STUDY OF WOOD SAWDUST WITH ADDITION OF PLANTATION WASTES AS A GROWTH MEDIUM ON YIELDS AND QUALITY OF WHITE OYSTER MUSHROOM

Imam Mudakir 1) and Utami Sri Hastuti 2)

1) Faculty of Teacher Training and Education, Jember University
Jl. Kalimantan No. 37 Jember 62121, Indonesia
2) Department of Biology, Faculty of Mathematics and Natural Science, State University of Malang
Jl. Semarang 5, Malang 651145, Indonesia
1) Corresponding author Email: imam_mudakir@yahoo.com

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ABSTRACT

The study aimed to investigate the use of wood sawdust as a medium for growth and the optimum addition ratio of plantation wastes that can increase the yields and quality of white oyster mushroom (Pleurotus ostreatus). This research used Completely Randomized Design (CRD) consisting of 7 levels of treatment ratio of wood sawdust and plantation wastes. The data analysis involved one way ANOVA followed by Duncan’s 5%. The results showed that the wood sawdust can be used as growing medium, and the addition of plantation wastes can increase the yields and the quality of white oyster mushroom. The addition of cocoa and coffee wastes with a ratio 25% was the optimum ratio treatment which increased the number of fruiting bodies, caps diameter, production weight, Biological Efficiency Ratio (BER) and protein, fats, carbohydrates and fiber content in white oyster mushrooms. It is recommended to be applied because both treatments would increase the yield and quality of white oyster mushroom.

Keywords: cocoa and coffee pods wastes, wood sawdust, yield and quality of white oyster mushroom.

INTRODUCTION

One of potential values of Jember is sawmill industry. This industry leaves sawdust waste that can be used for oyster mushroom growing medium. Logs, wood chips and sawdust are commonly used for a growing medium of oyster mushroom (Pleurotus sp). Any species of wood, soft or hard wood, except pine wood can be used as the medium as long as it is not containing any extractive substances that might inhibit the growth of fungi (Santoso, 1992). The benefit of using wood sawdust as a growing medium is that it is easily obtained in the form of waste, so the price is relatively cheap, easily mixed with other additives and easily molded and conditioned (Yuniasmara et al., 1999).

Generally, the chemical components of wood consists of three elements, namely carbohydrates compose of cellulose and hemicellulose, the non-carbohydrate composed of lignin and wood elements precipitating during the growth process are called extractive substances. The composition of the chemical elements consists of wood carbon 50%, hydrogen 6%, nitrogen 0.04% - 0.10%, ash 20-50% and the rest is oxygen (Dumanauw, 1990). Another potential of Jember is that it is geographically based on agriculture (plantations) which has been developed into agribusiness. Plantation sector is a major contribution of District Own Source Revenue. The sector has been pushed to increase production. However, the increase of plantation crops production will always be followed by the increase of farm waste (Mudakir, 2010).

Coffee is potentially grown in Jember. The total area of the coffee plantation in Jember comprises 16,882 ha with a production of 21.72 tons. Wet coffee processing will generate solid waste such as fruit peel in the fruit stripping process (pulping) and leather horn in the huling. Each hectare of coffee planting will produce approximately 1.8 tons of fresh waste. Solid waste coffee pods (pulp) have not been used optimally. They are generally stacked several months and spread foul odor and liquid that pollute the environment.
The coffee pod waste can be used for growing media because it contains organic materials needed for plant growth. Compost nutrient content of the coffee pods is 0.82% N, 52.4% organic C, 0.05% P₂O₅, 0.84% K₂O, 0.58% CaO, 0.86% MgO, while the content of the coffee pods (pulp) is 2.98% N, 45.3% organic C, 0.018% P₂O₅, 2.28% K₂O, 1.22% CaO and 0.21% MgO (Baon et al., 2005). The coffee pod waste is also potentially used as a growing medium to increase the yield and the quality of oyster mushrooms. The cocoa plantation crop in Jember is 4,641 ha with a production of 15.87 tons (Government of Jember, 2010). Cultivation and process of cocoa also produce organic solid waste abundantly. Based on the statistical data plantation in 2006, the area under cocoa in Indonesia is 992,448 ha, 560,880 tonnes of production and the level of productivity of 657 kg ha⁻¹ year⁻¹. The harvest yield per hectar was 6,200 kg of cocoa pods and 2,178 kg of fruit skin moist seed (Directorate General of Plantation, 2006).

Cocoa pods have a high content of organic matter, and it is quite varied. According to Shepherd and Yap (1986), organic matter content in the pods is N 16.6 kg t⁻¹, P₂O₅ 1.7 kg t⁻¹, K₂O 55.4 kg t⁻¹, MgO 3.0 kg t⁻¹ and CaO 2.3 kg t⁻¹. Meanwhile, organic matter content in the dry cocoa fruit pods is 90.4 % dry matter, 16.4% ash, 6.0% crude protein, crude fiber 31.5 %, 1.5% crude fat, N-free extract 4.52 %, ether extract 0.9%, 0.67 % Ca, 0.10% P, 0.64 % Mg, energy 3.51 kcal g⁻¹, energy metabolism of 2.10 kcal g⁻¹.

Nowadays the need and public awareness of nutritious food is increasing, this is due to the improvement of people's understanding of nutritious food for health. This condition is supported also by the increasing demand for an agricultural product including oyster mushroom. Oyster mushrooms are widely known by mushroom growers in Indonesia, including white oyster (Pleurotus ostreatus). This fungus can grow on sawdust, straw, rice husk, cotton waste, tea leaf waste, corn husk, paper waste and other lignocellulosic materials. Among the types of cultivated oyster mushroom, white oyster mushroom (P. ostreatus) is the most favored mushroom by farmers because it has adaptive properties and durability in storage. Some other kinds of fungi are less popular in Indonesia because of their unusual color and poison.

The fruiting body of white oyster mushroom is a shallow funnel-like shells (oysters). The fruiting body of this fungus has a cap (pileus) and stem (stipe or stalk). Pileus shaped like an oyster shell measuring 5-15 cm and the bottom surface of the layered like gills are white and soft. The stem size is varied (around 2-6 cm) depending on the environment and climate conditions that affect growth (Djarjah and Djarjah, 2001).

Physical factors that affect the growth and production of oyster mushroom are related to nutritional needs for growth for the fruit of oyster mushroom. The optimal temperature for the growth of mycelium is between 22-30°C, while for the formation of the fruit is between 12-28°C. The optimum humidity during growth mycelium is between 60-80% and the formation of the fruit is between 80-95%, it is about 6-7 for medium pH (Muchroji and Cahyana, 2003).

Light is needed to stimulate the growth of stem length and the diameter of the fruit cap of oyster mushroom, whereas the incubation period does not require light to grow mycelium optimally. When light is needed, fluorescent light is generally the best light to use. Therefore, it does not require additional light as long as it is not put in a completely dark room (Djarjah and Djarjah, 2001).

International rate of mushroom needs to fulfill only 22%, while the national rate of production only needs 0.16%. This is very far from the demand, whereas in Jember, current market demand for mushrooms supply reaches 175 kg day⁻¹. However, the production of mushroom industry was less than 100 kg day⁻¹ (Mudakir, 2010). To develop the mushroom industry especially white oyster mushroom in Jember, utilization of sawdust waste with the addition of plantation waste as a medium of white oyster mushroom is required.

**MATERIALS AND METHODS**

The experiment was conducted using a completely randomized design (CRD), consisting of seven additional ratio levels of plantations waste. There were cacao pods and coffee pods on wood sawdust in every baglog i.e: SL₀ = 100% wood sawdust + 0% waste plantation (control); SL₁ = 80% sawdust wood + 20% cocoa pod waste; SL₂ = 75% wood sawdust + 25% cocoa pods waste; SL₃ = 70%
wood sawdust + 30% cocoa pod waste; SL₄ = 80% wood sawdust + 20% coffee pods waste; 
SL₅ = 75% wood sawdust + 25% coffee pod waste and SL₆ = 70% wood sawdust + 30% 
coffee pod waste. The materials used were 
white oyster mushroom spawn, wood sawdust, 
cocoa pods, coffee pods, and chemicals for 
protein, fats, carbohydrate, and fiber content 
analysis. Each treatment was repeated four 
times and each replication consisted of 4 units of 
baglog. The analysis of the data used one way- 
ANOVA, followed by Duncan’s test (5%).

a. Research Implementation Procedures 
1. A mushroom house was prepared for this 
research; the size of the house in this 
study was 2.5 m in length, 1.5 m in width, 
and 2.8 m in height. It contained 2 blocks 
of shelves, and each shelf was divided 
into 4 rows with interval of 40 cm. Before 
used, the mushroom house had to be 
cleaned from any residual matter, and to 
be sprayed with 2% formalin to avoid 
contaminants or other diseases before it 
was kept in the room for 24 hours. 
2. Waste from wood sawdust was sieved to 
obtain uniformity in size, it required 
approximately 5 days to dry under 
sunlight (with 10% moisture content). 
Meanwhile, the cocoa and coffee pod 
waste was cut and dried to reach a 
moisture content of 5-10%, then crushed 
with a rolling pin and sifted. Each mixture 
was added by water until the water 
content of 40%. It was then stirred until 
smooth and covered with plastic to 
ferment for 24 hours. After fermented, the 
material was put into a plastic bag 
polypropilen 1.5 kg with a height of 30 cm.

3. Sterilization was done using the steamer 
tools with the sieve at the bottom to 
separate water and growing media. 
Mushroom growing media were inserted 
in the pasteurized tool (boiler steamer) 
with steam at a temperature of 80-90°C 
within 8-12 hours.

4. Cooling; Before inoculated with mushroom 
spawn, the growing media (baglog) were 
cooled for 12 hours until the temperature 
reached 35-40°C.

5. Innoculation spawn was performed in a 
sterile room that had been sprayed with 
alcohol. The end of baglog was cut open, 
and the center of the growing medium 
was loaded by spawn mushrooms, then 
on the tip of the baglog was mounted a 
plastic ring and covered with sterile oil 
paper and tied up with rubber band.

6. Incubation or fungus mycelium growing 
process was done by storing the media in 
the incubation room. Media was placed on 
the shelf incubation in a standing position. 
While the temperature required for 
mycelium growth was 22-30°C with a 
humidity of 60-80%.

7. Maintenance; After the media were 
covered with mycelium which took 30-40 
days from the inoculation, growing media 
that have grown mycelium marked with 
baglog were almost entirely white (85%). 
Then the medium can be relocated to the 
mushroom house with the baglog in 
horizontal position. During the maintainance, 
the temperature and humidity had to be 
maintained within a range of 12-28°C and 
80-95%, respectively. After a week of baglog 
displacement to mushroom house, the 
growth of mesellium would be 100%. To 
allow the appearance of the fruit in baglog 
hole, then plastic ring and paper cover were 
opened and the plastic tip of baglog was cut.

8. Harvesting; Oyster mushrooms could be 
harvested after reaching the optimal level 
which was when the growth of fruiting 
odies were large enough but not fully 
bloomed yet (cap diameter of about 7 
cm). It was generally 15 days after 
displacement of the incubation room to 
the maintenance of a mushroom house. 
Harvesting was done in the morning 
around 6:00 to 8:00 AM or in the 
afternoon about 4:00 to 6:00 PM.

b. Observation 
The research data including yield and 
quality parameters of oyster mushrooms 
were observed.

1. Oyster mushroom yield consists of: 
a. The number of fruit bodies; the number 
of white oyster mushroom fruit bodies 
were observed after each harvest, 
whole calculated body pieces (large 
and small size category). 
b. Cap diameter; cap diameter was 
measured using a meter in units of cm,
measurements on samples which have a diameter of the largest fruit body cap.
c. Weight of yield fruiting bodies; weight of oyster mushroom yield was measured by weighing the weight (g) of each unit in replicates for each treatment and the addition of waste cocoa and coffee pods on the substrate (baglog).
d. Biological Efficiency Ratio (BER) demonstrates the ability of the substrate unit to produce a unit of fungal fruiting body weight. Body weight was compared with the weight of fruit per baglog and multiplied by 100%.

2. Quality of oyster mushroom
The quality of the oyster mushroom observed with the nutrient content of oyster mushrooms using proximate analysis (Sudarmadji et al., 1996) consists of:

a. Determination of protein content using the Semi Micro Kjeldhal method.
b. Determination of fat content using Soxhlet method.
c. Determination of carbohydrate content using Luff Schoorl method
d. Determination of the Fiber content using of Neutral Detergent Fiber (NDF) method.

RESULTS AND DISCUSSION

a. Yields Oyster Mushrooms
Harvesting oyster mushroom was not generally in uniform between each treatment and it was in the morning or afternoon and almost every day of harvesting. Harvesting was done by holding the mushroom fruit body stalk and then turning it up regardless of the substrate. The parts of the oyster mushroom fruiting bodies that can be used were a part of the stalk and cap mushroom fruit body as shown in Figure 1. Based on the observation of morphological characters showed that the white oyster mushroom fruiting bodies were generally in white in color, grown in at the edge of the flat hood.

Remarks: 1: hood mold, 2: mushroom stalk, 3: edgeflathood

Figure 1. Morphological structure of white oyster mushroom
The yields of the oyster mushroom crop performance in the oyster mushroom cultivation could be measured from the constituent components results covering a total yield fruiting bodies, the diameter of the fruit body cap, heavy yield per unit baglog, and Biological Efficiency Ratio (BER) with the results can be found in Table 1.

<table>
<thead>
<tr>
<th>Ratio of waste treatment (SL) **</th>
<th>Number fruiting bodies (unit)</th>
<th>Caps diameter (cm)</th>
<th>Weight yield (g)</th>
<th>BER (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SL₀ (100% S:0% L)</td>
<td>22.31 a</td>
<td>10.65 a</td>
<td>411.25 a</td>
<td>50.77 a</td>
</tr>
<tr>
<td>SL₁ (80% S:20% Kk)</td>
<td>32.50 b</td>
<td>10.91 ab</td>
<td>473.00 b</td>
<td>56.31 b</td>
</tr>
<tr>
<td>SL₂ (75% S:25% Kk)</td>
<td>37.94 cd</td>
<td>10.89 ab</td>
<td>493.19 c</td>
<td>56.69 b</td>
</tr>
<tr>
<td>SL₃ (70% S:30% Kk)</td>
<td>34.50 bc</td>
<td>11.15 ab</td>
<td>498.75 c</td>
<td>56.36 b</td>
</tr>
<tr>
<td>SL₄ (80% S:20% Kp)</td>
<td>38.75 cd</td>
<td>11.68 b</td>
<td>498.88 c</td>
<td>60.47 c</td>
</tr>
<tr>
<td>SL₅ (75% S:25% Kp)</td>
<td>41.38 d</td>
<td>11.63 b</td>
<td>514.06 d</td>
<td>60.12 c</td>
</tr>
<tr>
<td>SL₆ (70% S:30% Kp)</td>
<td>46.56 d</td>
<td>11.29 ab</td>
<td>519.81 d</td>
<td>57.76 b</td>
</tr>
</tbody>
</table>

Remarks: *) The numbers accompanied by the same notation in the same column are not significantly different.
***) S = wood sawdust, Kk = cocoa pods wastes, Kp = coffee pods wastes.

The addition of pod waste of cocoa and coffee in general can increase the diameter of the oyster mushroom fruit body cap (pileus). These results indicated that giving pod waste of cacao and coffee to a certain level would be able to increase the weight of oyster mushroom yield, but it subsequently did not provide further yield improvement. In the control, due to the content of N, P, K and C organic, it was the lowest result of the lowest mushroom yields in weight. The lignocellulose as a carbon source that was used to form organic compound constituent of fungal cell was also required by the oyster mushroom.

The oyster mushrooms have a cellulase enzyme that can break down cellulose into glucose. Glucose can serve as a carbon source which is the macro element used as a constituent of fungal cell structures. According to Caney and Peerrally (1995), oyster mushrooms have lignoselulase enzyme that is able to remodel cellulose, lignin and other polysaccharides. One result of the reform is glucose that can be used by fungi as a carbon source. Substrates of baglog material consisted primary waste sawdust Falcata and it had a high cellulose content and low lignin content so well as it was used as a medium for growing mushrooms.

Cellulose is required by mushrooms as food, while lignin is non-carbohydrate compound which is difficult to breakdown via biological decomposition. Consequently, sawdust or other wastes which have a high lignin content is not good as mushroom growing medium due to the slow decomposition (Suriawiria, 2002). Sawdust from Faltata wood has low lignin content of...
about 25.7% and has a high cellulose content (46.0% alpha-cellulose and 74.9% Holo-cellulose). The results of this study demonstrated that the addition of cacao and coffee pod wastes could increase the production of oyster mushrooms. The report on the results of previous studies suggested that the addition of waste coffee with coffee pods ratio of 25% and 75% sawdust gave effect to increase the production of white oyster mushroom production by weight of 405.79g, and the amount of fruit body production of fruit 90.84 (Asyiah et al., 2011). It proved that coffee and cocoa pod waste used as growing media could increase the production of white oyster mushrooms on treatment SL2 (493.19 g) and treatment SL5 (514.06 g).

b. Quality Oyster Mushrooms

The analysis on the quality of oyster mushrooms using proximate analysis is to identify the protein, carbohydrate and fat in the oyster mushroom (Sudarmadji et al., 1996). The result of ANOVA revealed that the use of leather waste of cacao and coffee had a significant effect on protein, fat, carbohydrates, and fiber content. The results measured with Duncan's 5% can be seen in Table 2.

The highest protein content in addition to the cocoa pods in ratio of SL3 was 2.24% and the coffee pods treatment in ratio of SL5 was 2.24%. The highest fat content was SL3 (0.05%). The highest carbohydrates content was in the cocoa pod treatment of SL3 (5.76%) and the coffee pod treatment of SL5 (5.80%). The highest fiber content of the cocoa pods treatment in ratio of SL3 was 4.60% and the coffee pods treatment in ratio of SL2 was 4.71%.

The increase of protein content in the oyster mushroom was caused by the content of nitrogen in the substrate that was sufficient for the needs of the fungus in protein synthesis. Nitrogen is required for the formation of proteins, fats and various organic compounds. Nitrogen is also useful to accelerate the growth of fungus. The amount of total nitrogen content in whole baglog treatment showed an increase when compared with that of no addition of cocoa and coffee waste. Furthermore, fungi can use inorganic nitrogen to form nitrate, nitrite, ammonia or organic nitrogen to form amino acids. The composition of the substrate has an important influence on the protein content of white oyster mushroom. Oyster mushrooms have a complete amino acid content especially essential amino acid. Total essential amino acids in the white oyster mushroom is 33.5 g per 100 g of crude protein.

Table 2. Data of Protein, Fat, Carbohydrates and Fiber Content in White Oyster Mushroom on Cocoa and Coffee Pod Waste Treatment

<table>
<thead>
<tr>
<th>Ratio of Waste Treatment (SL) **</th>
<th>Protein Content (%)</th>
<th>Fat Content (%)</th>
<th>Carbohydrate Content (%)</th>
<th>Fiber Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SL1 (100% S:0 % L)</td>
<td>1.43 ^a</td>
<td>0.04 ^a</td>
<td>4.89 ^b</td>
<td>3.00 ^a</td>
</tr>
<tr>
<td>SL2 (80% S: 20% Kk)</td>
<td>1.74 ^b</td>
<td>0.04 ^a</td>
<td>5.39 ^c</td>
<td>3.67 ^c</td>
</tr>
<tr>
<td>SL3 (75% S:25% Kk)</td>
<td>2.21 ^c</td>
<td>0.04 ^a</td>
<td>5.03 ^b</td>
<td>4.50 ^d</td>
</tr>
<tr>
<td>SL4 (70% S:30% Kk)</td>
<td>2.24 ^c</td>
<td>0.05 ^b</td>
<td>5.76 ^d</td>
<td>4.60 ^de</td>
</tr>
<tr>
<td>SL5 (80% S:20% Kp)</td>
<td>1.85 ^b</td>
<td>0.04 ^a</td>
<td>4.39 ^a</td>
<td>3.35 ^b</td>
</tr>
<tr>
<td>SL6 (75% S:25% Kp)</td>
<td>2.24 ^c</td>
<td>0.04 ^a</td>
<td>5.60 ^cd</td>
<td>3.30 ^b</td>
</tr>
<tr>
<td>SL7 (70% S:30% Kp)</td>
<td>2.16 ^c</td>
<td>0.04 ^a</td>
<td>5.80 ^d</td>
<td>4.71 ^e</td>
</tr>
</tbody>
</table>

Remarks: *) The numbers which are accompanied by the same notation in the same column are not significantly different.

**) S = wood sawdust, Kk = cocoa pods wastes, Kp = coffee pods wastes.
Fats, the simplest types of lipids, are ester of glycerol and fatty acids (R-COOH), and they have three hydroxyl groups (-OH), which are linked to fatty acid (Tejasari, 2005). The fat content of oyster mushroom represents all classes of fat, i.e. free fatty acids, monoglycerides, diglycerides, triglycerides, sterols, sterol esters, and phospholipid. Most fatty acids are oleic acid (79.4%), palmitic acid (14.3%), and linoleic acid (6.3%). Primary neutral fat in white oyster mushroom is a triglyceride, which is about 29% (Cangy and Peerally, 1995). The dried and ground cocoa and coffee contributed to an increase in P₃O₅ baglog. Goenadi et al. (2005) stated that the cocoa fruit pods mineral nutrients was quite high, especially P₃O₅ nutrient.

The carbohydrates are food components consisting of polyhydroxy aldehydes or poly-hydroxyacetone and including condensate polymer-polymer formed. Naturally, there are three most important forms of carbohydrate, namely monosaccharides, oligosaccharides and polysaccharides. Substrates in baglog was a major source of nutrients that could be used by mushrooms. Nutrition could be utilized after the fungus excreted extra cellular enzymes that could break down into complex compounds and break down once more into compounds simpler. Fungi have the ability to excrete some types of enzymes into the environment and have another ability to breakdown complex carbohydrates such as cellulase, amylase, chitinase. Carbohydrate is a key element in the oyster mushroom. Carbohydrate compositions are soluble carbohydrates, pentosan, and hexosan. Polysaccharide complex is a component of the cell wall constituent (Chang, 2007).

The crude fiber is important in assessing the quality of food ingredients since this figure is an index and able to determine the nutritional value of food. In addition, the fiber content of crude fiber can be used to evaluate a food material processing and to determine the purity of the material or the efficiency of a process. Crude fiber is obtained in the leaching residue using acids and bases, generally in the form of cellulose, lignin and other compounds that cannot be identified with certainty. The increasing fiber content of white oyster mushroom was suspected because of the ability to utilize the compounds in the substrate. wherein the mineral nutrient content of cocoa fruit pods is high enough, especially nutrients of nitrogen and potassium.

Consequently, an increase in nutrients of the substrate occurs.

CONCLUSION

The study on the use of sawdust wood with the addition of plantation wastes had a significant influence on the yield and quality of white oyster mushroom. It is advisable to use this growth medium with ratio 75% wood sawdust and 25% cocoa pod waste (SL₂) and ratio 75% wood sawdust and 25% coffee pod waste with SL₅, for both of the treatments would increase the yield and quality of white oyster mushroom.

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REFERENCES


