ISSN: 2085-675X (Print)
ISSN: 2354-8770 (Electronic)

Jurnal Kefarmasian Indonesia
Available online at https://jkefarind.com/index.php/jki
Original Research Article
JKI

Isolation and Antibacterial Activity Isolate of The Endophytic Fungi of Shallot Tubers (*Allium cepa* L.) Against Pathogen Bacteria

Melzi Octaviani*, Miftahul Jannah, Rizki Wulandari, Rahayu Utami, Haiyul Fadhli

Sekolah Tinggi Ilmu Farmasi Riau, Pekanbaru, Riau, Indonesia

ARTICLE INFO

Article history:
Received 29 January 2024
Revised 09 June 2024
Accepted 25 June 2024
Published online 31 August 2024

*Corresponding author.
E-mail: *melzioctaviani@stifar-riau.ac.id*

DOI: https://doi.org/10.22435/jki.v14i2.6639

Citation: Octaviani M, Jannah M, Wulandari R, Utami R, Fadhli H. Isolation and Antibacterial Activity Isolate of The Endophytic Fungi of Shallot Tubers (*Allium cepa* L.) Against Pathogen Bacteria. Jurnal Kefarmasian Indonesia. 2024;14(2):126-136

ABSTRACT

Shallots (*Allium cepa* L.) are widely known by the public as a kitchen spice and traditional medicine. Shallots have antibacterial activity. Compounds that have antibacterial properties can be obtained by isolating endophytic microbes. Endophytic microbes are microbes that live in plant tissue, are able to form colonies in plant tissue without having detrimental effects on the host, and can produce secondary metabolites like the host. Phytochemical screening of shallot tubers showed that they contained alkaloids, flavonoids, and phenolics. This research aims to isolate and identify endophytic fungi from shallot tubers and determine the antibacterial activity of these endophytic fungal isolates. Endophytic fungi were isolated using the direct planting method, and then pure isolates were identified macroscopically and microscopically. Antibacterial activity testing was carried out using the agar diffusion method against the bacteria *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Bacillus cereus*, *Escherichia coli*, *Salmonella typhi*, and *Shigella dysenteriae*. There were 4 isolates of endophytic fungi produced during the isolation process, namely FEAC-U1 (*Aspergillus*), FEAC-U2 (*Penicillium*), FEAC-U3 (*Trichophyton*), and FEAC-U4 (*Rhizopus*). FEAC-U1 isolate showed the highest activity against *Staphylococcus epidermidis*, *Bacillus cereus,* and *Shigella dysenteriae*. FEAC-U2 isolate showed the highest activity against *Salmonella typhi*. FEAC-U3 isolate showed the highest activity against *Staphylococcus aureus* and *Escherichia coli*. The results of antibacterial activity testing on four isolates of shallot tuber endophytic fungi were able to inhibit the growth of the test bacteria.

***Keywords*:** Antibacterial; Endophytic fungi; Isolation; *Allium cepa*

INTRODUCTION

Bioactive compounds are currently being widely researched as compounds that provide benefits in the treatment of disease. These bioactive compounds can be obtained by isolating secondary metabolite compounds from endophytic fungi.[1] Endophytic fungi are an alternative in medicine because endophytic fungi produce the same secondary metabolite compounds as their host plants. Endophytic fungi produce bioactive compounds such as antioxidants, anticancer, antibacterial, antiviral, antifungal and so on.[2,3]

A plant that is widely known to contain secondary metabolites that are active as antibacterials is shallots. Shallots contain more polyphenols, flavonoids, flavonols

ISSN: 2085-675X (Print)
ISSN: 2354-8770 (Electronic)

and tannins compared to other types of onions.[4,5] Secondary metabolite compounds produced by shallots are known to have antibacterial activity against pathogenic bacteria and fungi.[6–8] Research results show that not only secondary metabolites produced by the shallot plant are nutritious, but also from endophytic fungi that live in the tissues of the shallot plant.

Akhsan et al., (2021) reported the results of their research on the potential of endophytic fungi in shallot plants (*Allium ascalonicum* L.) in controlling fungi. *Alleternaria porii* produces endophytic fungal isolates that have the potential to control plant pests against *Trichoderma* sp. and *Rhizopus* sp. with inhibitory diameters of 64.55% and 42.42%.[9] Choirani et al. (2018) conducted research on isolation, identification, and antifungal and anticholesterol testing of endophytic fungal isolates from shallot tubers. From this research, two endophytic fungal isolates were obtained, namely FEAC 1 and FEAC 2. The results of the antifungal activity test showed that the FEAC 2 isolate had an inhibition zone of 7.389 mm against *Candida albicans*. However, isolate FEAC 1 did not have activity against *Candida albicans*.[10]

The results of research by Prima et al., (2022) on evaluation of antibacterial and antioxidant activity of endophytic fungi isolated from *Capsicum annuum* L. and *Allium cepa* L. showed five isolates of endophytic fungi from red and green fruits of *C. annuum* and bulb of *A. cepa* have been isolated. Testing of antibacterial activity at a concentration of 5% ethyl acetate extract of endophytic fungal isolates showed strong antibacterial activity against Gram positive bacteria *S. aureus* and *B. subtilus*.[11]

Based on the background above, researchers are interested in testing the antibacterial activity of endophytic fungi from shallot tubers against Gram-positive and Gram-negative bacteria. This research aims to isolate endophytic fungi in shallot bulbs and determine the antibacterial activity of these endophytic fungal isolates. The results of this research are expected to provide information that endophytic fungal isolates contain secondary metabolite compounds that can inhibit bacterial growth.

METHODS

This research is an experimental laboratory, carried out from May to October 2023.

Equipment and materials

The main instruments used in this study were an autoclave (GEA Model YX280B), oven (Memmert), incubator (Memmert), incubator shaker (Selecta), analytical balance (Shimadzu), microscope (Shimadzu), UV-Vis spectrophotometer (Shimadzu).

The materials used were 70% ethanol, sterile distilled water, 5.3% sodium hypochlorite (Brataco), chloramphenicol antibiotic 30 µg/disk (Oxoid), chloramphenicol 0,005% (50mg/1000ml), Lactophenol Cotton Blue (Hi-Media), Nutrient agar (NA) (Merck), Potato Dextrose agar (PDA) (Merck), Yeast Extract powder (Hi-Media), Potato Dextrose Borth (Hi-Media), 0.9% NaCl solution, 2N sulfuric acid, concentrated hydrochloric acid, 1% iron (III) chloride, chloroform, 0.005 N ammonia chloroform, magnesium metal, activated carbon, Liebermann-Burchard reagent, Dragendorff's reagent, and Mayer's reagent. The samples used in this research were shallot tubers, which were taken from Alahan Panjang, Lembah Gumanti District, Solok Regency, West Sumatra. The bacteria used in this research were *Salmonella typhi* ATCC 14028, *Shigella dysenteriae* ATCC 12039, *Escherichia coli* ATCC 11775, *Bacillus cereus* ATCC 11778, *Staphylococcus aureus* ATCC 12600 and *Staphylococcus epidermidis* ATCC 12228 which were obtained from the Pekanbaru Health and Environmental Laboratory of the Riau Provincial Health Service.

Identification of the sample

The sample was identified at the Botanical Laboratory of the Biology Department, Faculty of Mathematics and

ISSN: 2085-675X (Print)
ISSN: 2354-8770 (Electronic)

Natural Sciences, Universitas Riau, Pekanbaru, with the letter 630/UN19.5.1.1.3-4.1/EP/2023.

Phytochemical screening

A phytochemical screening test was carried out on fresh leaf samples and endophytic fungus supernatants. The screening test included alkaloids, flavonoids, saponins, tannins, steroids, and terpenoids.[12]

Examination of flavonoid, phenolic, saponin, terpenoid and steroid compounds is carried out by chopping 4 g of fresh samples, then putting them in a test tube, adding 15 mL of ethanol and heating over a Bunsen for 15 minutes, then filtering it hot, then adding the filtrate. into another test tube and the remaining solvent is evaporated. Then add 5 mL of distilled water and 5 mL of chloroform ($CHCl_3$) each in the test tube, then shake vigorously and let sit for a few minutes until two layers are formed, namely the water layer at the top and the chloroform layer at the bottom. After that, separate the two layers formed. The water layer (top) is used to test flavonoid, phenolic and saponin compounds. The chloroform layer (bottom) is used to test steroid and terpenoid compounds.

The Alkaloid test was carried out by chopping 2 g of fresh samples and finely grinding them in a mortar moistened with 10 mL of chloroform ($CHCl_3$), then adding 10 mL of 0.05 M ammonia chloroform, then grinding and then filtering with cotton placed inside as a filter. After that, add 1 mL of 2 N sulfuric acid (H_2SO_4), then shake for 2 minutes and leave until separation occurs and two layers are formed. The top layer (acid) is taken, then 1-2 drops of Mayer's reagent are added.

Isolation and Purification of Endophytic Fungi

Endophytic fungi were isolated and purified in the pharmaceutical microbiology laboratory of the Sekolah Tinggi Ilmu Farmasi Riau. The shallot tubers were cleaned first using running water, then cut into samples measuring 1 cm x 1 cm, then surface sterilization was carried out by immersing the tubers in a 70% ethanol solution for 1 minute. Then soaked in 5.3% NaOCl for 5 minutes, soaked again in 70% alcohol for 30 seconds, rinsed with sterile distilled water several times. The sterilized samples were dried on filter paper and cut longitudinally with a catheter sterilized with alcohol. After that, the tuber sample pieces were placed on the PDAC medium under pressure. Sample inoculation was carried out in laminar air flow, then incubated at a temperature of 27-29°C for 5-7 days. Endophytic fungi that grow on PDAC medium are purified respectively on new PDAC medium. Then incubated for 5-7 days at 27°C. After incubation, the shape and color of the colonies were observed on the PDAC medium. Endophytic fungi that grow with different shapes and colors are purified and reproduced by cutting the fungus parts in new PDAC medium.[13]

Identification of Endophytic Fungal Isolates

Identification of endophytic fungal isolates was carried out at the Microbiology Laboratory, Faculty of Medicine, Universitas Riau. Identification is carried out by observing morphological characteristics and characteristics macroscopically and microscopically. Macroscopic observations include color of the surface and bottom of the colony, texture and concentric circles. Microscopic observations are carried out with the help of a microscope which includes the presence or absence of septa on the hyphae, the pigmentation of the hyphae and the shape of the hyphae.[14] The results of mushroom morphology observations were adjusted to references.[15]

Fermentation of Endophytic Fungal Isolates

Pure colonies of endophytic fungi that have been incubated are taken using a glowing spatula and placed in 50 mL of PDY liquid fermentation media in an Erlenmeyer. Then the Erlemeyer containing liquid fermentation media PDY and pieces of endophytic fungal culture

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ISSN: 2354-8770 (Electronic)

were shaken fermented using a shaker incubator at a speed of 130 rpm (shaking/minute), carried out at room temperature for 14 days. After that, the fermented liquid medium was put into a 15 mL centrifuge tube, then centrifuged at a speed of 2000 rpm for 20 minutes. The supernatant resulting from centrifugation was taken and filtered using filter paper. This supernatant is used to test antibacterial activity as a test solution.[14]

Antibacterial Activity Test

Antibacterial activity testing was carried out using the disc diffusion method in the pharmaceutical microbiology laboratory of the Sekolah Tinggi Ilmu Farmasi Riau. Tests were carried out on 4 supernatants of endophytic fungal isolates obtained, namely supernatants of isolates FEAC-U1, FEAC-U2, FEAC-U3 and FEAC-U4. The sterilized paper disc was dripped with 10 µL of the supernatant obtained and then left for 15 minutes to allow the solution to evaporate before being placed in the test medium. Aseptically, the paper disc is placed on the surface of the NA medium which contains the test bacteria. As a positive control, paper discs containing the antibiotic chloramphenicol were used at 30 µg/disk and as negative controls, empty paper discs soaked in 10 µL of distilled water were used. Testing was carried out using 6 types of test bacteria, namely *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Bacillus cereus*, *Escherichia coli*, *Salmonella typhi* and Shigella dysenteriae. Each with three repetitions, then incubated at 37°C and 40°C for 24 hours by inverting the Petri dish, measuring the diameter of the inhibitory area which was marked by the formation of a clear area around the disc, using a caliper.[16]

RESULTS AND DISCUSSION

Phytochemical screening was carried out on fresh samples of shallot tubers, showing that the fresh samples contained secondary metabolites of alkaloids, flavonoids, and phenolics (Table 1).

Table 1. Phytochemical Screening of Fresh Plants of Shallot Tubers

The Secondary Metabolites	Result	Description
Alkaloid	+	White precipitate
Flavonoid	+	Red color
Phenolic	+	Yellow color
Saponin	-	Does not form foam
Steroid	-	No red color
Terpenoid	-	No green/blue color

Isolation of endophytic fungi in this study was carried out using fresh, clean shallot tubers and then sterilization of the sample surface by immersing the sample in 70% alcohol for 1 minute, 5.3% hypochlorite (NaOCl) solution, then soaking it again in 70% alcohol, and rinsing it using sterile distilled water. The purpose of surface sterilization is to remove contamination from microorganisms on the surface of plants before they are inoculated into the media, so that endophyte colonies are obtained from plant tissue.[17]

The sample was placed on the surface of PDAC (Potato Dextrose Agar Chloramphenicol) media. The samples were incubated at room temperature (27^{o}C) for 7 days, and then the growing fungus was purified by cutting the fungal colonies growing on the media using an Ose needle and placing them on new PDAC media. Purification is carried out if there are still endophytic fungal colonies with different morphologies, so that a pure isolate is obtained that looks like the shape and color of the endophytic fungal colony are the same.

The results of the isolation of endophytic fungi from shallots were given the code FEAC (Fungi Endofit *Allium cepa*). The pure isolates obtained were 4 isolates, namely FEAC-U1, FEAC-U2, FEAC-U3, and FEAC-U4. Pure isolates are identified macroscopically by looking at the colony color, reverse color of the colony, diameter, colony shape, and concentric circles.[14] Microscopic identification is carried out by looking at the hyphae, hyphae color,

ISSN: 2085-675X (Print)
ISSN: 2354-8770 (Electronic)

hyphae shape, and the genus or species of the isolate.[15]

Macroscopic observations of the FEAC-U1 isolate obtained had a black colony color; the reverse color of the colony was grayish white; a diameter of 9 cm; a smooth colony shape; and no concentric circles. Microscopic observations of the FEAC-U1 isolate showed non-fibrous hyphae, hyaline hyphae color, spiral hyphae shape, and Aspergillus genus with simple conidophores, thin cell walls, and bubbles. At the tip of the conidiophore, irregular vesicles form.[15] Macroscopic observations of the FEAC-U2 isolate showed that the colony color was gray, the reverse color of the colony was yellowish white, the diameter was 11 cm, the colony shape was smooth, and there were no concentric circles. The results of microscopic observations of the FEAC-U2 isolate were fibrous hyphae, hyaline hyphae color, spiral hyphae shape, and the genus Penicillium with strands of conidia clustered around the phialide. The endophytic fungus Penicillium sp. has been widely reported as an endophyte that has cytotoxic antimicrobial activity.[18] This is because Penicillium sp. produces antimicrobial compounds that inhibit bacterial growth and produce antibiotic compounds in the form of penicillin.[19]

Macroscopic observations of the FEAC-U3 isolate had a rough surface, white surface color and yellowish white bottom color of the colony. Filamentous (fibrous) shape. It does not have concentration circles, namely circles that form in a colony. Concentric circles are often more clearly visible on the reverse side (opposite the colony). On microscopic examination, the shape of the rhizoid hyphae (branched hyphae) and the color of the hyphae, hyaline pigment (colorless, or blue when painted), it is known that this isolate comes from the Trichophyton tonsurans species.[15] The FEAC-U4 isolate has a smooth surface with a grayish white color on the surface and the reverse of the colony and does not have concentric circles. On microscopic examination, this isolate had hyaline hyphae and was rhizoid in shape, it was discovered that this isolate came from the genus Rhizopus.[15] The results of identification of shallot tuber endophytic fungal isolates based on macroscopic and microscopic observations can be seen in Figure 1-2 and Table 2.

Endophytic fungal fermentation uses PDY (Potato Dextrose Yeast) media because it contains the nutrients needed by endophytic fungi. Apart from that, liquid media is more effective in producing biomass and bioactive compounds when compared to using solid media.[20] This is because in the fermentation process there is an agitation process (stirring) which allows the nutrients in the liquid medium to continue to be homogeneous so that the endophytic fungi can absorb these nutrients more optimally. The fermentation process was carried out using a Shaker incubator at 130 rpm (revolutions/minute) at room temperature for 14 days. The aim of using a Shaker incubator is to move the media at a certain temperature and speed so that nutrients are distributed effectively so that microbial growth is even. This fermentation aims to ensure that the endophytic fungal isolate reaches the stationary phase. In this phase, the synthesis of secondary metabolites begins when several main nutritional components in the growth medium are depleted. The limitations of the main source of synthesis include sugar as a carbon source and protein as a source of amino acids. This can cause the release of substances resulting from the catabolism process which are secondary metabolites.[21]

The fermentation results are then centrifuged first to obtain the supernatant. Separation by centrifuge is carried out because microorganisms secrete secondary metabolites during the fermentation process out of the cells in the culture medium.[21] Each fermented culture was put into a 15 mL centrifuge tube which had previously been sterilized, then centrifuged at a speed of 2000 rpm for 20 minutes. The supernatant obtained was taken using a dropper pipette and then transferred into a vial, so that the

ISSN: 2085-675X (Print)
ISSN: 2354-8770 (Electronic)

supernatant was obtained which would be continued for testing antibacterial activity.

The results of phytochemical screening of the supernatant of endophytic fungal isolates showed that the supernatant of isolates FEAC-U1, FEAC-U2, FEAC-U3 and FEAC-U4 only contained alkaloids (Table 3).

The results of testing the antibacterial activity of the supernatant of shallot tuber endophytic fungus isolates were obtained from measuring the diameter of the barrier formed around the disc. The results of antibacterial activity testing can be seen in Table 4.

The results of testing the antibacterial activity of endophytic fungal isolates FEAC-U1 (*Aspergillus*), FEAC-U2 (*Penicillium*), FEAC-U3 (*Trichophyton*), and FEAC-U4 (*Rhizopus*) against the test bacteria showed antibacterial activity. Antibacterial activity can be seen from the clear zone around the disc. Endophytic fungal isolate FEAC-U1 showed the highest activity against *Staphylococcus epidermidis*, *Bacillus cereus* and *Shigella dysenteriae*; endophytic fungal isolate FEAC-U2 showed the highest activity against *Salmonella typhi*; and endophytic fungal isolate FEAC-U3 showed the highest activity against *Staphylococcus aureus* and *Escherichia coli*.

Antibacterial activity is due to the secondary metabolite content found in endophytic fungal isolates. Endophytic fungal isolates from shallot tubers contain compounds that have the potential to act as antibacterials, namely alkaloids. Alkaloid compounds work by inhibiting cell wall synthesis. Instability in the cell wall causes the selective permeability function, active transport function, and control of the protein structure of the bacterial cell to be disrupted, causing the bacterial cell to lose shape and lyse.[22] Damaged cell walls result in secondary metabolite compounds being able to penetrate deeper and damage the bacterial membrane.[23]

Table 2. Macroscopic and Microscopic Identification of Endophytic Fungal Isolates of Shallot Tubers

Isolate Code	Colony Surface Color	Colony Bottom Color	Diameter	Colony Shape	Concentric Circles	Hyphae	Hyphae Color	Hyphae Shape	Genus
FEAC-U1	Black	White gray	90 mm	Smooth	None	Hyaline	Non-Fibrous	*Spiral*	*Aspergillus*
FEAC-U2	Gray	Yellowish white	110 mm	Smooth	None	Hyaline	Fibrous	*Spiral*	*Penicillium*
FEAC-U3	White	Yellowish White	68.9 mm	Rough	None	Septum Hyphae	Hyaline pigmented	*Rhizoid*	*Trichophyton*
FEAC-U4	Gray White	Gray White	110 mm	Smooth	None	Septum Hyphae	Hyaline pigmented	*Rhizoid*	*Rhizopus*

Table 3. Phytochemical Screening of Endophytic Fungal Isolate Supernatant

The Secondary Metabolites	Result				Description
	FEAC-U1	FEAC-U2	FEAC-U3	FEAC-U4	
Alkaloid	+	+	+	+	Orange-brown color
Flavonoid	-	-	-	-	No yellow color
Phenolic	-	-	-	-	No blackish-green color
Saponin	-	-	-	-	Does not form foam
Steroid	-	-	-	-	No green-blue color
Terpenoid	-	-	-	-	No red-brown color

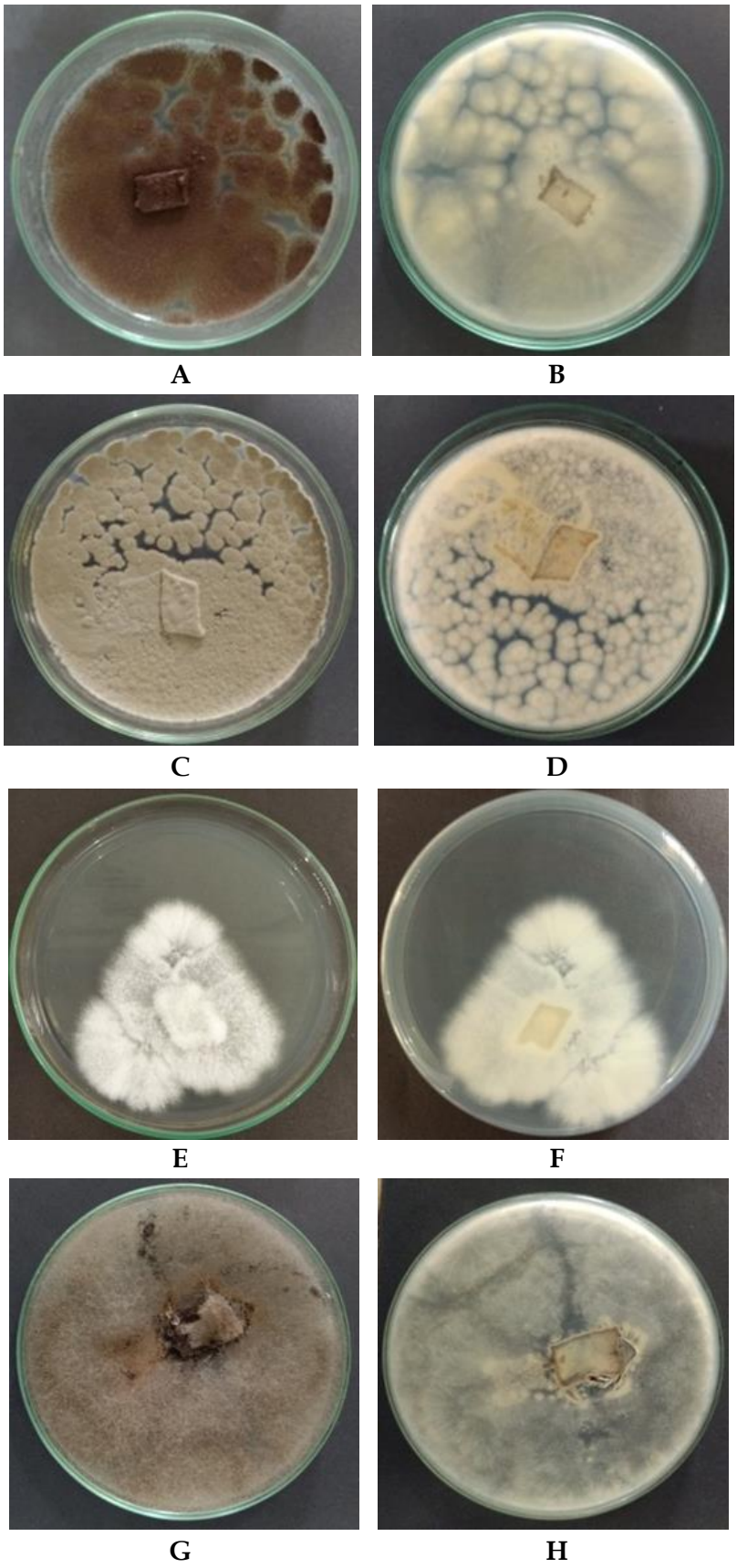

Figure 2. Macroscopic Observations of Endophytic Fungal Isolates FEAC-U1 (*Aspergillus*) front view (A), rear view (B); FEAC-U2 (*Penicillium*) front view (C), rear view (D); FEAC-U3 *(Trichophyton)* front view (E), rear view (F); FEAC-U4 (*Rhizopus*) front view (G), rear view (H)

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Table 4. Results of Antibacterial Activity Tests for Endophytic Fungal Isolates

Bacteria	Treatment	Mean diameter of inhibition zone±SD (mm)
Staphylococcus aureus	K(-)	-
	K(+)	22.95±0.89^{d}
	FEAC-U1	7.53±0.42^{d}
	FEAC-U2	-
	FEAC-U3	12.53±1.87^{c}
	FEAC-U4	6.80±0.46^{a}
Staphylococcus epidermidis	K(-)	-
	K(+)	32.13±0.42^{c}
	FEAC-U1	11.43±1.04^{b}
	FEAC-U2	11.33±1.04^{b}
	FEAC-U3	9.00±0.22^{a}
	FEAC-U4	8.83±0.36^{a}
Bacillus cereus	K(-)	-
	K(+)	30.66±0.61^{d}
	FEAC-U1	8.23±2.00^{c}
	FEAC-U2	6.93±1.27^{a}
	FEAC-U3	7.93±0.87^{b}
	FEAC-U4	7.80±0.58^{b}
Shigella dysenteria	K(-)	-
	K(+)	28.05±0.89^{e}
	FEAC-U1	9.67±2.25^{d}
	FEAC-U2	9.00±0.87^{c}
	FEAC-U3	7.49±0.29^{b}
	FEAC-U4	6.92±0.26^{a}
Eschericia coli	K(-)	-
	K(+)	31.15±0.80^{d}
	FEAC-U1	7.28±0.34^{a}
	FEAC-U2	7.45±0.45^{a}
	FEAC-U3	10.04±0.21^{c}
	FEAC-U4	9.19±0.05^{b}
Salmonella tyhpi	K(-)	-
	K(+)	31.31±0.13^{d}
	FEAC-U1	6.83±1.44^{a}
	FEAC-U2	9.33±1.76^{c}
	FEAC-U3	7.43±0.20^{b}
	FEAC-U4	6.65±0.32^{a}

Note :
Average data was obtained from 3 treatments. Different superscripts indicate significant differences ($p<0.05$).

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ISSN: 2354-8770 (Electronic)

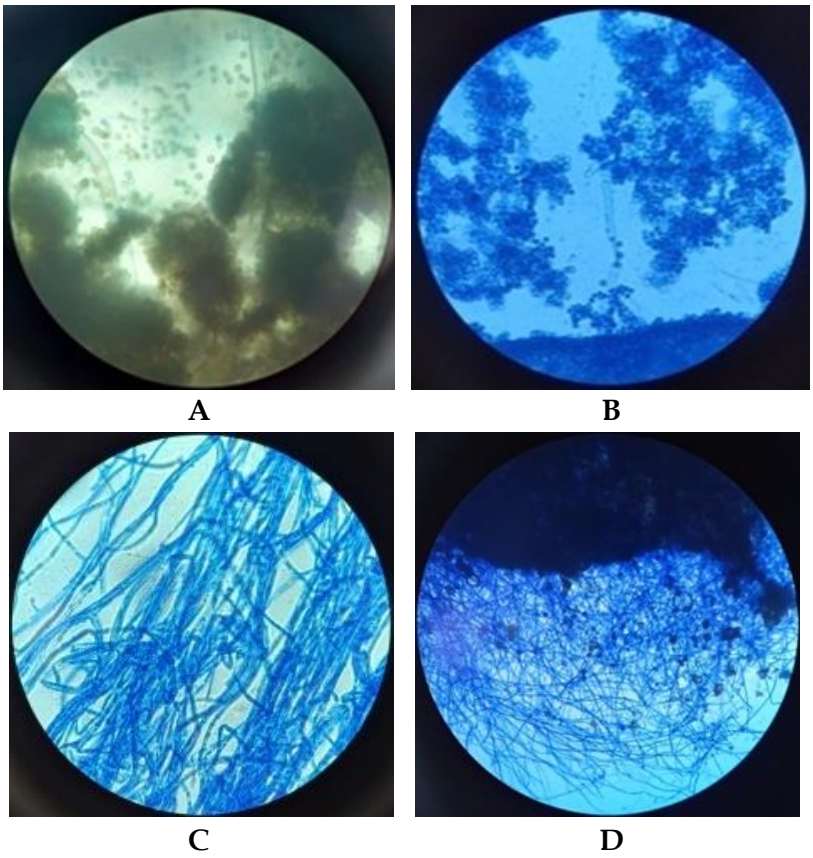

Figure 3. Microscopic Observations of Endophytic Fungal Isolates FEAC-U1 (*Aspergillus*) at 100x magnification (A); FEAC-U2 (*Penicillium*) at 10x magnification (B); FEAC-U3 *(Trichophyton)* at 100x magnification (C); FEAC-U4 (*Rhizopus sp*) at 10x magnification (D)

CONCLUSION

Based on the results of research that has been carried out, 4 endophytic fungal isolates were isolated from shallot tubers, namely FEAC-U1 (*Aspergillus*), FEAC-U2 (*Penicillium*), FEAC-U3 (*Trichophyton*) and FEAC-U4 (*Rhizopus*). FEAC-U1 isolate showed the highest activity against *Staphylococcus epidermidis*, *Bacillus cereus* and *Shigella dysenteriae*. FEAC-U2 isolate showed the highest activity against *Salmonella typhi*. FEAC-U3 isolate showed the highest activity against *Staphylococcus aureus* and *Escherichia coli*. The results of antibacterial activity testing on four isolates of shallot tuber endophytic fungi were able to inhibit the growth of the test bacteria.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

Acknowledgments

The author would like to thank the Sekolah Tinggi Ilmu Farmasi Riau for funding research funds through the 2023 Applied Research Grant with main number 13e.05.15.P3M.STIFAR.VIII.2023.

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