Waste of *Morus alba* as the main ingredients in making the cultivation media of oyster mushroom (*Pleurotus ostreatus*)

Amelia, Ira Taskirawati, and Baharuddin  
Faculty of Forestry, Hasanuddin University, Makassar, Indonesia  
Email: tasqira@unhas.ac.id

Abstract. *Morus alba* contains cellulose and hemicellulose needed for fungal growth. Besides, this plant also contains high protein wherein the protein required for the growth of fungal mycelium. In South Sulawesi, mulberry waste is also quite widely available, especially waste from feed silkworm’s mulberry. This study aims to diversify the cultivation media of oyster mushrooms. The method used in this study is the mixing of raw materials, sterilization of raw materials, inoculation, maintenance, and harvesting. There is five treatment in the blending of raw materials, the use of 100% mulberry waste powder (P1); 75% mulberry waste powder (P2); 50% mulberry waste powder (P3); 25% mulberry waste powder (P4); and 100% sawdust (P5) as a control. The use of 75% mulberry waste powder (P2) produces the best cultivation media. Whereby using this media, it takes 40 days from the growing media inoculating the mushrooms until the oyster mushrooms are ready to be harvested.

1. Introduction  
Non-timber forest products (NTFPs) have long have included in the essential part of the livelihood strategies of forest communities. NTFPs have been used by people around the forest, either directly or indirectly. Besides being easy to obtain useful NTFP species and does not require sophisticated technology to get it, NTFPs can also be obtained free of charge and have significant economic value. Besides, NTFPs have a contribution and link between inputs and outputs between industries, consumption, and investment. Therefore NTFP deserves to be the mainstay for the economy of forest communities.

Non-timber forest products are of various kinds, each of which has different benefits. Wood mushroom is one type of non-wood forest product that can use as food. Oyster mushroom (*Pleurotus ostreatus*) is one type of wood fungus that can be consumed and currently can also cultivate. Oyster mushroom cultivation now has the opportunity to be developed by people around the forest; this supported by the availability of raw materials for growing media substrates, namely sawn wood dust, which is quite abundant. According to Hidayat [1], an excellent growing medium substrate used is wood that has a content of cellulose and hemicellulose. Various types of wood fungi as low-grade plants are saprophytes; the compound can be decomposed and eaten by fungus mycelium. The variables or planting media type often used is rotten wood, sawdust, straw, and rice husks. Planting media types commonly used in the cultivation of oyster mushroom *Pleurotus ostreatus*.

During this time, the sawdust is one of the main ingredients in the manufacture of oyster mushroom growing medium. However, few studies have tried to use other materials to become the oyster mushroom growing medium. One is the research conducted by Taskirawati et al. [2] that uses the dregs sago as a critical ingredient in the manufacture of oyster mushroom growing medium. There are still many other raw materials worth a try for the development of the mushroom cultivation. In this
study, the planting medium used is a waste of mulberry (*Morus alba*). Mulberry waste consisting of leaves, twigs, and stems, contain cellulose and hemicellulose required by a fungus to grow. Also, the mulberry plant has a high protein content [3]. The protein contained in mulberry plants, it needed in the growth of fungal mycelium. This study aims to determine the composition of the waste is mulberry plants as the primary raw material in the manufacture of oyster mushroom cultivation media. In South Sulawesi, sewage plant mulberry silkworms feed are abundantly available and could use for alternative growing media used in the cultivation of oyster mushrooms.

## 2. Materials and Methods

The research has done in the Laboratory of Forest Products Utilization and Management, Faculty of Forestry, Hasanuddin University. Materials used in this study were Pleurotus ostreatus culture [F2], waste mulberry, sawdust sengon, bran, agricultural lime (CaCO₃), gypsum (CaSO₄), water, alcohol 70%, spirits, litmus paper (pH meter), newsprint, label paper, rubber bands, and ropes. The tools used in this study are hammer-mill; 20 and 40 mesh sieves; scales; buckets; plastic clips; 1 kg polypropylene plastic; paralon rings with a diameter of 5 cm and a length of about 3 cm; measuring cups; sterilizers; tweezers; bunsen lamps; hand sprayers; storage; and thermometers.

### 2.1. Preparation for White Oyster Mushroom Growth Media

Pretreatment of waste is by counting part mulberry branch or trunk mulberry waste to be small pieces. Results of chopped dried and then ground into a powder and ready to be used as a growing medium. Sawdust also sifted to obtain a uniform powder-sized planting medium that has a specific density without damaging the plastic bag. Besides, with a uniform powder size can also increase the growth of mycelium evenly. Before the powder is applied, first soaking in significant media to eliminate substances such as latex, oil, and others. Another function of soaking is to make the powder cleaner and softer—immersion waste mulberry powder conducted for two days, and replacement soaking water every 24 hours. The purpose of the replacement water immersion is to help remove the powder’s inhibiting substances and other impurities. After mixing, composted media for five days. After that, the media sterilized for 6 hours. Cooling media for 24 hours to do after sterilization. If this step has completed, the growing medium ready for inoculation.

### 2.2. Variables Observed

Variables observed the growth of oyster mushroom mycelium, pinhead growth of oyster mushrooms, and a harvest of oyster mushroom. Oyster mushroom harvest divided into three, namely, the growth of fruiting bodies, the wet weight, and the fruit body count.

## 3. Results and Discussion

### 3.1. Oyster mushroom mycelium growth

Oyster mushroom mycelium growth time is calculated from the baglog in inoculation with oyster mushrooms are presented in Figure 1. Baglog P4 is a baglog with the closure of the slowest mycelium is by old-growth 49 days. Meanwhile, the mycelium’s rapid growth is baglog P2 and P5 with a growth of 36 days old. According to Hendri et al. [4], oyster mushroom mycelium growth after the inoculation process needs to monitored at all times. If the condition of the growing media has met, then the mycelium will grow fast, from the observations in just 30 days baglog already filled with oyster mushroom mycelium. Kasmawati et al. [5] stated that the long incubation period of mycelium growth takes 30-60 days. The range of mycelium growth in this study according to two studies.
mulberry waste powder, P2: 75% mulberry waste powder + 25% sengon wood powder, P3: 50% mulberry waste powder + 50% sengon wood powder, P4: 25% mulberry waste powder + 75% sengon wood powder, P5: 100% sengon wood powder}

According to Rynko [6], mulberry contains many nutrients, especially protein. Proteins contained in mulberry leaves around 15.31 to 30.91%, approximately 9.70% carbohydrates, fiber 9.9 to 36.66%, 10-40% hemicellulose, and cellulose 21.8%. Besides, mulberry also contains amino acids, especially glutamine, leucine, lysine, and lipids. Meanwhile, according to Suriawiria [7], the life and development of oyster mushroom mycelium require a medium containing nitrogen, organic C, carbohydrates, lignin, cellulose, and some other substances that oyster mushrooms can be grown and been growing well. The explanation above shows that mulberry qualifies as a medium that can use for growing oyster mushrooms.

Internal factors affecting the growth of oyster mushroom mycelium is medium density. If the media is too dense, mycelium growth will slow down because oxygen will be challenging to get into the media so that the mycelium growth is inhibited [8]. According to Hardiadi et al. [9], a bag with 1 kg capacity, should be filled with media as much as 800-1000 g. This study uses polypropylene plastic bags the size of 1 kg with planting medium as much as 1000 g. So the baglog used for this study, according to the growth of mycelium.

External factors were consisting of temperature and humidity. In this study, the temperature at incubation space ranges from 22-29°C with humidity in the range of 55-90%. Temperature and humidity ranges are consistent with the Cahyanti [10] study that the temperature and humidity required by oyster mushroom mycelium growth between 26-30°C during humidity 75%. Additionally, Steviani [11], in her research long deployment, mycelium states affected by temperature and humidity incubation place the oyster mushroom mycelium growth, ideally to be achieved in the incubation chamber which has a temperature between 24 to 29°C and humidity of 90-100%.

3.2. Growth will mushroom fruit body pinhead
The growth of the oyster mushroom fruit body known after the entire surface of the mycelium baglog full and part baglog cover has opened. As long mushroom fruit body growth seen in Figure 2.

The mushroom fruit body’s growth calculated from the beginning of full mycelium, which has opened section, will cover until fruiting bodies grow the amount of approximately 1 cm. Baglog with the growth of mushroom fruit body will be the fastest is baglog P2 is two days.
Old-growth will be the slowest fruiting bodies are baglog P4, which is five days. Meanwhile, old-growth will mushroom fruit body with the composition of the leading media in the form of sawdust and pulp sago conducted by Nawaruddin et al. [12] was seven days.

As well as the mycelium growth, the mushroom fruit body’s growth also is influenced by external and internal factors. Based on research that has done Maulana [13], the optimal temperature for growth pinhead is 16-22 °C with a humidity of 95-98% with a planting medium waste corn stalks and cobs. According to Parjimo and Andoko [14], to stimulate the growth of shoots and fruit body needs moisture 80-90%. In this study, the maintenance room temperature range 24-29 °C with a humidity of 55-90%. When baglog in foster care to keep moisture, then performed regularly spraying water 2-3 times a day. Besides, the possibility of growth will also be affected by fruit body density media. According to Nawaruddin et al. [12], the most important thing to be aware of in foster care is maintaining the required temperature and humidity mushrooms, if the humidity is less, pinhead die and if too moist mushroom becomes wet.

In this study, the mycelium closing time is directly proportional to the prospective growth of fruiting bodies. Consistent with research, Ilyas et al. [15] explains the timing of the growth of fungal fruiting bodies with sawdust medium is directly proportional to the closing old mushroom mycelium. If the growth of mycelium good, it will affect the speed of the formation of fruiting bodies (primordial).

### Figure 2.
Old-growth will be the fruit body {P1: 100% mulberry waste powder, P2: 75% mulberry powder + 25% Waste wood powder sengon, P3: 50% mulberry powder + 50% waste wood dust sengon, P4: 25% powder mulberry waste + 75% sengon wood powder, P5: 100% sengon wood powder}

| Growth of pinhead (days) | Treatment |
|-------------------------|-----------|
| 3                       | P1        |
| 2                       | P2        |
| 3                       | P3        |
| 5                       | P4        |
| 3                       | P5        |

3.3. Oyster Mushroom Harvesting.
The characteristics of oyster mushroom harvested, which have not a curly hood, the color has not faded, the spores have not released, and the texture is still strong and supple. Meanwhile, things that need to consider in the harvesting is done by unplugging harvesting without leaving parts of mushrooms, clean and not splattered [16]. Three variables observed in the harvesting of old-growth oyster mushrooms are the fruiting bodies of would be the perfect fruiting body, fruiting bodies bazaar weight, and the amount of fruit body when harvested.
3.3.1. Old-growth of the body will be ready to harvest fruit until
Harvest time is the time required from prospective growth fruiting bodies until harvest. Old-growth of fruit body until the body will be ready for harvesting fruit requires only a short time. The growth will extend until harvest fruit body seen in Figure 3. Old-growth of fruit body until the body will be ready for harvesting fruit is 2-4 days. Old-growth of fruit body until the body will be ready for harvesting fruit baglog P1 and P2 is the fastest is two days.

Figure 3. Old-growth of fruit body until the body will be ready to harvest fruit for each treatment {P1: 100% mulberry waste powder, P2: 75% mulberry powder + 25% Waste wood powder sengon, P3: 50% of the waste powder mulberry + 50% sengon wood powder, P4: 25% mulberry waste powder + 75% sengon wood powder, P5: 100% sengon wood powder}

3.3.2. Oyster mushroom fruit body weight
The wet weight of the oyster mushroom fruit body shown in Figure 4. The number of the most abundant oyster mushroom harvest is baglog P3 is 115 grams, and the lowest is baglog P1 is as much as 42.5 grams. The white oyster mushroom production in the media mix of sawdust and rice husks, suggesting the addition of rice husk media 25% and 75% provide optimal results, the most optimal production of wet weight is 78.67 grams [13]. Research conducted by Ilyas et al. [15] demonstrated the use of sawdust media plant yields as much as 90 grams.

According to Suriawiria [7], available nutrients in growing media that can be absorbed by the oyster mushroom will increase the weight of the wet mushrooms. The nutrients influence big wet white oyster mushrooms in the form of carbohydrates and protein, fertility growing media, and humidity and temperature room mushrooms. Lignin plays a role in the metabolism of the fungus fruit flesh so that lignin can add oyster mushrooms’ wet weight. In this study, the nutrients in baglog and water thought to be the deciding factor in the growth of fruiting bodies. Fungi to produce fruit bodies need the nutrients that are greater than the growth of fungal mycelium, so remodel existing nutrients in the media to grow to produce fruit bodies. The water is also essential in the growth of oyster mushroom fruit bodies because if the water contained in baglog less, there will be drought baglog resulting mushroom fruit body is not getting more significant. Therefore, the availability of water contained in the baglog must be sufficient for the fungal fruiting body can thrive.
3.3.3. Number of oyster mushroom fruit body

The number of fruiting bodies of oyster mushrooms at harvest time shown in Figure 5. The highest number of fruiting bodies after harvest there baglog P4 as many as 12 pieces. Meanwhile, the number of fruiting bodies that are at least in baglog P5 as many as four pieces. This study also shows that the number of the oyster mushroom fruit body is not directly proportional to the weight of the oyster mushroom fruit body wet.

**Figure 4.** Wet weight fruit body {P1: 100% mulberry waste powder, P2: 75% mulberry powder + 25% Waste wood powder sengon, P3: 50% mulberry powder + 50% waste wood dust sengon, P4: 25% mulberry waste powder + 75% sengon wood powder, P5: 100% sengon wood powder}

**Figure 5.** Number of oyster mushroom fruit bodies {P1: 100% mulberry waste powder, P2: 75% mulberry waste powder + 25% sengon wood powder, P3: 50% mulberry waste powder + 50% sengon wood powder, P4: 25% powder mulberry waste + 75% sengon wood powder, P5: 100% sengon wood powder}
Baglog section where the fruiting bodies grow affects the number of oyster mushroom fruit bodies. If the fruit body grows not in the center of the ring baglog but grows on the side or bottom baglog, then this section will be a lot of fruit growing body. However, the fruit growing body having a smaller size and only partially large. Besides, 17% of rice bran contained in the cultivating medium can provide adequate nutrition for the formation of mycelium much so that it is capable of forming fruiting bodies. This study is in line with research Ilyas et al. [15], which states bran can provide adequate nutrition for the formation of secondary mycelium that much so that it can form fruit.

4. Conclusion
The use of the mulberry plant waste as much as 75% (P2) produces the best cultivated media. Where to use this medium, it takes about 40 days from cultivating medium inoculation oyster mushrooms until the mushrooms are ready for harvesting.

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