoparticle aggregation is essential for obtaining stable colloidal AgNPs with reproducible physicochemical characteristics (Poudel et al., 2022). The use of an appropriate capping or stabilizing agent is one strategy to prevent direct particle–particle interaction. Capping molecules can interact with the nanoparticle surface and generate a protective layer that provides steric and/or electrostatic stabilization, thereby limiting particle growth and aggregation.

One potential capping agent is myristic acid (tetradecanoic acid, $C_{14}H_{28}O_2$), a saturated fatty acid containing a carboxyl functional group and a long hydrocarbon chain. The carboxylate group can interact with the silver nanoparticle surface, while the hydrophobic alkyl chain can contribute to the formation of an organic surface layer. Previous studies have demonstrated the capability of myristic acid to stabilize AgNPs and influence their particle size and optical properties. Although early investigations specifically established the use of myristic acid as a capping molecule for AgNPs, more recent studies continue to emphasize the importance of capping agents and surface ligands in controlling nanoparticle size, morphology, aggregation, and colloidal stability. Thus, incorporation of myristic acid as an additional capping agent provides an opportunity to improve the stability of AgNPs synthesized through a plant-mediated route.

Despite the increasing number of studies concerning plant-mediated synthesis of AgNPs, several aspects remain insufficiently explored. Most studies have focused on the ability of plant extracts to simultaneously reduce and stabilize AgNPs, whereas the deliberate use of an additional fatty-acid-based capping agent to control aggregation has received comparatively less attention. In addition, studies involving *Ocimum* species have predominantly examined species such as *O. tenuiflorum*, *O. gratissimum*, and *O. americanum*, while the utilization of ruku-ruku leaf extract as a bioreducing agent and its combination with myristic acid as an external capping agent remains relatively limited (Singh, 2022). This creates an opportunity to investigate whether the combination of a plant-derived bioreductant and an additional surface capping agent can produce AgNPs with improved colloidal stability and controlled physicochemical characteristics.

Therefore, this study aims to synthesize AgNPs using ruku-ruku (*Ocimum* sp.) leaf extract as a natural bioreducing agent and myristic acid as a capping agent. The effect of myristic acid on the formation and stability of the synthesized AgNPs is investigated through their optical and physicochemical characteristics, particularly the SPR response, functional groups, and particle-size distribution. The results are expected to provide insight into

the role of plant-derived reducing compounds and myristic-acid surface capping in controlling the aggregation and stability of green-synthesized AgNPs.

II. METHOD

Materials and Equipment

The materials used in this study included a scale, a spatula, a funnel, an oven, tissue/masks, a sieve, a mortar and pestle, a fume hood, distilled water, $AgNO_3$, 250-ml Erlenmeyer flasks (two), 100-ml beakers, 250-ml beakers, 1000-ml beakers, a magnetic stirrer, ruku-ruku leaves, a UV-VIS spectrophotometer, an FT-IR and a particle size analyzer (PSA).

Preparation of ruku-ruku leaves

1. Separate the leaves from the stems, then select the best leaves for use
2. Wash the selected leaves thoroughly under running water
3. Bake the fresh ruku-ruku leaves in an oven at 40 ^{0}C for 1 hour
4. Grind the leaves using a mortar and pestle
5. Mix with approximately 100 ml of distilled water
6. Heat the ruku-ruku leaf water to 45 ^{0}C for 15 minutes
7. Strain the ruku-ruku leaf residue using a sieve
8. Store the liquid as a reducing agent

Preparation of ruku-ruku leaf extract

First, separate the ruku-ruku leaves from their stems, as we will be using the leaves to make ruku-ruku leaf extract. then we wash the leaves to remove any dirt adhering to them using running water; after cleaning, we proceed to the drying stage, where the leaves are sun-dried for several days to ensure they are dry and to reduce the moisture content in the ruku-ruku leaves. After the ruku-ruku leaves have been dried, we grind them into a fine powder. Once finely ground, we place the powder into a storage container to prevent the sample from being contaminated by surrounding debris.

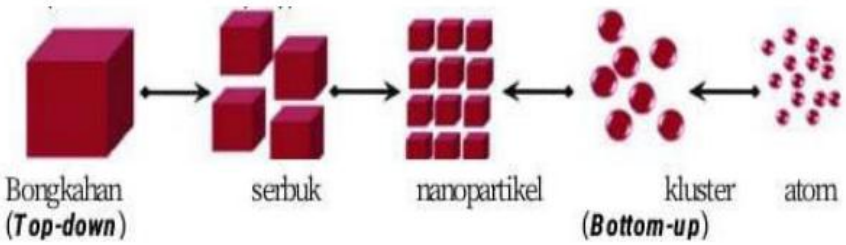
After grinding the ruku-ruku leaves, take a sample of the ground leaves (approximately 0.5 grams) and place it in a 250-ml Erlenmeyer flask. Then, mix the 0. 5 grams with 100 ml of distilled water. We then place the sample in a magnetic stirrer at 60°C for 15 minutes to ensure the sample is thoroughly homogenized. Next, we filter the solution to prevent the residue from being carried into the storage container, and then store the container at room temperature.

Synthesis of AgNPs

Weigh approximately 0.017×10 grams of $AgNO_3$, then add the weighed $AgNO_3$ to a container already filled with 1000 mL (1 liter) of distilled water. Mix thoroughly using a magnetic stirrer at 60°C, and store the solution in a storage container away from direct sunlight to prevent the formation of $AgNO_3$.

A 250-ml Erlenmeyer flask will be used for the AgNPs test. The flask is labeled "$AgNO_3$ + ruku-ruku leaf extract." Take the flask labeled "$AgNO_3$ + ruku-ruku leaf extract" for the test. Then, place this flask in a 250-ml Erlenmeyer flask containing approximately 100 ml of $AgNO_3$ solution, which is placed on a magnetic stirrer at 60°C, along with approximately 25 ml of ruku-ruku leaf extract for 30 minutes, and observe the color change from clear to brownish-yellow.

Methods such as top-down and Bottom-up



The synthesis of these nanoparticles can also employ two methods: top-down (converting particles larger than the nanoscale into nanoparticles) and bottom-up (converting smaller particles than the nanoscale into nanoparticles). The bottom-up method also has several advantages over the top-down method because it allows for easier manipulation of the nanoparticles to be synthesized. The bottom-up method is also carried out through a reduction reaction, and the principle of silver nanoparticle synthesis using this method involves the reaction of Ag^{+} ions to form Ag^{0}, which takes the form of silver nanoparticles (Oktavia & Sutoyo, 2021).

Hukum Lambert-Beer

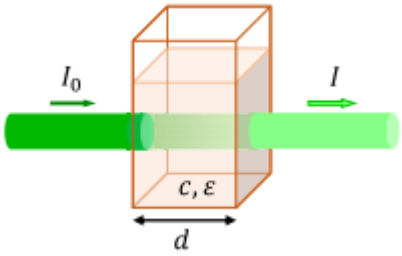
In his 1760 paper, Johann Heinrich Lambert explained Bouguer's statement mathematically; Lambert's law states that absorbance A and the path length of light d are directly proportional in a homogeneous medium, while the intensity of transmitted light decreases as the thickness of the absorbing medium increases (Oshina & Spigulis, 2021).

$$I = I_0 e^{-\mu_a d} \quad \text{..... 1}$$

$$A = \log\left(\frac{I_0}{I}\right) \propto d \text{.....2}$$

where I_0 is the incident light intensity, I is the light intensity after transmission through a thickness of d (cm), and μ_a is the absorption coefficient (cm^{-1}) of the medium (Oshina & Spigulis, 2021).

Beer extended this law of exponential absorption in 1852 to include the concentration of the solution (the mass of the absorbent) in the absorption coefficient. Beer's law also states that:



The graph above shows that the absorbance of monochromatic light passing through a homogeneous (transparent) medium is directly proportional to the concentration of sample substance C, as expressed by the following mathematical equation:

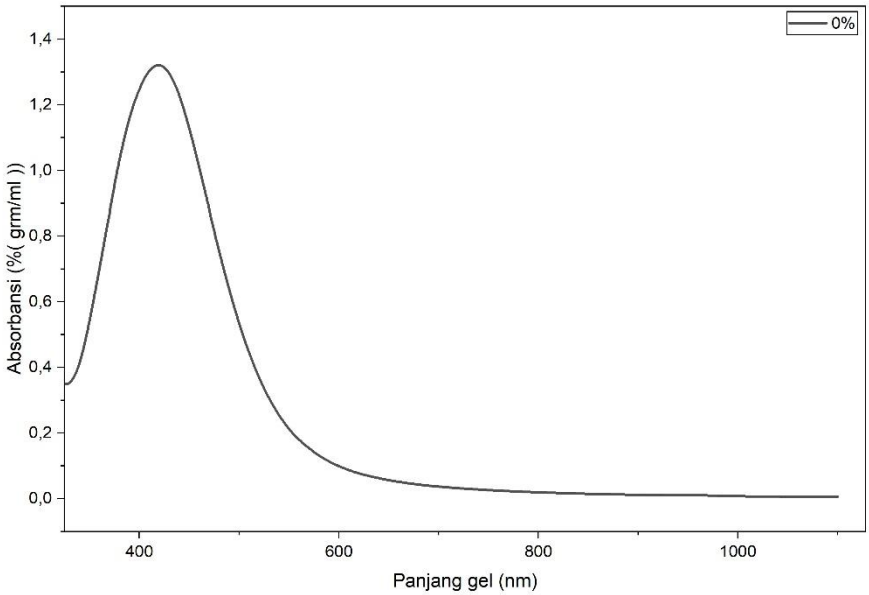
$$A \propto C$$

III. RESULTS AND DISCUSSION

Results

1. UV-Vis Spectrophotometer

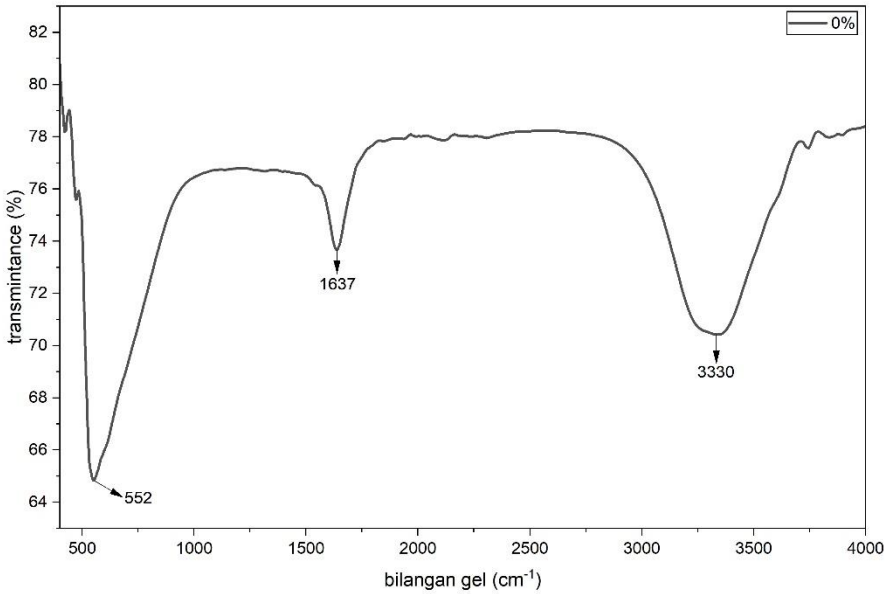
From the UV-Vis spectrophotometer test, we can see that the data generated is as follows :



Based on the data in the figure, we can see from the results of this UV-VIS spectroscopy that the AgNPs sample at a 0% myristic acid concentration exhibits a maximum absorption band at a wavelength of approximately 420 nm with an absorbance value of approximately 1.3. The appearance of an absorption band in this region is characteristic of the Surface Plasmon Resonance (SPR) of AgNPs and indicates the formation of silver nanoparticles through the reduction of Ag^{+} ions to Ag^{0}. The relatively broad SPR band suggests that the nanoparticle system likely has a non-uniform size distribution and/or interparticle interactions. Therefore, the UV-Vis spectrum at 0% concentration was used as a control to evaluate the effect of myristic acid addition on the SPR position, absorption intensity, band width, and stability of the AgNPs. Interpretation of changes in size and aggregation must subsequently be correlated with the results from the Particle Size Analyzer (PSA).

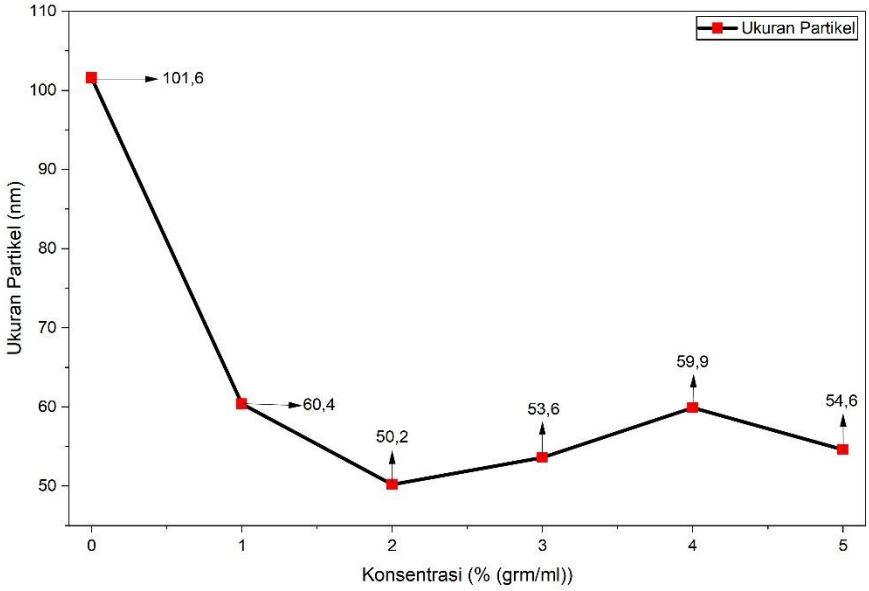
2. Fourier Transform Infrared Spectroscopy (FT-IR)

Based on the results of testing using Fourier Transform Infrared Spectroscopy (FT-IR), the data obtained are as follows:



The absorption band at 3330 cm^{-1} is quite broad. This indicates the presence of O–H groups, which likely originate from phenolic compounds, flavonoids, alcohols, or water molecules in the sample. These compounds may play a role in the reduction of Ag^{+} ions to Ag^{0} and help stabilize the silver nanoparticles. The peak at 1637 cm^{-1} may indicate the presence of aromatic C=C groups or water molecule bending vibrations. In leaf extracts, this band may also be associated with secondary metabolites that possess conjugated bond systems, such as phenolics and flavonoids. The peak at 552 cm^{-1} is located in the low wavenumber region. This band may be associated with metal–oxygen bond vibrations. However, identifying this peak as an Ag–O bond must be done with caution and should ideally be supported by other characterization results.

3. Particle Size Analyzer (PSA)



Based on the graph above, it can be seen that variations in concentration have a significant effect on the average size of the silver nanoparticles (AgNPs) produced. At a concentration of 0%, the largest particle size measured was 101.6 (nm). As the concentration increased from 1% to 2%, there was a significant decrease in particle size, reaching a minimum of 50.2 (nm) at a concentration of 2%. This decrease in size is caused by an increase in the number of bioactive compounds that act as electron donors, thereby accelerating the reduction of Ag^{+} ions to Ag^{0} and increasing the nucleation rate, which results in the formation of smaller particles. However, at concentrations ranging from 3% to 5%, the particle size again fluctuated and increased within the range of 53.6 (nm) to 59.9 (nm). This phenomenon indicates that a 2% concentration is the optimal condition for the formation of (AgNPs). Increasing the concentration beyond the optimum point can lead to an excess of reducing agents or stabilizers, which triggers agglomeration (clumping) among the particles.

Discussion

1. UV-VIS

The formation of silver nanoparticles (AgNPs) was confirmed using a UV-Vis spectrophotometer at wavelengths of 300–1100 nm. Based on this graph, the UV-Vis absorption spectrum of the control sample (0%) shows a maximum absorption peak (λ_{maks}) in the 420–430 nm wavelength range, with an absorbance value of 1.32. The appearance of an absorption peak at that wavelength is a characteristic feature of the Surface Plasmon Resonance (SPR) phenomenon, indicating that Ag^{+} ions from the solution ($AgNO_3$) have been successfully reduced to Ag^{0} by bioactive compounds from the ruku-ruku leaf extract. The symmetrical and isolated peak at a single wavelength indicates that the resulting silver nanoparticles are monodisperse with a predominantly spherical shape.

Konsentrasi	λmax UV-VIS (nm)	Absorbansi	Ukuran partikel PSA (nm)
0%	421 nm	1,3203 A	101,6 nm
1%	445 nm	1,3086 A	60,4 nm
2%	455 nm	1,0051 A	50,2 nm
3%	448 nm	1,0019 A	53,6 nm
4%	437 nm	1,1303 A	59,9 nm
5%	428 nm	1,8611 A	54,6 nm

Based on this table, the maximum UV-VIS value decreased from 421 nm at a 0% concentration to 455 nm at a 2% concentration and then decreased again to 428 nm at a 5% concentration. These changes indicate alterations in the optical characteristics of silver nanoparticles, which can be influenced by particle size and surface conditions.

These PSA results show that the particle size decreased from 101.6 nm at a 0% concentration to 50.2 nm at a 2% concentration. The size then increased slightly at 3% and 4%, to 53.6 nm and 59.9 nm, respectively, before decreasing to 54.6 nm at a 5% concentration.

There is no clear correlation between absorbance and particle size. The PSA size at a 5% concentration (54.6 nm) is not the smallest; however, the lowest absorbance is observed at a 3% concentration (1.0019 A), and the highest is at a 5% concentration (1.8611 A). Since absorbance is influenced by both the concentration of the nanoparticles and their optical properties, this indicates that absorbance cannot be used directly to measure particle size.

2. Fourier Transform Infrared Spectroscopy (FT-IR)

The FTIR spectrum in the graph shows several major absorption bands at wavenumbers of 3330, 1637, and 552 cm^{-1}. The spectrum is presented as transmittance (%), so that bands appearing lower on the graph indicate stronger absorption of infrared radiation by specific functional groups. The absorption band at 3330 cm^{-1} is a fairly broad and intense band. Absorption in this region is generally associated with the stretching vibration of the O–H group, particularly in compounds containing hydroxyl groups or where water molecules are bound or adsorbed onto the sample. If the sample consists of hydroxide-based materials, biomaterials, polymers, or hydrophilic materials, this band may indicate the presence of –OH groups. The width of the band may also indicate the presence of hydrogen bonds. Next, there is an absorption band at 1637 cm^{-1}. The region around 1600–1650 cm^{-1} can be associated with several types of vibrations, depending on the type of material being analyzed. One common possibility is the H–O–H bending vibration of adsorbed water, which typically appears around 1630–1650 cm^{-1}. However, if the sample contains certain organic compounds, this region may also be associated with C=C vibrations or conjugated carbonyl/amide groups. Therefore, definitive identification at 1637 cm^{-1} must be tailored to the sample's chemical composition and structure.

The band at 552 cm^{-1} is located in the low-wavelength region and may indicate metal–oxygen (M–O) bond vibrations, such as those found in inorganic materials or metal oxides. Absorption in the region around 400–700 cm^{-1} is often found in materials containing inorganic phases, so the presence of a band at 552 cm^{-1} may indicate the existence of a bond between a metal atom and oxygen. Secara keseluruhan, spektrum menunjukkan bahwa sampel memiliki gugus yang berhubungan dengan **–OH**, kemungkinan keberadaan **air teradsorpsi**, serta indikasi **ikatan logam–oksigen** pada daerah bilangan gelombang rendah. Tidak terlihat pita yang sangat dominan di sekitar **1700–1750 cm^{-1}**, yang biasanya merupakan karakteristik kuat gugus **C=O (karbonil)**. Hal ini dapat mengindikasikan bahwa gugus karbonil bukan merupakan gugus fungsi utama dalam sampel.

Daerah bilangan gelombang	0% (control/sebelum sintesis)	Setelah sintesis AgNP	Perubahan yang diamati	Dugaan gugus fungsi	interpretasi
±500-550 cm^{-1}	537 cm^{-1}	551, 547, 541, 543, 553 cm^{-1}	Terjadi pergeseran sekitar **4–16 cm^{-1}**	Vibrasi ikatan logam-oksigen /daerah fingerprint	Perubahan pita pada daerah ini dapat menunjukan adanya perubahan interaksi kimia yang berkaitan dengan pembentukan AgNP.Namun, penetapan spesifik sebagai Ag-O perlu didukung literatur atau karakterisasi lain.
±1635-1640 cm^{-1}	1636 cm^{-1}	1635, 1637, 1640 cm^{-1}	Terjadi pergeseran kecil sekitar 1-4 cm^{-1}	C=O/C=C; dapat berikatan dengan gugus amida	Pergeseran menunjukkan adanyan perubahan lingkungan kimia gugus yang mengandung oksigen/karbonil setelah sintesis. Gugus tersebut berpotensi berinteraksi dengan permukaan AgNp
±3300 cm^{-1}	3301 cm^{-1}	3298, 3304, 3306, 3308, 3322 cm^{-1}	Terjadi pergeseran sekitar 2-21 cm^{-1}	O-H stretching, kemungkinan juga N-H	Pergeseran pita menunjukan perubahan lingkungan gugus hidroksil atau hidroksil terkait hidrogen. Gugus -OH dari senyawa bioaktif ekstrak dapat berperan dalam reduksi Ag^{+} dan selanjutnya berintraksi dengan permukaan AgNP sebagai capping agent

Fourier Transform Infrared (FTIR) characterization was performed to determine changes in the functional groups present in the samples before and after the silver nanoparticle (AgNP) synthesis process. Based on the analysis

results, several major absorption bands shifted after AgNP synthesis. These shifts in wavenumber indicate changes in the chemical environment of the functional groups present in the sample, as well as their possible involvement in the synthesis and stabilization of silver nanoparticles. In the region around 500–550 cm^{-1}, the control sample exhibited a band at 537 cm^{-1}, whereas after AgNP synthesis, bands were observed at 541, 543, 547, 551, and 553 cm^{-1}. Thus, a band shift of approximately 4–16 cm^{-1} occurred. This low-wavenumber region can be associated with metal–oxygen (M–O) bond vibrations and is considered a fingerprint region. The change in band positions after synthesis indicates a change in the chemical interactions within the material following the formation of AgNPs. However, based on FTIR data alone, these bands cannot yet be specifically identified as Ag–O bonds; therefore, the identification of Ag–O bonds should be corroborated by literature reviews and other characterization methods.

The next band is in the 1635–1640 cm^{-1} region. In the control sample, a band was identified at 1636 cm^{-1}, whereas after AgNP synthesis, bands were observed at 1635, 1637, and 1640 cm^{-1}. The shifts observed were relatively small, ranging from about 1 to 4 cm^{-1}. Bands in this region can be associated with groups containing C=O or C=C, and based on the interpretation in the file, these bands may also be related to amide groups. The band shifts after synthesis indicate a change in the chemical environment of the oxygen- or carbonyl-containing groups. This suggests that these groups may have interacted with the surface of the silver nanoparticles during the synthesis process. A significant change was also observed in the region around 3300 cm^{-1}. The control sample exhibited a band at 3301 cm^{-1}, whereas after synthesis, bands were observed at 3298, 3304, 3306, 3308, and up to 3322 cm^{-1}. The shifts occurred in the range of 2–21 cm^{-1}. The bands in this region primarily correspond to O–H stretching vibrations, with a possible contribution from N–H vibrations. The shift in the O–H band after synthesis indicates a change in the chemical environment of the hydroxyl groups, particularly those involved in hydrogen bonding.

The –OH groups derived from bioactive compounds in the extract are believed to play an important role during AgNP synthesis. These groups may play a role in the reduction of Ag^{+} ions to Ag^{0}; subsequently, the same compounds or other functional groups may interact with the surface of the silver nanoparticles and act as capping agents. Thus, changes in the O–H band after synthesis may serve as an indication of the involvement of bioactive compounds in the extract in both the formation and stabilization of AgNPs.

3. Particle Size Analyzer (PSA

Based on the results of particle size measurements, variations in concentration affect the size of the silver nanoparticles (AgNPs) produced. At a concentration of 0%, a particle size of 101.6 nm was obtained; this then decreased to 60.4 nm at a concentration of 1% and reached a minimum size of 50.2 nm at a concentration of 2%. The decrease in particle size up to a 2% concentration indicates that this condition is optimal based on the particle size parameter, as it produces the smallest particles. However, increasing the concentration to 3% and 4% caused the particle size to increase to 53.6 and 59.9 nm, respectively. This increase in size may indicate a tendency toward aggregation or a shift in the balance between particle formation and growth at higher concentrations. At a 5% concentration, the particle size decreased again to 54.6 nm, but it was still larger than at the 2% concentration. Overall, the pattern of particle size changes showed a nonlinear relationship with increasing concentration. A 2% concentration produced the smallest particle size, namely 50.2 nm; therefore, based on the results of this study, it can be considered the optimal concentration for producing smaller AgNPs.

IV. CONCLUSION

Based on the results of research on the synthesis of silver nanoparticles (AgNPs) using ruku-ruku leaf extract, it can be concluded that AgNPs were successfully formed, as indicated by the appearance of UV-Vis absorption peaks in the 421–455 nm range associated with the Surface Plasmon Resonance (SPR) phenomenon. These results indicate that the bioactive compounds in the ruku-ruku leaf extract play a role in the reduction of Ag^{+} ions to Ag^{0}.

The FTIR characterization results showed changes and shifts in the absorption bands following the synthesis of AgNPs, particularly in the regions of 500–550 cm^{-1}, 1635–1640 cm^{-1}, and around 3300 cm^{-1}. These shifts indicate changes in the chemical environment of the functional groups following synthesis. O–H groups, as well as oxygen-containing, carbonyl, or amide groups, are thought to play a role in the formation and stabilization of AgNPs. The –OH groups from the bioactive compounds in the extract are thought to act as both reducing agents and capping agents on the surface of the AgNPs.

Variations in concentration also affected the particle size of AgNPs. The particle size decreased from 101.6 nm at a 0% concentration to 60.4 nm at 1% and reached its smallest size of 50.2 nm at a 2% concentration. At concentrations of 3% and 4%, the particle size increased to 53.6 and 59.9 nm, respectively, and then decreased slightly to 54.6 nm at a concentration of 5%. This pattern indicates a nonlinear relationship between concentration and particle size. Based on the particle size parameter, a 2% concentration is the most optimal condition because it produces the smallest AgNPs, namely 50.2 nm.

Thus, ruku-ruku leaf extract has the potential to be used as a bioreducing agent and stabilizer in the green synthesis of AgNPs, with a 2% concentration yielding the best results based on the particle size obtained. However, further confirmation regarding the morphology, size distribution, and crystal structure of the AgNPs is still needed through additional characterization.

REFERENCES

Alex, A. M., Subburaman, S., Chauhan, S., Ahuja, V., Abdi, G., & Tarighat, M. A. (2024). Green synthesis of silver nanoparticle prepared with Ocimum species and assessment of anticancer potential. *Scientific Reports*, *14*(1), 11707. https://doi.org/10.1038/s41598-024-61946-y

Alharbi, N. S. (2022). Green synthesis of silver nanoparticles using medicinal plants: Characterization and application. *Journal of Radiation Research and Applied Sciences*.

Arinda, D., Hidayat, R., Wardani, T. S., & Listyani, T. A. (2026). *KARAKTERISASI FISIKOKIMIA DAN ANALISIS FTIR (FOURIER TRANSFORM INFRARED SPECTROSCOPY) EKSTRAK ETANOL 70% DAUN PELAWAN (TRISTANIOPSIS MERGUENSIS (GRIFF.))*. *7*.

Dhaka, A., Chand Mali, S., Sharma, S., & Trivedi, R. (2023). A review on biological synthesis of silver nanoparticles and their potential applications. *Results in Chemistry*, *6*, 101108. https://doi.org/10.1016/j.rechem.2023.101108

Fahim, M., Shahzaib, A., Nishat, N., Jahan, A., Bhat, T. A., & Inam, A. (2024). Green synthesis of silver nanoparticles: A comprehensive review of methods, influencing factors, and applications. *JCIS Open*, *16*, 100125. https://doi.org/10.1016/j.jciso.2024.100125

James Sibarani, M. L. B. (2019). *SINTESIS NANOPARTIKEL PERAK (NPAg) MENGGUNAKAN EKSTRAK AIR DAUN KEMANGI (Ocimum Sanctum Linn.) DAN APLIKASINYA DALAM FOTODEGRADASI ZAT WARNA METILEN BIRU*.

Oktavia, I. N., & Sutoyo, S. (2021). REVIEW ARTIKEL: SINTESIS NANOPARTIKEL PERAK MENGGUNAKAN BIOREDUKTOR EKSTRAK TUMBUHAN SEBAGAI BAHAN ANTIOKSIDAN. *Unesa Journal of Chemistry*, *10*(1), 37–54. https://doi.org/10.26740/ujc.v10n1.p37-54

Oshina, I., & Spigulis, J. (2021). Beer–Lambert law for optical tissue diagnostics: Current state of the art and the main limitations. *Journal of Biomedical Optics*, *26*(10). https://doi.org/10.1117/1.JBO.26.10.100901

Poudel, D. K., Niraula, P., Aryal, H., Budhathoki, B., Phuyal, S., Marahatha, R., & Subedi, K. (2022). Plant-Mediated Green Synthesis of Ag NPs and Their Possible Applications: A Critical Review. *Journal of Nanotechnology*, *2022*, 1–24. https://doi.org/10.1155/2022/2779237

Saito, K., Xu, T., & Ishikita, H. (2022). Correlation between C═O Stretching Vibrational Frequency and p K_a Shift of Carboxylic Acids. *The Journal of Physical Chemistry B*, *126*(27), 4999–5006. https://doi.org/10.1021/acs.jpcb.2c02193

Singh, A. K. (2022). Ocimum sanctum mediated phytosynthesis of metallic nanoparticles: A review. *Bioresource Technology Reports*, *19*, 101118. https://doi.org/10.1016/j.biteb.2022.101118

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