Sago pulp and rice husk as an alternative material for the cultivation of oyster mushroom (*Pleurotus ostreatus*)

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Abstract. During this time, the wood powder is one of the primary raw materials in making mushroom cultivation media. Alternative other raw materials need to be developed to diversify the oyster mushroom cultivation media. Sago pulp waste and rice husk are chosen as the planting medium for oyster mushroom cultivation because they contain cellulose, hemicellulose, and lignin needed by the fungus. This study aims to determine the composition of sago pulp and rice husk as the best growing media for the growth and development of white oyster mushrooms. The method used in this study is mixing raw materials (the cultivation media), sterilizing raw materials, inoculating, maintaining, and harvesting. There are five treatments in mixing raw materials, namely the use of 100% sago pulp waste (P1); 75% of sago pulp and 25% of husk rice powder (P2); 50% of sago pulp and 50% of husk rice powder (P3); 25% sago waste and 75% husk rice powder (P4); and 100% rice husk (P5) as a control. The use of 50% sago pulp and 50% husk rice powder (P3) and 25% sago pulp and 75% husk rice powder (P4) produces the right cultivation media. Whereby using both of these mediums, it takes 42 days from the growing media inoculated mushrooms until the oyster mushrooms are ready to be harvested. However, if the use of baglog P3 as a growth medium will get better yields because of the wet weight (60 grams) and the number of mushroom fruit bodies (16 fruits) that harvested is higher.

1. Introduction
Non-wood forest products (NTFPs) are all biological objects, including environmental services originating from forests or forest stands except wood products. NTFPs have been used consumptively by communities around the forest, such as fruits, medicines, game animals, firewood, sago, as well as productively, such as resin, gaharu (*Aquilaria malaccensis*), rattan, essential oils, and honey. One type of NTFP that widely cultivated is oyster mushroom.

Oyster mushroom (*Pleurotus ostreatus*) is a type of wood fungus that can use as food. Currently, oyster mushroom cultivation has the opportunity to be developed because it supported by the availability of raw materials as a growing media substrate. The media commonly used for mushroom cultivation was sawdust, which is a sawmill waste.

Along with the development of the mushroom, business-related development of mushroom cultivation needs to increase as the growth medium. During this time, the sawdust is one of the raw materials that are widely used growing medium. In addition to using sawdust, several studies have used raw materials other than wood dust to use as a mushroom growing media. For example the utilizing sago pulp as a growing medium [1]. This study, using sago pulp combined with rice husk as a substitute for sawdust. Use of sago pulp and sawdust as a growing medium oyster mushroom with
media composition 75% sawdust and 25% pulp sago gives the best results. Meanwhile, other researcher added rice husks and rice bran in the manufacture of oyster mushroom media [2].

Sago pulp and rice husk waste were chosen as the growing media for oyster mushroom cultivation because it contains cellulose, hemicellulose, and lignin needed by the fungus. Sago pulp and rice husk waste are widely available, which can use as a growing medium. This study aims to determine the composition of sago pulp and rice husk as the best growing media for the growth and development of white oyster mushrooms. So there are a new alternative growth media that can be used for the cultivation of mushrooms and can increase the types of raw materials as an oyster mushroom growing medium.

2. Materials and Methods

This research conducted at the Laboratory of Forest Product Utilization and Management, Faculty of Forestry, Hasanuddin University. Materials used in this study were F2 Pleurotus ostreatus culture, sago waste, rice husks, bran, lime (CaCO₃), casts (CaSO₄), water, 70% alcohol, newsprint, label paper, raffia, rubber band, rubbing alcohol, and litmus paper (pH meter). While the tools used are hammer mill, 20 mesh, and 40 mesh sieves, scales, buckets, tarpaulins, plastic clips, 1 kg polypropylene plastic, paralon rings with a diameter of 5 cm and length 3 cm, tweezers, bunsen lamps, sterilizers, shelves storage, thermometer, measuring cup and hand sprayer.

2.1. Preparation for White Oyster Mushroom Growth Media.
Sago drugs have taken a wet waste, which is then dried by drying and then ground into a powder and ready to be a growing medium. Rice husk is also milled and then sieved intending to filter or separate the rice husk with uniform size, so we get a growth medium that has a specific density without damaging the plastic bag and get a uniform rate of mycelial growth. There were five treatments applied in this study which were 100% sago waste (P1); 75% sago pulp waste and 25% husk powder (P2); 50% sago waste and 50% (P3) husk powder; 25% sago waste and 75% (P4) husk powder; 100% husk powder (P5). The media composted for five days; after that, it sterilized for 6 hours. Media that has been sterilized and then cooled for 24 hours and is ready to be inoculated.

2.2. Variables Observed
The variables observed in this study are:
1. Time of mycelial growth (days).
2. The growth time of fruit body (days).
3. Harvest time (days)
4. The fresh weight of mushrooms produced per baglog (grams)
5. The amount of mushroom production per baglog (fruit)

3. Results and Discussion
In this study, there are three variables observed that the growth of oyster mushroom mycelium, pinhead growth of oyster mushrooms, and oyster mushroom harvest. The harvest of oyster mushrooms divided into three, namely the growth of the fruit body, the oyster mushroom body wet weight, and the number of oyster mushroom fruit bodies.

3.1. Growth of Oyster Mushroom Mycelium.
Mycelium growth observed from the inoculation of the fungus baglog until the whole surface covered by mycelia baglog — the duration of oyster mushroom mycelium closure presented in Figure 1. Figure 1 shows the composition of the media consisting of 25% sago pulp and 75% rice husk (P4) is the best composition of the growth media (baglog) for mycelium growth (18 days). Meanwhile, baglog P1, which uses 100% sago pulp, is the growing medium with the most extended closure of mycelium (38 days). Suriawiira [3] states that the life and development of oyster mushroom mycelium require media containing nitrogen, organic C, carbohydrates, lignin, cellulose, and several other
substances so that oyster mushrooms can grow and develop properly. Wijaya [4] adds an element increasing nitrogen in the media can increase the speed of the growth of oyster mushroom mycelium. In this study, the element nitrogen contained in rice husk and sago dregs is one of the essential elements needed for the growth of mycelium.

![Figure 1](image_url)

Figure 1 Duration of oyster mushroom mycelium growth in the media after the media inoculated oyster mushroom seedlings (days) [P1: 100% sago pulp, P2: 75% sago pulp + 25% rice husk, P3: 50% sago pulp + 50% rice husk, P4: 25% sago pulp + 75% rice husk, P5: 100% rice husk]

Internal factors that influence the growth of oyster mushroom mycelium are media density. Media with a composition of 100% sago pulp is a baglog with the most extended closure of mycelia. The presence of starch in hardened sago pulp causes oxygen content to reduced in the growing media. This result is in line with the statement Seswati et al. [5] when the media is too dense, then the mycelium growth will slow down because oxygen will be challenging to get into the media, so that inhibited mycelial growth. Besides, Setiagama [6] also states the density baglog also influences the spread of the mycelium because if the baglog too dense, then the mycelium will be difficult to spread to the entire surface of the baglog. Thus, in the process of filling baglog endeavored not too dense.

The external factors consist of temperature and humidity. In this study, the temperature in the incubation chamber with a range of 22-29°C with humidity ranged from 55-90%. Temperature and humidity range is consistent with research Cahyanti [7], where the temperature and humidity required for oyster mushroom mycelium growth between 26-30°C and humidity of 75%. Also, Stevani [8] suggests that a long spread of the mycelium is affected by temperature and humidity incubated. Ideally, oyster mushroom mycelium growth will achieve in the incubation chamber, which has a temperature of between 24-29°C and humidity of 90-100%.

3.2. Growth of Oyster Mushroom Pinhead.
The appearance of a white oyster mushroom pinhead known after the entire surface of the baglog is full of mycelium, and the baglog cover has removed. In this study, the appearance of pinhead time calculated from the first day it opened until a pinhead baglog. The pinhead growth time is showing in Figure 2.

The time pinhead mushroom growing most rapidly is baglog P3, which is 13 days. Time pinhead slowest growth is baglog P1, where old-growth pinhead is 27 days. In this study, the baglog with the fastest closure of mycelium (P4) is not the baglog with the fastest pinhead growth time (P3). The pinhead growth time is not directly proportional to the length of mycelium closure. This result is contrary to the statements of Nawaruddin et al. [1] and Ilyas et al. [9], where the length of mycelium closure is in line with the time of growth of pinhead fungus. Allegedly, when the baglog surface fully covered by mycelium, the inside of the baglog has not been filled with mycelium. That causes pinhead growth to be slower. Steviani [8] states that each treatment has different physical conditions so that
some can absorb the nutrients that are available in the media well, and some are not absorbing nutrients properly which results in the growth of fungi between one another is not the same.

![Figure 2 Pinhead growth time (P1: 100% sago pulp, P2: 75% sago pulp + 25% rice husk, P3: 50% sago pulp + 50% rice husk, P4: 25% sago pulp + 75% rice husk, P5: 100% rice husk)](image)

3.3. Oyster Mushroom Harvesting.

3.3.1. Oyster Mushroom Harvesting Time.
Harvest time is the time needed from when the baglog is inoculated with mushrooms until the fruit body of the mushroom is ready to be harvested or the time needed from pinhead growth until the fruit body is ready for harvest. The length of time from a pinhead to a fruiting body is ready to be harvested only requires a short time. Figure 3 shows the harvesting of oyster mushrooms, which is calculated from the emergence of pinhead until the fruit body is ready to be harvested in 2-3 days. This result is in line with research conducted by Susilawati and Raharjo [10] where the age of oyster mushroom harvesting is three days after the fruit will appear. Rochman [11] states the time to grow the mushroom fruit body to develop optimally about 2-4 days after the fruit will begin to grow.

The harvest time calculated from baglog inoculation with fungi until the fruiting body in baglog is ready to be harvested presented in Figure 4. The length of time for mushroom growth from inoculation to the first harvest is the treatment P3, and P4 is 42 days while the slowest is in the treatment P1 is 67 days.
Figure 3. Harvest time for oyster mushroom cultivation for each treatment calculated from the emergence of pinhead [P1: 100% sago pulp, P2: 75% sago pulp + 25% rice husk, P3: 50% sago pulp + 50% rice husk, P4: 25% sago pulp + 75% rice husk, P5: 100% rice husk ]

Figure 4. Harvest time for oyster mushroom cultivation for each treatment calculated from the inoculation of fungi [P1: 100% sago pulp, P2: 75% sago pulp + 25% rice husk, P3: 50% sago pulp + 50% rice husk, P4: 25% sago pulp + 75% rice husk, P5: 100% rice husk ]

The criteria for oyster mushrooms that are ready to be harvested according to Susilawati and Raharjo [10] are that the hood is fully open with the edges thinning, the color has not faded, the spores have not released, and the texture is still sturdy and flexible. Rochman [11] states that if oyster mushrooms are ready to be harvested but not harvested, it will reduce the quality of mushrooms such as dried fruit bodies so that it will reduce the fresh weight of mushrooms, curly fruit edges, and brown color. So the harvest time must be right to produce fresh mushrooms. Harvesting is done by pulling out all part of the fungus on the growing media, so there not rotted on the media that will interfere with the mushroom productivity.

3.3.2. Wet Weight of Oyster Mushroom Fruit Body.
The wet weight of oyster mushrooms harvested presented in Figure 5. Baglog P3 is a baglog with the most significant wet weight of oyster mushrooms, which is 78 grams, and the lowest is baglog P1, which is 20 grams. Based on research conducted shows that the composition of the media consisting of 50% sago pulp + 50% rice husk powder produces fruit bodies that tend to be more substantial than the other treatments. It suspected that fresh fruit body weight has something to do with the number of fruit bodies per baglog. This result is in line with the statement of Nawaruddin, et al. [1] that the number of fruit bodies formed in each baglog will affect the fresh weight of the mushrooms produced.
Figure 5. The wet weight of oyster mushrooms [P1: 100% sago pulp, P2: 75% sago pulp + 25% rice husk, P3: 50% sago pulp + 50% rice husk, P4: 25% sago pulp + 75% rice husk, P5: 100% rice husk]

Nutrients and water contained in the baglog suspected to be decisive in the growth process of the fruit body. To produce the mushroom fruit bodies needed nutrients higher than the growth of the mycelium. In this study, the nutrients needed by the fungus provided by the dregs of sago and rice husks. Meanwhile, water plays an essential role in the growth process of oyster mushroom fruit bodies because if the water contained in baglog less, there will be a drought that resulted in a fruit-growing body getting a bigger one. Therefore, the water contained in the baglog must be sufficient for the fungal fruiting body can thrive.

3.3.3. The number of Oyster Mushroom Bodies.
The number of oyster mushroom fruit bodies, when harvested, presented in Figure 6. In the media composition of 50% sago pulp + 50% rice husk powder (Baglog P3), the results tend to be more than other treatments. The highest number of fruit bodies is in the P3 baglog, as many as 16 pieces. Meanwhile, the number of fruiting bodies is the least in baglog P1, which is two pieces. In this study, there are differences in the number of fruit bodies in each baglog. According to Afriadi et al. [12], differences in the number of fruiting bodies produced every baglog due to differences in the ability of mycelium in the process of absorption of nutrients.

Figure 6. Number of oyster mushroom fruit bodies [P1: 100% sago pulp, P2: 75% sago pulp + 25% rice husk, P3: 50% sago pulp + 50% rice husk, P4: 25% sago pulp + 75% rice husk, P5: 100% rice husk]
Research conducted by Muchsin et al. [2] states that the addition of husks to making media will reduce the number of mushroom fruit bodies. The reduction in the number of the fruit body is thought to be due to the accumulation of silica so that oyster mushrooms can not degrade it. This study, the addition of rice husk to baglog media, did not affect the growth of fungi.

4. Conclusion
Based on the results of the study showed that the use of 50% sago pulp and 50% husk rice powder (P3) and 25% sago pulp and 75% husk rice powder (P4) produces the right cultivation media. Whereby using both of these mediums, it takes 42 days from the growing media inoculated mushrooms until the oyster mushrooms are ready to be harvested. However, if the use of baglog P3 as a growth medium will get better yields because of the wet weight (60 grams) and the number of mushroom fruit bodies (16 fruits) that harvested is more significant.

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