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Enzyme Activities and Growth Abilities: Exploring Wood Decay Fungi in Banyuasin Oil Palm Plantations

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Abstract: Wood fungi, frequently identified as the cause of Wood Rot Disease, produce enzymes that break down key components of plant cell walls, such as cellulose and lignin, allowing the fungi to act as pathogens. This study aims to identify wood fungi present in oil palm plants in Banyuasin, South Sumatra, and to test their growth abilities on various types of wood and enzyme activites (ligninase, cellulase, and hemicellulase). The research methods consist of isolation using an exploration method, morphological identification, and enzyme activities tests (cellulase, hemicellulase, and ligninase). Wood fungus isolation used Potato Dextrose Agar (PDA) media. Fungal morphology was identified macroscopically and microscopically. The data obtained from fungal morphology observations, fungal growth on wood, and enzyme activity were analyzed descriptively. A total of 11 isolates were obtained. Isolates A6, A7, and A11 showed high enzymatic activity, particularly in breaking down lignin, cellulose, and hemicellulose, which potentially causes BPB in oil palms. The cellulase enzyme activity, measured with CMC substrate, indicated that isolate A6 had the highest value (157.30 U/mL), followed by A8 (151.75 U/mL), while A10 had the lowest value (20.58 U/mL). Using Avicel substrate to measure hemicellulase, isolate A10 showed the highest value (108.67 U/mL). For ligninase measured with tannin substrate, isolate A4 had the highest activity (59.89 U/mL), and A10 had the lowest (2.42 U/mL).

Keywords: Enzyme activity, elaeis guineensis, growth abilities, identification, oil palm, wood fungus.

Introduction

Oil palm *(Elaeis guineensis Jacq.)* is a highly important plantation crop as it produces oil used for food, industry, and biofuels (biodiesel). Indonesia is one of the largest palm oil producers in the world, with a plantation area of 33.5 million hectares, 11.3 million of which are already in production. Sumatra has the largest palm oil plantation, covering about 8 million hectares and producing 21.3 million tons of palm oil (BPS, 2020; BPS, 2021; Ditjenbun, 2022). However, as a major producer, Indonesia faces significant challenges in increasing production, one of which is basal stem rot (BSR) disease. BSR has been found in palm oil plantations in North Sumatra, Riau, and Lampung, with an infection rate of 20%-30%, leading to losses of up to IDR 2 trillion annually if the infection rate reaches 1% (Wahyuni, 2022).

BSR disease is caused by the fungus Ganoderma boninense, which can reduce palm oil yields by up to 80% of the average oil production (Ab Wahab *et al.,* 2022; Atmaja *et al.,* 2020). This disease causes oil palm trees to collapse and die one by one, reducing the population from 130 trees per hectare to 70 trees per hectare (Budi *et al.,* 2022). In third-generation plantations, the mortality rate reaches 40%. Ganoderma sp. is known to attack oil palm plantations up to 81.8% (Nurika *et al.,* 2020; Siddiqui *et al.,* 2021).

The fungus responsible for BSR is

classified as a wood decay fungus, commonly found on decayed parts of trees or at the base of the trunk (Bharuddin *et al.,* 2022). More than a thousand species of fungi can cause wood rot, mainly from the classes Basidiomycetes and Ascomycetes. Fungi from these classes have the ability to decompose wood by producing ligninase and cellulase enzymes, which break down lignin and cellulose in wood (Sugano *et al.,* 2021; Zhuo and Fan, 2021).

White rot fungi, such as Phanerochaete chrysosporium, are known for their ability to efficiently degrade lignin and cellulose through ligninase production. This process helps decompose organic material and release nutrients trapped in wood (Sugano *et al.,* 2021; Okal *et al.,* 2020). In contrast, brown rot fungi, like Serpula lacrymans, primarily break down cellulose rather than lignin, also causing significant wood damage (Zhu *et al.,* 2020). Identifying and characterizing wood-decay fungi is important to understanding their role in wood degradation and their impact on ecosystems, especially in oil palm plantations (Suryadi *et al.,* 2022; Vetter *et al.,* 2023).

Previous studies have shown that wood-decay fungi significantly impact ecosystems and nutrient cycles. These fungi play a crucial role in organic material degradation, ultimately affecting soil health and ecosystem balance (Parra-Saldivar *et al.,* 2020). Understanding the diversity of wood-decay fungi also provides a basis for developing better management strategies to combat diseases caused by pathogenic fungi, as well as opportunities for biotechnological applications, such as biofuel production (Priwiratama *et al.,* 2020). Therefore, a better understanding of the diversity of wood-decay fungi in oil palm plantations can support sustainable agricultural practices and effective conservation measures (Zhu *et al., 2*023; Yang *et al.,* 2023).

This study aims to identify the species of wood-decay fungi in oil palm plantations (Elaeis guineensis Jacq.), examine their growth potential on different types of wood, and assess the potential of ligninase, cellulase, and hemicellulase enzymes in wood-decay fungi living in oil palm trees *(Elaeis guineensis Jacq.)*. Additionally, this research is expected to make a significant contribution to the management and control of BSR in oil palm, as well as provide further insights into the biotechnological potential of enzymes produced by wood-decay fungi in oil palm plantations.

Material and Methods

Material

The materials used were Potato Dextrose Agar (PDA) media, 70% alcohol, sterile distilled water, and wood fungus tissue samples as the main subjects for analysis. Other chemicals included sengon wood, CuSO4, NaOH, H2SO4, CuSO4 crystals, K2SO4 crystals, 0.1 N NaOH, 0.1 N HCl, and 1% phenolphthalein.

Culture preparation

A Potato Dextrose Agar Chloramphenicol (PDA-C) medium was prepared by mixing 39g of Potato Dextrose Agar with distilled water up to 1000ml and adding 100mg of Chloramphenicol. The medium was sterilized using an autoclave at 121°C and 1.5 atm pressure for 15 minutes, and fungi were aseptically inoculated. Cultures were incubated and subcultured monthly.

Morphological identification

Macroscopic characteristics of the basidiocarp and culture colonies were recorded, including basidiocarp shape, color, and texture. Microscopic identification involved examining pure cultures through the slide culture method to observe hyphae and spore structures. For microscopic identification, the pure cultures were examined for their microscopic features using the slide culture method. Data obtained from microscopic observations were combined with macroscopic features to support identification. Microscopic characteristics observed included hyphae, spore shape, and spore-bearing structures.

The slide culture preparation started by placing sterile filter paper at the bottom of a petri dish and moistening it with sterile distilled water. A sterile glass slide was placed on the wet filter paper. Thin PDA medium in the petri dish was cut into blocks using a sterile scalpel. The pure-grown fungi were inoculated on the upper side of the glass slide, then covered with a sterile

coverslip and incubated for 4-7 days. After incubation, mycelium was observed growing on the agar block surface. The preparation was then observed using a microscope (Meiliawati & Kuswytasari, 2013). The characteristics of each isolate were compared based on the key determination in the Pictorial Atlas of Soil and Seed Fungi, Second Edition.

Fungal Growth Ability Test

The wood was cut into pieces measuring 1 cm x 1 cm x 2 cm, sanded, and dried in an oven at a temperature of ±100°C. The woods used included sengon, teak, and mahogany. The test preparation followed the established pattern in Suprapti and Djarwanto (2014). The test process was carried out using the ROOH (Refining of Oven-dry Overlapping Homogeneous) method and referred to the Indonesian National Standard (SNI 7207:2014). The oven-dried wood was weighed and placed in glass bottles containing pure fungal cultures. The bottles were incubated for 12 weeks.

Qualitative Enzyme Activity Test

For the qualitative test of cellulase enzyme potential, the agar medium composition for fungal selection used 3.9 g of PDA. After the PDA medium was weighed, it was dissolved in distilled water and sterilized using an autoclave at 121˚C and 1.5 atm pressure for 15 minutes. Then, 0.5% Na-carboxymethylcellulose was added to the sterile medium. The fungal isolates to be tested were inoculated onto Potato Dextrose Agar medium. The fungi were grown and incubated at room temperature for 3-5 days. After incubation, the plates were immersed in a 0.2% Congo red solution (Sigma Aldrich) and rinsed with 1 M NaCl solution for 15 minutes. The appearance of clear zones around each fungal colony was measured as an indicator of cellulase activity. The experiment was conducted in duplicate (Hankin et al., 1975). The clear zone around the colony was observed and measured using calipers. Then, the ratio between the diameter of the clear zone on the medium and the fungal colony diameter was calculated, called the Enzyme Activity Index (IAE).

A qualitative test of hemicellulase enzyme potential was carried out using a medium consisting of 3.9 g Potato Dextrose Agar (PDA), 150 g Avicel 102, and 100 mL citrate buffer with a pH of 4.0. The PDA and Avicel were accurately weighed and then dissolved in citrate buffer pH 4.0 to maintain pH stability during testing. Once the ingredients were thoroughly mixed, the media solution was sterilized using an autoclave at 121°C and 1.5 atm pressure for 15 minutes. The fungal isolates to be tested were inoculated onto Potato Dextrose Agar. The fungi were grown and incubated at 25°C for 3-5 days. After incubation, the plates were soaked with 0.2% Congo red solution (Sigma Aldrich) and rinsed with 1 M NaCl solution for 15 minutes. The formation of clear zones around each fungal colony was measured as an indicator of cellulase activity. The experiment was performed in duplicate (Hankin et al., 1975). Clear zones around the colonies were observed and measured using calipers.

For the qualitative test of ligninase enzyme potential, the agar media composition for fungal selection used 3.9 g PDA, 1% tannin, and 100 mL citrate buffer pH 4.0. The 3.9 g PDA and 1% tannin were weighed, then dissolved in citrate buffer and sterilized with an autoclave at 121°C and 1.5 atm pressure for 15 minutes. The isolated fungi were inoculated onto Potato Dextrose Agar. The fungi were grown and incubated at 25°C for 3-5 days. The appearance of brown zones around each fungal colony was measured as an indicator of lignin activity. The experiment was performed in duplicate (Hankin et al., 1975). Brown zones around the colonies were observed and measured using calipers.

Enzyme Activity Testing by Optical Density (OD) Method

Enzyme activity testing by Optical Density (OD) method involved growing mold isolates on a basal medium with a reed substrate. Spores from seven-day-old isolates were washed and suspended in a solution to obtain a concentration of 10^8 spores/ml. A total of 5 ml of the spore suspension was inoculated into a flask containing 50 ml of basal medium and 2.5 grams of sterilized reed substrate. The culture was incubated at 28°C for 8 days, with mold growth observed by measuring dry biomass every 24 hours. The isolates in the exponential growth phase were used as starters for cellulase production (Huang et al., 2015).

Cellulase enzyme production was initiated by inoculating 5 ml of the mold starter into a flask containing 50 ml of basal medium. The culture

was incubated on a rotary shaker at 200 rpm and 28°C until reaching the stationary phase. Crude enzyme extraction was performed by adding 100 ml of 0.1% Tween 80 at pH 6 to the incubated culture, followed by centrifugation at 4000 rpm for 15 minutes at 4°C. The supernatant, containing the crude enzyme, was used for further analyses, including reducing sugar content, enzyme activity tests, and pH measurement.

For reducing sugar analysis, the Somogyi-Nelson method was employed. A 1 ml sample was diluted to 10 ml with distilled water, then 1 ml of the mixture was combined with 1 ml of Nelson reagent and heated at 100°C for 20 minutes. After cooling, arsenomolybdate reagent and distilled water were added, and absorbance was measured at 520 nm. The absorbance values were subtracted from the blank and converted to reducing sugar content using a standard curve.

Enzyme activity tests were conducted for cellulase, hemicellulase, and ligninase. For the cellulase OD test, a sample solution containing 1 ml 1% CMC substrate, 0.9 ml acetate buffer (pH 5), and 0.1 ml crude enzyme was incubated at 45°C for 30 minutes. The reaction was stopped with trichloroacetic acid (TCA), heated, cooled, and Nelson C solution was added. Absorbance was measured at 520 nm. The hemicellulase OD test involved incubating a mixture of 150 mg Avicel 102 substrate, 4 ml acetate buffer, and 1 ml crude enzyme at 45°C for 30 minutes. After stopping the reaction with TCA and heating, the same absorbance measurement process was followed. For the ligninase OD test, the sample consisted of 1% tannin substrate, 1 ml acetate buffer, and 0.5 ml crude enzyme, incubated at 45°C for 30 minutes. TCA was used to stop the reaction, and Nelson C solution was added after heating and cooling. Absorbance was also measured at 520 nm for this test.

Research Design and Data Analysis

This study uses a descriptive research approach with experimental methods. The descriptive research approach aims to describe, identify, or explain a phenomenon, object, or symptom without manipulating or changing the variables. Data analysis for fungal growth was calculated by referring to the weight difference of the sample before and after treatment, divided by the initial dry weight of the sample. The percentage of weight loss was classified according to SNI 01-7207-2006. Enzyme activity for the Optical Density (OD) method was calculated with control and blank samples tested alongside the samples using the same method. The control consisted of previously inactivated enzymes, while the blank contained no enzymes and only used phosphate buffer pH 7 reacting with the substrate. Enzyme activities were expressed in international units (U/ml). Enzyme activity was calculated using the following equation (Anggarawati, 2012):

$$\mathbf{AS\ (U/mL) = [(As - Ab) - (Ak - Ab)]}$$

Where:
As = Sample absorbance
Ab = Blank absorbance
Ak = Control absorbance
t = Incubation time
V = Enzyme volume
BM = Molecular weight of glucose = 180

Result and Discussion

Morphological Identification

The isolates studied can be grouped into several different fungal species, namely *Agaricus placomyces, Baeospora myosura, Marasmius oreades, Bolbitius sp., Tyromyces sp., Lepiota clypeolaria, Mycena juniperina, Macrolepiota procera, Aminita virosa, Pleuteus cervinus, and Ganoderma sp.* Isolate A01, classified as *Agaricus placomyces*, has a cap-shaped, white basidiocarp, while Isolate A02, identified as *Baeospora myosura,* has a convex, light brown basidiocarp. Other isolates, like *Marasmius oreades* and *Ganoderma sp.*, also show unique features. The presence of zoning in some colonies suggests more complex growth patterns, while the texture and surface of the colonies provide further insights into fungal structure. The result show the diversity of basidiocarp morphology and fungal colonies that can be found in various isolates.

Each isolate showed unique physical characteristics, ranging from varying basidiocarp shapes such as hood, convex, umbonate, to fan-shaped. The texture of the basidiocarp was mostly dry, with some isolates exhibiting a smooth, fibrous, or hard texture. The color of the basidiocarp also varies, ranging from white, light brown, to purplish brown, which indicates variations in the pigment produced by each

isolate (Barman, *et al.,* 2020). Colony characteristics also varied greatly, with some isolates showing clear zonation, indicating different colony growth patterns. Colony colors range from white, yellow, brown, green, to black, which provides striking visual variations in each isolate (Senanayake, *et al.,* 2020). Some isolates also showed color differences between the surface and reverse parts of the colony, which may be caused by differences in pigment distribution or environmental conditions during colony growth. The surface texture of the colony is mostly raised, giving the colony a three-dimensional appearance, although some isolates have a flat surface texture or a combination of flat and raised (Senanayake, *et al.*, 2020; Bhunjun, *et al.*, 2020).

Qualitative Enzyme Activity of Wood Fungi

Enzymatically, the fungi demonstrated the ability to degrade plant cell wall components, such as hemicellulose, cellulose, and lignin. Hemicellulase enzymes, including xylanase and mannanase, break down hemicellulose chains into simple sugars (Zhuo & Fan, 2021; Gbenebor *et al.*, 2023). Cellulase enzymes, comprising endoglucanase, exoglucanase, and β-glucosidase, hydrolyze cellulose into glucose, a process vital for carbon recycling in ecosystems. Lignin degradation, a more complex process, occurs via enzymes like laccase and lignin peroxidase, enabling fungi to access the cellulose and hemicellulose embedded in plant cell walls. The wood fungi isolated in this study exhibited the ability to produce cellulase, hemicellulase, and ligninase enzymes, which break down plant cell wall components.

Isolate A1 Isolate A7

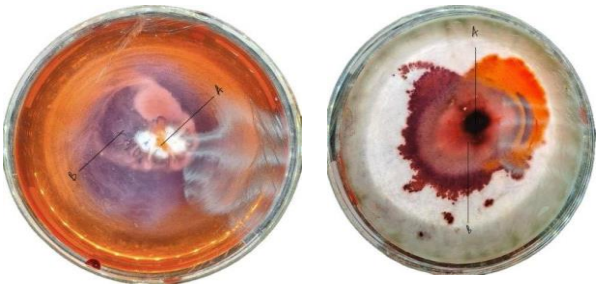

Figure 1. Qualitative analysis of fungal isolates A1 and A7 on 1% CMC medium, using the Congo red method: a) Fungal colonies; b) Clear zone

Table 1. Cellulase Enzyme Activity Index (EAI) of Wood-Decaying Fungi

Fungi Isolate	Clear Zone	Clear Zone Diameter (mm)	Colony Diameter (mm)	Enzyme Activity Index
A1	++	40	10	4.00
A2	++	30	16	1.88
A3	--	--	35	--
A4	--	--	15	--
A5	++	30	15	2.00
A6	++	10	5	2.00
A7	++	25	5	5.00
A8	--	--	15	--
A9	++	33	8	4.13
A10	--	--	30	--
A11	++	35	15	2.33

Figure 1 shows that isolates A1 and A7 large clear zones formed around their colonies. There are 7 isolates were able to produce cellulase enzymes. Table 1 shows that the highest cellulase activity was observed in isolates A1 and A7, signifying efficient cellulose breakdown. Isolate A7 showed the highest cellulase enzyme activity index of 5.00. the isolated wood fungi exhibited significant cellulase activity, indicating their ability to degrade cellulose, a key structural component of plant cell walls.

Isolate A2 Isolate A5

Figure 2. Qualitative analysis of fungal isolates A2 and A5 on 1% Avicel medium, using the Congo red method: a) Fungal colonies; b) Clear zone.

Figure 2 shows that isolates A2 and A5 large clear zones formed around their colonies. There are 5 isolates were able to produce cellulase enzymes. Table 2 shows that the highest hemicellulase activity was observed in isolates A2 and A5, signifying efficient hemicellulose breakdown. Isolate A2 showed the highest hemicellulase enzyme activity index of 4.00. the isolated wood fungi exhibited significant

hemicellulase activity, indicating their ability to degrade hemicellulose, a key structural component of plant cell walls. Hemicellulase enzymes break down cellulose into smaller sugars like glucose, which the fungi use for energy.

Table 2. Hemicellulase Enzyme Activity Index (EAI) of Wood-Decaying Fungi

Fungi Isolate	Clear Zone	Clear Zone Diamater (mm)	Colony Diameter (mm)	Enzyme Activity Index
A1	++	10	5	2.00
A2	++	20	5	4.00
A3	--	--	15	--
A4	--	--	2	--
A5	++	15	4	3.75
A6	--	--	2	--
A7	++	10	6	1,67
A8	--	--	2	--
A9	--	--	5	--
A10	--	--	5	--
A11	++	30	10	3.00

Isolate A6 Isolate A11

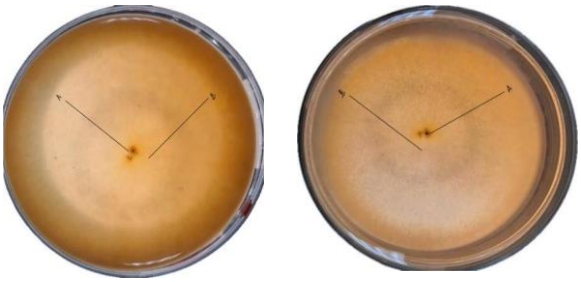

Figure 3. Qualitative analysis of fungal isolates A6 and A11 on 1% tannin medium: a) Fungal colonies; b) Brown zone.

According table 3 show that there are 9 isolates were able to produce ligninase enzymes. Figure 3 shows that isolate A6 had the highest ligninase enzyme activity index of 15.00, forming a large brown zone in the test, followed by isolates A11 and A5. Lignin degradation is crucial as it allows fungi to access the cellulose and hemicellulose in the cell wall. These results indicate that certain fungi are well-equipped to degrade lignin, making them effective decomposers in wood and plant matter.

Table 3 Ligninase Enzyme Activity Index (EAI) of Wood-Decaying Fungi

Fungi Isolate	Clear Zone	Clear Zone Diamater (mm)	Colony Diameter (mm)	Enzyme Activity Index
A1	++	15	5	3.00
A2	++	20	10	2.00
A3	--	--	5	--
A4	++	40	8	5.00
A5	++	25	3	8.33
A6	++	30	2	15.00
A7	++	25	10	2.50
A8	++	30	5	6.00
A9	++	20	8	2.50
A10	--	--	25	--
A11	++	20	2	10.00

Qualitative cellulase activity tests revealed that some fungal isolates have strong enzymatic potential. For example, Isolate A1 exhibited a 40 mm clear zone, indicating high cellulase activity, while A7 had the highest enzyme activity index (EAI) of 5.00. In contrast, isolates A3, A4, A8, and A10 did not display enzymatic activity (Chethana *et al.*, 2021; Cui *et al.,* 2021). Ligninolytic activity also varied among isolates. Isolate A6 showed the highest enzyme activity with a brown zone of 30 mm, yielding an EAI of 15.00, followed by A11 (EAI of 10.00) and A5 (EAI of 8.33). These results suggest a strong potential for these fungi in lignin degradation, which is crucial for breaking down complex polymers (Zhuo & Fan, 2021; Gbenebor *et al.,* 2023). The enzymatic activity index for hemicellulase, cellulose, and ligninase highlighted several fungal isolates with strong degradation capabilities. Isolates A6, A11, and A5, for instance, showed exceptional activity, particularly in cellulose and lignin degradation, which has industrial applications for breaking down plant material. On the other hand, some isolates, such as A3 and A10, showed no significant enzymatic activity under the tested conditions.

Enzyme Activity by Optical Density (OD) Method

Using the standard sugar curve, the concentration of reducing sugars was obtained to calculate cellulase enzyme activity. In this study, enzyme activity was expressed in U/ml.

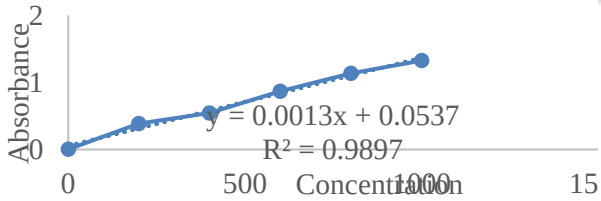

Figure 4. Standard Sugar Curve.

Figure 4 shows the standard curve of reducing sugars, illustrating a linear relationship between sugar concentration (X) and absorbance (Y). This graph is used to measure enzyme activity by determining the concentration of reducing sugars formed in the enzymatic reaction. The linear equation (y = 0.0013x + 0.0537) indicates that every increase in sugar concentration of 1 µg/ml increases absorbance by approximately 0.0013 units. With a determination coefficient (R^2) of 0.9897, the graph is used to calculate the sugar concentration in unknown samples by measuring their absorbance.

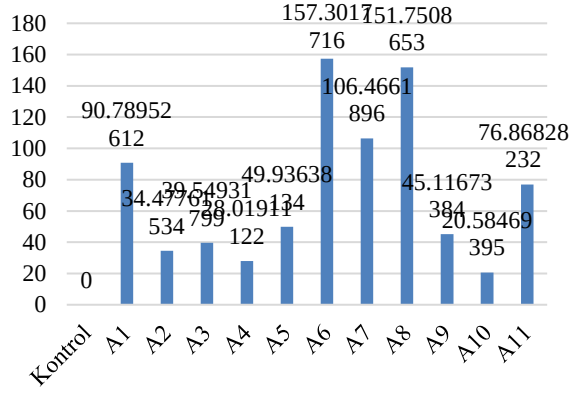

Figure 5. Cellulase Enzyme Activity in Isolates

According figure 5 shows the results of the Optical Density (OD) test. The highest cellulase enzyme activity, measured using CMC as a substrate, was observed in isolate A6 with a value of 157.30 U/mL, followed by isolate A8 with a value of 151.75 U/mL. Meanwhile, the lowest activity occurred in isolate A10 with a value of 20.58 U/mL. The highest activity, which is essential for the breakdown of cellulose, a primary structural component of plant cells. This suggests that the fungi have a strong ability to degrade cellulose, enabling them to infect and damage plant tissues effectively.

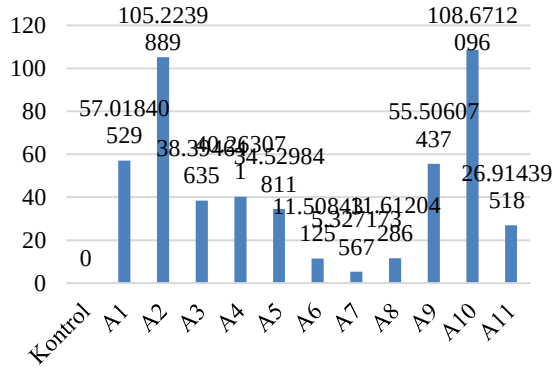

Figure 6. Hemicellulase Enzyme Activity in Isolates

According figure 6 shows the results of the Optical Density (OD) test. On the Avicel substrate to measure hemicellulase, isolate A10 showed the highest activity of 108.67 U/mL, while isolate A7 had the lowest activity of 5.33 U/mL. Hemicellulase, while showing lower activity than cellulase, still contributed to the breakdown of hemicellulose, another critical component of the plant cell wall. Hemicellulase activity was measured by the formation of clear zones around the colonies in xylan-containing medium.

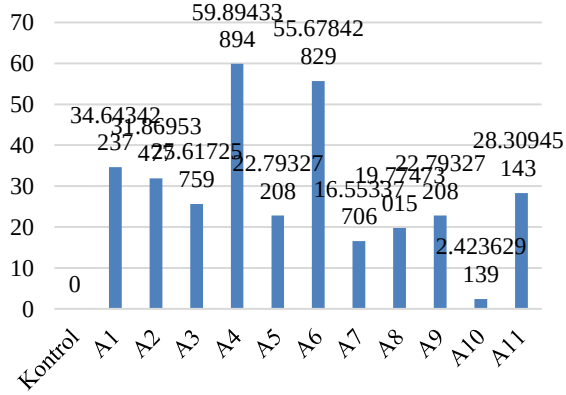

Figure 7. Lignin Enzyme Activity in Isolates

According figure 7 shows the results of the Optical Density (OD) test. For the tannin substrate, used to calculate ligninase activity, isolate A4 showed the highest activity of 59.89 U/mL, while isolate A10 had the lowest activity of only 2.42 U/mL Ligninase, responsible for breaking down lignin, the most complex and rigid component of plant cell walls, also exhibited varying levels of activity across the fungal isolates. High ligninase activity, as demonstrated by isolate A6, allows the fungus to

break down lignin and access the cellulose and hemicellulose components contained in the cell walls. This is an important mechanism in the pathogenesis of Ganoderma boninense, which causes BPB (Yang, *et al.,* 2023; Okal, *et al.,* 2020).

Fungal Growth Ability

According to table 4, In mahogany wood, 81.82% of the isolates were able to degrade mahogany, with isolate A10 showing the highest degradation, causing a 2% weight loss. In teak wood, 36.36% of the isolates were able to degrade teak, with isolate A9 showing the highest degradation, causing a 2% weight loss. In sengon wood, 100% of the isolates were able to degrade sengon wood, with isolate A9 emerging as the most aggressive, causing a 10% weight loss.

Table 4. Fungal Growth Ability on Different Types of Wood

Isolates	Wood Type	Initial Weight (g)	Wet Weight After Treatment (g)	Dry Weight After Treatment (g)	Weight Loss Precentage (%)
A1	Mahogany	1,70	1,91	1,69	1
	Teak	1,89	2,14	1,89	0
	Sengon	0,65	0,71	0,63	2
A2	Mahogany	1,83	2,04	1,82	1
	Teak	1,47	1,65	1,47	0
	Sengon	0,84	0,91	0,81	3
A3	Mahogany	1,67	1,86	1,66	1
	Teak	1,83	2,06	1,82	1
	Sengon	0,76	0,83	0,75	1
A4	Mahogany	1,39	1,55	1,38	1
	Teak	1,61	2,15	1,60	1
	Sengon	0,71	0,77	0,70	1
A5	Mahogany	1,60	1,81	1,60	0
	Teak	1,95	2,19	1,94	1
	Sengon	0,44	0,48	0,43	1
A6	Mahogany	1,08	1,19	1,07	1
	Teak	1,61	1,81	1,61	0
	Sengon	0,60	0,65	0,59	1
A7	Mahogany	1,08	1,30	1,08	0
	Teak	1,36	1,53	1,36	0
	Sengon	0,81	0,88	0,79	2
A8	Mahogany	1,15	1,28	1,14	1
	Teak	1,73	1,95	1,73	0
	Sengon	0,44	0,46	0,42	2
A9	Mahogany	1,36	1,51	1,35	1
	Teak	1,48	1,55	1,38	2
	Sengon	0,59	0,86	0,57	10
A10	Mahogany	1,79	1,98	1,77	2
	Teak	1,84	2,07	1,84	0
	Sengon	0,59	0,63	0,57	2
A11	Mahogany	1,26	1,39	1,25	1
	Teak	1,63	1,83	1,63	0
	Sengon	0,61	0,65	0,59	2

Overall, these results show significant variation in enzyme activity between various isolates, likely reflecting differences in enzymatic abilities to break down specific substrates. In mahogany wood, 81.82% of the isolates were able to degrade mahogany, with isolate A10 showing the highest degradation, causing a 2% weight loss. In teak wood, 36.36% of the isolates were able to degrade teak, with isolate A9 showing the highest degradation, causing a 2% weight loss. In sengon wood, 100% of the isolates were able to degrade sengon wood, with isolate A9 emerging as the most aggressive, causing a 10% weight loss.

The chemical composition of wood varies greatly between species, affecting its physical and chemical properties and how it can be degraded by certain organisms, such as fungi. Teak, for example, has a cellulose content of around 40-45%, hemicellulose 15-25%, and lignin 30-35%. Cellulose is a polysaccharide that gives wood its structural strength, while lignin, which is also high in teak, provides stiffness and resistance to microbial degradation. Lignin, which is more difficult to degrade than cellulose and hemicellulose, makes teak more resistant to attack by pathogens such as fungi. On the other hand, mahogany has a lower cellulose content, around 40-45%, with a higher hemicellulose content, around 25-30%, and lignin around 25-30%. Meanwhile, sengon wood contains around 43-50% cellulose, 25-30% hemicellulose, and 20-25% lignin. Sengon wood has a high cellulose content, which makes it easier to degrade by cellulase enzymes produced by fungi. The lower lignin content compared to teak wood makes sengon wood easier to decompose by rotting microorganisms. The differences in chemical content in each type of wood greatly affect how fungi, with the various enzymes they produce, can degrade each type of wood more efficiently or not (Yang, *et al.,* 2023; Okal, *et al.*, 2020).

In summary, the study shows that the isolated wood-decaying fungi exhibit considerable diversity in both morphology and enzymatic activity. Some isolates, such as A6, A11, and A5, have high potential for industrial applications involving cellulose, hemicellulose, and lignin degradation. Understanding the enzymatic properties of these fungi offers valuable insights into their role in plant material breakdown and their potential as pathogens in oil palm plantations (Fukasawa, 2021; Subowo, 2011).

Conclusion

The research found that the studied isolates belong to various fungal species. Seven isolates produced cellulase, five produced hemicellulase, and nine produced ligninase enzymes. Isolate A7 had the highest cellulase activity, A2 had the highest hemicellulase activity, and A6 showed the highest ligninase activity. Isolate A6 exhibited the highest cellulase activity (157.30 U/mL), while A10 had the lowest (20.58 U/mL). For hemicellulase, A10 had the highest activity, and A7 the lowest. In ligninase, A4 had the highest activity. Regarding wood degradation, 81.82% of the isolates degraded mahogany, 36.36% degraded teak, and all isolates degraded sengon wood, with A9 showing the most significant impact. These results highlight the variability in enzyme activity and wood degradation among the isolates.

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