Journal Pharmaceutical Science and Application
Volume 6, Issue 1, Page 1-8, June 2024
E-ISSN: 2301-7708

TRACING OF SECONDARY METABOLITES AND ANTIMICROBIAL ACTIVITY OF SAPINDACEAE AS AN EFFORT TO PRESERVE HERBAL PLANTS: A REVIEW

Antonius Oenunu Sanan[1], Triana Hertiani[2], Yosi Bayu Murti[2*]

[1]Master in Pharmaceutical Sciences, Faculty of Pharmacy, Universitas Gadjah Mada, Yogyakarta 55281, Indonesia.
[2]Departement of Pharmaceutical Biology, Faculty of Pharmacy, Universitas Gadjah Mada, Yogyakarta 55281, Indonesia.

Corresponding author email: yosibayu.murti@ugm.ac.id

ABSTRACT

Background: Sapindaceae plants in the community are used to treat various diseases. This plant is traced to contain secondary metabolites with various pharmacological activities, including antimicrobials. **Objective**: This review article aims to provide information about Sapindaceae plants with antimicrobial potential and summarize the content of secondary metabolite compounds. **Methods**: This review article uses sources from international and national journals obtained by online search and considers two criteria, namely inclusion and exclusion. Then, it was further selected to obtain data in the form of secondary metabolites that can potentially be antimicrobial. **Results**: Some parts of the Sapindaceae plant contain essential secondary metabolites such as alkaloids, flavonoids, phenols, tannins, saponins, and triterpenoids. These secondary metabolites have a potential pharmacological activity that has been tested against antimicrobials. **Conclusion**: Sapindaceae plants contain diverse secondary metabolites and have antimicrobial activity. Further research is needed to explore other Sapindaceae plant species to find compounds and other pharmacological activities to address various diseases in the community.

Keywords: Sapindaceae; Secondary metabolite component; Antimicrobial Activity.

INTRODUCTION

Indonesia has 13,576 species of medicinal plants, 15,671 types of health herbs, and 1,183 traditional medicines[1]. Secondary metabolites, such as alkaloids, flavonoids, essential oils, glycosides, tannins, saponins, and terpenes, are characteristic of medicinal plants[2-3]. Plants are a significant source of natural bioactive compounds due to their ability to synthesize different bioactive[4]. The place where plants grow also affects the synthesis and accumulation of secondary metabolites[5]. Not many plant species worldwide contain bioactive substances[6]. The use of medicinal plants has increased in the last thirty years. About eighty percent of people worldwide still use herbal remedies as the primary method to improve their health[7]. This results in low prices, low side effects, or toxicity, leading to increased demand and use of herbal remedies[8].

Sapindaceae is one of the flowering plant tribes that is often referred to as the soapberry tribe or leak-Arakan[9]; the Sapindaceae plant family consists of around 2000 tropical and subtropical species, which are primarily upright trees and shrubs (five of the 150 generations are lianas). Several types of plants from the

DOI : https://doi.org/10.24843/JPSA.2024.v06.i01.p01

tribe Sapindaceae have been used in everyday life and have economic benefits, including as tropical fruits, namely rambutan (*Naphaleum lappaceum*), kelengkeng (*Dimocarpus longan*), kusambi (*Schleicher oleosa* L oken), (*Sapindus rarak* DC) lerak and matoa (*Pometia pinnata*)[10].

Plants from the Sapindaceae family are widely distributed in Southeast Asia, South Asia (Cambodia, India, Myanmar, Sri Lanka, Thailand, and Vietnam), and Indonesia, covering Sumatra, Java, Kalimantan, Maluku, and Nusa Tenggara. The bioactivity of several plants belonging to Sapindaceae has been studied, among others, as antioxidants, anti-inflammatory, antidiabetic[11,12], and antimalarials[13]. Various bioactive compounds from Sapindaceae have been isolated and empirically in the community and have been widely used in treating several diseases such as fever, skin pain, sprains, dysentery, anti-inflammatory, and wound healing. Therefore, this study aims to determine the content of secondary metabolite compounds, and the potential antimicrobial activity of Sapindaceae plants is expected to further strengthen in this case, convincing the public that Sapindaceae has pharmacological activity and is beneficial to health.

METHODS

The methods in this study were obtained from various sources, such as a literature search. The process of data disbursement through searches on Google, PubMed, and Google Scholar by searching for antibacterial activity from plants of the tribe Sapindaceae, such as rambutan, kelengkeng, meta, kusambi, and leak. The keyword used in the literature search is antimicrobial bioactive compounds from Sapindaceae. The search data is then further selected to obtain data related to antimicrobial activity and secondary metabolites that can potentially be antimicrobial. The inclusion criteria in library search are: 1). Articles using Indonesian and English, 2). Articles are available in the form of full descriptions, 3). The literature explains the antimicrobial activity and the content of secondary metabolites that have the potential to be antimicrobial, while the exclusion criteria are literature in the form of article reviews.

RESULTS AND DISCUSSION

Based on the search results, 30 scientific articles were obtained. It was found that Sapindaceae plants and their plant parts contain secondary metabolite compounds and have the potential to be antimicrobial.

1. *Naphaleum lappaceum* (Rambutan)

   Tracing the class of phytochemical compounds from various parts of the rambutan plant shows the presence of tannins, polyphenols, triterpenoids, alkaloids, flavonoids, and saponins in the skin of rambutan fruit [14]. Rambutan seeds contain polyphenols and fats. Rambutan leaves contain saponins, flavonoids, alkaloids, monoterpenes, sesquiterpenes, quinones, polyphenols, terpenoids, and tannins [15].

   Tracing on rambutan leaf extract inhibited the growth of Staphylococcus aureus bacteria with concentrations of 5%, 20%, 50%, and 75%. Inhibitory zones at 0 mm, 16 mm, 21 mm, and 26 mm. The study used the disc diffusion method or paper discs to test antibacterial activity [16].

   Previous studies have tested the antibacterial properties of rambutan leaf extract, which can kill bacteria *Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli,* and others. *Candida albicans, Staphylococcus epidermidis, Bacillus subtilis*, and bacterial tests have been carried out on the antibacterial

DOI : https://doi.org/10.24843/JPSA.2024.v06.i01.p01

properties of rambutan leaf fraction against P. aeruginosa, S. dysenteriae, B. cereus, and E. coli bacteria [17,18].

2. *Dimocarpus longan* (Kelengkeng)

Longan peel ethanol extract contains flavonoids, phenolics, polyphenols, terpenoids, steroids, alkaloids, saponins, and coumarins[19]. Longan leaf ethanol extract contains saponin group compounds, flavonoids, triterpenoids, tannins, steroids, and glycosides[20]. In a study on ethanol extract, seeds and longan peel were tested for antibacterial activity by dilution with antibacterial activity test results for 95% ethanol peel extract. Longan at 0.25% to 4% has not shown antibacterial activity against *Staphylococcus aureus*, while 95% ethanol extract of longan seeds at concentrations of 2% to 8% has antibacterial activity against *Staphylococcus aureus*[21]. The ethanol fraction of longan seeds has antibacterial and antibiofilm activity against *Staphylococcus aureus* ATCC 6538. The ethyl fraction with a concentration of 100000 ppm has the most excellent antibacterial activity against *Staphylococcus aureus* ATCC 6538 with a DHP of 14.59 ± 0.01 mm. 100000 ppm concentration has the highest antibiofilm activity in *Staphylococcus aureus* ATCC 6538 bacteria with percent inhibition of biofilm formation 99.08%. The ethyl acetate fraction is the most significant fraction of antibacterial activity, and antibiofilms contain flavonoids, tannins/polyphenols, and triterpenoid saponins[22]. The chemical content in longan skin is gallic acid, flavone glycosides, and hydrodynamic, with the main flavones in quercetin and kaemferol[23].

The ether, chloroform, and ethyl acetate fractions of longan leaves and branches have antibacterial, antioxidant, and toxic activity against Artemia salina L. (BST method)[24]. Longan stem chloroform extract also has potential against *Candida albicans* and *Aspergillus niger* fungi with an inhibitory power concentration of 100 µg[25]. Extracts in longan seeds contain phenolic compounds such as corylagine, gallic acid, and ellagic acid and have bioactive compounds[26]. The study was reinforced by the same study stating that oil from longan seeds has the potential to be antibacterial against *Escherichia coli* with a KHM value of 45.74%. Leaf and stem extract of 500 g Nephelium longan plant growing in Tangail Bangladesh showed antimicrobial and antibacterial properties. Inhibition of bacteria *Staphylococcus aureus* (inhibitory zone 14 mm), *Escherichia coli* (inhibitory zone 17 mm), *Salmonella typhi* (inhibitory zone 18 mm), *Vibrio mimicus* (inhibitory zone 18 mm), and *Sarcina lutea* (inhibitory zone 20 mm) were all inhibited by Nephelium longan plants[27].

3. *Schleichera oleosa L oken* (Kusambi)

Phytochemical studies of kusambi bark extract contain triterpenoids, phenolics, alkaloids, and flavonoids[28]. Kusambi leaf and seed extracts contain components of alkaloid compounds, tannins, phenolics, saponins, flavonoids, and triterpenoids[29]. Phenolics and flavonoids are the most abundant components in kusambi leaves. 96% methanol extract on leaves can bind seven compounds (flavonoids, alkaloids, tannins, triterpenoids, phenols, and saponins). Fruit peels contain saponins, alkaloids, phenolics, tannins, terpenoids, and flavonoids[30].

Antibacterial activity test found S. aureus bacteria on ethyl acetate fraction skin inhibition value of 59.76% and positive control

DOI : https://doi.org/10.24843/JPSA.2024.v06.i01.p01

(Ciprofloxacin) of 53.59% [31]. Activity test on C. albicans fungus on kusambi seed oil isolates results from minimum inhibitory concentration (MIC) 333.33 µl / ml. Kusambi oil has a practical MIC value against 81.25% of C.albicans microbial isolates, which is as efficient as Amphotericin-B and higher than Itraconazole (73.44%), Clotrimazole (71.875%), Nystatin (68.75%) and Fluconazole (59.375%) [32]. Kusambi leaf methanol extract proved to inhibit the growth of *Trichophyton spp*. It established the inhibitory power of kusambi leaf extract (*Schleichera oleosa* (Lour.) Oken) against the development of *Trichophyton spp*. The test was carried out by disc method with concentration treatment of 5%, 10%, 15%, 20%, and 25%, negative control with DMSO 1%, and positive control ketoconazole 2%. The results showed that kusambi leaf methanol extract inhibited the growth of *Trichophyton spp* with the largest inhibitory zone diameter at a concentration of 25%, which is 9.7mm[33].

4. *Pometia pinnata* (Matoa)

Matoa leaves have secondary metabolites comprising flavonoids, phenolics, saponins, tannins, and steroids. The antibacterial metabolites contained in matoa leaf extract are flavonoids, phenolics, steroids, saponins, and tannins[34]. Matoa bark contains tannins, flavonoids, terpenoids, steroids, alkaloids, and saponins[35].

Tracing on matoa leaf extract contains saponin compounds that have antimicrobial activity against *Staphylococcus epidermidis*[36]. Some research results also state that matoa leaf ethanol extract has antifungal activity against *Trichophyton mentagrophytes* with a high inhibitory zone average test at a concentration of 30%[37]. Other studies have also shown that matoa leaf extract contains flavonoid compounds with vigorous antioxidant activity[38-39]. Testing of matoa leaf endophytic fungi that have been carried out shows that ethyl acetate extract of matoa leaf endophytic fungi has antimicrobial activity against *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Candida albicans*[40]. Research was also conducted on matoa bark extract against *Staphylococcus aureus* bacteria. The results showed that matoa bark has a strong antibacterial influence against *Staphylococcus aureus* bacteria; the average diameter is 10-20 mm[41].

5. *Sapindus rarak DC* (Lerak)

The content of phytochemical compounds found in lerak fruit are alkaloids, tannins, flavonoids, polyphenols, and saponins[42]. The fruit, bark, seeds, and leaves of lerak plants contain saponins, alkaloids, steroids, antiquinones, flavonoids, polyphenols, and tannins[43].

The antimicrobial effect of lerak ethanol extract is 0.01% better than NaOCl 5% against *Streptococcus* mutans and *Candida albicans*[44-45]. Another study that tested the antibacterial power between lerak fruit extract without skin and lerak fruit extract and skin in inhibiting the growth of *Propionibacterium acnes*. The test results are known that the combination of treatment of lerak fruit extract without skin with a concentration of 30% has the most significant effect on the average diameter of the growth inhibition zone of *Propionibacterium acnes* but is not significantly different from lerak fruit extract with skin with a concentration of 25%, so it can be said that the treatment of lerak fruit extract without skin with a concentration of 30% and

DOI : https://doi.org/10.24843/JPSA.2024.v06.i01.p01

lerak fruit extract with skin with a concentration of 25% is the most effective treatment combination in inhibits the growth of *Propionibacterium acnes*[46].

CONCLUSION

Sapindaceae plants contain secondary metabolite compounds and have antimicrobial activity. The class of secondary metabolite compounds found in Sapindaceae plants contains alkaloids, flavonoids, phenols, tannins, saponins, and triterpenoids. Most Sapindaceae plants have antimicrobial potential. The parts of this plant that have been studied and have potential as antimicrobials are stem bark, leaves, fruits, seeds, fruit skins, fruit skins, fruit flesh, and stems; further research needs to be done to explore other Sapindaceae plant species to find compounds and other pharmacological activities to overcome various diseases in the community.

ACKNOWLEDGEMENT

The author would like to thank all those who have helped write this review article.

CONFLICT OF INTEREST

There is no conflict of interest in this paper. This article was written independently without affiliation with other parties.

REFERENCES

1. Badan Penelitian dan Pengembangan Kesehatan Kementrian Kesehatan, 2012. Laporan Riset Tumbuhan Obat dan Jamu 2012. Karanganyar: Badan Penelitian dan Pengembangan Kesehatan Kementrian Kesehatan RI.
2. Mills, S. dan Bone, K., 2000. Principles and Practice of Phytotherapy: Modern Herbal Medicine. Churchill Livingstone, Edinburgh.
3. Burkhart CG & Burkhart CN. 2007. Expanding The Microcomedone Theory and Acne Therapeutics: Propionibacterium acnes Biofilm Produces Biological Glue that Holds Corneocytes Together to Form Plug. Journal Am Acad Dermatol, 57:722-724.
4. Farias, D.F., Souza, T.M., Viana, M.P., Soares, B.M., Cunha, A.P., Vasconcelos, I.M., dkk., 2013. Antibacterial, Antioxidant, and Anticholinesterase Activities of Plant Seed Extracts from Brazilian Semiarid Region. BioMed Research International, 2013: e510736.
5. Cirak C, Radusiene J. 2019. Factors affecting the variation of bioactive compounds in Hypericum species. Biol Futura 70: 1-15.
6. Shoemaker M, Hamilton B, Dairkee SH, Cohen I, Campbell M. 2005. In vitro anticancer activity of twelve Chinese medicinal herbs. Phytoth Res 19 (1): 649-51.
7. Ekor M. 2013. The growing use of herbal medicines: issues relating to adverse reactions and challenges in monitoring safety. Front Pharmacol 4: 177.
8. Jigna P, Sumitra C. 2006. In-vitro antimicrobial activities of extracts of Launaea procumbens Roxb. (Labiatae), Vitis vinifera L. (Vitaceae) and Cyperus rotundus L. (Cyperaceae). Afr J Biomed Res 9: 89-93.
9. Rahmawati, R., Tahir, M., dan Amir, A.H.W., 2021. Kandungan Senyawa Kimia Dan Aktivitas Farmakologi Tanaman Matoa (*Pometia Pinnata* JR Forster & JG Forster). *As-Syifaa Jurnal Farmasi*, **13**: 108–115.
10. Rodriguez EM. 1958. The wood of Argentine Sapindaceae. Structure, characteristics, and applications. Rev Fac Agron Y Vet [Buenos Aires] 14 (2): 271-305.
11. Simpson B, Claudie D, Smith N, Wang JP, McKinnon R, Semple S. 2010. Evaluation of the anti-

DOI : https://doi.org/10.24843/JPSA.2024.v06.i01.p01

inflammatory properties of Dodonaea polyandra, a Kaanju traditional medicine. J Ethnopharmacol 132: 340-343.
12. Muthukumran P, Begumand VH, Kalaiarasan P. 2011. Antidiabetic activity of Dodonaea viscosa (L) leaf extracts. Intl J Pharm Tech Res 3: 136-139.
13. Waako PJ, Gumede B, Smith P, Folb PI. 2005. The in vitro and in vivo antimalarial activity of Cardiospermum halicacabum L. and Momordica foetida Schumch. et Thonn. J Ethnopharmacol 99: 137-143.
14. Alina, R., n.d. Uji Aktivitas Antibakteri Fraksi Kulit Buah Rambutan (*Nephellium lappaceum* L.) dalam Menghambat Pertumbuhan Bakteri E. coli Penyebab Diare.
15. Dalimartha, 2005, Atlas Tumbuhan Obat Indonesia, jilid 3, Puspa Swara, Jakarta.
16. Jayanti, T. D., Ariyanti, and Masruriati, E., 2017, Uji Aktivitas Antibakteri Infusa dan Sirup Daun Rambutan (Nepheliumlappaceum Linn) terhadap Bakteri Salmonella Typhi secara In Vitro, Jurnal Farmasetis, 6 (2), 71–76.
17. Ilham, I. A., 2010, Uji Aktivitas Antimikroba Ekstrak Metanol Larut Heksan dan tidak Larut Heksan Daun Rambutan (Nephelium lappaceum L) terhadap Beberapa Mikroba Patogen, [Skripsi], Fakultas Ilmu Kesehatan, Universitas Islam Negeri Alauddin Makasar.
18. Sulistiyaningsih, S., Mudin, N., Wicaksono, I. A., and Budiman, A., 2017, Antibacterial Activity of Ethanol Extract and Fraction of Rambutan Leaf (Nephelium lappaceum) Against Pseudomonas aeruginosa multiresistant, National Journal of Physiology, Pharmacy and Pharmacology, 8 (2), 257- 261.
19. Tobaq, F., Mandalas, H., dan Sugiaman, V., 2023. Efek Antibakteri Ekstrak Kulit Kelengkeng (Dimocarpus Longan L.) terhadap Porphyromonas gingivalis. e-GiGi, 12: 60–66.
20. Anggraeny, E.N. dan Pramitaningastuti, A.S., 2016. Studi Uji Daya Antiinflamasi Dan Antipiretik Ekstrak Etanol Daun Lengkeng (*Dimocarpus longan* Lour) Pada Tikus Putih Jantan (Rattus norvegicus) Galur Wistar. Jurnal Ilmiah Farmasi.
21. Muhtadi, M., 2011. Aktivitas Antibakteri Ekstrak Etanol Kulit dan Biji Kelengkeng (Euphoria longan (Lour.) Steud) Terhadap *Escherichia coli* dan *Staphylococcus aureus* Serta Toksisitasnya Terhadap Artemia salina Leach. Pharmacon: Jurnal Farmasi Indonesia, 12: 33–39.
22. Prasety, O.S., Soegianto, L., dan Wijaya, S., 2019. Uji Aktivitas Antibakteri dan Antibiofilm Fraksi Biji Kelengkeng (Euphoria longan Lour. Steud.) terhadap Staphylococcus aureus ATCC 6538. Jurnal Farmasi Sains dan Terapan (Journal of Pharmacy Science and Practice), 6: 84–90.
23. Jaitrong, S., Rattanapanone, N., dan Manthey, J., 2006. Analysis of the phenolic compounds in longan (Dimocarpus longan Lour.) peel. Proceedings of the Florida State Horticultural Society, 119: 371–375.
24. Ripa, F. A., Haque, M., and Bulbul, I. J., 2010, In vitro Antibacterial Cytotoxic and Antioxydant activities of Plant Nephelium longan, Journal of Biological Science, 13 (1), p. 22-27.
25. Rahman, K. M., Kamrun, N., Mohammad, G. U. K., Choudhury, M. H., 2007, Phytochemical and Biological Studies on Nephelium longan, Boletin Latinoamericano y

DOI : https://doi.org/10.24843/JPSA.2024.v06.i01.p01

del Caribe de Plants Madicinales y Aromaticans, 6 (3), 68-72.

26. Soong, Y. Y. and Philip John Barlow, 2005, Isolation and Structure Elucidation of Phenolic Compounds from longan (Euphoria longan Lour. Steud.) seed by High-Performance Liquid Chromatography–Electrospray Ionization Mass Spectrometry.
27. Syarifah, M., 2010, Isolasi, Karakterisasi, dan Uji Aktivitas Antibakteri Minyak Biji Buah Kelengkeng Lokal dan Impor serta Identifikasi Asam Lemak Penyusunnya, Skripsi, Jurusan Kimia, Fakultas MIPA, Universitas Negeri Malang, Malang.
28. Uyun J. 2016. Analisis Kandungan Senyawa Metabolit Sekunder Dari Kulit Batang Kesambi (*Schleichera oleosa*) Dan Uji Aktivitas Fraksi Terhadap Bakteri Patogen [Skripsi]. Sekolah Tinggi Analis Kimia (STAK) Cilegon.
29. Khandekar, U., Bobade, A., dan Ghongade, R., 2015. Evaluation of antioxidant ectivity, in-vitro antimicrobial activity and phytoconstituents of schleichera oleosa lour oken. International Journal of Biological & Pharmaceutical Research, 6: 137–143.
30. Holil, K., & Griana, T. P. (2020). Analisis fitokimia dan aktivitas antioksidan ekstrak daun kesambi (Schleichera oleosa) metode DPPH. Journal of Islamic Pharmacy, 5(1), 28-32.
31. Situmeang, B., Ilham, I., Ibrahim, A.M., Amin, F., Mahardika, M., Bialangi, N., dkk., 2022. Aktivitas Antioksidan Dan Antibakteri Dari Fraksi Ekstrak Metanol Kulit Batang Kesambi *(Schleichera Oleosa*). Jurnal Kimia (Journal of Chemistry), 53–59.
32. Patra GC, Sahu PS, Panda P, Sahoo S, Mohapatra S, Bindhani BK. Anti-mycotic effect of ‘kusum oil’ extract on candida albicans clinical isolates from endophthalmitis cases. Int J Pharm Bio Sci 2012; 3: B475-84.
33. Khoiroh, Z. dan Griana, T.P., 2019. Potensi Daun Kesambi (Schleichera Oleosa) Sebagai Kandidat Agent Anti Jamur Untuk Penyakit Onikomikosis (Infeksi Jamur Pada Kuku). Journal of Islamic Medicine, 3: 36–41.
34. Azlin, S.Z., Sidoretno, W.M., dan Dewi, A.P., 2023. Uji Aktivitas Antibakteri Fraksi Etil Asetat Daun Matoa (Pometia Pinnata J.R & G. Forst) terhadap *Staphylococcus Aureus*. JFARM - Jurnal Farmasi, 1: 30–41.
35. Ngajow, M., Abidjulu, J., dan Kamu, V.S., 2013. Pengaruh Antibakteri Ekstrak Kulit Batang Matoa (Pometia pinnata) terhadap Bakteri Staphylococcus aureus secara In vitro. Jurnal MIPA, 2: 128–132.
36. Rossalinda, R., Wijayanti, F., & Iskandar, D. (2021). Effectiveness of Matoa Leaf (Pometia pinnata) Extract as an Antibacterial Staphylococcus Epidermidis. Stannum: Jurnal Sains dan Terapan Kimia, 3(1), 1–8.
37. Sidoretno, W. M., & Gustari, M. (2021). Aktivitas Antijamur Ekstrak Etanol Daun Matoa (Pometia Pinnata J.R. & G.Forst) terhadap Pertumbuhan Jamur Trichophyton Mentagrophytes. Photon: Jurnal Sain dan Kesehatan, 11(2), 137-148.
38. Hehakaya, M. O., Edy, H. J., & Siampa, J. P. (2022). Formulation and Antioxidant Activity Test of Body Scrub Matoa Leaves (Pometia Pinnata). Pharmacon, 11(4), 1778-1785.
39. Tahalele, E., & Sutriningsih, S. (2018). Formulasi Sediaan Kosmetik Krim dari Ekstrak Daun Matoa (Pometia Pinnata) dan Uji Aktivitas Antioksidan. Indonesia Natural

DOI : https://doi.org/10.24843/JPSA.2024.v06.i01.p01

Research Pharmaceutical Journal, 3(2), 44–55.

40. Fajrina, A., Bakhtra, D. D. A., & Mawarni, A. E. (2020). Isolasi dan Uji Aktivitas Antimikroba Ekstrak Etil Asetat Jamur Endofit dari Daun Matoa (*Pometia Pinnata*). Jurnal Farmasi Higea, 12(1), 81–89.
41. Ngajow, M., Abidjulu, J., dan Kamu, V.S., 2013. Pengaruh Antibakteri Ekstrak Kulit Batang Matoa (Pometia pinnata) terhadap Bakteri Staphylococcus aureus secara In vitro. Jurnal MIPA, 2: 128–132.
42. Silviani, Yusianti. Short Communication: Inhibitory effect of Sapindus rarak ethyl acetate extract on Staphylococcus aureus. Bioteknologi. 2017;14(1): 16- 18.
43. Fatmawati, Ira. 2014. Efektivitas Buah Lerak (*Sapindus Rarak De Candole*) sebagai Bahan Pembersih Logam Perak, Perunggu, dan Besi. Jurnal Konservasi Cagar Budaya Borobudur. Vol. 8, No 2.
44. Nevi Y, Fadhlina I. Efek antibakteri buah lerak terhadap *Streptococcus* mutans. Maj Kedokteran Gigi (Dent.J). 2009; 14(1): 53-8.
45. Yanti, N., 2016. Efek Antibakteri Ekstrak Etanol Buah Lerak (Sapindus rarak DC) Sebagai Alternatif Bahan Irigasi Saluran Akar Gigi (Penelitian InVitro). [dikutip 2 Desember 2023]. Tersedia dari: http://repositori.usu.ac.id/handle/123456789/688.
46. Putri, R.K., Hastuti, U.S., dan Rohman, F., 2018. Daya Antibakteri Ekstrak Ethanol Buah Lerak (*Sapindus rarak* dc) dalam Beberapa Macam Konsentrasi Terhadap Propionibacterium acnes. Sains dan Matematika, 6: 61–66.

DOI : https://doi.org/10.24843/JPSA.2024.v06.i01.p01