Journal of Halal Science and Research (JHSR)
Vol. 5, No. 1, Month February, Year 2024, Page 39 – 46
doi: 10.12928/jhsr.v5i1.9508

P-ISSN: 2715-6214
E-ISSN: 2964-4909

Turi leaf extract Ag nanoparticle liquid soap (Review of physical properties and antibacterial activity)

Wilda Amananti[1*], Aldi Budi Riyanta[1]
[1]*Pharmacy Study Program, Politeknik Harapan Bersama, Mataram Street 9, Pesurungan Lor, Margadana, Tegal City 52193, Indonesia*
[*]*Corresponding author: amanatiku@gmail.com*

ABSTRACT

Research has been carried out on manufacturing liquid soap silver nanoparticles of Turi leaf extract. Ag nanoparticles have been used in various cosmetic and personal care products. This is because Ag nanoparticles have potential advantages such as increasing product stability, increasing absorption, and the ability to give special effects to the skin. From the physical properties test results, all soap formulas meet the standards set based on organoleptic, physical properties, pH, density, and viscosity. This research discusses the antibacterial activity of liquid soap. Formula 1 showed better antibacterial activity than formulas 2 and 3, with an inhibitory area reaching 23.84 mm. This can be explained by the fact that Formula 1 has a smaller particle size, namely 2161 nm. Formula 1 has the lowest $AgNO_3$ concentration. The higher the concentration of $AgNO_3$ used in the synthesis, the greater the amount of Ag^+ that must be reduced, resulting in greater agglomeration and a larger size distribution of Ag nanoparticles.

Keywords: Ag nanoparticles, Antibacterial activity, Liquid soap

INTRODUCTION

Silver (Ag) nanoparticles have shown interesting potential in pharmaceutical applications. (Anis et al., 2023). The unique properties of these silver nanoparticles are their very small size (in the nanometer range) (Ti et al., 2023). allow them to have different effects compared to larger silver particles. Using silver (Ag) nanoparticles as an antibacterial agent has become an interesting research area. The properties that make silver nanoparticles effective as antibacterial agents are due to their large surface area. Silver nanoparticles are very small in the nanometer range. This size causes them to have a large surface area in proportion to their volume. This large surface allows more interaction with bacteria and increases the killing potential of bacteria. (Khatun et al., 2023). Silver nanoparticles can be effective against various bacteria, including gram-positive and gram-negative bacteria. These include common disease-causing pathogens, including *Staphylococcus aureus* (Neto et al., 2020), *Escherichia coli* (Neme et al., 2023), and *Pseudomonas aeruginosa*. (Ferreres et al., 2023).

Ag nanoparticles have been used in various cosmetic and personal care products. (Xi et al., 2022). This is because Ag nanoparticles have potential advantages such as increasing product stability, increasing absorption, and the ability to give special effects to the skin. (Tang et al., 2023). Using silver nanoparticles in liquid soap can provide antibacterial benefits, thus helping to reduce the growth and spread of bacteria on the skin. (Anand et al., 2022). Stable silver nanoparticles can have a long shelf life and be used in various antibacterial applications.

However, there are concerns about the potential health and environmental impacts of using Ag nanoparticles. Ag nanoparticles wasted in the environment through liquid soap products can also harm aquatic ecosystems and living organisms. (Tortella et al., 2020). Silver nanoparticle biosynthesis is an alternative in dealing with environmental problems. Making or synthesizing silver nanoparticles uses biological materials, such as plant extracts or microorganisms, as reducing and stabilizing agents (Herrera-Marín et al., 2023). This method has become an interesting research subject because it has

P-ISSN: 2715-6214
E-ISSN: 2964-4909

several advantages, such as reduced environmental impact and relatively low production costs. (Anis et al., 2023)..

Turi leaves (*Sesbania grandiflora*) are one of the bioreductors that can synthesize silver nanoparticles (Das et al., 2013). This plant contains phytochemical compounds such as flavonoids, tannins, alkaloids, saponins, and terpenoids. (Malar et al., 2019). This bioactive compound can act as a reducing and stabilizing agent in the synthesis of silver nanoparticles because it has a -OH group that can donate electrons to Ag^{+} ions. (Hossain et al., 2022). This paper discusses the formulation of Turi leaf extract nanoparticle liquid soap. This article also examines the liquid soap's physical properties and antibacterial activity.

RESEARCH METHOD

Materials

The materials used in the research were $AgNO_3$ (Merck), Potassium hydroxide (Merck), and distilled water (Merck). Escherichia coli bacteria on nutrient agar media, antibiotic agar I media, Vogel Johnson's Agar media, gentian violet reagent. UV-Vis spectrophotometer, analytical balance, blender, stopwatch, and laboratory glassware.

Methods

1. Turi Leaf Extraction

   10 grams of powdered Turi leaves mixed with 100 ml of distilled water and boiled for 2 hours at 80°C. During the process, a light brown solution is formed. Then, the prepared extract was allowed to cool at room temperature, and finally, it was filtered using Whatman filter paper.
2. Synthesis of silver nanoparticles of Turi leaf extract

   Silver nanoparticles were prepared in 3 concentrations, namely 1 mM, 2 mM, and 3 mM. In each way, as much as 20 mL of silver nitrate solution 1 mM, 2 mM, and 3 mM was taken in a flask, and 1 mL of Turi leaf extract was added drop by drop. The color of the reaction mixture changed from colorless to yellowish brown, indicating the formation of Ag nanoparticles. Ag nanoparticle formation was monitored periodically by UV-Vis spectroscopy at different time intervals.
3. Turi Leaf Extract Silver Nanoparticle Liquid Soap Formulation

   Table 1 shows the formulation of Turi leaf extract silver nanoparticle soap. bahan-bahan yang digunakan dalam pembuatan sabun ini adalah Turi leaf extract Ag nanoparticles, Olive oil, KOH, CMC, SLS, Stearic acid BHA, Aquades.

Table 1. Formulation of Turi leaf extract nanoparticle liquid soap (Lomboan et al., 2021).

Material	Unit	Formulas		
		1	**2**	**3**
Turi leaf extract Ag nanoparticles	ml	1	2	3
Olive oil	ml	15	15	15
KOH	ml	8	8	8
CMC	gram	0.5	0.5	0.5
SLS	gram	0.5	0.5	0.5
Stearic acid	gram	0.25	0.25	0.25
BHA	gram	0,5	0.5	0.5
Aquades	ml	100	100	100

4. Test the physical properties of liquid soap.

   The physical properties test was carried out by measuring the physical properties of silver nanoparticle liquid soap based on organoleptic, pH, density, and viscosity tests.

RESULT AND DISCUSSION

Ag nanoparticle liquid soap made from Turi leaf extract. This paper reviews the physical stability and antibacterial activity of Ag nanoparticle liquid soap made from thorn leaf extract. There are three

P-ISSN: 2715-6214
E-ISSN: 2964-4909

liquid soap formulas with different concentrations of $AgNO_3$, namely F1, F2, and F3, which are 1 mM, 2 mM, and 3 mM, respectively. There are several stages in this research. The first stage is extracting Turi leaves, and the second is making silver nanoparticles from Turi leaf extract. The process of forming silver nanoparticles in this study was proven. The color of the reaction mixture changed from colorless to yellowish brown, indicating the formation of Ag nanoparticle products. The results of previous research stated that the formation of Ag nanoparticles could be observed visually by the appearance of a yellowish-brown color. The formation of Ag nanoparticles was monitored periodically by UV-Vis spectroscopy. The results of the UV-Vis spectroscopy of silver nanoparticles of Turi leaf extract are as follows: UV-Vis spectrophotometer test results of silver nanoparticles of Turi leaf extract are shown in Figure 1.

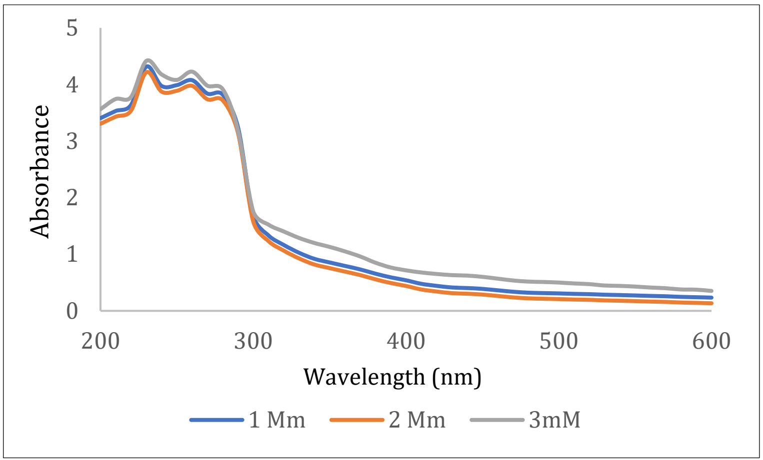


Figure 1. UV-Vis spectrophotometer test results of silver nanoparticles of Turi leaf extract.

The formation of nanoparticles can be monitored by UV Vis spectrometry measurements, the most frequently used quantitative method. The advantage of UV Vis spectroscopy is that it is fast, sensitive, and easy to use. Additionally, it can choose between several nanoparticles. $AgNO_3$ nanoparticles are formed, and the absorbance spectrum appears within 230. The growth of silver nanoparticles using a bioreactor consists of 3 phases. In the activation phase (phase 1), plants reduce silver in the $AgNO_3$ solution to form Ag^0. Continuing with the growth phase (phase 2), this phase is the ripening or preparation process in which small nanoparticles spontaneously combine to form larger particles. The termination phase (phase 3) is the last stage, where the Ag nanoparticles are capped, and, at the same time, a silver nanoparticle size with a certain diameter is formed. The particle size of the Ag nanoparticles of Turi leaf extract is based on the PSA (particle size analysis) test. Table 2 shows the particle size of Ag nanoparticles of Turi leaf extract.

Table 2. Particle size of Ag nanoparticles Turi leaf extract (Fitri et al., 2020)

Concentration $AgNO_3$	Particle Size
1 mM	2161 nm
3 mM	4869 nm

The third stage in this research was making Turi leaf extract Ag nanoparticle liquid soap. The soap was tested for physical properties and antibacterial activity.

Physical Properties Test Results of Ag Nanoparticle Soap Turi Leaf Extract

Like any other substance, liquid soap has physical properties that describe its characteristics without changing its chemical composition. These are some common physical properties of liquid soap. Appearance Liquid soap typically appears as a translucent or transparent fluid. The color can vary depending on the ingredients used, but it is often clear or slightly colored. Viscosity, viscosity refers to the thickness or flow resistance of a liquid. Liquid soap usually has a moderate viscosity, allowing it to

P-ISSN: 2715-6214
E-ISSN: 2964-4909

flow easily from a dispenser but still cling to surfaces. Density is the mass per unit volume of a substance. Liquid soap has a higher density than water, which can vary depending on the specific formulation. Odor: Liquid soap may have a distinct fragrance or be formulated to be odorless. The scent can vary based on the type of soap and any added fragrances. pH Level: The pH level of liquid soap can vary, but it is generally designed to be around a neutral pH (7) or slightly alkaline. This helps maintain skin compatibility and effective cleaning. Solubility: Liquid soap is soluble in water and can be easily mixed and dissolved to form a homogeneous solution. (Rasyadi et al., 2020). Following are some of the physical properties tests performed on soap products.

Organoleptic Test

An organoleptic test is a sensory evaluation that involves the examination of a product using the senses, such as sight, smell, taste, touch, and hearing. When conducting an organoleptic test for liquid soap, you will primarily focus on sight, smell, and touch, as tasting or hearing the soap is not typically part of the evaluation. Table 3 shows the Physical Properties of Turi Leaf Extract Nanoparticle Liquid Soap based on organoleptic tests.

Table 3. Physical properties of Turi leaf extract nanoparticle liquid soap based on organoleptic tests (Lestari et al., 2020).

Observation	F_1	F_2	F_3
Form	Liquid soap	Liquid soap	Liquid soap
Color	Green	Green	Green
Smell	Extract	Extract	Extract
Homogeneity	Homogeneous	Homogeneous	Homogeneous

pH of liquid soap

Testing the pH of liquid soap is important for several reasons, as it can impact both the effectiveness of the soap and its potential impact on the skin. The skin's natural pH is slightly acidic, typically 4.5 to 5.75. Using a soap with a pH close to that of the skin helps maintain the skin's acid mantle, a protective barrier against bacteria and other contaminants. Soaps with too high or too low pH levels can disrupt this balance, leading to skin irritation, dryness, or other skin issues. The cleaning effectiveness of soap is often optimized within a certain pH range. In general, soaps work best in a mildly alkaline environment. If the pH is too high or too low, it can affect the soap's ability to emulsify oils and remove dirt, compromising its cleaning efficacy. (Nurrosyidah et al., 2019). Table 4 shows the Physical Properties of Turi Leaf Extract Nanoparticle Liquid Soap based on the Ph test.

Table 4. Physical properties of Turi leaf extract nanoparticle liquid soap based on the pH test (Rosmainar, 2021).

Observation	F1	F2	F3
pH	10	10	10

The pH value in the soap formula is stable at pH 10. Determining the pH value aims to determine the acidity level of liquid soap. In general, liquid soap products have a pH that tends to be alkaline. The basic ingredient in liquid soap is KOH, which produces a saponification reaction with fats, oils, or synthetic detergents with a pH value above neutral pH. The skin surface has a pH ranging from 5.5 to 6.0. This value is influenced by the levels of released horn cells and other impurities attached to the skin. Only formulas F2 and F3 comply with the standards in the formulas produced. And stable for 6 weeks of storage. Suppose the pH of liquid soap does not meet the specified requirements. In that case, it will cause the horn layer of the skin to swell or become irritated due to increased skin permeability and accelerate the loss of the fatty acid coat on the skin surface. (Rasyadi et al., 2020).

Density test liquid soap

P-ISSN: 2715-6214
E-ISSN: 2964-4909

Density testing is a crucial aspect of quality control in manufacturing liquid soap. It ensures that the soap product meets specified standards and formulations. Consistent density indicates uniform composition, which is important for product performance and customer satisfaction. Understanding the density of liquid soap is essential for formulating the product correctly. Manufacturers must know the density to achieve the desired concentration of active ingredients, additives, and fragrances. This ensures that the soap performs as intended and meets regulatory requirements. Knowing the density of liquid soap is important for accurate dosing and dispensing. Proper dosing ensures effective cleaning and minimizes waste, whether used in household settings or industrial applications. Consistent density allows users to dispense the correct amount of soap for optimal results. (Usman & Baharuddin, 2023). Table 5 shows the Physical Properties test results of Turi Leaf Extract Nanoparticle Liquid Soap based on the density test.

Table 5. Physical properties test results of Turi leaf extract nanoparticle liquid soap based on density test (Rasyadi et al., 2019).

Observation	F_1(g/ml)	F_2(g/ml)	F_3(g/ml)
Density test	1.05	1.04	1.05

Based on the results of density checks carried out, all liquid bath soap formulas for kaffir lime leaves and robusta coffee meet the Indonesian National Standard for liquid soap preparations, namely 1.01 – 1.10 (Rosmainar, 2021). And stable for 6 weeks of storage. There is no significant difference in each formula added for raw materials for making liquid ingredients in this density parameter.

Viscosity Test

Testing the viscosity of liquid soap is crucial for several reasons, as it helps ensure product quality, performance, and user satisfaction. Viscosity refers to the thickness or resistance to flow of a liquid, and in the context of liquid soap, it plays a significant role in the overall product characteristics. Viscosity testing helps maintain consistent product quality. Customers expect a certain thickness or flowability from liquid soap, and consistent viscosity ensures that each batch meets these expectations. The viscosity of liquid soap affects the user experience. If the soap is too thin, it may be perceived as watery and less effective in cleaning. On the other hand, dispensing and spreading the soap may become challenging if it is too thick. Liquid soap is often dispensed using pumps or other mechanisms. Proper viscosity ensures the soap flows smoothly through these dispensers without clogging or causing operational issues. Meeting or exceeding consumer expectations for viscosity contributes to overall satisfaction with the product. A well-formulated liquid soap with the right viscosity is more likely to be preferred by consumers. (Hutauruk et al., 2020). Table 6 shows the physical properties test of Turi leaf extract nanoparticle liquid soap based on the viscosity test.

Table 6. Physical properties test of Turi leaf extract nanoparticle liquid soap based on viscosity test (Murti et al., 2018).

Observation	F_1(poise)	F_2(poise)	F_3(poise)
Viscosity	0.0188	0.0162	0.0168

Antibacterial Activity Test

Testing the antibacterial activity of liquid soap is crucial for several reasons, as it helps ensure the product's effectiveness, safety, and compliance with regulatory standards. Antibacterial soaps are commonly used to reduce the risk of infection and promote cleanliness. Testing ensures that the soap effectively kills or inhibits the growth of harmful bacteria, protecting consumers from potential infections. The primary purpose of antibacterial soap is to eliminate or reduce bacteria on the skin. Testing helps confirm the product's efficacy in achieving this goal. It ensures the soap meets the claimed antibacterial properties and performs as intended. Regular testing is part of the manufacturer's quality control processes. It helps identify any variations in the antibacterial activity of the product, ensuring

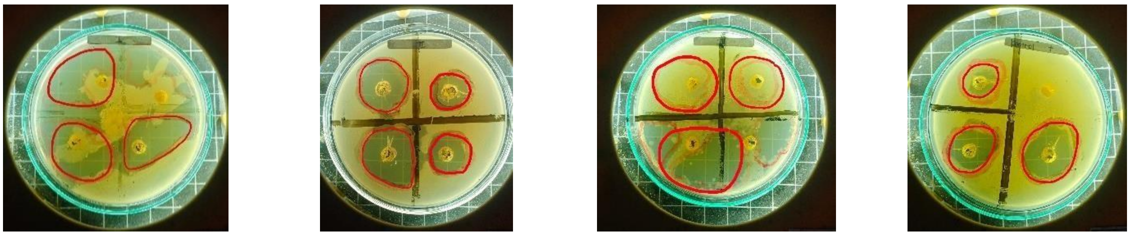
P-ISSN: 2715-6214
E-ISSN: 2964-4909

consistent quality and performance throughout the production process. Table 7 shows the antibacterial activity of Ag nanoparticle liquid soap turi leaf extract.

Table 7. Antibacterial activity of Ag nanoparticle liquid soap Turi leaf extract (Lestari et al., 2020).

Formulas	Extent of Inhibitory Power
1	6,21 cm^2
2	2,95 cm^2
3	7,69 cm^2
Control (+)	4,98 cm^2
Control (-)	0

The test found that Ag nanoparticle soap from turi leaf extract showed an inhibitory zone for Escherichia coli bacteria. Formula 3 has greater bacterial inhibitory power compared to formulas 1 and 2. This can be explained by the fact that the particle size of Formula 3 has the largest particle size among the others. Table 2 shows the particle size of each nanoparticle F1, F2, and F3 based on the results of PSA measurements. The PSA measurement results are in the form of a distribution so that they can be used to determine the overall particle size. (Scherer et al., 2019). The large particle size improves its antibacterial properties. The higher concentration of $AgNO_3$ used in the synthesis reduces the amount of Ag+, resulting in greater agglomeration and a larger distribution of Ag nanoparticles. (Abdulazeem et al., 2023). Figure 2 shows the image of the inhibitory area of the antibacterial activity test of Ag nanoparticle soap from Turi leaf extract against *Staphylococcus aureus* bacteria.



(a) (b) (c) (d)

Figure 2. Image of the inhibitory area of the antibacterial activity test of Ag nanoparticle soap from Turi leaf extract against *Staphylococcus aureus* bacteria. (a) Formula I, (b) Formula II, (c) Formula III, and (d) Kontrol (+)

CONCLUSION

Research has been carried out on the manufacture of turi leaf extract silver nanoparticle liquid soap. From the results of the physical properties test, all soap formulas meet the standards set based on organoleptic physical properties, pH, density and viscosity. This research discusses the antibacterial activity of liquid soap. Formula 1 showed better antibacterial activity than formulas 2 and 3 with an inhibitory area reaching 23.84 mm. This can be explained because formula 1 has a smaller particle size, namely 2161 nm. The large particle size is caused by imperfect production and synthesis methods for nanoparticles. an annealing process at high temperatures is needed to form a good crystal structure. Formula 1 has the lowest $AgNO_3$ concentration. The higher the concentration of $AgNO_3$ used in the synthesis, the greater the amount of Ag^+ that must be reduced, resulting in greater agglomeration and resulting in a larger size distribution of Ag nanoparticles.

REFERENCES

Abdulazeem, L., Alasmari, A. F., Alharbi, M., Alshammari, A., & Muhseen, Z. T. (2023). Utilization of aqueous broccoli florets extract for green synthesis and characterization of silver nanoparticles, with potential biological applications. *Heliyon*, *9*(9), e19723. https://doi.org/10.1016/j.heliyon.2023.e19723

Anand, B., Kim, K., Sonne, C., & Bhardwaj, N. (2022). Advanced sanitation products infused with silver nanoparticles for viral protection and their ecological and environmental consequences. *Environmental Technology & Innovation*, *28*, 102924. https://doi.org/10.1016/j.eti.2022.102924

Anis, S. N. S., Liew, W. C., Marsin, A. M., Muhamad, I. I., Teh, S. H., & Khudzari, A. Z. M. (2023). Microwave-assisted green synthesis of silver nanoparticles using pineapple leaves waste. *Cleaner Engineering and Technology*, *15*, 100660. https://doi.org/10.1016/j.clet.2023.100660

Das, J., Das, M. P., & Velusamy, P. (2013). Sesbania grandiflora leaf extract mediated green synthesis of antibacterial silver nanoparticles against selected human pathogens. *Spectrochimica Acta. Part a, Molecular and Biomolecular Spectroscopy (Print)*, *104*, 265–270. https://doi.org/10.1016/j.saa.2012.11.075

Ferreres, G., Ivanova, K., Torrent-Burgués, J., & Tzanov, T. (2023). Multimodal silver-chitosan-acylase nanoparticles inhibit bacterial growth and biofilm formation by Gram-negative Pseudomonas aeruginosa bacterium. *Journal of Colloid and Interface Science (Print)*, *646*, 576–586. https://doi.org/10.1016/j.jcis.2023.04.184

Fitri, D., Kiromah, N. Z. W., & Widiastuti, T. C. (2020). Formulasi dan karakterisasi nanopartikel ekstrak etanol daun salam (Syzygium polyanthum) pada berbagai variasi komposisi kitosan dengan metode gelasi ionik. *Journal of Pharmaceutical Science and Clinical Research*, *5*(1), 61. https://doi.org/10.20961/jpscr.v5i1.39269

Herrera-Marín, P., Fernández, L., Pilaquinga, F., Debut, A., Rodríguez, A., & Espinoza-Montero, P. (2023). Green synthesis of silver nanoparticles using aqueous extract of the leaves of fine aroma cocoa Theobroma cacao linneu (Malvaceae): Optimization by electrochemical techniques. *Electrochimica Acta*, *447*, 142122. https://doi.org/10.1016/j.electacta.2023.142122

Hossain, N., Islam, M. A., & Chowdhury, M. A. (2022). Synthesis and characterization of plant extracted silver nanoparticles and advances in dental implant applications. *Heliyon (Londen)*, *8*(12), e12313. https://doi.org/10.1016/j.heliyon.2022.e12313

Hutauruk, H., Yamlean, P. V. Y., & Wiyono, W. (2020). Formulasi dan uji aktivitas sabun cair ekstrak etanol herba seledri (Apium graveolens L) terhadap bakteri Staphylococcus aureus. *PHARMACON*, *9*(1), 73. https://doi.org/10.35799/pha.9.2020.27412

Khatun, M., Khatun, Z., Karim, M. R., Habib, M. R., Rahman, M. H., & Aziz, M. A. (2023). Green synthesis of silver nanoparticles using extracts of Mikania cordata leaves and evaluation of their antioxidant, antimicrobial and cytotoxic properties. *Food Chemistry Advances*, *3*, 100386. https://doi.org/10.1016/j.focha.2023.100386

Lestari, G., Noptahariza, R., & Rahmadina, N. (2020). Uji aktivitas antibakteri formulasi sabun cair ekstrak kulit buah durian (Durio zibethinus l.) terhadap bakteri Staphylococcus aureus. *Cendekia Journal of Pharmacy (Online)*, *4*(2), 95–101. https://doi.org/10.31596/cjp.v4i2.77

Lomboan, E. R., Yamlean, P. V. Y., & Suoth, E. J. (2021). UJI aktivitas antibakteri sediaan sabun cair ekstrak etanol daun cengkeh (Syzygium aromaticum) terhadap bakteri Staphylococcus aureus. *PHARMACON*, *10*(1), 767. https://doi.org/10.35799/pha.10.2021.32784

Malar, S., Venkatesan, M., Arumugam, V., Geetha, N., Saravanan, N., Murugesan, S., Ramachandran, S., Ayyasamy, R., & Pugazhendhi, A. (2019). Green synthesis and characterization of titanium dioxide nanoparticles (TiO2 NPs) using Sesbania grandiflora and evaluation of toxicity in zebrafish embryos. *Process Biochemistry*, *80*, 197–202. https://doi.org/10.1016/j.procbio.2019.02.010

Murti, I. K. A. Y., Putra, I. P., Suputri, N. N. K. T., Wijayanti, N., & Yustiantara, P. S. (2018). Optimasi konsentrasi olive oil tehadap stabilitas fisik sediaan sabun cair. *Jurnal Farmasi Udayana*, 15. https://doi.org/10.24843/jfu.2017.v06.i02.p03

Neme, I., Gonfa, G., & Masi, C. (2023). Castor seeds hull activated carbon impregnated with silver nanoparticles for removal of Escherichia coli from water. *Case Studies in Chemical and Environmental Engineering*, *7*, 100320. https://doi.org/10.1016/j.cscee.2023.100320

Neto, L. A. A., Pereira, T. M., & Silva, L. (2020). Evaluation of behavior, growth, and swarming formation of Escherichia coli and Staphylococcus aureus in culture medium modified with silver nanoparticles. *Microbial Pathogenesis*, *149*, 104480. https://doi.org/10.1016/j.micpath.2020.104480

P-ISSN: 2715-6214
E-ISSN: 2964-4909

Nurrosyidah, I. H., Asri, M., & Ma'ruf, A. F. (2019). Physical stability test of solid soap of temugiring (Curcuma heyneana Valeton & Zijp) rhizomes extract. *PHARMACY: Pharmaceutical Journal of Indonesia*, *16*(2), 209. https://dx.doi.org/10.30595/pharmacy.v16i2.4505

Rasyadi, Y., Fendri, S. T. J., & Wahyudi, F. T. (2020). Formulasi, evaluasi fisika, dan uji stabilitas sediaan pomade dari ekstrak etanol daun pare (Momordica charantia L.). *PHARMACY: Pharmaceutical Journal of Indonesia*, *17*(2), 281. https://doi.org/10.30595/pharmacy.v17i2.6988

Rasyadi, Y., Yenti, R., & Jasril, A. P. (2019). Formulasi dan uji stabilitas fisik sabun mandi cair ekstrak etanol buah kapulaga (Amomum compactum Sol. ex Maton). *Pharmacy (Purwokerto)*, *16*(2), 188. https://doi.org/10.30595/pharmacy.v16i2.5675

Rosmainar, L. (2021). Formulasi dan evaluasi sediaan sabun cair dari ekstrak daun jeruk purut (Citrus hystrix) dan kopi robusta (Coffea canephora) serta uji cemaran mikroba. *Jurnal Kimia Riset*, *6*(1), 58. https://doi.org/10.20473/jkr.v6i1.25554

Scherer, M. D., Spósito, J. C. V., Falco, W. F., Grisolia, A. B., Andrade, L., Lima, S. M., Machado, G., Nascimento, V. a. D., Gonçalves, D. A., Wender, H., Oliveira, S. L., & Caires, A. R. L. (2019). Cytotoxic and genotoxic effects of silver nanoparticles on meristematic cells of Allium cepa roots: A close analysis of particle size dependence. *Science of the Total Environment*, *660*, 459–467. https://doi.org/10.1016/j.scitotenv.2018.12.444

Tang, T., Nguyen, T. H., Tran, C. M., Doan, V. K., Nguyen, N. T., Vu, B. T., Dang, N. N., Duong, T. T., Phạm, V. H., Tran, L. D., Vo, T. V., & Nguyen, T. (2023). Fabrication of silver nanoparticle-containing electrospun polycaprolactone membrane coated with chitosan oligosaccharides for skin wound care. *Journal of Science: Advanced Materials and Devices*, *8*(3), 100582. https://doi.org/10.1016/j.jsamd.2023.100582

Ti, A., Ej, I., & Adebayo, A. H. (2023). Evaluation of antioxidant and antimicrobial properties of silver nanoparticles biosynthesized using weed (Dactyloctenium aegyptium) extracts for sustainable environment, agriculture and ethnomedicine. *Materials Today: Proceedings*. https://doi.org/10.1016/j.matpr.2023.06.223

Tortella, G., Rubilar, O., Durán, N., Díez, M., MartíNez, M. Á., Parada, J., & Seabra, A. B. (2020). Silver nanoparticles: Toxicity in model organisms as an overview of its hazard for human health and the environment. *Journal of Hazardous Materials*, *390*, 121974. https://doi.org/10.1016/j.jhazmat.2019.121974

Usman, Y., & Baharuddin, M. (2023). Uji Stabilitas dan Aktivitas Sabun Mandi Cair Ekstrak Etanol Daun Alpukat (Persea americana Mill.). *Jurnal MIPA (Edisi Elektronik)*, *12*(2), 43–49. https://doi.org/10.35799/jm.v12i2.44775

Xi, J., Kan, W., Zhu, Y., Huang, S., Wu, L., & Wang, J. (2022). Synthesis of silver nanoparticles using Eucommia ulmoides extract and their potential biological function in cosmetics. *Heliyon (Londen)*, *8*(8), e10021. https://doi.org/10.1016/j.heliyon.2022.e10021