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In Silico Biological Activity Prediction of Bioactive Compounds from *Dumortiera hirsuta* (Sw.) Nees. Using Way2Drug PASS Online

Abdillah Maulana Farhan[1], Waki'atil Rosida[1], Fuad Bahrul Ulum[1*]

[1]Laboratory of Botany, Department of Biology, Faculty of Mathematics and Natural Sciences, University of Jember, Jember, Indonesia.
*Correspondence Author: fuad.fmipa@unej.ac.id

Abstract

The liverwort *Dumortiera hirsuta* (Sw.) Nees. is recognized as a potential source of pharmacologically active metabolites. Bioactive compounds from *D. hirsuta* have been previously reported through in vitro metabolomic analyses using gas chromatography–mass spectrometry (GC–MS) and liquid chromatography–mass spectrometry (LC–MS). In this study, the biological activities of the GC-MS-identified metabolites were evaluated in silico using the Way2Drug PASS Online platform. The results indicated that ten metabolites from *D. hirsuta* exhibit medicinal potential, with Pa values greater than 0.7, suggesting a high probability of biological activity. Among these compounds, stigmasterol (Pa = 0.970) and lathosterol (Pa = 0.960) demonstrated the strongest antihypercholesterolemic potential, indicating their role as natural agents for reducing cholesterol levels. These findings highlight the pharmacological potential of *D. hirsuta* metabolites and warrant further validation through in vitro cholesterol-lowering assays to confirm their predicted activities.

Keywords: antihypercholesterolemic, *Dumortiera hirsuta*, in silico, PASS Online

Introduction

Dumortiera hirsuta (Sw.) Nees. is a thalloid liverwort commonly found in humid environments such as moist forest floors and shaded riverbanks. The species is widely distributed across tropical and subtropical regions of Asia and America but is rarely reported in Europe (Forrest et al., 2011). Previous phytochemical studies have revealed that *D. hirsuta* contains a wide range of bioactive secondary metabolites, including terpenes, flavonoids, and phenolic compounds, which are known for their pharmacological relevance (Setyati et al., 2021). Moreover, Liu et al. (2018) demonstrated that extracts of *D. hirsuta* exhibited significant anticancer activity against the HT-29 human colon cancer cell line, suggesting that this species holds considerable promise as a source of plant-derived therapeutic agents. However, further optimization involving dosage formulation, toxicity profiling, and pharmacokinetic evaluation is necessary to validate its potential use as a natural drug resource.

The discovery and development of plant-derived bioactive compounds often begin with in silico predictions of biological activity, which serve as an essential preliminary step in identifying pharmacologically relevant targets (Brogi et al., 2020). Computational approaches such as the Way2Drug PASS Online platform enable the prediction of biological activity spectra for chemical substances based on their structural formulas expressed in SMILES notation. This platform provides Pa (probability of being active) and Pi (probability of being inactive) scores for each compound, allowing researchers to evaluate the likelihood of specific biological activities (Druzhilovskiy et al., 2017).

Gas chromatography–mass spectrometry (GC–MS) remains one of the most reliable analytical techniques for identifying volatile and semi-volatile metabolites, as it separates compounds based on retention time and mass spectral properties (Setyati et al., 2024). Integrating GC–MS metabolite profiling with in silico activity prediction offers a powerful approach to uncovering the pharmacological potential of unexplored bryophyte taxa.

The present study aimed to identify and predict the biological activities of bioactive compounds detected by GC–MS in *D. hirsuta* using the Way2Drug PASS Online platform. This research provides the first attempt to combine GC–MS based metabolite identification with in silico biological activity prediction in this liverwort species. The study thus contributes novel insights into the pharmacological potential of *D. hirsuta* and establishes a foundation for future in vitro and in vivo investigations of its bioactive compounds.

Materials and Methods

The present study employed an in silico approach using secondary data from previously published literature. The list of bioactive compounds of *D. hirsuta* was obtained from Dogra et al. (2024), who identified metabolites of this species through GC–MS analysis. The corresponding chemical structures of these compounds were retrieved from the PubChem database (pubchem.ncbi.nlm.nih.gov) in the form of SMILES (Simplified Molecular Input Line Entry System) notation.

Each SMILES structure was subsequently uploaded to the Way2Drug PASS Online platform (www.way2drug.com/passonline) to predict the potential biological activities of the identified metabolites. The program calculates two probability scores for each compound: Pa (probability of being active) and Pi (probability of being inactive). Compounds with Pa > 0.7 were interpreted as having strong predicted biological activity, whereas those with Pa < 0.7 were considered to have lower activity potential.

To visualize and verify the structural representations of the identified compounds, chemical structures were constructed using the ASKCOS MIT online tool (askcos.mit.edu). The resulting dataset of predicted biological activities was used to assess the pharmacological potential of *D. hirsuta* metabolites.

Results and Discussion

In Silico Potential

Bioactive compounds of *D. hirsuta* were previously identified using gas chromatography–mass spectrometry (GC–MS) by Dogra et al. (2024), a technique that separates and detects compounds based on their retention time and mass spectral fragmentation patterns. In the present study, these compounds were evaluated in silico using the Way2Drug PASS Online platform to predict their potential biological activities and drug-likeness properties. The prediction results provide Pa (probability of activity) and Pi (probability of inactivity) values for each compound. Compounds with Pa > 0.7 were considered to possess strong potential pharmacological activity. Table 1 summarises the predicted biological activities of the GC–MS–identified bioactive compounds from *D. hirsuta*.

Based on the in silico results, the bioactive compounds exhibiting the highest Pa values were stigmasterol (0.970) and lathosterol (0.960), both predicted to act as antihypercholesterolemic agents. Antihypercholesterolemic activity refers to the ability of a compound to reduce elevated cholesterol levels in the body, thereby contributing to the prevention of cardiovascular and metabolic disorders (Upadhyay, 2021). Such properties are highly beneficial for human health, as persistently high cholesterol levels are associated with an increased risk of atherosclerosis and coronary heart disease.

Lathosterol (Lat) is one of the bioactive compounds that has a cholesterol-like chemical compound structure. The compound can be further identified in plant samples, including liverwort. Medically, the compound has the potential to be an antihypercholesterolemic, which can lower cholesterol levels by inhibiting the enzyme HMG-CoA reductase (Ullah et al., 2020). Other biological activities of Lat can be modified as antiparasites, namely by inhibiting the activity of lathosterol oxidase (LSO). LSO plays an important role in the synthesis of sterols with C-5–C-6 double bonds that maintain membrane stability and intracellular pH homeostasis. Further research on lathosterol should be carried out to target its health potential (Wang et al., 2018).

Longipinene is one of the terpene compounds that has great potential in the health field (Narayanan et al., 2017). The results of the analysis of In silico Way2drug in *D. hirsuta* samples obtained a value of Pa (0.702) with antileukemic potential. Antileukemic activity refers to the compound's potential to inhibit or prevent leukemia cell proliferation. Leukemia is one of the blood cancers that can affect the functionality of the bone marrow and lymphatic tissue. Utilization of natural bioactive compounds in therapeutic applications is essential in antileukemic treatment, because treatment with chemotherapy and radiotherapy can cause side effects (Cotoraci et al., 2021). Longipinene, in addition to having antileukemic potential, also has several other biological activities, namely as antidiabetic, antidiarrheal effects, antiinflammatory, antioxidant, antitumor, anticancer, antiulcer, and hepatoprotective (Narayanan et al., 2017).

Phytyl stearate is one of the compounds of the lipid ester group that is hydrophobic (Costa et al., 2025). The results of the analysis of In silico Way2drug in *D. hirsuta* samples obtained a value of Pa (0.702) with antiulcerative potential. Antiulceratives are one of the biological activities that can prevent injuries to the digestive organs, such as in the stomach, caused by bacterial infections (Sharifi-Rad et al., 2018). One of the mechanisms of antiulcers is to ward off free radicals (antioxidants) that are in the mucosal area and can inhibit the

growth of ulcer-causing bacteria such as *Helicobacter pylori*, *E. coli, Campylobacter* spp., and *Streptococcus* spp. (Okolo et al., 2025).

Hexadecanoic acid, methyl ester, has another name, methyl palmitate. The compound is a bioactive compound identified in *D. hirsuta* samples that has a value (Pa 0.758) with potential as an anti-inflammatory or for the prevention of inflammation. The mechanism of these compounds as anti-inflammatories is by significantly inhibiting the growth of proinflammatory cytokines such as TNF-α, IL-1β, and IL-6, which can damage tissues. Other biological activities of hexadecanoic acid, methyl ester are as antioxidants, antihyperlipidemic, and antimicrobial (Agarwal et al., 2019).

Table 1. Bioactive Compound identified from *D. hirsuta* using GC-MS (Dogra et al., 2024)

RT (min)	Bioactive Compounds	Area%	BAP Pass Online	Pa	Pi
26.473	Longipinene	8.16	Antileukemic	0.702	0.005
30.722	Phytyl stearate	3.68	Antiulcerative	0.804	0.004
32.610	Hexadecanoic acid, methyl ester	0.86	Anti-inflammatory, intestinal	0.758	0.002
36.294	Phytol	5.82	Antiviral (Rhinovirus)	0.710	0.003
43.192	Phthalic acid, bis(2-ethylhexyl) ester	6.45	Antieczematic	0.895	0.005
46.339	Tetracosane	2.94	Phenol O-methyltransferase inhibitor	0.871	0.002
48.025	Squalene	1.17	Anti-inflammatory	0.701	0.016
54.298	Stigmasterol	5.43	Antihypercholesterolemic	0.970	0.002
53.924	Lathosterol	4.68	Antihypercholesterolemic	0.960	0.002
59.707	Tris(2,4-di-tert-butylphenyl) phosphate	6.22	General anesthetic	0.785	0.005

Phytol is one of the secondary metabolites found in *D. hirsuta*. Phytol is a natural terpenoid compound that has antioxidant activity and plays a role in reducing inflammation. This compound inhibits the production of the COX-2 enzyme in the formation of prostaglandins, which are the main mediators of inflammation. This inhibition is effective in relieving inflammatory symptoms because it can reduce leukocyte migration and enzymatic activity that triggers inflammation (Cintya et al., 2024). Tetracosane is an aliphatic hydrocarbon compound with values of Pa (0.871) and Pi (0.002). This compound shows high cytotoxicity to cancer cells, so that it has the potential for apoptosis and necrosis in gastric adenocarcinoma (AGS) cells (Uddin et al., 2012). Previous studies have reported that Tetracosane compounds have the potential to be antibiotics and also have cytotoxic activity against HT-29 colon cancer cells by inducing cell apoptosis (Saputri et al., 2015).

Squalene is a class of linear triterpene compounds synthesized in plants for the synthesis of secondary metabolites such as sterols, hormones, or vitamins. Previous research has shown that squalene can reduce skin damage from UV radiation, LDL levels, and cholesterol in the blood, prevent the onset of cardiovascular disease, and have antitumor and anticancer effects against ovarian, breast, lung, and colon cancers (Lozano-Grande et al., 2018). Squalene is an unsaturated fat found on the surface of the skin to soften the skin and function as an antitumor. Previous research has also stated that squalene can synergize with α-tocoperol and β-sitosterol compounds as antioxidants, with squalene as a competitive compound in the crocin bleaching reaction by lowering oxidation levels (Sogandi & Nilasari, 2019).

Tris(2,4-di-tert-butylphenyl) phosphate compound with the chemical formula C42H63O4P is an organophosphate compound which is a phosphate ester derived from di-tart-butylphenol. This

compound has previously been widely found in Camellia sasanqua Thunb. Flowers, Chimonanthus spp. Leaves and Plukenetia volubilis L. seeds (Zahara et al., 2022). These compounds can be used as anti-enterococcal and antioxidant (Alraddadi et al., 2024).

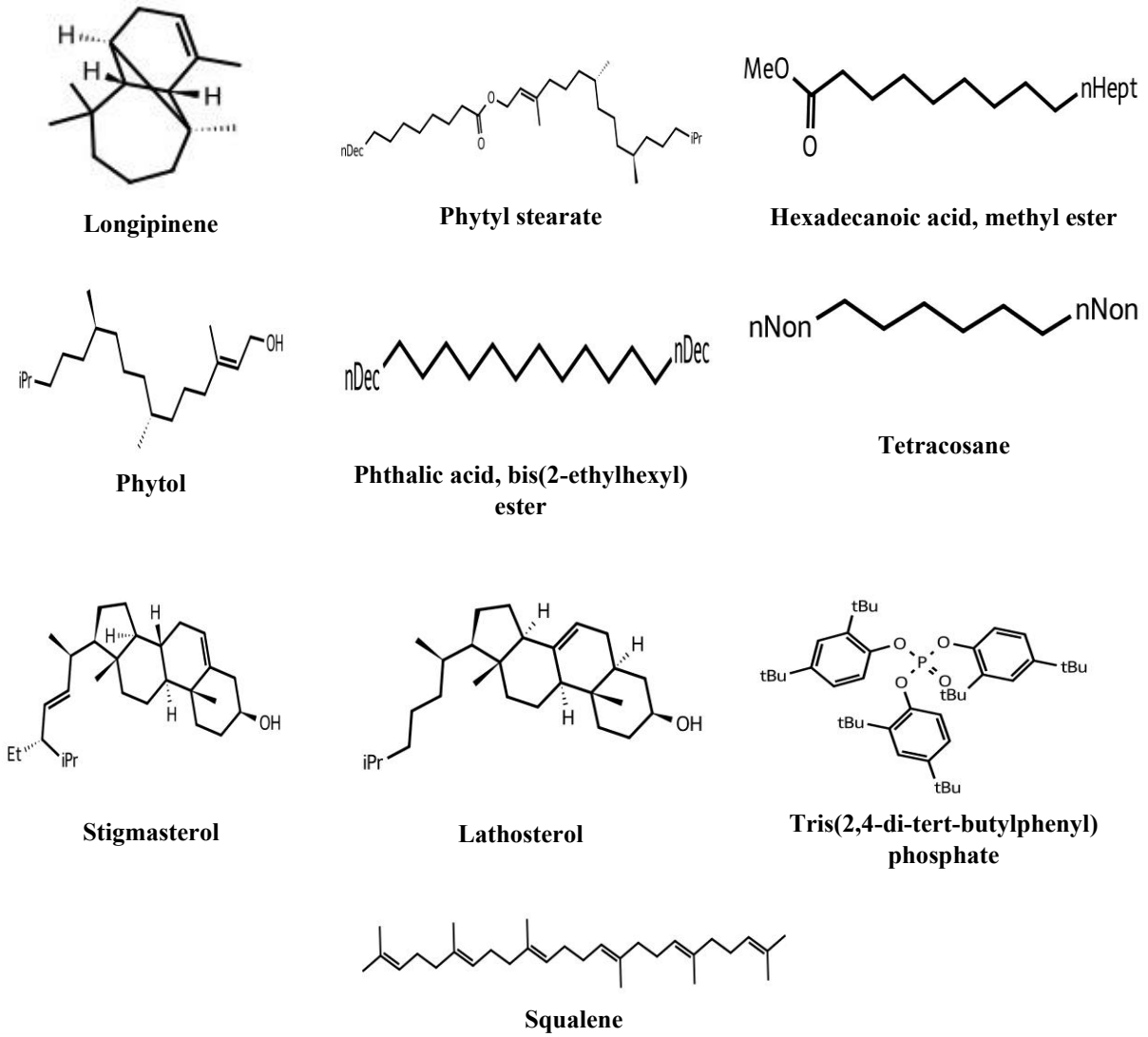

Figure 1. Structures of bioactive compounds from Dumortiera hirsuta, illustrated using the ASKCOS MIT platform

Future Potential Development

D. hirsuta is a thalloid liverwort widely distributed across tropical and subtropical regions of Asia, where it typically inhabits shaded and humid environments such as riversides, waterfalls, and moist rock surfaces (Alam et al., 2011). This species is known to contain a variety of secondary metabolites, including triterpenoids, flavonoids, steroids, alkaloids, terpenoids, and saponins, which contribute to its broad pharmacological potential. Ethnobotanical records indicate that *D. hirsuta* has been traditionally utilized in parts of India as an antimalarial and antibiotic agent, reflecting its long-standing medicinal value (Fathoni et al., 2017; Halder & Mitra, 2020).

The pharmacological potential of *D. hirsuta* has been confirmed in several experimental studies. Setyati et al. (2021) reported that the ethyl acetate extract of *D. hirsuta* exhibited antibacterial activity against *Escherichia coli, Staphylococcus aureus*, and *Salmonella typhi*. The extract produced moderate inhibition zones on culture media, indicating bacteriostatic and bactericidal effects. The mechanism of action was proposed to involve disruption of bacterial cell membrane integrity, leading to apoptosis and cell lysis. Such activity highlights the potential of *D. hirsuta* as a source of natural antimicrobial agents for combating drug-resistant pathogens.

In addition, Liu et al. (2018) demonstrated that *D. hirsuta* extract exhibited anticancer activity in colon cancer models. Using a mouse model with chemically induced colon carcinoma, administration of the extract resulted in a notable reduction in tumor cell proliferation. This effect was attributed to the presence of riccardin, a bis-bibenzyl compound isolated from *D. hirsuta*, known for its cytotoxic and pro-apoptotic properties. These findings suggest that the liverwort's metabolites could be developed into plant-derived anticancer therapeutics. Further validation using in vitro cell line assays and pharmacokinetic profiling would be essential to elucidate the mechanisms and optimize dosage formulations.

Given its diverse range of metabolites, *D. hirsuta* holds significant promise for future pharmaceutical development. Compounds such as flavonoids, terpenes, and alkaloids, along with unique derivatives like riccardin, could serve as leads for new drug discovery programs (Liu et al., 2018; Sen et al., 2023). Moreover, the increasing global demand for plant-based medicines and the emergence of antibiotic and chemotherapeutic resistance have intensified interest in bryophyte-derived bioactives. The commercialization of *D. hirsuta*-based formulations could provide a sustainable and innovative alternative within the pharmaceutical and nutraceutical industries (Setyati et al., 2021; Mansour et al., 2022).

This study highlights the pharmacological potential of the liverwort *D. hirsuta* through the integration of GC–MS metabolite profiling and in silico biological activity prediction using the Way2Drug PASS Online platform. Ten bioactive compounds previously identified from *D. hirsuta* were evaluated for their predicted pharmacological properties, yielding several metabolites with high Pa values, indicative of strong biological activity. Among them, stigmasterol (Pa = 0.970) and lathosterol (Pa = 0.960) showed the greatest potential as antihypercholesterolemic agents, while other compounds such as longipinene, phytyl stearate, hexadecanoic acid methyl ester, phytol, tetracosane, and squalene exhibited diverse biological activities, including antileukemic, antiulcerative, anti-inflammatory, antioxidant, and anticancer effects.

These findings provide scientific evidence that *D. hirsuta* is a promising source of naturally derived metabolites with broad therapeutic relevance. The in silico approach applied here offers a rapid, cost-effective means of prioritizing candidate compounds for further validation. Nevertheless, in vitro and in vivo investigations are essential to confirm the predicted activities, determine toxicity profiles, and elucidate underlying mechanisms of action.

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References

Agarwal, H., Nakara, A., & Shanmugam, V. K. (2019). Anti-inflammatory mechanism of various metal and metal oxide nanoparticles synthesized using plant extracts: A review. Biomedicine and Pharmacotherapy, 109(October 2018), 2561–2572. https://doi.org/10.1016/j.biopha.2018.11.116

Alam, A., Tripathi, A., Vats, S., Behera, K. K., & Sharma, V. (2011). In vitro antifungal efficacies of aqueous extract of Dumortiera hirsuta (Swaegr .) Nees against sporulation and growth of postharvest phytopathogenic fungi Afroz Alam *, Abhishek Tripathi , Sharad Vats , Kambaska Kumar Behera. Archive for Byrology, 103(2011), 1–9.

Alraddadi, T. M., Bahaffi, S. O., Alkhateeb, L. A., & Sadaka, M. W. (2024). Analysis of bioactive compounds present in Boerhavia elegans seeds by GC-MS. Open Chemistry, 22(1). https://doi.org/10.1515/chem-2024-0068

Bakrim, S., Benkhaira, N., Bourais, I., Benali, T., Lee, L. H., El Omari, N., Sheikh, R. A., Goh, K. W., Ming, L. C., & Bouyahya, A. (2022). Health Benefits and Pharmacological Properties of Stigmasterol. Antioxidants, 11(10), 1–32. https://doi.org/10.3390/antiox11101912

Brogi, S., Ramalho, T. C., Kuca, K., Medina-Franco, J. L., & Valko, M. (2020). Editorial: In silico Methods for Drug Design and Discovery. Frontiers in Chemistry, 8(August), 1–5. https://doi.org/10.3389/fchem.2020.00612

Cintya, W., Budastra, G., Ulya, T., Anandia, S., & Maulidya, I. (2024). Jurnal Biologi Tropis Literature Review : Exploration of Bioactive Components of Avicennia marina and Its Biological Activities.

Costa, V., Costa, M., Rebelo, R., Arques, F., Ferreira, M., Gameiro, P., Barros, T., Geraldo, D., Monteiro, L. S., Paiva-martins, F., Gameiro, P., Barros, T., Geraldo, D., & Monteiro, L. S. (2025). Phytyl Phenolipids as Promising Biomembrane Antioxidants Phytyl Phenolipids as Promising Biomembrane Antioxidants. 0–18. https://doi.org/10.20944/preprints202502.0150.v1

Cotoraci, C., Ciceu, A., Sasu, A., Miutescu, E., & Hermenean, A. (2021). The anti-leukemic activity of natural compounds. Molecules, 26(9), 1–29. https://doi.org/10.3390/molecules26092709

Dogra, N., Kapila, S., Secrain, S., Pannu, A., Sethi, M., Sharma, S., & Sabharwal, H. (2024). Phytochemicalanalysis and Antioxidant Activity of an Indian Liverwort Dumortiera Hirsuta Subsp. Hirsuta (Sw.) Nees. Plant Archives, 24(1). https://doi.org/10.51470/plantarchives.2024.v24.no.1.013

Druzhilovskiy, D. S., Rudik, A. V., Filimonov, D. A., Gloriozova, T. A., Lagunin, A. A., Dmitriev, A. V., Pogodin, P. V., Dubovskaya, V. I., Ivanov, S. M., Tarasova, O. A., Bezhentsev, V. M., Murtazalieva, K. A., Semin, M. I., Maiorov, I. S., Gaur, A. S., Sastry, G. N., & Poroikov, V. V. (2017). Computational platform Way2Drug: from the prediction of biological activity to drug repurposing. Russian Chemical Bulletin, 66(10), 1832–1841. https://doi.org/10.1007/s11172-017-1954-x

Fathoni, I., Poerwanto, S. H., & Astuti, R. R. U. N. W. (2017). Bioactivity study of moss Dumortiera hirsuta (Swaegr.) nees ethanolic extract on parasitemic level of Plasmodium berghei vincke and lips, 1948 in mice (Mus musculus L.). Asian Journal of Pharmaceutical and Clinical Research, 10(Special Issue August), 5–8. https://doi.org/10.22159/ajpcr.2017v10s3.21349

Forrest, L. L., Allen, N. S., Gudiño, J. A., Korpelainen, H., & Long, D. G. (2011). Molecular and morphological evidence for distinct species in Dumortiera (Dumortieraceae). Bryologist, 114(1), 102–115. https://doi.org/10.1639/0007-2745-114.1.102

Halder, K., & Mitra, S. (2020). A Short Review of the Ethno-Medicinal Perspectives of Bryophytes. International Journal of Ecology and Environmental Sciences, 46(1), 73–81.

Lakshmi Narayanan, B., Kannappan, K., Subburaju, T., & Sajeeth, C. I. (2017). GC-MS analysis and HPTLC fingerprinting profile of hydroalcoholic extract of polygonum barbatum Linn. leaves. Indian Journal of Pharmaceutical Sciences, 79(3), 477–482. https://doi.org/10.4172/pharmaceutical-sciences.1000253

Liu, H., Li, G., Zhang, B., Sun, D., Wu, J., Chen, F., Kong, F., Luan, Y., Jiang, W., Wang, R., & Xue, X. (2018). Suppression of the NF-κB signaling pathway in colon cancer cells by the natural compound Riccardin D from Dumortierahirsute. Molecular Medicine Reports, 17(4), 5837–5843. https://doi.org/10.3892/mmr.2018.8617

Lozano-Grande, M. A., Gorinstein, S., Espitia-Rangel, E., Dávila-Ortiz, G., & Martínez-Ayala, A. L. (2018). Plant Sources, Extraction Methods, and Uses of Squalene. International Journal of Agronomy, 2018. https://doi.org/10.1155/2018/1829160

Mansour, S. S., Carpena, M., Echave, J., Chamorro, F., Pereira, A. G., Barral-Martinez, M., ... & Prieto, M. A. (2022). Plant-Based Nanoantibiotics: An Effective Strategy to Overcoming Antibiotic Resistance. In Medical Sciences Forum (Vol. 12, No. 1, p. 12). MDPI.

Okolo, M. L. O., Adegoke, S. A., Zakari, D. A., Bello, K. E., & Omatola, C. A. (2025). Isolation and characterization of terrestrial Streptomyces strains with antimicrobial and anti-ulcer activities. Tropical Journal of Pharmaceutical Research, 24(1), 85–96. https://doi.org/10.4314/tjpr.v24i1.12

Saputri, D. D., Bintang, M., & Pasaribu, F. H. (2015). Isolation and Characterization of Endophytic Bacteria from Tembelekan (Lantana camara L.) as Antibacterial Compounds Producer. Current Biochemistry, 2(2), 86–98. https://doi.org/10.29244/cb.2.2.86-98

Sen, K., Khan, M. I., Paul, R., Ghoshal, U., & Asakawa, Y. (2023). Recent advances in the phytochemistry of Bryophytes: Distribution, structures and biological activity of Bibenzyl and Bisbibenzyl compounds. Plants, 12(24), 4173.

Setyati, D., Luthfiah, L., & Arimurti, S. (2021). Antibacterial Activity of Liverworts of Dumortiera hirsute (Sw.) Nees Ethyl Acetate Extract Against Pathogenic Bacteria. Berkala Sainstek, 9(2), 75. https://doi.org/10.19184/bst.v9i2.22645

Setyati, D., Su'udi, M., Ravitamala, E. S., Miladina, F. F., Babudin, B., Utarti, E., Arimurti, S., Nugraha, A. S., Putri, Y. A., Farhan, A. M., & Ulum, F. B. (2024). Antimicrobial and Phytochemistry study of Dendrobium linearifolium Teijsm. & Binn. from Gumitir, Jember, Indonesia. BIO Web of Conferences, 101, 1–12. https://doi.org/10.1051/bioconf/202410101001

Sharifi-Rad, M., Fokou, P. V. T., Sharopov, F., Martorell, M., Ademiluyi, A. O., Rajkovic, J., Salehi, B., Martins, N., Iriti, M., & Sharifi-Rad, J. (2018). Antiulcer agents: From plant extracts to phytochemicals in healing promotion. In Molecules (Vol. 23, Issue 7). https://doi.org/10.3390/molecules23071751

Sogandi, S., & Nilasari, P. (2019). Identifikasi Senyawa Aktif Ekstrak Buah Mengkudu (Morinda citrifolia L.) dan Potensinya sebagai Inhibitor Karies Gigi. Jurnal Kefarmasian Indonesia, 22(5), 73–81. https://doi.org/10.22435/jki.v9i2.1289

Uddin, S. J., Grice, D., & Tiralongo, E. (2012). Evaluation of cytotoxic activity of patriscabratine, tetracosane and various flavonoids isolated from the Bangladeshi medicinal plant Acrostichum aureum. Pharmaceutical Biology, 50(10), 1276–1280. https://doi.org/10.3109/13880209.2012.673628

Ullah, H., Khan, A., Rehman, N. U., Halim, S. A., Khan, H., Csuk, R., Al-rawahi, A., Al-hatmi, S., & Al-harrasi, A. (2020). Journal Pre-proof.

Upadhyay, R. K. (2021). Antihyperlipidemic and

cardioprotective effects of plant natural products: A review. International Journal of Green Pharmacy, 15(1), 11–29. https://www.embase.com/search/results?subaction=viewrecord&id=L2011902169&from=export%0Ahttp://dx.doi.org/10.22377/ijgp.v15i1.3014

Wang, N., Kuczmanski, A., Dubrovska, G., & Gollasch, M. (2018). Palmitic acid methyl ester and its relation to control of tone of human visceral arteries and rat aortas by perivascular adipose tissue. Frontiers in Physiology, 9(MAY), 1–10. https://doi.org/10.3389/fphys.2018.00583

Zahara, K., Bibi, Y., Masood, S., Nisa, S., Sher, A., Ali, N., Kumar, S., Qayyum, A., Ahmed, W., Sami, R., Al-Mushhin, A. A. M., & Aljahani, A. H. (2022). Isolation and Identification of Bioactive Compounds from Bidens spp. Using HPLC-DAD and GC-MS Analysis and Their Biological Activity as Anticancer Molecules. Molecules, 27(6), 1–17. https://doi.org/10.3390/molecules27061927