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

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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, Biologycal Eficiency 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 hulling. 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.

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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% P_2O_5, 0.84% K_2O, 0.58% CaO, 0.86% MgO, while the content of the coffee pods (pulp) is 2.98% N, 45.3% organic C, 0.018% P_2O5, 2.28% K_2O, 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}, P_2O_5 1.7 kg t^{-1}, K_2O 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 funnellike 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 (Djarijah and Djarijah, 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 mycellium 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 (Djarijah and Djarijah, 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: SL_0 = 100% wood sawdust + 0% waste plantation (control); SL_1 = 80% sawdust wood + 20% cocoa pod waste; SL_2 = 75% wood sawdust + 25% cocoa pods waste; SL_3 = 70%

wood sawdust + 30% cocoa pod waste; SL_4 = 80% wood sawdust + 20% coffee pods waste; SL_5 = 75% wood sawdust + 25% coffee pod waste and SL_6 = 70% wood sawdust + 30% coffee pod waste. The materials used were white oyster mushroom spawm, wood sawdust, cocoa pods, coffee pods, and chemicals for protein, fats, carbohydate, 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. Maintainance; 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 bodies 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 Soxchlet 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 stucture of white oyster mushroom

Table 1. Data of number of fruit bodies, cap diameter, yield weight and *BER* white oyster mushroom on cocoa pods and coffee pods wastes treatment

Ratio of waste treatment (SL) **)	Observations type*)			
	Number fruiting bodies (unit)	Caps diameter (cm)	Weight yield (g)	BER (%)
SL_0 (100% S:0 % L)	22.31 a	10.65 a	411.25 a	50.77 a
SL_1 (80% S: 20% Kk)	32.50 b	10.91 ab	473.00 b	56.31 b
SL_2 (75% S:25% Kk)	37.94 cd	10.89 ab	493.19 c	56.69 b
SL_3 (70% S:30% Kk)	34.50 bc	11.15 ab	498.75 c	56.36 b
SL_4 (80% S:20% Kp)	38.75 cd	11.68 b	498.88 c	60.47 c
SL_5 (75% S:25% Kp)	41.38 d	11.63 b	514.06 d	60.12 c
SL_6 (70% S:30% Kp)	46.56 d	11.29 ab	519.81 d	57.76 b

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

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 Eficience Ratio (BER) with the results can be found in Table 1.

The results of the use of wood sawdust with the addition of fruit cocoa pods and coffee pod waste as growing media on baglog showed a significant effect on the number of fruiting bodies, the diameter of cap, the weight of fruiting bodies/baglog, and BER white oyster mushroom. The highest number of fruiting bodies was SL_2 (37.94 fruits) and SL_6 (46.56 fruits). The highest cap diameter was 11.5 cm and 11.68 cm for SL_3 and SL_4, respectively. The highest weight yield of SL_3 was 498.19 g and SL_6 was 519.81 g. The best treatment of SL_2 and SL_5 were 493.19 g and 514.06 g, respectively. Meanwhile, the higest value of Biological Efficiency Ratio (BER) of SL_2 was 56.69%, and SL_4 was 60.47%.

Mushroom fruit bodies derived from the mycelium formed sporangium and grew into a pinhead or primordia (shoots or candidates of fungal fruiting bodies) and eventually developed into fruiting bodies of fungi. In general, the addition of cocoa and coffee pod waste tends to increase the number of oyster mushroom fruiting bodies. According to the results of research and Shepherd and Yap (1986), the organic material in dry cocoa pods contains ash, crude protein, crude fiber, crude fat, N-free extract, ether extract, Ca, P, Mg and energy metabolism.

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 Cangy and Peerally (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 SL_2 (493.19 g) and treatment SL_5 (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 SL_3 was 2.24% and the coffee pods treatment in ratio of SL_5 was 2.24%. The highest fat content was SL_3 (0.05%). The highest carbohydrates content was in the cocoa pod treatment of SL_3 (5.76%) and the coffee pod treatment of SL_6 (5.80%). The highest fiber content of the cocoa pods treatment in ratio of SL_3 was 4.60% and the coffee pods treatment in ratio of SL_6 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

Ratio of WasteTreatment(SL) **	Observations Type*)			
	Protein Content (%)	Fat Content (%)	Carbohydrat Content (%)	Fiber Content (%)
SL_0(100% S:0 % L)	1.43 [a]	0.04 [a]	4.89 [b]	3.00 [a]
SL_1(80% S: 20% Kk)	1.74 [b]	0.04 [a]	5.39 [c]	3.67 [c]
SL_2(75% S:25% Kk)	2.21 [c]	0.04 [a]	5.03 [b]	4.50 [d]
SL_3(70% S:30% Kk)	2.24 [c]	0.05 [b]	5.76 [d]	4.60 [de]
SL_4(80% S:20% Kp)	1.85 [b]	0.04 [a]	4.39 [a]	3.35 [b]
SL_5(75% S:25% Kp)	2.24 [c]	0.04 [a]	5.60 [c d]	3.30 [b]
SL_6(70% S:30% Kp)	2.16 [c]	0.04 [a]	5.80 [d]	4.71 [e]

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, mono-glycerides, 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 P_2O_5 baglog. Goenadi *et al.* (2005) stated that the cocoa fruit pods mineral nutrients was quite high, especially P_2O_5 nutrient.

The carbohydrates are food components consisting of polyhydroxy aldehydes or poly-hydroxyaceton 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. Carbo-hydrate 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 (SL_2) and ratio 75% wood sawdust and 25% coffee pod waste with SL_5, for both of the treatments would increase the yield and quality of white oyster mushroom.

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