Cultivation of white oyster mushroom (*Pleurotus ostreatus*) on some ligno-celluloses materials

F Soares*, E N Herliyana and I Mansur

1 Tropical Silviculture Study Program, IPB University Postgraduate School, Jl. Ulin Kampus IPB Darmaga, Bogor 16680, Indonesia.
2 Department of Silviculture, Faculty of Forestry and Environment, IPB University, Bogor 16680, Indonesia

*Corresponding email: feliciano22soares@gmail.com

Abstract. White oyster mushroom (*Pleurotus ostreatus*) is a mushroom that is often consumed by the public and cultivated because it has a high nutritional content and a wide variety of essential amino acids, proteins, fats, minerals, and vitamins. This study aims to analyze the response of several ligno-celluloses materials to the growth of white oyster mushrooms, to compare the treatment of several ligno-celluloses materials to the growth of white oyster mushrooms, and to determine the appropriate concentration on the growth of white oyster mushrooms. The experimental design used in this study was a Factorial Completely Randomized Design (CRD). As the result of the interaction test, the P-value obtained is 0.999>0.05, thus h0 is not rejected. The test of seeds obtained p-value 0.005<0.05 h0 is rejected, based on the test of the influence of planting media obtained p-value 0.000<0.05 h0 is rejected. From the graph of the average comparison, it is known that the type of F3 seed on the M4 planting medium caused the highest duration of mycelium growth compared to the influence of the type of seed and other growing media.

1. Introduction

Fungi are plants that do not have chlorophyll so they cannot carry out the process of photosynthesis to produce their own food. Some mushrooms are harmful but others are beneficial. One type of mushroom that is beneficial is the white oyster mushroom [1]. Oyster mushrooms as vegetable ingredients are rich in essential amino acids such as valine, leucine, isoleucine, tryptophan, threonine and phenylalanine. Oyster mushrooms have a soft and chewy texture and are rich in fiber so that they have potential as a source of dietary fiber and protein substitute for meat [2]. White oyster mushroom (*Pleurotus ostreatus*) is a mushroom that is often consumed and cultivated by the public because it has a high nutritional content and a wide variety of essential amino acids, proteins, fats, minerals, and vitamins. White oyster mushroom has 6.0% protein content and 57.5% higher carbohydrates, and 3.9% lower fat content compared to beef [3]. Complete nutrients needed by oyster mushrooms include carbohydrates (cellulose, hemicellulose, and lignin), protein (urea), fat, minerals (CaCO3 and CaSO4), and vitamins [4]. While sengon wood which is generally used as a medium for oyster mushrooms contains cellulose (49.40%), hemicellulose (24.59%), lignin (26.8%), ash (0.60%), silica (0.20%).
Cultivation of white oyster mushrooms requires nutrients that exist in wood waste and agricultural waste because in the waste there are nutrients such as lignin which converts carbohydrate macromolecules into simple sugar molecules with the help of lignin's cellulose, hemicellulose, protein, and vitamins enzymes [5]. Ideal mushroom cultivation is started from the selection of pure culture (F0), then isolated under sterile conditions, made in Petri dishes or bottles containing PDA media. Incubate at room temperature and form fine threads or hyphae so that the pure culture will proceed to the F1 stage, namely the stage of making parent seeds after making pure culture (F0) where F1 seed production utilizes grains such as corn, grain, sorghum, and seeds [6].

White oyster mushroom inoculum includes seeds that are important for maintaining the quality of further growth, including the formation of fruit bodies. The growth and development of white oyster mushrooms are strongly influenced by four important factors, namely mushroom seeds, planting substrate, environmental conditions, and media materials [7]. This study was conducted to analyze the response of several lignocelluloses materials to the growth of white oyster mushrooms, to compare the treatment of several lignocelluloses materials to the growth of white oyster mushrooms, and to determine the appropriate concentration on the growth of white oyster mushrooms.

2. Method
The research was implemented in the sub-village of Palimanu, Fatukero Village, Railako Sub District, Ermera Municipality, Timor Leste starting from May to August 2021. The experimental design used in this study was a Factorial Completely Randomized Design (CRD) described as follows: Factor A is a seed treatment factor consisting of three treatments, namely B1: F1 seed, B2: F2 Seed, B3: F3 Seed, and factor B is the media treatment factor which consists of 9 levels, namely M0: 100% sengon wood powder (standard), M1: 75% sengon wood powder + 25% coffee husk, M2: 50% sengon wood powder + 50% coffee husk, M3: 25% sengon wood powder + 75% coffee husk, M4: 0% sengon wood powder + 100% coffee husk, M5: 75% sengon wood powder + 25% bamboo powder, M6: 50% sengon wood powder + bamboo powder 50%, M7: 25% sengon wood powder + 75% bamboo powder, M8: 0% sengon wood powder + 100% bamboo powder. Each ratio of the ingredients above was mixed with additional ingredients to make baglog media such as 600 grams of rice bran, 200 grams of lime (CaCO3), approximately 300 ml of sugar water, and added water until the media water content is 60%.

Sengon wood powder, coffee husk, and bamboo powder were mixed with additional ingredients to make F1 media evenly distributed, and then water was added with a level of 45%-60%. The pH of the medium was adjusted to reach 6.8-7. After that those mixed materials were composted for 2 days. Seedlings of F1 and F2 were put into short-necked bottles with a height of 10 cm as much as 2/3 parts, while F3 in polypropylene plastic was 17 cm high and compacted and then covered with a media cap. After that, the media were sterilized using an autoclave at 121°C, the pressure of 15 psi for 15-20 minutes, and cooled for 6-12 hours before inoculation with pure culture.

To determine the effect of the given treatment on fungi growth, the F test was carried out. If the variance gave significant results, then Duncan's test was carried out at a 95% confidence level to determine the difference between treatments [8]. Data processing was using Microsoft Office Excel 2010 and SPSS 15.0 software.

2.1 Research Implementation
2.1.1 Preparation of Planting Media
According to Achmad et al. [9], the preparation of planting media includes substrate formulation, initial wetting, composting, and media packaging. Substrate formulation aims as a guide in the substrate manufacturing process, besides that it also serves as a standard cost of the production process. Substrate formulations usually consist of the ingredients used and the amount of each ingredient. The materials used to make the growing media are a wood powder that has been sifted as much as 85-90%, rice bran 10-15%, and calcium carbonate (CaCO3) as much as 1-2%. Next is to do the initial wetting of the sawdust until evenly distributed.
2.1.2 **Planting Media Packaging**

The planting media that has finished the composting process is then packaged in heat-resistant plastic bags, namely the type of polypropylene (commonly called PP plastic). The size of the plastic bag depends on the weight set. For example, for a media weight of 1 kg, use PP plastic measuring 30 x 20 cm with a thickness of 0.5 mm. After that, the planting medium is compacted using a press or bottle until the bottom of the plastic is flat and resembles a wooden log (baglog). At the end of the plastic ring is installed, then closed with cotton, and attached to the baglog cover with a plastic cover so that water does not enter the baglog during sterilization.

2.1.3 **Media Sterilization**

Media sterilization aims to kill harmful microorganisms in the oyster mushroom cultivation process so that the planting media are free from contaminants \[^{10}\]. Sterilization was carried out at 95°C for 90 minutes. The sterilized growing media are then cooled until the temperature reaches room temperature for about 25°C. The cooling process can be carried out in a special room, which has good air circulation so that the hot air released by the baglog can gradually cool down. If the amount of planting media is large enough, it can be assisted by using a blower or Air Conditioner (AC) to reduce the temperature of the media. Cooling of the planting media must be done because the oyster mushroom seeds will die if the temperature of the growing media is still high (hot).

2.1.4 **Inoculation**

After the temperature of the growing media is cold, the next process is the insertion or provision of seeds (inoculation) of oyster mushrooms into the growing media. The inoculation process was carried out aseptically. So, the planting medium not contaminated with unwanted microorganisms and it is would be detrimental in the cultivation of white oyster mushrooms. The inoculation process is almost the same as when making pure cultures or parent seeds or seedlings.

2.1.5 **Incubation**

After the planting medium has been inoculated with oyster mushroom seedlings, the next step is to incubate the growing media. Incubation aims to help oyster mushroom mycelium grow in suitable conditions for growth conditions until the mycelium meets the growing media (full-grown).

2.1.6 **Fruiting Body Forming**

The next stage, after the planting medium (baglog), has been filled with oyster mushroom mycelium. That is the formation of the oyster mushroom fruiting body. The process of forming the fruiting body begins with the application of pressure (stress) in the form of differences in temperature, humidity, and oxygen. In this phase, the room temperature begins to be lowered to around 22-25°C and the humidity to 80-85%. Giving oxygen is done by opening the growing media that has been filled with mycelium. There are several methods of opening the planting media, firstly by opening the cotton cover and secondly by tearing the plastic of the planting medium using a razor blade or knife that has been sterilized using 70% alcohol.

2.1.7 **Maintenance**

1. **Maintenance of Growing Room**
   
   The maintenance of the room is carried out by giving lime to the floor, cleaning the growth room, and ensuring that no sunlight can enter directly into the growth room.

2. **Sprinkling**

   Watering aims to supply water content in the substrate to support the growth of mycelia. Watering is done using a sprayer which is done once a day during the rainy season and 2-3 times a day during the dry season.
3. **Temperature and humidity settings**
The temperature reaches 20-30°C with fairly high humidity of 80-100%, if it is not suitable then watering is carried out.

4. **Pest and Disease Prevention**
Prevention of pests and diseases needs to be done to maintain the optimal growth of white oyster mushrooms. Prevention of pests and diseases can be done by choosing good quality raw materials, making sure the water content is not too wet, and doing room sanitation.

2.1.8 **Harvest**
Oyster mushrooms are ready to be harvested when the size is optimal, which is characterized by the characteristics of the oyster mushroom body cap being enlarged and not broken. Harvesting is done by removing all parts of the fruit body of the oyster mushroom that is ready to harvest. Harvest is not suggested if the size of the oyster mushroom is not optimal because it will reduce the weight of the harvest.

3. **Result and Discussion**

3.1. **Duration of mycelium growth**

| Source of Variation | SS          | df | MS          | F            | P-value   | F crit |
|---------------------|-------------|----|-------------|--------------|-----------|--------|
| Type of seeds       | 60.46914    | 2  | 30.23457    | 5.817102     | 0.005154  | 3.168246 |
| Planting media      | 17534.62    | 8  | 2191.827    | 421.7055     | 0.000001  | 2.115223 |
| Interaction         | 15.75309    | 16 | 0.984568    | 0.18943      | 0.999668  | 1.834629 |
| Within              | 280.6667    | 54 | 5.197531    |              |           |        |
| Total               | 17891.51    | 80 |              |              |           |        |

a. Based on the results of the interaction test, the p-value obtained is 0.999 > 0.05 so that H0 is not rejected. This shows that there is no interaction between the treatment of the type of seed and the growing media.

b. Based on the test of the significant effect of the type of seed, the p-value is 0.005 < 0.05, so H0 is rejected. This shows that there is a treatment of the type of seed on the duration of mycelium growth.

c. Based on the test of the significant effect of planting media. the p-value obtained is 0.000 <0.05 so H0 is rejected. This shows that there is a growing media treatment on the duration of mycelium growth.

**Figure 1.** Interaction plot between growing media and type of seed for duration of mycelium growth
From the average comparison graph above, it can be seen that the F3 type of seed on the M4 growing medium caused the highest duration of mycelium growth compared to the significant effect of the type of seed and other growing media.

3.2. The total number of mushroom fruiting bodies

Table 2. Analysis variance number of mushroom bodies

| Source of Variation | SS     | df  | MS          | F         | P-value     | F crit  |
|---------------------|--------|-----|-------------|-----------|-------------|---------|
| Seeds type          | 70.69136 | 2   | 35.34568    | 1.671337  | 0.197573    | 3.168246|
| Growing media       | 447.6543 | 8   | 55.95679    | 2.645943  | 0.015909    | 2.115223|
| Interaction         | 349.9753 | 16  | 21.87346    | 1.034297  | 0.437806    | 1.834629|
| Within              | 1142    | 54  | 21.14815    |           |             |         |
| Total               | 2010.321| 80  |             |           |             |         |

a. Based on the results of the interaction test, the p-value obtained is 0.437 > 0.05 so that H0 is not rejected. This shows that there is no interaction between the treatment of the type of seed and the growing media.

b. Based on the significant effect test of the type of seed, the p-value was obtained, namely 0.197 > 0.05 so that H0 was not rejected. This shows that there is no treatment of the type of seed on the total number of mushroom fruiting bodies.

c. Based on the test of the significant effect of planting media, the p-value obtained is 0.016 <0.05 so H0 is rejected. This shows that there is a planting media treatment on the total number of mushroom fruiting bodies.

From the average comparison chart above, it can be seen that the type of F2 seed on the M0 planting medium caused the highest total number of mushroom fruiting bodies compared to the significant effect of the type of seed and other growing media.

However, because from the results of 2-way ANOVA above, it is known that the type of seed does not have a significant effect, so when viewed from the significant effect of planting yields only, the M0 planting medium caused the highest number of whole mushroom fruiting bodies compared to the significant effect of other planting media such as graphs below:
Figure 3. Average plot between growing media and type of seed for duration of total fruiting bodies

3.3. Observation of total weight

Table 3. Analysis variance observation of total weight

| Source of Variation | SS    | df | MS       | F        | P-value | F crit |
|---------------------|-------|----|----------|----------|---------|--------|
| Type seeds          | 1065.877 | 2  | 532.9385 | 0.336238 | 0.715938 | 3.168246 |
| Growing media       | 69941.57   | 8  | 8742.697  | 5.515886 | 4.18E-05 | 2.115223 |
| Interaction         | 32963.61   | 16 | 2060.225  | 1.299824 | 0.231438 | 1.834629 |
| Within              | 85590.16   | 54 | 1585.003  |          |         |        |
| Total               | 189561.2   | 80 |          |          |         |        |

a. Based on the results of the interaction test, the p-value obtained is 0.231 > 0.05 so that H0 is not rejected. This shows that there is no interaction between the treatment of the type of seed and the growing media.
b. Based on the significant effect test of the type of seed, the p-value was obtained, namely 0.716 > 0.05 so that H0 was not rejected. This shows that there is no treatment of the type of seed on the total weight observation.
d. Based on the test of the significant effect of planting media, the p-value obtained is 0.000 < 0.05 so H0 is rejected. This shows that there is a planting media treatment on total weight observations.

Figure 4. Interaction plot between growing media and type of seed of total fruiting bodies
From the average comparison chart above, it can be seen that the F2 type of seed on the M0 planting medium caused the highest total weight observation compared to the significant effect of the type of seed and other planting media.

3.4. First Day of Harvest

3.4.1 Effect of seed type
Based on the results of the Kruskall Wallis test on the effect of the type of seed, it was obtained that the p-value was 0.6916 > 0.05 so that H0 was not rejected. This showed that the type of seed has no significant effect on the first day of harvest.

3.4.2 Effect of planting media
Based on the results of the Kruskall Wallis test on the effect of planting media, the p-value was 0.000 < 0.05, so H0 was rejected. This showed that the planting medium has a significant effect on the first day of harvest.

Because the planting medium affects the first day of harvest, it will be seen which planting medium produces the highest harvest on the first day. Based on the graph below, M4 growing media produced the highest first day of harvest compared to other planting media.

![Plot Rata-Rata](image)

**Figure 5.** Average plot for growing media of first-day harvest

3.5. Fruit body diameter

3.5.1 Effect of seed type
Based on the results of the Kruskall Wallis test on the effect of the type of seed, it was obtained that the p-value was 0.9479 > 0.05 so that H0 was not rejected. This showed that the type of seed has no significant effect on the diameter of the fruiting body.

3.5.2 Effect of planting media
Based on the results of the Kruskall Wallis test on the effect of planting media, the p-value was 0.000 < 0.05, so H0 was rejected. This showed that the planting medium has a significant effect on fruiting body diameter.
3.6. Stalk length

3.6.1 Effect of seed type
Based on the results of the Kruskall Wallis test on the effect of the type of seed, it was obtained that the p-value was 0.997 > 0.05 so that H0 was not rejected. This showed that the type of seed has no significant effect on the length of the stalk.

3.6.2 Effect of growing media
Based on the results of the Kruskall Wallis test on the influence of the planting medium, the p-value was 0.009 <0.05, so H0 was rejected. This showed that the planting medium has a significant effect on the length of the stalk.

4. Conclusion
Based on the results of data analysis which showed that the planting medium affected all observational variables (length of mycelium growth, the first day of harvest, total fruit body, fruiting body diameter, observation of total weight, stalk length, and stem diameter) while the type of seed only affected the length of growth. mycelium and in other variables the type of seed had no effect.

Acknowledgment
The authors wish to thank the Networked ASEAN Peat Swamp Forest Communities (NAPC) Project funded by ICT Virtual Organization of ASEAN Institutes and NICT ASEAN IVO, which support the Focused Group Discussion on Techno-Socio Innovation on Sustainable Peatland Management and to all the committee members of ICEFC for your continuous support on this paper preparation.

References
[1] Elmiwati, Sitepu N, Savitri D A 2015 Pengaruh kombinasi beberapa media terhadap pertumbuhan dan produksi jamur tiram putih Jurnal BioConcetta 1(2):8-19
[2] Saragih R 2015 Nugget jamur tiram (Pleurotus ostreatus) sebagai alternatif pangan sehat vegetarian E-Journal WIDYA Kesehatan dan Lingkungan 1(2): 90-95
[3] Martawijaya E, Nurjayadi 2011 Bisnis Jamur Tiram di Rumah Sendiri (Bogor: IPB Pr)
[4] Astuti H K, Kuswytasari N D 2013 Efektivitas pertumbuhan jamur tiram putih (Pleurotus ostreatus) dengan variasi media kayu sengon (Paraserianthes falcatoria) dan sabut kelapa (Cocos nucifera) Jurnal Sains dan Seni 2(2)
[5] Sutarman 2012 Keragaan dan Produksi Jamur Tiram Putih (Pleurotus ostreatus) pada media serbuk gergaji dan ampas tebu bersuplemen dedak dan tepung jagung Skripsi Universitas Muhammadiyah Sidoajo
[6] Darliana 2008 Pengaruh dosis dedak dalam media tanam terhadap pertumbuhan dan hasil jamur tiram putih (Pleurotus floridae) Bandung: UNBAR Jurnal Penelitian wawasan Tridharma 6
[7] Suriawiria 2006 Sukses Beragrobisnis Jamur Kayu Shiitake, Tiram putih, dan Tiram. (Jakarta: Penebar Swadaya)
[8] Gasperz V 1991 Metode Rancangan Percobaan (Bandung: CV. Armico)
[9] Achmad, Mugiono, Arlianti, A Azmi C 2011 Panduan Lengkap Jamur (Jakarta: Penebar Swadaya)
[10] Syafiih A, Achmad, Herliyana E N 2013 Perbandingan faktor media dari campuran serbuk gergaji sengon, jabon dan limbah substrat jamur tiram pada pertumbuhan miselia jamur tiram (Pleurotus Spp.) Jurnal Silvikultur Tropika 4(3):196 200