Jurnal Ners Volume 9 Nomor 3 Tahun 2025 Halaman 4073 - 4078
JURNAL NERS
Research & Learning in Nursing Science
http://journal.universitaspahlawan.ac.id/index.php/ners

ANTIBACTERIAL ACTIVITY OF THE SECONDARY METABOLITE OF *FUSARIUM* LBSU ISOLATE FROM THE CAT'S WHISKERS PLANT (*ORTHOSIPHON STAMINEUS*)

Sati Agriani Zega[1], Rico Halim[2], Astri Natalia Ginting[3], Finna Piska[4*]
Program Studi Farmasi, Fakultas Kedokteran, Kedokteran Gigi, Universitas Prima Indonesia
satiagrianizega@gmail.com[1], ricohalim33@gmail.com[2], astriani.natalia@gmail.com[3],
finnapiska@unprimdn.ac.id[4]

Abstrak

Tanaman kumis kucing diketahui mengandung metabolit bioaktif yang berpotensi sebagai agen terapeutik, sedangkan rizosfernya merupakan habitat bagi mikroorganisme yang menghasilkan metabolit sekunder. Isolat Fusarium LBSU merupakan isolat yang berasal dari rizosfer tanaman kumis kucing. Metabolit sekunder diproduksi melalui fermentasi cair, dilanjutkan dengan ekstraksi menggunakan etil asetat. Aktivitas antibakteri diuji menggunakan metode difusi cakram terhadap Escherichia coli dan Staphylococcus aureus. Aktivitas antibakteri tertinggi diperoleh terhadap Escherichia coli sebesar 23,565 mm, lebih tinggi dibandingkan Staphylococcus aureus yaitu sebesar 15,3 mm. Temuan ini mendukung pengembangan lebih lanjut metabolit sekunder dari isolat rizosfer sebagai sumber alternatif agen antibakteri yang ramah lingkungan dan efektif.

Kata Kunci: *Fusarium LBSU, Rizosfer, Kumis Kucing, Metabolit Sekunder, Antibakteri.*

Abstract

The cat's whisker plant is known to contain bioactive metabolites that have potential as therapeutic agents, while its rhizosphere is a habitat for microorganisms that produce secondary metabolites. Fusarium LBSU isolate were isolate from the rhizosphere of cat's whiskers plant. Secondary metabolites are produced through liquid fermentation, followed by extraction using ethyl acetate. Antibacterial activity was tested using the disk diffusion method against the Escherichia coli and Staphylococcus aureus. The highest antibacterial activity obtained against Escherichia coli 23.565 mm, higher than Staphylococcus aureus which is 15.3 mm. These findings support the further development of secondary metabolites from rhizosphere isolate as an alternative source of environmentally friendly and effective antibacterial agents.

Keywords: *Fusarium LBSU, Rhizosphere, Cat's Whiskers, Secondary Metabolites, Antibacterial.*

✉ Corresponding author : Finna Piska
Affiliation : Universitas Prima Indonesia
Email : finnapiska@unprimdn.ac.id
Phone number : 085265660423

INTRODUCTION

Antibiotics are active substances that play a crucial role in reducing the impact of diseases caused by pathogenic microbes in living organisms, One of the main targets of antibiotics is infection-causing bacteria, particularly those associated with degenerative diseases. However, inappropriate or excessive use of antibiotics can lead to alterations in gut microbiota, potentially contributing to the development of neurodegenerative diseases such as Alzheimer's. Dysbiosis, or microbial imbalance in the gut triggered by antibiotics, has been linked to an increased risk of such diseases, as gut microbiota play an essential role in regulating the immune system and brain function.[1] Furthermore, the irrational use of antibiotics is often driven by a lack of public awareness regarding their proper use, which contributes to the rise in antibiotic resistance, Antibiotic resistance is currently a significant global health concern. In Indonesia, around 40% of bacteria had already shown resistance in 2013, a figure that rose to 60.4% by 2019.[2]

The growing phenomenon of antibiotic resistance in Indonesia has raised serious concerns regarding its implications for public health. Infections caused by antibiotic-resistant bacteria can worsen degenerative conditions such as atherosclerosis and neurodegenerative diseases, as well as increase the risk of chronic illnesses like diabetes and heart disease.[3] One approach to addressing antibiotic resistance is the development of antibacterial compounds derived from natural resources, such as plants and microorganisms. One such plant with significant potential as an antibacterial source is *Orthosiphon stamineus*, commonly known as cat's whiskers, which has long been used in traditional medicine across various tropical countries.[4]

This plant is known to contain a variety of bioactive compounds with medicinal properties, including antioxidant, antidiabetic, antihypertensive, and antibacterial activities.[5] Additionally, microorganisms inhabiting the plant's rhizosphere, such as the fungus *Fusarium* LBSU, may also produce secondary metabolites with antibacterial properties. Research on rhizosphere microbes has shown that compounds produced by these organisms can serve as alternatives to conventional antibiotics in combating resistant bacterial infections. Therefore, this study aims to explore the potential of secondary metabolites produced by *Fusarium* LBSU, isolate from the rhizosphere of *Orthosiphon stamineus*, as antibacterial agents, with the hope of contributing new solutions to the growing issue of antibiotic resistance.

METODE

This study is an experimental research at testing the antibacterial effectiveness of rhizosphere fungal extract *Fusarium* sp. LBSU obtained from the cat's whiskers plant (*Orthosiphon stamineus*). The disk diffusion method was employed to measure antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*, The research was conducted at the Integrated Research Laboratory, Prima Indonesia University, Medan, from January to February 2024. The population in this study consisted of *Fusarium* sp. LBSU rhizosphere isolates obtained from *Orthosiphon stamineus*. The sample used was a colony of *Fusarium* sp., which was harvested for the extraction of active compounds and subsequently tested for antibacterial activity.

The sampling technique involved isolating *Fusarium* sp. from the rhizosphere of *O. stamineus* and cultivating it on *Potato Dextrose Agar* (PDA) to produce pure colonies. These colonies were then inoculated into *Potato Dextrose Broth* (PDB) for fermentation, after which the resulting extract was used for testing. Data collection was conducted by measuring the diameter of the inhibition zones on media inoculated with *Staphylococcus aureus* and *Escherichia coli.* following application of the *Fusarium* extract, as well as assessing antioxidant activity using the DPPH method. The Fusarium isolates used in this study were obtained from the results of isolation carried out by previous researchers, Evianti Dwi Septia in 2025 at the Microbiology Laboratory, Faculty of Medicine, Dentistry, and Health Sciences, Prima Indonesia University.

The equipment and materials used in this study included the *Fusarium* sp. LBSU rhizosphere isolate, *Potato Dextrose Agar* (PDA) (Merck), *Potato Dextrose Broth* (PDB) (Merck), ethyl acetate, distilled water (aquadest), filter paper (Whatman No. 41, 125 mm), tissue, 50 mg vitamin C, *Nutrient Agar* (NA), *Nutrient Broth* (NB), n-hexane, and microbial cultures of *Staphylococcus aureus* and *Escherichia coli*.

Data analysis was carried out by measuring the diameter of inhibition zones formed around the discs inoculated with *Fusarium* extract on NA or NB media, followed by calculating the percentage of free radical inhibition in the antibacterial test. The obtained data will be presented in tables and narrative form, explaining the antibacterial effectiveness and activity of the *Fusarium* extract. The research process is described as follows:

1. Meintenance of *Fusarium* sp. LBSU Isolate

Fusarium sp. LBSU separates were revived on Potato Dextrose Agar (PDA) media in test tubes and brooded at 30°C for 4 days to reestablish their reasonability and development capacity. After the hatching period, 3 ml of sterile physiological NaCl arrangement (0.8%) was included to the culture tube to gather spores from the surface of the media. The coming about spore suspension was gradually homogenized, at that point 0.1 ml was immunized into PDA media in a sterile petri dish that had been arranged already. (Piska *et al*., 2020).

2. Preparation of *Potato Dextrose Broth* (PDB) Media

The *Potato Dextrose Broth* (PDB) media was prepared by weighing 7.4 grams of PDB powder using an analytical balance and dissolving it in 300

mL of distilled water (aquadest). The solution was prepared in three 1000 mL Erlenmeyer flasks and stirred using a magnetic stirrer until homogeneous. After achieving homogeneity, the PDB solution was sterilized using an autoclave at 121°C and 15 psi for 15 minutes to ensure the media's sterility (Piska *et al*., 2020).

3. Fermentation

After the *Fusarium* sp. LBSU culture grew optimally on PDA media, the colony was cut using a 6 mm diameter cork borer to ensure uniformity in the size of the inoculum to be used in fermentation. The three colony pieces were at that point aseptically embedded into a 1 liter Erlenmeyer carafe containing 300 ml of sterile PDB media as a fluid maturation medium. Hatching was carried out for three weeks at 30°C with the assistance of an hatchery shaker to guarantee that the air circulation and homogenization conditions of the arrangement were kept up, hence supporting ideal development and generation of auxiliary metabolites (Piska *et al.*, 2020).

4. Isolation of Secondary Metabolite Extract

The preparation of NA media begins by weighing 3.3 grams of NA powder which is then dissolved in 120 ml of distilled water, stirred until homogeneous, and heated to boiling to dissolve the agar components. After that, the arrangement is sterilized utilizing an autoclave at a temperature of 121°C for 15 minutes, at that point poured into a sterile petri dish in a biosafety cabinet (BSC) as much as 20 ml per dish and cleared out to solidify. After a three-week fermentation incubation period, the *Fusarium* sp. culture is filtered using filter paper on a Buchner funnel and a vacuum device to separate spores and mycelium from the filtrate. The procedure for extracting secondary metabolites from this filtrate is carried out by mixing ethyl acetate in a 1:1 ratio, followed by phase separation and evaporation using a rotary evaporator (Piska *et al*., 2020).

5. Preparation of *Nutrient Agar* (NA) and *Nutrient Broth* (NB) Media

Nutrient Agar (NA)

Media was prepared by weighing 3.36 grams of NA powder and dissolving it in 120 mL of distilled water in a beaker glass, which was then heated on a hot plate stirrer until boiling. *Nutrient Broth* (NB) media was made by dissolving 1.32 grams of NB powder in 6 mL of distilled water on a hot plate stirrer until boiling. After the heating process, both media were sterilized using an autoclave at 121°C for 15 minutes. NA media was used for bacterial inoculation and antibacterial activity testing, while NB media was used for bacterial fermentation. (Piska *et al*., 2020).

6. Revitalization of Bacteria

After the incubation process, the clear zone (inhibition zone) formed around the disc containing the extract was observed as an indicator of antibacterial activity. In this test, sterile NA media was used to grow two pathogenic bacteria, *Escherichia coli* and *Staphylococcus aureus*, which had been suspended in sterile physiological NaCl solution and inoculated evenly onto the surface of the media using a sterile cotton swab. The supernatant from the extraction using ethyl acetate solvents was dropped onto disc paper (6 mm in diameter), then placed on NA media and incubated at 37°C for 24 hours. (Piska *et al*. 2020).

7. Antibacterial Test

After bacterial incubation, the antibacterial test was conducted using the disk diffusion method on *Nutrient Agar* (NA) media. Suspensions of *Escherichia coli* and *Staphylocuccus aureus* bacteria, with known bacterial concentrations, were collected using a strile *cotton swab* and evenly spread on the surface of the NA media. The extraction (ethyl acetate) were each applied to sterile paper. discs at a volume of mL. The NA media inoculated with the pathogen bacteria.the petri dishes were incubated 37^{o}C for 24 hours. After incubation, the clear zones formed around the discs were abservad and measured to evaluate the antibacterial the two pathogenic bacteria. The positive control used was chloramphenicol 30 mcg used. The negative control used is aquadest (Piska *et al*., 2020).

Antibacterial activity calculation formula: R1=(X1-X2)/X2

Description:

R1: Ratio

X1: Clear zone diameter

X2: Disc paper diameter (6 mm) (Piska *et al*., 2020).

RESULT AND DISCUSSION

Escherichia coli using the rhizosphere fungal extract *Fusarium* sp. LBSU obtained from the *Orthosiphon stamineus* plant, the following results were obtained:

Table 1: Results of *Fusarium* LBSU Isolate Revitalization.

Parameter	Condition	Rejuvenation Results
Media Used	*Potato Dextrose Agar* (PDA)	*Fusarium* sp. colonies grew optimally, round-shaped, with fine hairs, and pink to orange in color
Colony Color	Pink to Orange	Colonies were pink in the early growth phase, turning orange as they matured
Colony Morphology	Grown on media surface	Round colonies with fine hairs and conidiophores
Incubation Temperature	30°C	Optimal growth at this temperature after 4 days of incubation
Incubation Time	4 days	Colonies appeared after 2 days of incubation and reached optimal size on day 4

Physiological NaCl Concentration	0,8%	Spores detached well from the media surface, successful incubation
Inoculation Result	PDA media petri dish	Colonies developed well and homogeneously, showing good isolate viability

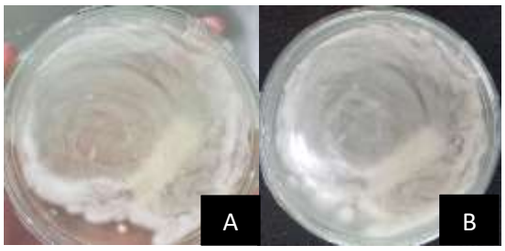

Figure 1: Results of *Fusarium* LBSU Isolate Revitalization

(a) *Fusarium* before rejuvenation
(b) *Fusarium* after rejuvenation

Bacterial cultures of *Staphylococcus aureus* and *Escherichia coli* were inoculated onto NA and NB media to observe their growth after incubation for 24 hours at 37°C.

Table 2: Antibacterial Activity Test Results

Clear Zone Value	Test 1	Test 2
Ethyl acetate extract against *S.aureus*	0,944	0,766
Fusarium ethyl acetate extract against *E.coli*	0,083	0,083
Positive Control for *S.aureus*	0,555	-
Positive Control for *E.coli*	3,799	-
Negative control for *S.aureus*	-	-
Negative control for *E.coli*	-	-

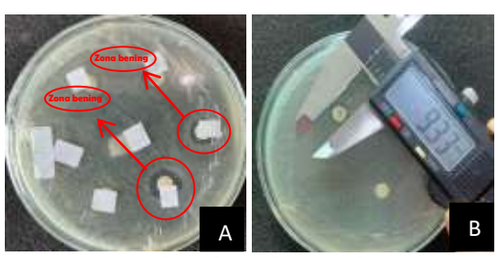

Figure 2: Results of Antibacterial Test

(a) positive control activity against *S. aureus*,
(b) positive control activity against *S. aureus*

Discussion

Fusarium fungi are known as one of the fungal genera that can produce various secondary metabolites with antimicrobial activity, including antibacterial. According to Shi *et al*. (2024), more than 180 secondary compounds have been identified from various *Fusarium* species, which show potential as antimicrobial agents against various pathogenic microorganisms. One specific example is *Fusarium* solani isolated from the Gannan navel orange plant. Research by Zhang *et al*. (2023) showed that the ethyl acetate extract of this endophyte has strong antibacterial activity against *Escherichia coli*, MRSA (Methicillin-resistant *Staphylococcus aureus)*, and Xanthomonas campestris, with MIC (Minimum Inhibitory Concentration) values between 250–500 µg/mL.

The antibacterial activity shows the effectiveness of the compound against both Gram-positive and Gram-negative bacteria. In addition, a review by Amuzu *et al*. (2023) also revealed that various *Fusarium* species from different plants are able to produce effective bioactive compounds. These compounds are able to inhibit the growth of pathogens such as *Staphylococcus aureus*, Klebsiella pneumoniae, and Bacillus cereus. Interestingly, some compounds showed very low MIC values, even below 1 µg/mL, thus indicating the great potential of *Fusarium* as an alternative source of natural antibacterial agents for pharmaceutical or agricultural purposes.

Fusarium fungi are known to be able to produce secondary metabolites that have antibacterial activity, especially when extracted using organic solvents such as ethyl acetate. Research by Efendi *et al*. (2020) showed that ethyl acetate extract from Fusarium isolates obtained from the kencur plant (Kaempferia galanga) was able to inhibit the growth of *Escherichia coli* and *Staphylococcus aureus* bacteria, with the inhibition zone formed being in the range of 5–10 mm. This activity indicates that the compounds resulting from secondary metabolites from *Fusarium* have the potential as natural antibacterials. In addition to ethyl acetate, other solvents such as methanol and chloroform have also been used in other studies to extract bioactive compounds from *Fusarium* oxysporum and *Fusarium* solani isolates. For example, according to Pratiwi *et al*. (2022), the ethyl acetate fraction of *Fusarium* solani isolated from the roots of the Cassia alata plant showed significant antibacterial activity against both Gram-positive and Gram-negative bacteria, with relatively low MIC values. Meanwhile, methanol solvent produces extracts with a broader spectrum of activity, although it does not always show higher inhibitory potential than ethyl acetate. Thus, the selection of solvent types in the extraction process greatly affects the antibacterial effectiveness of secondary metabolites of Fusarium fungi, which have the potential to be further developed as a source of natural antimicrobial compounds.

In accordance with the research question, six strains of rhizosphere microbes isolated from cattail roots (*Orthosiphon aristatus*) showed the

characteristics of a bipherical shape and pink color. In this study, the ethyl acetate extract derived from the *Fusarium* LBSU isolate was evaluated for its antibacterial activity against two representative bacterial strains: *Staphylococcus aureus* (Gram-positive bacteria) and *Escherichia coli* (Gram-negative bacteria). The purpose of this evaluation was to determine the spectrum and effectiveness of the bioactive compounds contained in the mushroom extract, especially in terms of their ability to inhibit bacterial growth through the formation of an inhibition zone. The results of the antibacterial test showed that the ethyl acetate extract showed significantly higher inhibitory activity against *E. coli*, with an average inhibition zone of 23.565 mm, which was categorized as "high." In contrast, the inhibition zone measured against *S. aureus* was only 5.425 mm, which was included in the "low" activity category (Septia *et al*., 2025)

These discoveries recommend that auxiliary metabolites display within the ethyl acetic acid derivation extricate of Fusarium LBSU disconnect show specific antibacterial movement, showing more prominent viability against Gram-negative microscopic organisms. This contrast in defenselessness may be credited to auxiliary contrasts within the bacterial cell divider. Gram-positive microbes such as S. aureus have a thick peptidoglycan layer, which, in spite of the fact that giving inflexibility, needs an external layer. In differentiate, Gram-negative microscopic organisms such as E. coli have a more slender peptidoglycan layer, but are encased by an extra external film composed of lipopolysaccharides (LPS), phospholipids, and proteins. This external film frequently acts as a particular boundary, blocking the section of certain hydrophobic or tall atomic weight antibacterial specialists (Chen & Wu, 2023; World Wellbeing Organization, 2022).

In this study, ethyl acetate extract was able to effectively penetrate this barrier in *E. coli*, indicating that the active compounds in the extract may have certain chemical properties, such as small molecular size or lipophilicity, that increase their permeability across the bacterial membrane. Interestingly, the higher efficacy observed against *E. coli* is consistent with findings from previous studies on natural products, including those from plants and fungi. For example, bioactive compounds from *Orthosiphon stamineus* (commonly known as "cat's whiskers") have also been reported to exhibit greater antibacterial effects against Gram-negative bacteria (Faramayuda *et al*., 2023; Septyani & Shinta, 2021).

This design underscores the significance of understanding the physicochemical intuitive between antibacterial compounds and bacterial cell structures, as well as the potential components by which these characteristic items apply their impacts.Some proposed mechanisms include disruption of membrane integrity, inhibition of DNA gyrase, disruption of protein synthesis, or inhibition of peptidoglycan biosynthesis. In addition, various classes of secondary metabolites, such as flavonoids, alkaloids, terpenoids, and phenolic compounds, are known to exhibit antibacterial properties through various pathways (Faramayuda et al., 2023; Sakti *et al*., 2023).

The exact composition of the ethyl acetate extract of *Fusarium* LBSU remains to be fully elucidated; however, the observed activity against E. coli strongly suggests the presence of at least one or more bioactive metabolites that may function through synergistic or individual mechanisms. Although the activity against S. aureus was relatively weak, it should not be discounted. Several factors may have contributed to the limited activity observed in this study. First, the extraction solvent (ethyl acetate) mainly isolated semi-polar compounds; thus, some potent polar antibacterial constituents may not have been efficiently extracted. Second, the concentration of active compounds in the extract may have been suboptimal. Third, innate resistance mechanisms of S. aureus, such as the presence of efflux pumps or altered target sites, may limit the efficacy of the compounds (Chen & Wu, 2023).

Nevertheless, these results highlight the potential of *Fusarium* LBSU as a valuable source of novel antibacterial compounds, particularly for targeting Gram-negative pathogens, which are often more difficult to treat due to their outer membrane and multidrug resistance. Future studies may explore the use of alternative or dual solvents (e.g., methanol, ethanol, or water) to increase extraction yields and broaden the metabolite spectrum of the isolate. In addition, fractionation and purification of the extract followed by identification of compounds using techniques such as LC-MS, GC-MS, or NMR spectroscopy will be essential in elucidating the structure and function of the bioactive molecules involved (Septia *et al*., 2025).

Nevertheless, these results highlight the potential of *Fusarium* LBSU as a valuable source of novel antibacterial compounds, particularly for targeting Gram-negative pathogens, which are often more difficult to treat due to their outer membrane and multidrug resistance. Future studies may explore the use of alternative or dual solvents (e.g., methanol, ethanol, or water) to increase extraction yields and broaden the metabolite spectrum of the isolate. In addition, fractionation and purification of the extract followed by identification of compounds using techniques such as LC-MS, GC-MS, or NMR spectroscopy will be essential in elucidating the structure and function of the bioactive molecules involved (Septia *et al*., 2025).

In addition, further antibacterial testing against a broader panel of Gram-positive and Gram-negative clinical isolates will provide more comprehensive insights into the antimicrobial spectrum of the extract. Investigation of the minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) will also help to gauge its efficacy and determine potential therapeutic applications. Toxicity and cytotoxicity studies will be required to evaluate the

safety profile of the extract, especially if it is to be considered for pharmacological or therapeutic use. In conclusion, the ethyl acetate extract of *Fusarium* isolate LBSU showed promising antibacterial activity, especially against *Escherichia coli*, indicating its potential as a natural source of antibacterial agents targeting Gram-negative bacteria. Although inhibition against *Staphylococcus aureus* was lower, the presence of antibacterial activity suggests that further optimization of the extraction method or purification process may improve the efficacy (Septia *et al*., 2025).

These findings support further exploration of endophytic fungi such as *Fusarium* spp. as a reservoir of bioactive compounds with potential pharmaceutical applications (Tambaru *et al*., 2020).

CONCLUSION

The ethyl acetic acid derivation extricate from the Fusarium LBSU disconnect illustrated higher antibacterial potential against Escherichia coli (hindrance zone of 23.565 mm) compared to Staphylococcus aureus (hindrance zone of 5.425 mm). Although its antibacterial activity against *S. aureus* was categorized as low, this extract holds potential for development as a natural antibacterial agent, particularly against Gram-negative bacteria.

REFERENCES

Chen, K. & Wu, H., 2023. A review of current antibiotic resistance and promising antibiotics with novel modes of action to combat antibiotic resistance. *Journal of Health Education*, 205, p.356.

Faramayuda, F., Julian, S., Windyaswari, A., Mariani, T., Elfahmi & Sukrasno, 2023. Flavonoid pada Tanaman Kumis Kucing. *Proceeding of Mulawarman Pharmaceuticals Conferences*, 20(3), p.3. Available at: https://doi.org/10.25026/mpc.v13i1.478 [Accessed 2 June 2025].

Sakti, B., Andriana, D. & Widyaningrum, I., 2023. Uji Aktivitas Antibakteri Ekstrak Etanol dan Fraksi Etanol-Air Daun Kumis Kucing (Orthosiphon stamineus) Terhadap Pseudomonas aeruginosa. *Journal Kedokteran Komunitas (Journal of Community Medicine)*, 11(2).

Septyani, L.V. & Shinta, N.P.M.A., 2021. Kandungan Fitokimia dan Aktivitas Farmakologi Orthosiphon aristatus. *Media Farmasi*, 17(1), pp.62. Available at: https://doi.org/10.32382/mf.v17i1.2048 [Accessed 2 June 2025].

Septia, E.D., Hutauruk, R.H., Razoki & Piska, F., 2025. Isolation and identification of Fusarium in cat's whiskers (Orthosiphon aristatus) plants. *Journal of Tropical Microbiology*, 10(2), pp.123–130.

Piska, F., Teruna, H. Y., & Saryono. (2020). *Terpenoid as Antibacterial Produced by Endophyte Fusarium oxysporum LBKURCC41 from Dahlia variabilis Tuber*. *Journal of Physics: Conference Series*, 1655(1), 012034.

Piska, F., Teruna, H. Y., & Saryono. (2020). *Terpenoid as Antibacterial Produced by Endophyte Fusarium oxysporum LBKURCC41 from Dahlia variabilis Tuber*. *Journal of /Physics: Conference Series*, 1655(1), 012034.

Piska, F., Teruna, H. Y., & Saryono. (2020). *Terpenoid as Antibacterial Produced by Endophyte Fusarium oxysporum LBKURCC41 from Dahlia variabilis Tuber*. *Journal of Physics: Conference Series*, 1655(1), 012034.

Piska, F., Teruna, H. Y., & Saryono. (2020). *Terpenoid as Antibacterial Produced by Endophyte Fusarium oxysporum LBKURCC41 from Dahlia variabilis Tuber*. *Journal of Physics: Conference Series*, 1655(1), 012034.

Tambaru, E., Masniawati, A. & Jumatang, 2020. Potensi Antagonid Isolat Bakteri Bacillus spp. Asal Rizosfer Tanaman Lada (Piper nigrum L.) sebagai Agen Pengendali Jamur Fusarium sp.JDF ANTAGONISTIC. *Jurnal Biologi Makasar*, 5(1), pp.69–78.

World Health Organization, 2022. Global Antimicrobial Resistance and Use Surveillance System (GLASS). In *World Health Organization* (Issue 8.5.2017). Availableat:https://dataindonesia.id/sektor-riil/detail/angka-konsumsi-ikan-ri-naik-jadi-5648-kgkapita-pada-2022 [Accessed 2 June 2025].