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LC-MS/MS Based Identification of Antifungal Bioactive Compounds from White Turi (*Sesbania grandiflora* L.) Stem Bark Extract

[1]*A.A.Istri Mirah, [2]A.A.K.Darmadi, [3]N.L Suriani, [4]I.W.Suanda, [5] I.M.Subrata

1. Departement of Biology Education, Faculty of Science and Technology, PGRI Mahadewa University, Bali, Indonesia *
2. Departmenet of Biology, Faculty of Matematics and Natural Science, Udayana University, Denpasar, Bali, Indonesia
3. Departmenet of Biology, Faculty of Matematics and Natural Science, Udayana University, Denpasar, Bali, Indonesia
4. Departement of Biology Education, Faculty of Science and Technology, PGRI Mahadewa University, Bali, Indonesia
5. Departement of Biology Education, Faculty of Science and Technology, PGRI Mahadewa University, Bali, Indonesia

*Correspondence email: mirahdharmadewi@mahadewa.ac.id

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Abstrak: Tumbuhan turi putih (*Sesbania grandiflora* L.) merupakan salah satu tanaman dari famili Fabaceae yang tersebar luas di kawasan tropis dan diketahui memiliki berbagai aktivitas farmakologis. Meskipun demikian, pemanfaatan kulit batang sebagai sumber agen antifungi masih belum banyak dilaporkan. Penelitian ini bertujuan untuk mengidentifikasi profil fitokimia serta senyawa bioaktif dari ekstrak kulit batang turi putih yang berpotensi sebagai antifungi alami. Sampel diekstraksi menggunakan metode maserasi dengan pelarut etanol 70% selama 72 jam, kemudian dilakukan skrining fitokimia secara kualitatif menggunakan metode standar (Mayer, Wagner, Dragendorff, Liebermann–Burchard, dan $FeCl_3$). Analisis lanjutan dilakukan menggunakan LC-MS/MS (Agilent 6545 Q-TOF LC/MS System) untuk mengidentifikasi senyawa aktif. Hasil penelitian menunjukkan bahwa ekstrak mengandung alkaloid, terpenoid, fenolik, tanin, dan saponin. Selanjutnya, analisis LC-MS/MS dilakukan untuk mengkarakterisasi komponen bioaktif dan berhasil mengidentifikasi beberapa senyawa yang berpotensi sebagai antifungi pada fraksi air F6, yaitu adenine, phenylethyl alcohol, benzenedicarboxylic acid bis (2-ethylhexyl) ester, octadecane, dan 2,3-dimetoksibenzaldehid Senyawa-senyawa tersebut diketahui memiliki mekanisme antifungi melalui gangguan membran sel, denaturasi protein, dan inhibisi metabolisme sel jamur. Hasil ini menunjukkan bahwa kulit batang turi putih berpotensi dikembangkan sebagai bahan dasar produk kesehatan alami berbasis antifungi.

Kata kunci: Produk kesehatan alami; Senyawa bioaktif; *Sesbania grandiflora* L.; LC-MS/MS (*Agilent 6545 Q-TOF LC/MS System*).

Abstract: White turi (*Sesbania grandiflora* L.) is a tropical plant belonging to the Fabaceae family that is widely distributed and known for its diverse pharmacological activities. However, the utilization of its stem bark as a source of antifungal agents has been relatively underexplored. This study aimed to identify the phytochemical profile and bioactive compounds of white turi stem bark extract with potential antifungal properties. The sample was

extracted using a maceration method with 70% ethanol for 72 hours. Qualitative phytochemical screening was conducted using standard methods, including Mayer, Wagner, Dragendorff, Liebermann–Burchard, and $FeCl_3$ assays. Further analysis was performed using LC-MS/MS (Agilent 6545 Q-TOF LC/MS System) to identify bioactive compounds. The results revealed the presence of alkaloids, terpenoids, phenolics, tannins, and saponins. LC-MS/MS analysis of the F6 water fraction identified several potential antifungal compounds, including adenine, phenylethyl alcohol, benzenedicarboxylic acid bis (2-ethylhexyl) ester, octadecane, and 2,3-dimethoxybenzaldehyde. These compounds are known to exhibit antifungal mechanisms through disruption of cell membranes, protein denaturation, and inhibition of fungal cellular metabolism. Overall, the findings suggest that white turi stem bark extract has strong potential for development as a natural antifungal agent and as a raw material for plant-based health products.
Keyword: Bioactive compounds; natural health products; *Sesbania grandiflora* L.; LC-MS/MS (*Agilent 6545 Q-TOF LC/MS System*).

1. Introduction

Fungal infections have become a significant global health problem affecting humans, animals, and plants. The increasing prevalence of fungal diseases, such as candidiasis, aspergillosis, and dermatophytosis, is associated with the growing resistance of pathogenic fungi to conventional antifungal drugs [1] [2]. This resistance has led to reduced effectiveness of available treatments and increased morbidity, thereby highlighting the urgent need to discover alternative antifungal agents that are effective, safe, and environmentally friendly. Natural products derived from plants have long been recognized as potential sources of antimicrobial agents due to their rich content of secondary metabolites [3]. S*esbania grandiflora* is commonly used in traditional medicine in Indonesia, including in Balinese communities, as part of local herbal practices. Various parts of the plant are utilized for medicinal purposes. The leaves are typically used to treat inflammation, fever, and wounds, while the flowers are consumed as vegetables and are believed to support digestive health. The stem bark is traditionally used for treating diarrhea, mouth ulcers, and inflammation due to its astringent properties. Traditional preparation methods generally involve simple techniques such as boiling, crushing, or squeezing plant parts, and the preparations are administered either orally or topically. The use of this plant is not limited to the white turi variety. Both white and red varieties of *Sesbania grandiflora* are used in traditional practices. However, differences in phytochemical composition between the two varieties may influence their biological activity, although both are considered beneficial in traditional medicine.

Plants belonging to the Fabaceae family are known to contain various bioactive compounds, including flavonoids, alkaloids, phenolics, terpenoids, and saponins, which have demonstrated antimicrobial and antifungal activities [4], [5]. One plant with promising pharmacological potential is *Sesbania grandiflora* L., commonly known as white turi, which is widely distributed in tropical regions, including Indonesia. Previous studies reported demonstrated that biological sources such as endophytic fungi are capable of producing diverse secondary metabolites, including flavonoids, alkaloids, terpenoids, and tannins, which exhibit significant biological activities such as antioxidant and antimicrobial effects. For instance, Sukmawaty *et al.* (2020) reported that ethyl acetate extract of *Aspergillus* sp. showed strong antioxidant activity (IC_{50} = 38.64 ppm) and contained multiple bioactive compounds identified through phytochemical screening. These findings highlight the important role of secondary metabolites in biological activity and support the exploration of natural sources, including plant-derived extracts such as *Sesbania grandiflora*, as potential candidates for developing natural antifungal agents [40].

Previous studies have reported that different parts of *Sesbania grandiflora*, such as leaves, flowers, and seeds, exhibit antibacterial, antioxidant, and anti-inflammatory properties due to the presence of diverse phytochemical compounds [6] [7]. However, studies focusing specifically on the stem bark of white turi as a source of antifungal agents are still very limited. Moreover, comprehensive research integrating phytochemical screening with advanced analytical techniques such as Liquid

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Chromatography–Mass Spectrometry (LC-MS/MS) remains scarce, particularly for samples originating from Bali, Indonesia.

Phytochemical screening is an essential preliminary step to identify classes of secondary metabolites present in plant extracts [8]. Meanwhile, LC-MS/MS is a highly sensitive and accurate analytical technique capable of identifying bioactive compounds at the molecular level [9]. The combination of these methods is crucial for revealing the chemical composition and biological potential of plant extracts, especially in the discovery of novel antifungal agents. To the best of our knowledge, studies focusing on LC-MS/MS-based identification of antifungal bioactive compounds from the stem bark of *Sesbania grandiflora* in the Bali region remain very limited. Therefore, this study aims to analyze the phytochemical profile and identify bioactive compounds in white turi stem bark extract using LC-MS/MS, as well as to evaluate its potential as a natural antifungal agent.

2. Research Method

a. Study Design

This study employed an experimental laboratory design to analyze the phytochemical profile and identify bioactive compounds of white turi (*Sesbania grandiflora* L.) stem bark extract with potential antifungal activity.

b. Tools and Materials

The instruments used in this study included column chromatography apparatus, UV-Vis spectrophotometer (Shimadzu UV-1800), ultraviolet lamp, Liquid Chromatography–Mass Spectrometry (LC-MS/MS) (*Agilent 6545 Q-TOF LC/MS System*), PCR machine, electrophoresis sequencer (ABI 3730 xl), Scanning Electron Microscope (SEM), analytical balance, rotary evaporator, and standard laboratory glassware.

c. Sample Preparation and Extraction

White turi stem bark was collected from Kerambitan Village, Tabanan, Bali, Indonesia. The sample was cleaned, air-dried for 2 days, and oven-dried at 40°C for 6 hours. The dried sample was ground into powder and sieved using an 80-mesh sieve. A total of 600 g of powdered sample was macerated using 70% ethanol for 72 hours and repeated five times to maximize extraction yield. The filtrate was concentrated using a rotary evaporator at 50°C to obtain crude extract [8].

d. Phytochemical Screening

Phytochemical screening was conducted qualitatively to identify secondary metabolites, including alkaloids, flavonoids, terpenoids, phenolics, tannins, and saponins, using standard procedures [8].Alkaloids were detected using Mayer, Wagner, and Dragendorff reagents. Flavonoids were identified using Mg-HCl and Bate-Smith methods. Terpenoids and steroids were tested using Liebermann–Burchard reagent, while phenolics and tannins were identified using $FeCl_3$ reagent. Saponins were confirmed using the foam test [16].

e. Fractionation of Extract

The crude extract (100 g) was fractionated using liquid-liquid partition method. The extract was first partitioned with n-hexane (5 × 100 mL) to obtain non-polar fractions. The remaining extract was dissolved in ethanol:water (7:3), followed by partitioning with chloroform and n-butanol sequentially. Each fraction was concentrated using a rotary evaporator to obtain concentrated extracts [19].

f. Identification of Bioactive Compounds Using LC-MS/MS

The most active fraction (F6 water fraction) was analyzed using LC-MS/MS to identify bioactive compounds. This technique combines chromatographic separation and mass spectrometry detection based on

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molecular weight and fragmentation patterns [9], [19].Compound identification was performed by comparing the obtained mass spectra with available databases and literature [14].

g. Data Analysis

The phytochemical screening results were analyzed descriptively, while LC-MS/MS data were interpreted based on chromatogram profiles, retention time, and comparison of mass spectra with reference databases [20].

3. Results and Discussion

a. Phytochemical Screening

The results of phytochemical screening of white turi (*Sesbania grandiflora* L.) stem bark extract revealed the presence of several classes of secondary metabolites, including alkaloids, terpenoids, phenolics, tannins, and saponins. The identification was based on characteristic color changes and precipitate formation using specific reagents in **Table 1.**

Table 1. Phytochemical Screening Results of White Turi Stem Bark Extract

No	Test Reagent	Observation	Result
1	Wagner	Brown precipitate formed	Alkaloid (+)
2	Mayer	White precipitate formed	Alkaloid (+)
3	Dragendorff	Orange-red precipitate formed	Alkaloid (+)
4	Bate-Smith	No significant color change	Flavonoid (-)
5	Liebermann–Burchard	Green to purple color	Terpenoid (+), Steroid (-)
6	$FeCl_3$	Green-black coloration	Phenolic (+)
7	$FeCl_3 + H_2SO_4$	Brown precipitate formed	Tannin (+)
8	Foam test	Stable foam formed	Saponin (+)

The presence of alkaloids suggests antimicrobial potential due to their ability to interfere with nucleic acid synthesis and enzyme activity in microbial cells [10]. Terpenoids are known to disrupt fungal cell membranes by altering lipid structures, leading to increased permeability and cell leakage [11].

Phenolic compounds and tannins contribute to antifungal activity through protein denaturation and enzyme inhibition, which impair fungal metabolism [12]. Tannins are also reported to inhibit chitin synthesis in fungal cell walls [22]. Saponins play an important role in antifungal mechanisms by interacting with membrane sterols, causing membrane destabilization and cell lysis [17]. The absence of flavonoids indicates that antifungal activity in this extract is likely dominated by other metabolite groups. Overall, the combination of these compounds suggests a synergistic antifungal effect.

b. LC-MS/MS Analysis

The LC-MS/MS analysis of the most active fraction (F6 water fraction) revealed the presence of multiple bioactive compounds. The chromatogram showed several peaks with different retention times, indicating the diversity of chemical constituents in the extract.

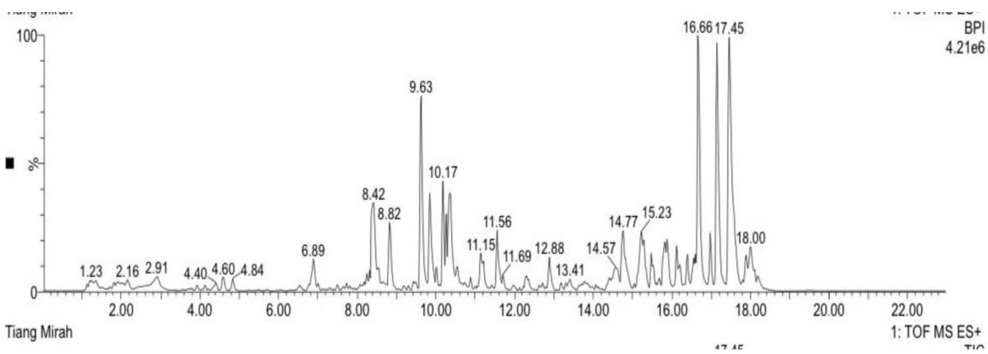

Figure 1. LC-MS/MS Chromatogram of White Turi Stem Bark Extract (F6 Fraction)

A total of ten major compounds were identified based on molecular weight, retention time, and mass fragmentation patterns

Table 2. Identified Compounds From LC-MS/MS Analysis of Fraction F6

Peak	*Molecular Weight (g/mol)*	*Molecular Formula*	*Retention Time (%area)*	*Fragment Ion (m/z)*	*Compound Based on MS database*
Peak 1	136,0612	$C_5H_5N_5$	1,23	110,148,158, 205,220	*Adenine*
Peak 2	123,0813	$C_8H_{10}O$	2,91	89,110,123,1 63	*Phenylethyl alcohol*
Peak 3	167,0746	$C_8H_{10}O_3$	4,80	82,113,149,1	*2,3-dimetoksi benzaldehid*

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Peak 4	439,3576	$C_{30}H_{47}O_2$	8,42	43,235 953,1120,11 40	*4,4'Ethylenebis(2,6-di-tert butylphenol)*
Peak 5	423,3616	$C_{30}H_{47}O$	9,63	421,441,961, 989	*4-(Octadecyloxy)biphenyl*
Peak 6	374,3019	$C_{20}H_{36}N_7$	14,77	151,253,421, 556,820	*4,6-Di(1-pyrrolidinyl)-N-(2,2,6,6-tetramethyl-4-piperidinyl)-1,3,5-triazin-2-amine*
Peak 7	254,3646	$C_{18}H_{38}$	15,23	235,188,165, 85	*Octadecane*
Peak 8	348,8420	$C_{23}H_{40}O_2$	16,66	228,320,369, 390	*10,12tricosadiynoic acid*
Peak 9	303,3046	$C_{21}H_{44}$	17,14	421,431,438, 551	*Eicosane,2-methyl*
Peak 10	338,3424	$C_{24}H_{38}O_4$	17,45	243,312,343, 362	*Benzenedicarboxylic acid,bis (2-ethylhexyl) ester*

The identified compounds include nitrogen-containing compounds (adenine), phenolic derivatives, fatty acid derivatives, and aromatic compounds. Several of these compounds are known to exhibit biological activities, including antimicrobial and antifungal effects. Notably, compounds such as phenylethyl alcohol, benzenedicarboxylic acid derivatives, octadecane, and 2,3-dimethoxybenzaldehyde are suggested to contribute to antifungal activity. The presence of these compounds indicates a potential correlation between the phytochemical composition and antifungal properties of the extract.

Bioactive compounds found in the stem bark extract of *Sesbania grandiflora* have indeed been subjected to further testing against pathogenic fungi, although the number of studies specifically focusing on stem bark is still limited compared to other plant parts. Existing research demonstrates that extracts of this plant, including stem bark, possess measurable antifungal activity, particularly under in vitro conditions.

A study by Chittam et al. (2022), evaluated the antibacterial and antifungal activity of *Sesbania grandiflora* stem bark extracts using different solvents (petroleum ether, chloroform, aqueous, and methanol) through the disc diffusion method. The results showed that the methanolic extract exhibited the strongest antifungal activity compared to other solvent fractions, indicating that polar compounds play a significant role in inhibiting fungal growth .

There are notable differences in the composition of bioactive compounds among various parts of *Sesbania grandiflora*. Previous studies indicate that the leaves are particularly rich in flavonoids, phenolics, and saponins, with compounds such as quercetin and kaempferol contributing to strong antioxidant and antimicrobial activities. In contrast, the stem bark contains more specific and less common compounds, including 2-arylbenzofurans such as sesbagrandiflorain A and B, which are associated with unique pharmacological activities. Meanwhile, the roots have been reported to contain isoflavonoids such as isovestitol, medicarpin, and sativan, along with triterpenoids like betulinic acid, which exhibit antimicrobial and antituberculosis activity. Flowers and leaves also share high levels of phenolic and flavonoid compounds, although their concentrations may vary, with leaves generally showing higher levels of total phenolics. These variations indicate that each plant part possesses a distinct phytochemical profile and biological function. The stem bark, in particular, tends to contain more structurally unique compounds, while leaves and flowers are dominated by widely distributed antioxidant metabolites. Therefore, the selection of plant parts plays a crucial role in determining the biological activity and potential application of *Sesbania grandiflora* as a natural antifungal agent.

Phenylethyl alcohol has been widely reported to exhibit antifungal activity by disrupting fungal membranes and inhibiting spore germination [21]. Similarly, 2,3-dimethoxybenzaldehyde, a phenolic compound, may induce oxidative stress and protein denaturation in fungal cells, leading to growth inhibition [12]. Benzenedicarboxylic acid derivatives are known to interfere with microbial metabolic pathways, contributing to antimicrobial activity [21]. Hydrocarbon compounds such as octadecane and eicosane may enhance membrane interactions and facilitate the penetration of active

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compounds into fungal cells. The variation in retention time reflects differences in polarity and molecular weight of the compounds, where lower molecular weight compounds elute faster than higher molecular weight compounds [20]. This indicates that the extract contains a wide range of chemical constituents with different physicochemical properties. Overall, the LC-MS/MS analysis confirms that white turi stem bark extract contains multiple bioactive compounds that may contribute synergistically to antifungal activity. These findings support the potential application of *Sesbania grandiflora* as a natural source of antifungal agents. In particular, stem bark extracts have been reported to possess significant antifungal activity. Experimental studies using different solvents (methanol, chloroform, aqueous, and petroleum ether) showed that bark extracts of Sesbania grandiflora were able to inhibit fungal growth through disc diffusion assays, with methanolic extracts showing the strongest activity . Similarly, earlier studies also confirmed that extracts from stem bark and leaves exhibited inhibitory effects against fungi and bacteria, indicating broad-spectrum antimicrobial potential .

The antifungal activity of these extracts is closely related to the presence of secondary metabolites such as alkaloids, phenolics, terpenoids, tannins, and saponins. These compounds act through multiple mechanisms, including disruption of fungal cell membranes, inhibition of enzymatic systems, and interference with essential metabolic pathways. Such mechanisms are widely recognized in plant-derived antifungal agents.

In addition, studies on other parts of Sesbania grandiflora support these findings. Ethanolic extracts of roots, leaves, and flowers have demonstrated antimicrobial and antifungal activity against pathogens such as Candida albicans, indicating that the plant possesses consistent bioactivity across different organs . Furthermore, the identification of unique compounds in the stem bark, such as 2-arylbenzofurans, suggests that this plant part may contain structurally distinct metabolites with potential pharmacological effects.

Bioactive compounds derived from *Sesbania grandiflora* have demonstrated the ability to inhibit the growth of pathogenic fungi affecting humans, animals, and crops, although most studies are still limited to in vitro conditions. Extracts from various parts of the plant, including leaves, flowers, roots, and stem bark, have shown antifungal activity against microorganisms such as *Candida albicans* and other pathogenic fungi. These antifungal effects are closely associated with the presence of secondary metabolites such as alkaloids, phenolics, terpenoids, tannins, and saponins, which act through multiple mechanisms including disruption of cell membrane integrity, enzyme inhibition, and interference with fungal metabolic processes (Khan et al., 2019; Mahmoud et al., 2019).

In particular, stem bark extracts are considered a promising source of bioactive compounds due to their unique phytochemical composition, which may differ from other plant parts and contribute to stronger antimicrobial activity (Hidayati et al., 2020). Similar findings have been reported in studies of plant-derived antifungal agents, where bioactive compounds exhibit measurable inhibitory effects against fungal pathogens through in vitro assays such as disc diffusion and minimum inhibitory concentration tests (Cenobio-Galindo et al., 2024). However, despite these promising results, most studies remain at the laboratory scale, and there is still limited evidence regarding their effectiveness and safety in vivo. Therefore, further studies are needed to validate the application of *Sesbania grandiflora* extracts as antifungal agents in medical, veterinary, and agricultural contexts.

4. Conclusion

This study demonstrate that white turi (*Sesbania grandiflora* L.) stem bark extract contains various phytochemical compounds, including alkaloids, terpenoids, phenolics, tannins, and saponins, which are known to possess antimicrobial properties. LC-MS/MS analysis of the F6 water fraction successfully identified ten bioactive compounds, namely adenine, phenylethyl

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alcohol, 2,3-dimethoxybenzaldehyde, 4,4'-ethylenebis(2,6-di-tert-butylphenol), 4-(octadecyloxy)biphenyl, triazine derivative, octadecane, 10,11-tricosadiynoic acid, eicosane (2-methyl), and benzenedicarboxylic acid, bis(2-ethylhexyl) ester. Among these, five compounds—adenine, phenylethyl alcohol, benzenedicarboxylic acid bis(2-ethylhexyl) ester, octadecane, and 2,3-dimethoxybenzaldehyde—are suggested to contribute to antifungal activity. These findings indicate that white turi stem bark extract has strong potential as a natural antifungal agent and can be further developed as a source of plant-based bioactive compounds

5. Reference

[1]B. Bongomin, S. Gago, R. O. Oladele, and D. W. Denning, "Global and multi-national prevalence of fungal diseases," *Journal of Fungi*, vol. 3, no. 4, pp. 1–15, 2017. https://doi.org/10.3390/jof3040057.

[2]M. C. Fisher et al., "Emerging fungal threats to animal, plant and ecosystem health," *Nature*, vol. 484, pp. 186–194, 2018.

[3]P. Cos, A. J. Vlietinck, D. V. Berghe, and L. Maes, "Anti-infective potential of natural products," *Journal of Ethnopharmacology*, vol. 106, pp. 290–302, 2020.

[4]S. Verma, A. Singh, and P. K. Mishra, "Phytochemical and pharmacological properties of *Sesbania grandiflora*," *Journal of Medicinal Plants Research*, vol. 12, pp. 1–10, 2018.

[5]R. Hidayati, S. Rahayu, and A. Nugroho, "Secondary metabolite profile of *Sesbania grandiflora*," *Biodiversitas*, vol. 21, no. 1, pp. 345–352, 2020. https://doi.org/10.13057/biodiv/d210142.

[6]N. L. Suriani, I. W. Suanda, and A. A. K. Darmadi, "Antioxidant activity of *Sesbania grandiflora* leaf extract," *Journal of Biological Research*, vol. 25, pp. 45–52, 2021.

[7]A. A. K. Darmadi et al., "Antibacterial activity of plant extracts," *Indonesian Journal of Pharmacy*, vol. 31, no. 2, pp. 78–85, 2022.

[8]J. B. Harborne, *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*, 3rd ed. London: Chapman & Hall, 1998.

[9]M. Ali, S. Khan, and R. Ahmed, "Application of LC-MS/MS in natural product analysis," *Analytical Chemistry*, vol. 93, pp. 1–15, 2021.

[10]S. Jain, R. Jain, and P. Sharma, "Alkaloids: Mechanism of antimicrobial activity," *Microbiological Research*, vol. 15, pp. 102–110, 2019.

[11]M. Mahmoud, A. A. Aly, and M. A. Ibrahim, "Terpenoids as antifungal agents," *Journal of Fungi*, vol. 5, pp. 1–12, 2019.

[12]A. Komala, S. Widyastuti, and R. Pratiwi, "Mechanism of antifungal compounds," *Pharmacognosy Reviews*, vol. 13, pp. 45–50, 2019. https://doi.org/10.3390/jof5020042
[13]M. Javaid, A. Rasool, and M. Zafar, "Role of plant extracts in antifungal activity," *Mycology*, vol. 8, pp. 12–20, 2017.
[14]H. Hameed, M. Shahid, and S. Ahmed, "LC-MS analysis of plant bioactive compounds," *Biochemical Analysis*, vol. 22, pp. 67–75, 2016.
[15]S. Watson and V. Preedy, *Bioactive Foods in Promoting Health*. London: Academic Press, 2007.
[16]M. Mujeeb, A. Aeri, and A. Bagri, "Phytochemical screening and antimicrobial activity," *Journal of Pharmaceutical Sciences*, vol. 4, pp. 1–7, 2014.
[17]L. Mamtha, R. Rao, and S. Kumar, "Tannins and saponins as antifungal agents," *Journal of Applied Microbiology*, vol. 125, pp. 1–9, 2024.
[18]N. Nur, "Phytochemical analysis of *Sesbania grandiflora*," *Indonesian Journal of Biology*, vol. 5, pp. 34–40, 2019. https://doi.org/10.18196/jfaps.v6i2.23715
[19]A. Syah, "LC-MS/MS analysis of natural compounds," *Journal of Chemistry*, vol. 10, pp. 1–8, 2020.
[20]H. Hussein, A. Khalil, and M. Hassan, "Retention time in chromatography," *Analytical Methods*, vol. 8, pp. 12–18, 2016.
[21]R. Sales, J. Silva, and M. Costa, "Antifungal activity of plant-derived compounds," *Journal of Ethnopharmacology*, vol. 190, pp. 100–110, 2016.
[22]D. Djunaedy, "Mechanism of antifungal compounds," *Journal of Plant Pathology*, vol. 8, pp. 45–50, 2008.
[23]I. Dalimunthe and Rachmawan, "Alkaloid compounds and biological activity," *Journal of Natural Products*, vol. 5, pp. 23–30, 2017.
[24]G. Gholib, "Mechanism of antimicrobial activity of alkaloids," *Pharmaceutical Journal*, vol. 3, pp. 12–18, 2009.
[25]T. Robinson, *The Organic Constituents of Higher Plants*. London: Academic Press, 1995
[26]Isman, M. B. Botanical insecticides in the twenty-first century. *Annual Review of Entomology*, 65, 233–249. 2020. https://doi.org/10.1146/annurev-ento-011019-025010
[27]Hidayati, R., Rahayu, S., & Nugroho, A. Secondary metabolite profile of *Sesbania grandiflora*. *Biodiversitas*, 21(1), 345–352. 2020. https://doi.org/10.13057/biodiv/d210142
[28]Khan, I., Ullah, N., Zha, L., Bai, Y., Khan, A., Zhao, T., Che, T., & Zhang, C.Antimicrobial and antioxidant activities of plant extracts: A review. *Molecules*, 24(3), 485. 2019. https://doi.org/10.3390/molecules24030485
[29]Mukherjee, P. K., et al. Trichoderma research in the genome era. *Annual Review of Phytopathology*, 57, 295–319. 2019. https://doi.org/10.1146/annurev-phyto-082718-100314

[30]C. Galindo, A. J., et al. Biofungicides based on plant extracts: On the road to organic farming. *International Journal of Molecular Sciences*, 25(13), 6879.2024. https://doi.org/10.3390/ijms25136879
[31]M. E. Daub and K. R. Chung, "Cercosporin: A phytoactivated toxin," *APSnet Features*, 2007.
[32]J. H. Daughari and J. S. Obidah, "In vitro antifungal activity of *Leptadenia lancifolia* bark extract," *International Journal of Integrative Biology*, vol. 3, no. 2, pp. 111–117, 2008.
[33]L. Hamidah, Mukarlin, and Riza, "Bioherbicidal activity of *Mikania micrantha* leaf extract on *Melastoma affine*," *Jurnal Protobiont*, vol. 4, no. 1, pp. 89–93, 2015.
[34]H. N. F. Hanin and R. Pratiwi, "Phenolic, flavonoid content and antioxidant activity of *Acrostichum aureum* leaves," *Journal of Tropical Biodiversity and Biotechnology*, vol. 2, pp. 51–55, 2017. https://doi.org/10.22146/jtbb.29819
[35]D. Hardian, "Component analysis of polar and non-polar solvent extractives of wood charcoal (*Diospyros* sp.)," Undergraduate Thesis, Hasanuddin University, Makassar, 2020.
[36]A. H. Hariana, *Medicinal Plants and Their Efficacy*. Jakarta: Penebar Swadaya, 2013.
[37]Haryanto et al., *Growing Lettuce and Mustard*. Jakarta: Penebar Swadaya, 2002.
[38]U. W. Hawas et al., "Lipid content and antimicrobial activity of some Egyptian Fabaceae plants," *Journal of Medicinal Plants Research*, vol. 6, no. 44, pp. 5604–5608, 2012.
[39]M. A. Hayat, *Fixation for Electron Microscopy*. New York: Academic Press, 1981.
[40]Sukmawaty, E., Hafsan, H., Masri, M., Shintia, I., Wahyuni, S., & Amir, U. N. A. Phytochemical screening and antioxidant activity of ethyl acetate extract of endophytic fungi *Aspergillus* sp. *Jurnal Biotik*, 8(2), 218–231, 2022. https://doi.org/10.22373/biotik.v8i2.8194
[41]Chittam, K. P., Patil, S. B., & Patil, M. S. (2022). Anti-bacterial and anti-fungal evaluation of bark extracts of *Sesbania grandiflora* L. *International Journal of Health Sciences*, 6(S1), 2022. https://doi.org/10.53730/ijhs.v6nS1.7272