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The Effect of Synergistic Oil Palm Frond Waste and Varied Nutrients on the Production White Oyster Mushroom (*Pleurotus Ostreatus*)

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Abstract

Purpose - This study aims to investigate the effect of additional nutrients (molasses and tofu dregs) on mycelium growth and the overall production of white oyster mushrooms using powdered oil palm fronds and sawdust as growing media.

Design/methodology/approach - The methodology were analysed using ANOVA and Duncan's Multiple Range Test, a two-factor completely randomised design was conducted with factor M (sawdust and powdered frond combination) as the growing media composition and factor N (molasses and tofu dregs combination) as the nutrient composition.

Findings - The results were shown that the growing media composition (sawdust and palm fronds) at different percentages did not have a significant effect on mycelium growth over the media and the age of the emergence of fruiting bodies but it had an effect on the wet harvest weight (M3).

Originality/value – The best nutrient addition is the treatment N2 for the growth of mycelium over the media and treatment N3 for the wet harvest weight, while interaction treatment M3N3 displayed the highest increase in wet harvest weight.

Keywords *Pleurotus ostreatus;* powdered oil palm fronds; sawdust, molasses; tofu dregs

Paper type Research paper

Introduction

Mushroom is a horticultural commodity that can be used for food and nutraceutical purposes. Chang and Miles (2004) stated that mushrooms are defined as the fruiting bodies of macrofungi that can appear either above ground (epigeous) or below ground (hypogenous) and are large enough to be seen by the naked eye and picked by hand. The consumption of mushrooms dates back to antiquity since ancient Greece and Rome civilisations when one of the most appreciated species, *Amanita caesarea*, was baptised as Caesar's mushroom, while other poisonous species were previously used to dethrone popes, kings, and emperors (Van Griensven, 1988). Certain edible mushrooms are high in selenium, an important element that is commonly deficient in most diets (Falandysz, 2008). Pre-clinical and clinical studies have previously reported that mushroom consumption reduces body weight and inhibits the development of cancerous cells (Feeney *et al.*, 2014). On the other hand,

the *Pleurotus s*pecies contains a high ratio of potassium to sodium and is thus considered an ideal food for patients suffering from heart diseases and hypertension (Ha Thi Hoa and Chun-Li Wang, 2015).

It is estimated thatover100 mushroom species have been cultivated commercially, of which around 20 have been exploited commercially. The most cultivated genera worldwide which account for 85% of the global cultivation of edible mushrooms are *Lentinulaedodes* (shiitake), *Agaricus* (mainly *Agaricus bisporus*), *Auricularia*, and *Flammulina*, thus supporting an industry that was previously valued at approximately $58 billion in 2013 (Royse DJ., *et al*., 2017).

To date, there is no standard formula for growing various mushroom species as a huge diversity of raw materials can be employed based on the country or the area where the mushroom farm is located. Therefore, profitability can be enhanced by reducing transport costs and managing wastes effectively in these locations (Pardo, J., *et al.*, 2017). Indonesia has the potential to be a producer of edible mushrooms as it has various types of mushrooms that are highly nutritious and can be used as health products, thus potentially adding revenue to the state (Ghorai, S., et al., 2009). In various Indonesian regions, there are many agricultural businesses that specifically cultivate mushrooms and turn them into high-value products (Banasik, A., et al., 2017). It was previously shown that the production fluctuated between 2009 to2013, whereby the production reached 61,376 tons in 2009 and decreased to 56,094 tons in 2010. Subsequently, it increased to 107,617 tons in 2013 (Budiasa, I. W., 2014).

Oyster mushroom production in Indonesia, however, has not sufficiently met the needs of the community due to the use of conventional cultivation technology and limited availability of planting media. It has been previously mentioned that the use of various media compositions and the addition of nutrients will have a positive impact on the growth and production of oyster mushrooms (Budiasa, I. W., 2014).For instance, white oyster mushroom (*P.ostreatus*) can grow on a variety of media with different lignocelluloses (Carmen Sánchez, 2009), while it has been shown that white oyster mushroom in Saudi Arabia grows well in a mixed media containing 25% of palm fronds and 75% of organic waste (wheat stalks, sawdust, boobiala/*Myoporum serratum*) (Alananbeh K. *et al.*, 2014). In contrast, the composition of the growing media for king oyster mushroom (*P.Eryngii*) varies. Nevertheless, the basic constituents consist of a mixture of sawdust, straw, cornstalk, or cottonseed husk that is supplemented with organic protein material (as N element enrichment) to ensure that the C/N ratio reaches 30-40% with a 70% moisture content (Rodriguez-Estrada *et al.*, 2009 *in* Carrasco, J., *et al*., 2018).

In Japan, another oyster mushroom growing media formula with high productivity that is commonly used consists of 11.1% corn, 3.9% rice bran, 3.9% wheat bran, 2% soybean husk, 2% cottonseed husk, 2% dry tofu dregs, and 74.5% sawdust with a moisture content of 65-75% (Yamanaka, 2017). In Indonesia, sawdust is generally used as the growing media for white oyster mushroom cultivation. Mane et al., (2007) stated that the availability of sawdust is a limiting factor in the cultivation of oyster mushrooms and issues will arise if sawdust is difficult to obtain in the cultivation area. Therefore, it is necessary to find alternatives that are easily available in the area.

One media that can be used as an alternative for oyster mushroom cultivation is waste from oil palm plantations. Indonesia is the largest producer of oil palm in the world. According to Harahap, F, et al., (2019), the area of oil palm plantations in the past five years was10.754.801 million ha in 2014, 11.260.276 million ha in 2015, 11.201.465 million ha in 2016, 12.383.101 ha in 2017, and 12.761.586 million ha in 2018. The increase in the number of oil palm plantations also leads to an increase in oil palm frond waste. According to Garg and Gupta (2009) and Mardiana, S., et al., (2017), agro-industrial wastes and their derivatives can cause environmental and health problems.

Oil palm fronds are composed of 14.8% lignin, 62.3% α-cellulose, 24.2% hemicelluloses, and 1.8% extractive (Goh et al., 2010). Owing to the large amount of oil palm frond waste available and its nutrient contents, oil palm waste can be used as an alternative growing media for white oyster mushroom cultivation. According to Lusiana, et al., (2014), oil palm fronds are composed of 54.88% cellulose and 17.51% lignin. The composition

of agricultural wastes that are often used as growing media for oyster mushrooms such as sawdust, corn stalk, corn cob, straw, cereals, and sugar cane waste (bagasse) can have varying results in terms of mushroom colonisation, fruit body growth, and fecundity (Hoa, H.T., et al., 2015).

Molasses, on the other hand, is a liquid byproduct of the sugar refining process that contains a high amount of sugar and inorganic acids that can no longer be further processed into sugar crystals (Veana, F, et al., 2014). Molasses can also be used as an alternative source of iron and it represents approximately 7% of the wet weight of sugarcane sap (Ghosh and Balakrishnan, 2003). Nevertheless, molasses can still be processed into various products such as alcohol, animal feed mixtures, soy sauce, or artificial sweeteners (Olbrich, 2006). Rossi, I. H., et al., (2003) previously noted that molasses contains K, Ca, and Cl elements that affect the growth of white oyster mushrooms. Molasses also contains sugar which is an energy source for the metabolism of white oyster mushroom cells that stimulate mycelium growth. Molasses also contains nitrogen content ranging from 2-6% which supports the growth of mycelium. Rossi, I. H., et al., (2003) also previously showed that molasses can increase mushroom growth and production.

Tofu dregs are a solid byproduct that remains after the processing of soybeans into tofu. According to Li, B., Qiao, M., & Lu, F., (2012), tofu dregs contain 21.3-27% protein, 43-51 % crude fiber, and 4.5-17% fat. Mudakir, I., & Hastuti, U. S., (2015), and Buswell, J. A., & Chang, S. T., (1994) have previously shown that tofu dregs can increase mushroom growth and production. Thereby, the utilisation of oil palm fronds from oil palm plantation byproducts in combination with the additional nutrients of molasses from sugar mill byproducts and tofu dregs from tofu factory byproducts as the growing media is expected to have a positive synergistic effect on the growth and production of oyster mushrooms, thereby effectively utilising agricultural waste that is widely available in North Sumatra.

Studies involving the use of different strains, lignocellulosic substrates, spawn types, moisture content, and physicochemical conditions for mushroom cultivation are important to increase the cultivation productivity of each mushroom type (Kirbag and Akyuz, 2008; Onuoha et al., 2009). There is also a need to integrate various activities that should be coordinated for the commercial exploitation of mushroom production as well as waste management (Pardo-Giménez et al., 2017). In this study, several media combinations with the addition of nutrients from tofu waste and molasses are investigated in the production of white oyster mushrooms. Specifically, the effect of additional nutrients (molasses and tofu dregs) on mycelium growth and the overall production of white oyster mushrooms using powdered oil palm fronds and sawdust as growing media is investigated. This study also focuses on the production of organic oyster mushrooms without the use of synthetic chemicals in the cultivation process.

Material and Methods

The isolate F2oyster mushroom was cultured on malt extract agar (MEA) and was previously obtained from isolateF1 that was cultured in the agro-technology laboratory of the Faculty of Agriculture, University of Medan Area. The treatments for the culture media consisted of treatment factor M, a combination of oil palm fronds and sawdust used as growing media [M0 (100% sawdust), M1 (100% powdered frond), M2 (75% powdered frond + 25% sawdust), M3 (50% powdered frond + 50% sawdust), and M4 (25% powdered frond + 75% sawdust)] and treatment factor N which is a combination of molasses and tofu dregs used as nutrient addition [N1 (1% molasses + 12% tofu dregs), N2 (1% molasses + 6% tofu dregs), N3 (2% molasses + 12% tofu dregs), N4 (2% molasses+ 6% tofu dreg), N5 (3% molasses + 12% tofu dregs), and N6 (3% molasses + 6% tofu dregs)]. The nutrient contents of the M factor (carbon, nitrogen, and mineral content) were analysed at the Industry Standardisation and Research Center at Medan, North Sumatra.

The analytical methods employed in this study were factorial completely randomised design (CRD) and analysis of variance (ANOVA) with Duncan's Multiple Range Test based on the following formula:

$$\mathbf{Yijk = \mu + \alpha i + \beta j + (\alpha\beta)ij + \grave{E}ijk,}$$

This study was performed as described in the following stages: a) oil palm fronds were destroyed with a mill and then sifted using a 10-mesh sand sieve to maintain uniform powder size, b) the media were mixed with 10%

bran, 0.5% corn flour, 0.5% lime ($CaCO_3$), sawdust and powdered oil palm fronds (90%), molasses (molasses 1%, molasses 2%, and molasses 3 %), and tofu dregs (6% tofu dregs, and 12% tofu dregs), c)water was then added to the combination of powdered medium and nutrients until the water content of the growing medium reached 60-65%, and d) the media were composted for 4 days and $CaCO_3$was added to achieve a pH of 5.5-6.5 for optimal mycelium growth (Carrasco, 2016).

After composting, the media were put into 2 kg-sized polypropylene bags (baglogs) and sterilised at>100^{o}C for 6 hours. After sterilisation, the media were cooled for 24 hours and subsequently inoculated using 3 teaspoons of F2 seedlings per baglog. The baglogs were then incubated by arranging the baglogs on shelves in a slightly dark room to enhance the growth of mycelium. Spare baglogs were also prepared to anticipate the occurrence of pests and diseases in the baglogs. Every morning and evening, the floor of the room was watered and the room was misted to maintain environmental conditions that are suitable for the growth of oyster mushroom, with temperatures ranging from 25-28^{o}C and humidity levels of 80-90%. Prevention of pests and diseases was performed by cleaning the materials, tools, and the room periodically as well as frequent sanitisation of workers. Pest control was done by manually cleaning and picking spider webs found on the shelves. Disease control was performed by removing baglogs contaminated by fungi, bacteria, or viruses. The observational parameters in this study include the following: a) growth of mycelium over the media/baglog (cm), b) age of emergence of fruiting bodies (days after inoculation), and wet harvest weight (gram/baglog). Harvesting was performed in the morning according to the proposed harvest criteria (Luoma, D. L., *et al.,* 2006*)*

Results

Mycelium Growth over the Media/Baglog (cm)

The results showed that the combination of oil palm fronds and sawdust as growing media together with molasses and tofu dregs as additional nutrients had a significant effect on the growth of mycelium over the substrate. This is because the initial formation of mycelium is significantly influenced by the nutrient contents of the media substrate and nutrients added to the baglog. The different compositions of growing media (M0, M1, M2, M3, and M4) did not show any significant difference in the growth of mycelium over the media at 35 days after inoculation (Figure 1). This observation is consistent with the findings by Carmen Sanchez (2009) who indicated that white oyster mushrooms can grow on various media with different lignocelluloses. However, the best mycelium growth over the media observed in this study was obtained using M3 (50% oil palm frond + 50% sawdust). The addition of nutrients in the N2 treatment (1% molasses + 6% tofu dregs) also showed the best mycelium growth over the media and was significantly different compared to N5 and N6.

It was observed that although molasses and tofu dregs influenced and accelerated mycelium growth over the media, the increase in molasses concentration from 1% to 2% or 3% decreased the speed of mycelium growth over the media (N3, N4, N5, and N6). Likewise, increasing the tofu dreg concentration from 6% to 12% did not increase the growth rate of mycelium over the media (N1, N3, and N5). The best nutrient addition for mycelium growth over the media was 1% molasses and 6% tofu dregs (M3N2), which was observed 25 days after inoculation (DAI). High sugar (>1% molasses) and high tofu dreg (>6%) concentrations are likely to harm the metabolism of cell biosynthesis, thereby inhibiting the acceleration of mycelium growth over the media (Table 1 and Figure 1).

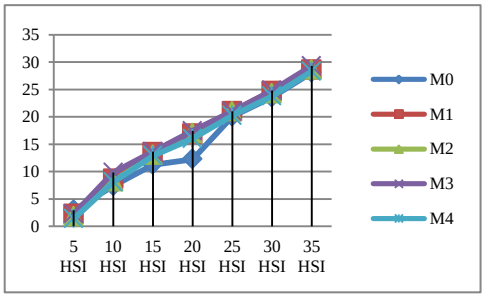

Figure 1. Growth of mycelium using various media compositions.

Table 1. Averagegrowth of mycelium over the media/baglog at 5-35 DAI based on variousmedia compositions and additional nutrients

Treatment	Mycelium growth over media/baglog (cm)						
	5 DAI	10 DAI	15 DAI	20 DAI	25 DAI	30 DAI	35 DAI
Media							
M0	2,97 aA	7,36 d C	11,25 c B	12,24 c B	20,05 ns	23,58 ns	28,10 ns
M1	2,23 ab A	8,67 b B	13,50 aA	16,86 ab A	21,00 ns	24,68 ns	28,58 ns
M2	1,78 b AB	8,20 bc B	13,02 ab A	17,02 aA	21,00 ns	24,23 ns	28,60 ns
M3	2,26 aA	9,82 a A	13,62 aA	17,43 aA	20,99 ns	24,83 ns	29,29 ns
M4	1,37 b B	8,08 c CB	12,89 b A	15,05 b AB	20,23 ns	23,78 ns	28,30 ns
Nutrition							
N1	2,35 ns	8,2 cd B	11,76 c C	15,79 ns	20,27 ns	23,56 ns	28,94 a AB
N2	2,05 ns	9,4 a A	13,91 a A	16,29 ns	21,08 ns	25,04 ns	29,62 a A
N3	2,35 ns	8,9 ab A	12,71 b B	15,88 ns	20,84 ns	23,83 ns	29,20 a A
N4	2,36 ns	8,7 bc AB	13,07 b A	14,86 ns	21,01 ns	24,25 ns	29,09 a A
N5	1,92 ns	7,3 e C	12,83 b AB	15,95 ns	20,61 ns	24,43 ns	27,95 b B
N6	1,73 ns	8,0 d BC	12,86 b B	15,56 ns	20,12 ns	24,20 ns	26,66 c C
Interaction							
M0N1	3,24 ns	6,38 d D	9,15 e	12,39 ns	20,33 ns	23,56 b	28,38 aA
M0N2	3,26 ns	8,77 b C	11,80 c	12,19 ns	20,35 ns	23,33 b	29,75 aA
M0N3	2,91 ns	8,25 c C	11,67 cd	12,04 ns	20,86 ns	22,12 b	28,95 aA
M0N4	3,44 ns	6,72 d D	11,77 c	12,85 ns	19,83 ns	23,54 b	28,50 aA
M0N5	2,53 ns	7,45 c C	10,94 de	11,87 ns	20,50 ns	23,84 b	26,39 cb B
M0N6	2,43 ns	6,59 d D	12,19 c	12,10 ns	18,47 ns	25,11 a	26,70 b B
M1N1	2,99 ns	8,27 c C	12,81 bc	16,79 ns	20,59 ns	23,66 b	30,00 aA
M1N2	2,41 ns	8,83 b C	14,33 a b	17,81 ns	22,27 ns	24,81 a	29,71 aA
M1N3	2,60 ns	10,12 b A	12,99 b	15,96 ns	21,69 ns	26,72 a	30,00 aA
M1N4	1,99 ns	9,42 b B	14,47 b	18,66 ns	21,51 ns	24,77 a	29,69 aA
M1N5	2,02 ns	7,17 cd CD	14,23 a	17,61 ns	20,82 ns	25,19 a	27,34 b A
M1N6	1,39 ns	8,21 c C	12,18 c	14,37 ns	19,14 ns	22,92 b	24,74 c B
M2N1	1,82 ns	8,48 c C	12,12 c	17,08 ns	20,51 ns	23,64 b	30,00 aA

M2N2	1,30 ns	8,02 c C	13,77 b	17,08 ns	20,92 ns	24,95 a	29,24 aA
M2N3	2,40 ns	9,18 b BC	13,49 b	18,39 ns	21,10 ns	23,19 b	29,90 aA
M2N4	1,67 ns	8,62 bc C	13,00 b	16,64 ns	22,39 ns	24,82 a	29,00 aA
M2N5	1,84 ns	6,54 d D	12,28 c	16,33 ns	19,97 ns	25,69 a	26,99 b AB
M2N6	1,68 ns	8,37 c C	13,47 b	16,58 ns	21,14 ns	23,14 b	26,50 b B
M3N1	2,27 ns	10,09 b AB	12,14 c	17,08 ns	20,24 ns	24,08 b	28,98 aA
M3N2	**1,99 ns**	**12,92 aA**	**16,04 a**	**18,18 ns**	**21,89 ns**	**27,70 a**	**30,00 aA**
M3N3	2,63 ns	9,46 b B	13,33 b	17,08 ns	20,79 ns	24,48 b	29,19 aA
M3N4	3,28 ns	9,44 b B	13,13 b	18,02 ns	21,13 ns	23,39 b	29,34 aA
M3N5	1,84 ns	8,48 c C	13,66 b	16,46 ns	20,85 ns	24,38 b	29,69 aA
M3N6	1,80 ns	8,52 c C	13,41 b	17,81 ns	21,03 ns	24,96 a	28,52 aA
M4N1	1,44 ns	8,02 c C	12,60 c	15,63 ns	19,70 ns	22,88 b	27,33 b A
M4N2	1,29 ns	8,24 c C	13,63 b	16,19 ns	19,97 ns	24,43 b	29,40 aA
M4N3	1,23 ns	7,63 c C	12,08 c	15,92 ns	19,76 ns	22,71 b	28,00 ab A
M4N4	1,53 ns	9,34 b B	12,98 b	8,15 ns	20,21 ns	24,74 ab	28,92 aA
M4N5	1,37 ns	6,72 d D	13,04 b	17,47 ns	20,90 ns	23,03 b	29,33 aA
M4N6	1,37 ns	8,57 c C	13,04 b	16,96 ns	20,83 ns	24,89 a	26,83 b B

Note: Numbers followed by the same letters in the same column indicate non-significant differences (ns) at levels of 95% (lowercase) and 99% (uppercase). DAI = Days after inoculation

Age of Emergence of the Fruiting Body (DAI)

Based on the results of this study, no noticeable differences in the average age of the emergence of fruiting bodies were observed using different combinations of oil palm fronds and sawdust (M0, M1, M2, M3, and M4) and different combinations of molasses and tofu dreg additions (N1, N2, N3, N4, N5, and N6). Nevertheless, the treatment interaction of M3N2 (50% palm frond + 50% sawdust, 1% molasses + 6% tofu dregs) showed the fastest emergence of the fruiting body, thus indicating that the combined interaction of M3N2 was the ideal combination of media composition and additional nutrients. This finding indicates that the appropriate availability of the elements C and N as well as macro- and micro-elements in the media will lead to a faster and healthy emergence of mushroom fruiting bodies (Table 2, Figures2 and3).

Ginting et al., (2013) previously stated that carbon elementsplay a role in strengthening plant cell walls. Likewise, Mufarrihah (2009) stated that phosphorus and nitrogen are elements that accelerate the formation of fruiting bodies. In this study, molasses displayed levels of 0.4-1.5% for N, 0.6-2.0%for P_2O_5, 0.1-1.1%for CaO, 0.03-0.1%for MgO, and2.6-5.0% forK_2O (Simanjuntak, 2009), while tofu dregs displayed levels of 4.27%for N, 0.42%for P_2O_5, 3.97%for K_2O and 45.14%for carbon.

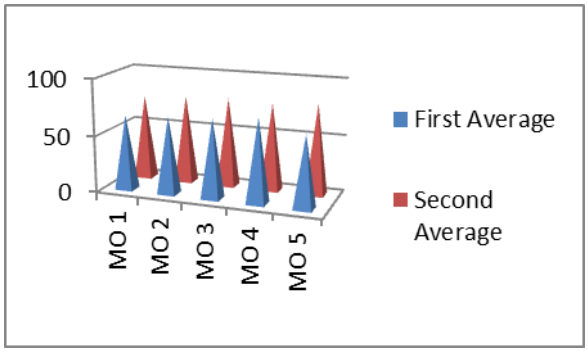

Figure 2.Age of emergence of the fruiting body usingvarious media compositions.

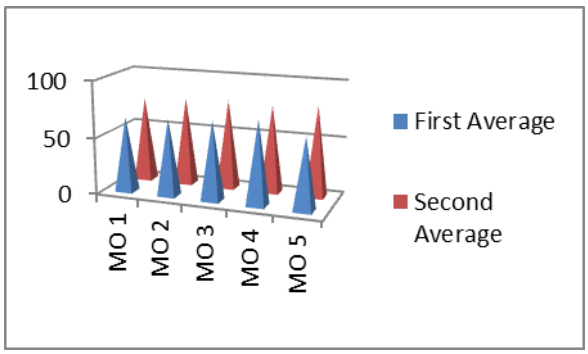

Figure3.Age of emergence of the fruiting body using various additional nutrients.

Table 2. Average age of the emergence of the fruiting body based on the media composition and additional nutrients used in this study.

Treatment	Age of Emergence of Fruiting Body (DAI)	
	Average (First)	Average (Second)
Media		
M0	66,30 bc B	75,43 ns
M1	68,36 b AB	78,08 ns
M2	69,86 b A	78,99 ns
M3	74,44 a A	77,83 ns
M4	63,20 c B	80,25 ns
Nutrition		
N1	69,63 a A	78,43 ns
N2	72,58 a A	79,21 ns
N3	69,28 ab A	78,53 ns

N4	67,99 b AB	80,19 ns
N5	64,62 c B	78,08 ns
N6	66,48 bc B	74,27 ns
Interaction		
M0N1	72,20 a A	76,23 ns
M0N2	75,30 a A	76,44 ns
M0N3	62,10 bc B	78,50 ns
M0N4	59,93 c B	75,18 ns
M0N5	64,40 b B	74,53 ns
M0N6	63,90 b B	71,74 ns
M1N1	71,60 a A	77,75 ns
M1N2	63,48 b B	81,23 ns
M1N3	67,60 b A	77,75 ns
M1N4	66,01b A	77,96 ns
M1N5	72,75 a A	77,75 ns
M1N6	68,75 b A	76,05 ns
M2N1	69,50 b A	81,63 ns
M2N2	68,81 b A	78,00 ns
M2N3	69,70 ab A	76,75 ns
M2N4	70,25 a A	84,00 ns
M2N5	73,88 a A	80,70 ns
M2N6	67,05 b A	72,88 ns
M3N1	63,15 b B	80,16 ns
M3N2	50,45 d C	72,13 ns
M3N3	67,13 b A	80,29 ns
M3N4	64,60 b B	83,25 ns
M3N5	77,26 a A	77,13 ns
M3N6	56,60 cd BC	74,03 ns
M4N1	71,74 a A	76,38 ns
M4N2	65,35 b AB	88,25 ns
M4N3	79,90 a A	79,38 ns
M4N4	79,20 a A	80,58 ns
M4N5	74,60 a A	80,28 ns

M4N6	76,10 a A	76,65 ns

Note: Numbers followed by the same letters in the same column indicate non-significant difference (ns) at levels of 95% (lowercase) and 99% (uppercase). DAI = Days after inoculation

Apart from the influence of elements contained in the growing media, the appearance of fruiting bodies is also influenced by external factors such as temperature, humidity, and water content. According to Benito, M., et al., (2005), the temperature should be maintained at 20-30^{0}C, while the humidity and water content of the media should be maintained at 90-94% and 60-65%, respectively,for the formation of fruiting bodies (Yano, T., et al., 1998).

Wet Harvest Weight (gram/baglog).

The results for the wet harvest weight showed that the M3 media treatment (50% palm frond + 50% sawdust) was the best growing media as it resulted in the heaviest wet harvest weight. Additional nutrient treatments (molasses and tofu dregs) also had a very significant effect on wet harvest weight, in which the N3 treatment (2% molasses + 12% tofu dregs) was the best nutrient treatment and the M3N3 treatment was the best treatment interaction for the wet harvest weight. The wet harvest weight is influenced by the amount of nutrition in the media. Nutrition content, especially the elements C and N, facilitates the metabolism of food that is necessary for the growth of oyster mushrooms and increases their weight(Table 3, Figure 4, and Figure 5).

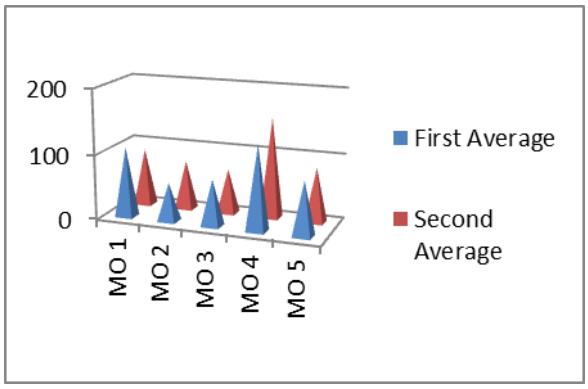

Figure 4.Wet harvest weight usingvarious media compositions.

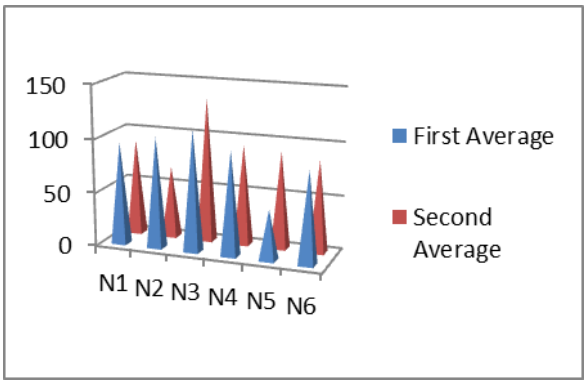

Figure 5. Wet harvest weight usingvarious additional nutrients.

Table 3. Average wet harvest weight based on various media compositions and additional nutrients used in this study

Treatment	Wet Harvest Weight (gram)	
	Average (First)	Average (Second)
Media		
M0	107,18 b AB	86,76 b B
M1	58,86 d C	75,09 b B
M2	71,45 cd BC	68,33 b B
M3	129,61 aA	154,10 aA
M4	83,21 c B	84,03 b B
Nutrition		
N1	95,22 ab AB	89,85 b B
N2	103,19 aA	67,00 c C
N3	112,52 aA	134,58 aA
N4	97,07 aA	93,71 aA
N5	46,52 c C	90,86 b B
N6	85,86 b B	85,97 b BC
Interaction		
M0N1	120,17 b	88,82 d
M0N2	172,60 a	69,77 d
M0N3	123,31 b	117,39 c
M0N4	112,46 b	103,12 cd
M0N5	30,94	63,22 de
M0N6	83,63 b	78,26 d
M1N1	70,99 c	42,56 e
M1N2	45,37 c	51,91 e
M1N3	68,41 c	96,27 d
M1N4	64,93 c	50,19
M1N5	43,47 c	104,63 c
M1N6	60,01 c	75,18 d
M2N1	84,90 b	72,38 d

M2N2	69,14 c	48,78 e
M2N3	85,45 b	103,46 c
M2N4	60,72 c	80,84 d
M2N5	34,10 c	64,29 d
M2N6	94,37 b	73,98 d
M3N1	130,94 ab	150,74 b
M3N2	136,70 a	93,37 d
M3N3	182,43 a	240,66 a
M3N4	145,85 a	168,25 b
M3N5	79,63 b	150,17 bc
M3N6	102,15 b	116,92 c
M4N1	69,09 c	94,22 d
M4N2	92,13 b	71,19 d
M4N3	102,99 b	115,12 c
M4N4	101,45 b	66,17 d
M4N5	44,45 c	71,99 d
M4N6	89,17 b	85,52 d

Note: Numbers followed by the same letters in the same column indicate non-significant difference (ns) at levels of 95% (lowercase) and 99% (uppercase).

These results are consistent with the findings by Morais, M. H., et al., (2000) who indicated that the wet harvest weight of mushrooms is determined by the fertility of the media and the presence of food substances such as carbohydrates and proteins. The sucrose content contained in molasses and tofu dregs can be efficiently absorbed by the mushroom, thus increasing the harvest weight of white oyster mushrooms. On the other hand, Mattila, P., et al., (2002) noted that sufficient nutrition available in the growing media can be absorbed by the mushroom and thus increase the wet weight of the mushroom. Gaitán-Hernández, R., & Norberto Cortés, G. M., (2014) also stated that while the provision of nutrients will supply nutrition to a certain extent, increasing the nutrients will result in a decrease of the total lignocelluloses content that is necessary to increase the weight of white oyster mushroom.

Table 4. Nutrient analysis of oyster mushroom growing media.

No	Parameter	Unit	Growing Media				
			M0	M1	M2	M3	M4
1	Carbon (C)	%	25,4	17,6	22,2	22,9	21,7
2	Nitrogen Total	%	0,39	0,38	0,39	0,39	0,43
3	Phosphor (P_2O_5)	%	0,46	0,92	1,05	0,71	0,32
4	Kalium (K_2O)	%	0,63	0,34	0,44	0,43	0,2

5	Magnesium (Mg)	mg/Kg	890	408	391	425	412
6	Sulfur (S)	%	0,62	0,64	0,02	1,24	1,23
7	Mangan (Mn)	mg/Kg	24,6	18,8	21,1	18,4	12,1
8	Copper (Cu)	mg/Kg	< 0,006	< 0,006	0,46	0,56	< 0,006
9	Kalsium (Ca)	%	0,16	0,14	0,11	0,12	0,13
10	Ferrum(Fe)	mg/Kg	60,4	30,4	28,5	40,5	63,6
11	Zink (Zn)	mg/Kg	3,14	3,1	3,08	8,57	0,93

The nutrient content of the oyster mushroom growing media consisting of sawdust and oil palm fronds at various combinations is shown in Table 4. The average wet harvest weight using various media compositions (Table 3) indicated that M3 media treatment (50% oil palm fronds + 50% sawdust) was the best media treatment as it contained appropriate nutrients for oyster mushroom production. Additionally, the M3N3 combination treatment showed the best overall result, thus indicating that the mixture of 50% sawdust and 50% oil palm fronds combined with additional nutrients (2% molasses and 12% tofu dregs) produced the highest yield of oyster mushrooms.

Conclusions

The use of different compositions of growing media (powdered oil palm frond and sawdust) did not significantly affect the growth rate of mycelium over the media. However, media treatment M3 (50% oil palm frond + 50% sawdust powder) showed the heaviest white oyster mushroom wet harvest weight, while the additional molasses and tofu dreg nutrient treatment N2 (1% molasses + 6% tofu dregs) showed the fastest mycelium growth over the media. Additional nutrient treatment N3 (2% molasses + 12% tofu dregs) showed the heaviest white oyster mushroom wet harvest weight, while the interaction treatment M3N3 consisting of additional nutrients (molasses and tofu dregs) with growing media composition (oil palm fronds and sawdust) showed the highest increase in white oyster mushroom wet harvest weight

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