Utilization of Cotton Waste from PT Sri Rejeki Isman Tbk. Spinning Division as Basic Material for White Oyster Mushroom (*Pleurotus ostreatus*) Planting Media

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Abstract

There are five types of cotton waste produced by the Spinning Division of PT. Sri Rejeki Isman Tbk: dropping, flat strip recyclean, flat strip c, air waste, and fan open end, which has a smaller trash content. The research objective is to determine the potential utilization of cotton waste as the basic material for white oyster mushroom planting media, to determine effect of planting media formula on the growth of white oyster mushroom, and to determine the best formula for white oyster mushroom planting media. Utilization of cotton waste are examined by 5 formulas: control with 100% sengon wood powder + 200 gram bran + 10 gram lime (S_0), 50% dropping + 50% sengon wood powder + 200 gram bran + 10 gram lime (S_{1a}), 75% dropping + 25% sengon wood powder + 200 gram bran + 10 gram lime (S_{1b}), 50% fan open end + 50% sengon wood powder + 200 gram bran + 10 gram lime (S_{2a}) and 75% fan open end + 25% sengon wood powder + 200 gram bran + 10 gram lime (S_{2b}). This study uses a 5x3 Completely Randomized Design (CRD 5x3) and is then analyzed using the One Way Anova test and the Least Significant Difference (LSD) test. The best formula was chosen for planting media based on the highest score in Zero-One Integer Programming. Parameters observed on the planting media are changes in the content of cellulose and lignin, while on the fungal growth is the form of mycelium fulfillment time; the number of fruit bodies; hood width; wet weight, and stem length. This study indicates that cotton waste can be used as a base material for white oyster mushroom planting media, where the best formula is S_{2b}. During fungal growth, in the planting media with formula S_{2b}, cellulose degradation occurs from 66.7% to 60.8%, and lignin degradation occurs from 10.5% to 6.6%. In addition to the media, formula S_{2b} produces mushrooms with growth characteristics including mycelium fulfillment time of 28.33±1.53 days, the number of fruit bodies 17.67±8.96, hood width 5.76±0.87 cm, wet weight 143.33±26.27 grams, and stalk length 4.52±0.55 cm.

Keywords: *Cellulose, Cotton Waste Planting Media, Lignin, White Oyster Mushroom*

1. INTRODUCTION

Mushrooms are fruiting bodies of macrofungi (Parinduri et al., 2018). Fungi are categorized as a group of fungi that belong to the class *Basidiomycota* and the order *Agaricus* (Adebayo et al., 2009). The fungus has been known as a nutritious food because it contains protein, folic acid, to vitamin B_{12} (Oyedele et al., 2018). In addition, mushrooms are also rich in minerals and have low fat and sugar content. According to Miles and Chang (1997) in Adebayo et al. (2009), the nutritional content contained in mushrooms consists of protein with levels of 25 - 50%, fat 2 - 5%, sugar 17 - 47%, micro cellulose 7 - 38%, minerals 8 - 12%, and vitamins such as D; C; B_1; B_5; B_6; niacin; and riboflavin. The rich nutritional content makes mushrooms called vegetarian meat (Khan et al., 2017). The benefits of mushrooms for body health are as follows: lowering blood cholesterol, increasing the immune system, overcoming digestive and liver disorders, being rich in vitamins and minerals as well as protein, improving blood circulation (Umarie et al., 2011).

Currently, there are hundreds of species of fungi that have been identified. Some of these fungal species contribute to meeting the need for food and medicine. One type of mushroom that can be cultivated to meet food needs is the oyster mushroom (*Pleurotus sp.*). Oyster mushroom is a food mushroom from the *Basidiomycota* group and belongs to the *Homobasidiomycetes* class with the general characteristics of a white to cream fruit body and a semicircular hood similar to an oyster shell with a slightly concave center (Parinduri et al., 2017). Oyster mushroom varieties that have been widely cultivated include gray oyster mushroom (*P. sajor-caju [Fries] sing*), golden oyster mushroom (*P. citrinopileatus sing*), pink oyster mushroom (*P. flabelatus*), black oyster mushroom (*P. sapidus*), abalone mushroom (*P. cystiodus*) and white oyster mushroom (P. *ostreatus var. florida nom. prov. eger*) (Piryadi, 2013). The most common type of oyster mushroom among these varieties is the white oyster mushroom.

White oyster mushrooms are included in the group of white mushrooms which are characterized by the growth of pale white mycelium all over the growing media (Sumarsih, 2015). White oyster mushroom is a type of wood remodeling mushroom that generally grows on sengon wood powder planting media. In addition, white oyster mushrooms also grow on various media such as sawdust, straw, husks, cotton waste, tea leaf waste, corn husks, bagasse, paper waste, and other agricultural and industrial wastes containing lignocellulosic materials. However, the most potential planting media material as a mushroom growing medium is sawdust (Sutarman, 2012). The best sawdust as a mushroom growing media material comes from hardwood types and does not contain a lot of sap, such as sengon wood and gelam wood, besides that the powder chosen must be clean and dry (Rosmiah et al., 2020).

One of the materials that can be used as a growing medium for white oyster mushrooms is agricultural waste derived from cotton waste from the textile industry. One of the textile industries producing cotton waste is PT Sri Rejeki Isman Tbk., which is located at 88 KH Samanhudi Street, Jetis, Sukoharjo 57511, Solo, Central Java. PT Sri Rejeki Isman Tbk. consists of several divisions, and the divisions that produce cotton waste are Spinning Division VII and Spinning Division XII. The difference between the two divisions is the composition of raw materials during production. The Spinning VII Division produces yarn with 100% new cotton as raw material, while the Spinning XII Division uses a mixture of 50% new cotton and 50% cotton waste from the Spinning VII Division. All types of cotton waste produced by the Spinning Division XII cannot be reused because the division is where the final yarn spinning process occurs.

The cotton waste from the Spinning Division XII will then be handled by compressing it so that it forms bales (beams with a size of 100x80x40 cm and a weight of 130-150 kg). The cotton waste produced will then be sold to mushroom farmers to be used as alternative planting media at a price of ± Rp 9,000 per bale, or disposed of in a landfill. However, not every day there are mushroom farmers who will buy the cotton waste, and not all cotton waste can be directly disposed of in landfills. Cotton waste that is not purchased will accumulate in the factory area and wait to be disposed of in a landfill. This buildup will certainly affect production activities. The location used to accumulate waste should be used as a place for storing raw materials or storing products when conditions are overloaded. In addition, the accumulation of waste for a long time will cause the decomposition of the waste. The rotten waste will then turn black and cause an odor.

Cotton waste from the textile industry is cotton that does not meet standard criteria. Cotton waste is composed of two components, namely cotton fiber and trash. Trash particles are parts of the cotton plant that are mixed with cotton fibers during harvesting and become crushed and smaller parts during the spinning process. Cotton stalks or twigs are the main component of trash (Gordon and You-Lou, 2007).

There are 5 kinds of cotton waste produced by the Spinning XII division, namely dropping, flat strip recyclean, flat strip c, air washer, and fan open end; which are distinguished by the content of *trash*. Dropping is cotton waste generated during the first cleaning, while fan open end is cotton waste generated during the last cleaning. Dropping has a higher content of impurities than fan open end. According to previous research using the MDTA (Micro Dust Trash Analyzer) method, the *trash content* in dropping was 7.5% while the *trash content* in fan open end was 1% (Shaikh and Pujara, 2016).

In general, textile industrial cotton waste has a chemical composition, including cellulose 57 – 80%, pentosan 6 – 9%, and lignin 11 – 25% (Mutia et al., 2018). Each chemical composition is in the form of a range because the chemical composition of cotton waste is influenced by the amount of *trash content* and cotton fibers in the cotton waste. Trash in cotton waste contains 67.58% cellulose and 20.31% lignin (Soemardi, 1982; in Saroso, 2002). The cotton fiber in cotton waste contains 90-98% cellulose and 0.7-1.6% lignin (Franck, 2005; in Mutia et al., 2018). This causes the more amount of *trash* in a cotton waste, the lower the percentage of cellulose. Unlike the case with the percentage of lignin, the more the number of impurities in a cotton waste, the higher the lignin percentage.

In the growth of white oyster mushrooms, a carbon source is needed from the hydrolysis of cellulose. Cellulose cannot stand alone because it binds to lignin to form lignocellulose. White oyster mushrooms can obtain a carbon source through the degradation process of lignocellulose bonds first. The higher the lignin percentage in cotton waste used as a growing medium, the greater the energy required for white oyster mushrooms to break the lignin bonds. Therefore, this study needs to be carried out to determine the potential use of cotton waste as the basic material for white oyster mushroom planting media, to determine the effect of planting media formula on white oyster mushroom growth, and to determine the best formula for white oyster mushroom planting media.

2. MATERIAL AND METHODS

According to Arif et al. (2014), the high content of cellulose in the planting media causes mushrooms to obtain a large energy source. The energy is used by the fungus for the growth process and breaking the lignin bonds in lignocellulose. This means that the more lignin content in the growing media, the more energy is needed to break the lignin bonds. The more energy needed to break the lignin bond, the remaining energy for the mushroom growth process will decrease.

Therefore, testing of the cotton waste formula on white oyster mushroom planting media needs to be done. Cotton waste used in the test is divided into two, cotton waste originating from blowing operations (dropping) and cotton waste originating from open end operations (fan open end). The characteristics of dropping and fan open end are shown in Figure 1 and Figure 2. Dropping has a greater *trash content* than fan open end where the *trash content* in dropping is 7.5% while the *trash content* in fan open end is 1%. The larger *trash content* causes dropping to have a higher lignin content when compared to fan open end. After knowing the chemical content of each type of waste, each type of waste is then mixed with sengon wood powder (a common growing medium for white oyster mushrooms) with different compositions to determine the best formula for white oyster mushroom planting media. Furthermore, the test results can be used to distinguish the selling value of the two types of cotton waste from the Spinning XII Division. In addition, the results of this test can also be used as consideration for PT Sri Rejeki Isman Tbk. reprocesses its by-products into a new product that has high economic value.

Figure 1. Dropping Cotton Waste

Figure 2. Fan Open End Cotton Waste

The approach that will be used in this research is a quantitative approach. A quantitative approach is a research approach that is based on the positivist paradigm in developing science (Zulfikar and Budiantara, 2014). In addition to the research approach, the method used is also a quantitative method. Quantitative research is research that uses data analysis in the form of numeric/numbers

(Suryani and Hendryadi, 2015). Regarding the place of research, research was carried out in several places. A sampling of cotton waste was carried out at the Spinning Division XII of PT Sri Rejeki Isman Tbk., which is located at 88 KH Samanhudi Street, Jetis, Sukoharjo 57511, Solo, Central Java. Proximate analysis of cotton waste samples was carried out at the CV Chem-Mix Pratama Analysis Laboratory. The process of making planting media, inoculation of mushroom cultures, and observation of fungal growth were carried out at the Media Agro Merapi Farmers Studio. The research was conducted for three months, starting from March to May 2021. The data collection technique used consisted of three techniques, namely literature study, survey, and examination.

The design used in this study was a 5x3 Completely Randomized Design (CRD 5x3), so there were 15 baglogs consisting of:

S_0 = 100 % sengon wood powder + 200 gram bran + 10 gram lime (control)

S_{1a} = 50% dropping + 50% sengon wood powder + 200 gram rice bran + 10 gram lime

S_{1b} = 75% dropping + 25% sengon wood powder + 200 gram rice bran + 10 gram lime

S_{2a} = 50 % fan open end + 50 % sengon wood powder + 200 gram bran + 10 gram lime

S_{2b} = 75% fan open end + 25% sengon wood powder + 200 gram bran + 10 gram lime

Baglog is a bag that contains mushroom growth media and serves as a place for planting mushroom seeds.

The stages of implementing this research are divided into six stages, namely the stage of taking cotton waste samples in the Spinning XII Division, the stage of making planting media from cotton waste samples, the stage of proximate analysis of each baglog formula before planting seeds, the stage of inoculation of white oyster mushroom culture on the planting media, the stage of checking mycelium fulfillment time; the number of fruit bodies; hood width; wet weight; and stalk length, and the proximate analysis stage of each baglog formula.

The data obtained will be analyzed and processed to determine the potential utilization of cotton waste as the basic material for white oyster mushroom planting media, determine the effect of planting media formula on white oyster mushroom growth, and determine the best formula for white oyster mushroom planting media. Data on the content of cellulose and lignin in the planting media both before planting and after harvesting were obtained from the proximate test results. Data on the effect of planting media formula on growth parameters of white oyster mushroom which included mycelium fulfillment time, the number of fruit bodies, hood width, wet weight, and stalk length were measured manually and analyzed statistically using one-way analysis of variance. If there is an effect on the treatment, then the LSD test is continued. After a one-way analysis of variance and LSD test was performed, the best formula was determined using zero-one integer programming.

3. RESULT AND DISCUSSION

3.1 Results

The result of the white oyster mushroom baglog proximate test. Based on the results of the proximate test carried out on each baglog formula, data on the chemical content, especially the content of cellulose and lignin, were obtained as shown in Table 1. Observation of fungal growth parameters.

Table 1. Cellulose and Lignin Analysis Results in Baglog

No	Formula	Cellulose (%)		Lignin (%)	
		Before planting	After harvest	Before planting	After harvest
1	S_0	22.6	17.8	8.9	4.6
2	S_{1a}	46.8	42.7	18.6	14.2
3	S_{1b}	48.8	45.3	17.7	13.5
4	S_{2a}	62.9	57.6	11.9	7.8
5	S_{2b}	66.7	60.8	10.5	6.6

Based on the results of observations, mycelium fulfillment time (full colony) of white oyster mushrooms are shown in Figure 3.

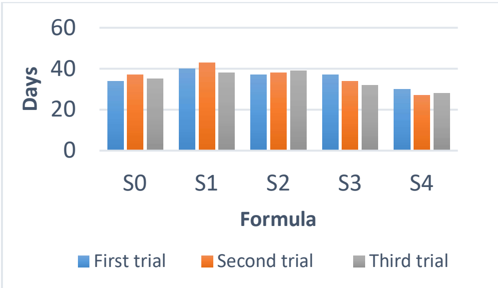

Figure 3. Observation Results of Mycelium Fulfillment Time (Full Colony)

Based on the results of observations, number of white oyster mushrooms fruit bodies are shown in Figure 4.

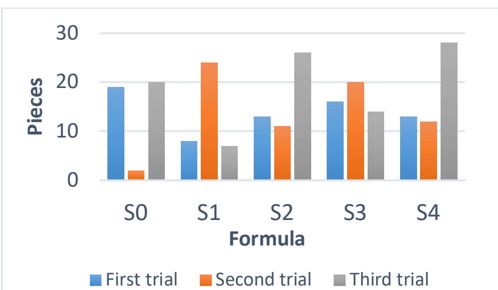

Figure 4. Observation Results of Number of Fruit Bodies

Based on the results of observations, hood width of white oyster mushrooms are shown in Figure 5.

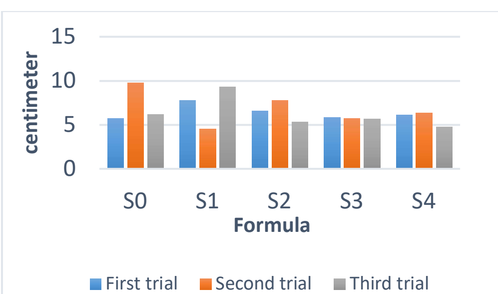

Figure 5. Observation Results of Hood Width

Based on the results of observations, wet weight of white oyster mushrooms are shown in Figure 6.

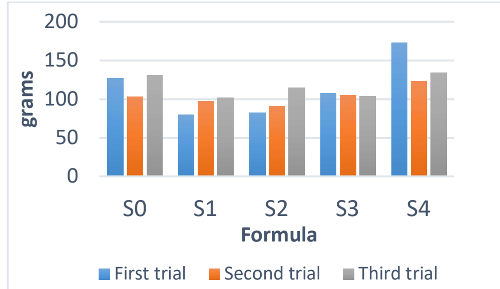

Figure 6. Observation Results Wet Weight

Based on the results of observations, stalk length of white oyster mushrooms are shown in Figure 7.

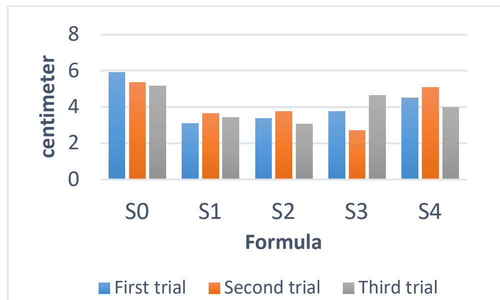

Figure 7. Observation Results of Stalk Length

3.2 Discussion

3.2.1. Potential utilization of cotton waste as the basic material for white oyster mushroom planting media

Cotton waste has the potential to be used as a base material for white oyster mushroom planting media, it is proven that oyster mushrooms can grow and develop in cotton waste-based planting media accompanied by degradation of the cellulose and lignin content in the formula S_{1a} from 46.8% and 18.6% to 42.7% and 14.2%, on formula S_{1b} media from 48.8% and 17.7% to 45.3% and 13.5%, on formula S_{2a} media from 62.9% and 11.9% to 57.6% and 7.8%, in the formula S_{2b} media from 66.7% and 10.5% to 60.8% and 6.6%, respectively. Apart from the aspect of planting media, from the aspect of fungal growth it can also be proven that the formulas S_{1a}, S_{1b}, S_{2a}, and S_{2b} have a mycelium fulfillment time of 40.33±2.52; 38.00±1.00; 34.33±2.52 and 28.33±1.53 days, number of fruit bodies 13.00±9.54; 16.67±8.14; 16.67±3.06 and 17.67±8.96 pieces, hood width 7.23±2.43;

6.57±1.19; 5.76±0.10 and 5.76±0.87 cm, wet weight 93.00±11.53; 96.00±17.06; 105.67±2.08 and 143.33±26.27 grams, and stalk length 3.39±0.28; 3.41±0.35; 3.70±0.96 and 4.52±0.55 cm.

3.2.2. Effect of planting media formula on white oyster mushroom growth

The effect of the planting media formula on the growth of white oyster mushrooms was determined based on the significant value of the one-way analysis of variance for each parameter.

Table 2. ANOVA Test Results for Each Parameter

Parameter	Sig
Mycelium fulfillment time (days)	0.000
Number of fruit bodies (pieces)	0.942
Hood width (cm)	0.658
Wet weight (grams)	0.021
Stalk length (cm)	0.004

Results of one way Anova test are shown in Table 2. Based on the results of the one way Anova test with a significance level of 0.05, it shows that the significance value for the parameters of mycelium fulfillment time, wet weight, and stalk length is less than 0.05. This means that H_0 is rejected or H_1 is accepted, which means that there is a significant difference between the formulas of planting media based on cotton waste in the parameters of mycelium fulfillment time, wet weight, and stalk length. The existence of a significant difference means that the growth of fungi, especially in the parameters of mycelium fulfillment time, wet weight, and stalk length is influenced by the formula of the planting media.

After knowing that there is a real difference in a parameter, then proceed to find out the real difference between each formula in each parameter. The significant difference of each formula in each parameter was searched using the Least Significant Difference (LSD) test.

Table 3. LSD Test Results for Mycelium Fulfillment Time

Formula	Average
S_{2b}	$28.33±1.53^{a}$
S_{2a}	$34.33±2.52^{b}$
S_0	$35.33±1.53^{bc}$
S_{1b}	$38.00±1.00^{cd}$
S_{1a}	$40.33±2.52^{d}$

LSD test results for mycelium fulfillment time parameter are shown in Table 3. Based on the Least Significant Difference test table for the mycelium fulfillment time parameter above, it can be seen that the formulas S_{1a} and S_{2b} with S_0 are significantly different (with a significance value of 0.010 and 0.001).

Table 4. LSD Test Results for Wet Weight

Formula	Average
S_{1a}	$93.00±11.53^{a}$
S_{1b}	$96.00±17.06^{a}$
S_{2a}	$105.67±2.08^{a}$
S_0	$120.33±15.14^{ab}$
S_{2b}	$143.33±26.27^{b}$

LSD test results for wet weight parameter are shown in Table 4. Based on the Least Significant Difference test table for the wet weight parameter above, it can be seen that there is no formula that is significantly different from S_0.

Table 5. LSD Test Results for Stalk Length

Formula	Average
S_{1a}	$3.39±0.28^{a}$
S_{1b}	$3.41±0.35^{a}$
S_{2a}	$3.70±0.96^{ab}$
S_{2b}	$4.52±0.55^{bc}$
S_0	$5.49±0.39^{c}$

LSD test results for stalk length parameter are shown in Table 5. Based on the Least Significant Difference test table for the stalk length parameters above, it can be seen that the formula S_{1a}; S_{1b} and S_{2a} with S_0 were significantly different (with a significance value of 0.001; 0.001 and 0.003).

3.2.3. Determination of the best formula using zero one integer programming

The ranking analysis was calculated based on the growth criteria of white oyster mushrooms. The criteria (parameters) include time to fulfill mycelium, number of fruit bodies, hood width, wet weight, and stalk length. Assessment of the order of importance of these parameters is done subjectively by experts or practitioners in their fields. The assessment of the order of importance of the parameters produces a weight for each of the following criteria. Ranking and weight for each criteria are shown in Table 6.

Table 6. Alternative Function Criteria

No.	Function	Ranking	Weight
1.	Mycelium fulfillment time	2	30
2.	Number of fruit bodies	4	10
3.	Hood weight	3	10
4.	Wet weight	1	45
5.	Stalk length	5	5
Number of rankings			100%

In this zero-one integer programming method, an analysis is carried out for all criteria by showing preferences as important and less important references for each alternative.

a. Function I (Mycelium Fulfillment Time)

Alternative preferences for mycelium fulfillment time criteria (I) are shown in Table 7, the zero-one method of assessing function I (mycelium fulfillment time) is presented in the following table. Zero-one assessment results of mycelium fulfillment time criteria are shown in Table 8. Based on the assessment that has been done, the best alternative in function I (mycelium fulfillment time) is alternative E (formula S_{2b} or baglog with a composition of 75% fan open end).

Mycelium growth in formula S_{2b} is faster because, among all types of formulas, the *trash content* in formula S_{2b} is the smallest among other formulas. The smaller the value of *trash content* in a planting media, the smaller the lignin content in it. This causes the fungus does not to need to break the lignin bond first to get cellulose and hemicellulose. In addition, the fulfillment of mycelium is also assisted by the addition of rice bran and lime to the planting media. Rice bran contains nitrogen, phosphorus, and potassium which serve to accelerate the growth of mycelium. Lime contains calcium which functions to facilitate the work of enzymes. When observed, the mycelium looks white, which will gradually cover the baglog. When the baglog has been filled with mycelium, the next pinhead will appear. The pinhead will then grow into a white oyster mushroom.

Table 7. Mycelium Fulfillment Time Preference

Alternative	Preference	Description
Alt. S_0 (A)	A>C A>B A<D A<E	Alt. A is superior to Alt. C&B, Alt. A is less superior than Alt. D&E
Alt. S_{1a} (B)	B<C B<A B<D B<E	Alt. B is less superior than Alt. C, A, D & E
Alt. S_{1b} (C)	C>B C<A C<D C<E	Alt. C is superior to Alt. B Alt. C is less superior than Alt. A, D & E
Alt. S_{2a} (D)	D>A D>C D>B D<E	Alt. D is superior to Alt. A, C & B Alt. D is less superior than Alt. E
Alt. S_{2b} (E)	E>D E>A E>C E>B	Alt. E is superior to Alt. D, A, C & B

Table 8. Zero-One Assessment Results of Mycelium Fulfillment Time

Alt.	A	B	C	D	E	Amount	Index
A	X	1	1	0	0	2	2/10
B	0	X	0	0	0	0	0/10
C	0	1	X	0	0	1	1/10
D	1	1	1	X	0	3	3/10
E	1	1	1	1	X	4	4/10

b. Function II (Number of Fruit Bodies)

Alternative preferences for number of fruit bodies criteria (II) are shown in Table 9. Based on the preferences below (Table 9.), the zero-one method of assessing the function of the number of fruit bodies (II) is presented in the following table. Zero-one assessment results of number of fruit bodies criteria are shown in Table 10. Based on the assessment that has been done, the best alternative in function II (number of fruit bodies) is alternative B (formula S_{1a} or baglog with a composition of 50% dropping).

Table 9. Number of Fruit Bodies Preference

Alternative	Preference	Description
Alt. S_0 (A)	A>C A>D A>E A<B	Alt. A is superior to Alt. C, D & E Alt. A is less superior than Alt. B
Alt. S_{1a} (B)	B>A B>C B>D B>E	Alt. B is superior to Alt. A, C, D & E
Alt. S_{1b} (C)	C>EC=D C<A C<B	Alt. C is superior to Alt. E Alt. C is as superior as Alt. D Alt. C is less superior than Alt. A & B
Alt. S_{2a} (D)	D>ED=C D<A D<B	Alt. D is superior to Alt. E Alt. D is as superior as Alt. C Alt. D is less superior than Alt. A & B
Alt. S_{2b} (E)	E<C E<D E<A E<B	Alt. E is less superior than Alt. C, D, A & B

Table 10. Zero-One Assessment Results of Number of Fruit Bodies

Alt.	A	B	C	D	E	Amount	Index
A	X	0	1	1	1	3	3/10
B	1	X	1	1	1	4	4/10
C	0	0	X	0.5	1	1.5	1.5/10
D	0	0	0.5	X	1	1.5	1.5/10
E	0	0	0	0	X	0	0/10

Formula S_{1a} produced mushrooms with fewer fruiting bodies because formula S_{1a} had the highest composition of sawdust (both from trash and sengon sawdust) when compared to other formulas so that the nutrients possessed were almost the same as formula S_0 (control). Formula S_{1a} also has an average value of the number of fruit bodies that is closest to formula S_0. The number of fruit bodies is affected by how easily nutrients can be absorbed by the fungus. Nutrients that are well absorbed are characterized by secondary growth on the pinhead so that the number of fruit bodies formed will be more. Pinheads are hyphae that intertwine to form mycelium and experience thickening. If the pinhead grows in large numbers, the fungus that grows will also be a lot. However, it is feared that the more fungus that grows will affect the size of the fungus that grows both in terms of the width of the hood and wet weight. Therefore, the mushrooms that grow are expected to have a small number of fruit bodies so that the mushrooms can grow bigger and heavier.

c. Function III (Hood Width)

Alternative preferences for hood width criteria (III) are shown in Table 11. Based on the preferences (Table 11), the zero-one method of assessing the hood width function (III) is presented in the following table. Zero-one assessment results of hood width criteria are shown in Table 12. Based on the assessment that has been done, the best alternative in function III (hood width) is alternative B (formula S_{1a} or baglog with a composition of 50% dropping).

Table 11. Hood Width Preference

Alternative	Preference	Description
Alt. S_0 (A)	A>C A>D A>E A<B	Alt. A is superior to Alt. C, D & E Alt. A is less superior than Alt. B
Alt. S_{1a} (B)	B>A B>C B>D B>E	Alt. B is superior to Alt. A, C, D & E
Alt. S_{1b} (C)	C>D C>E C<A C<B	Alt. C is superior to Alt. D&E Alt. C is less superior than Alt. A & B
Alt. S_{2a} (D)	D=E D<C D<A D<B	Alt. D is as superior as Alt. E Alt. D is less superior than Alt. C, A & B
Alt. S_{2b} (E)	E=D E<C E<A E<B	Alt. E is as superior as Alt. D Alt. E is less superior than Alt. C, A & B

Table 12. Zero-One Assessment Results of Hood Width

Alt.	A	B	C	D	E	Amount	Index
A	X	0	1	1	1	3	3/10
B	1	X	1	1	1	4	4/10
C	0	0	X	1	1	2	2/10
D	0	0	0	X	0.5	0.5	0.5/10
E	0	0	0	0.5	X	0.5	0.5/10

The width of the hood is greatly influenced by the number of fruit bodies that grow. The number of mushroom fruit bodies that grew on the media with formula S_{1a} was the smallest number of fruit bodies among the other formulas so that the width of the hood produced was the largest hood width when compared to other formulas. The number of fruit bodies in formulas S_{2a} and S_{2b} is the largest number of fruit bodies among the other formulas, so that the width of the resulting hood is the smallest hood width when compared to other formulas. The fruit body of the mushroom is a pinhead that grows. The hood of a young mushroom will be in the form of a bud, while the hood of an adult mushroom will widen and thin along the sides of the hood.

d. Function IV (Wet Weight)

Alternative preferences for wet weight criteria (IV) are shown in Table 13. Based on the preferences below (Table 13), the *zero-one* method of assessing the wet weight (IV) function is presented in the following table. Zero-one assessment results of wet weight criteria are shown in Table 14. Based on the assessment that has been done, the best alternative for function IV (wet weight) is alternative E (formula S_{2b} or baglog with a composition of 75% fan open end).

Table 13. Wet Weight Preference

Alternative	Preference	Description
Alt. S_0 (A)	A>D A>C A>B A<E	Alt. A is superior to Alt. D, C & B Alt. A is less superior than Alt. E
Alt. S_{1a} (B)	B<C B<D B<A B<E	Alt. B is less superior than Alt. C, D, A & E
Alt. S_{1b} (C)	C>B C<D C<A C<E	Alt. C is superior to Alt. B Alt. C is less superior than Alt. D, A & E
Alt. S_{2a} (D)	D>C D>B D<A D<E	Alt. D is superior to Alt. C&B Alt. D is less superior than Alt. A & E
Alt. S_{2b} (E)	E>A E>D E>C E>B	Alt. E is superior to Alt. A, D, C & B

Table 14. Zero-One Assessment Results of Wet Weight

Alt.	A	B	C	D	E	Amount	Index
A	X	1	1	1	0	3	3/10
B	0	X	0	0	0	0	0/10
C	0	1	X	0	0	1	1/10
D	0	1	1	X	0	2	2/10
E	1	1	1	1	X	4	4/10

Formula S_{2b} produced mushrooms with the best wet weight because cellulose, hemicellulose, and lignin compounds could be well-composed. These compounds are needed as nutrients for fungal growth. In addition, formula S_{2b} has the smallest trash content when compared to other formulas. This is because, in formula S_{2b}, the percentage of cotton is more than sawdust (both sawdust mixed with cotton waste and sawdust derived from sengon wood powder). The larger the cotton composition, the lower the lignin content. The low lignin content causes the energy needed to break down lignin to be utilized by fungi for growth.

e. Function V (Stalk Length)

Alternative preferences for stalk length criteria (V) are shown in Table 15. Based on the preferences (Table 15), the zero-one method of assessing the stalk length function (V) is presented in the following table. Zero-one assessment results of stalk length criteria are shown in Table 16. Based on the assessment that has been done, the best alternative for function V (stalk length) is alternative A (formula S_0 or control baglog with a composition of 100% sengon wood powder).

Table 15. Stalk Length Preference

Alternative	Preference	Description
Alt. S_0 (A)	A>E A>D A>C A>B	Alt. A is superior to Alt. E, D, C & B
Alt. S_{1a} (B)	B<C B<D B<E B<A	Alt. B is less superior than Alt. C, D, E & A
Alt. S_{1b} (C)	C>B C<D C<E C<A	Alt. C is superior to Alt. B Alt. C is less superior than Alt. D, E & A
Alt. S_{2a} (D)	D>C D>B D<E D<A	Alt. D is superior to Alt. C&B Alt. D is less superior than Alt. E&A
Alt. S_{2b} (E)	E>D E>C E>B E<A	Alt. E is superior to Alt. D, C & B Alt. E is less superior than Alt. A

Table 16. Zero-One Assessment Results of Stalk Length

Alt.	A	B	C	D	E	Amount	Index
A	X	1	1	1	1	4	4/10
B	0	X	0	0	0	0	0/10
C	0	1	X	0	0	1	1/10
D	0	1	1	X	0	2	2/10
E	0	1	1	1	X	3	3/10

Formula S_0 or control baglog with a composition of 100% sengon sawdust produces mushrooms with the best stalk length because baglog made with a mixture of cotton waste has less lignin content (judging by the amount of *trash content*) when compared to baglog made only from sengon wood powder, so that the growth of mycelium in baglog made from a mixture of cotton waste took place better than baglog made only from sawdust. Good mycelium growth is characterized by mycelium spreading evenly on all sides of the baglog. The mycelium that spreads and accumulates each other will later grow into a pinhead. Pinheads that are formed can grow anywhere. However, the pinheads that appear on the control baglog can only grow around the baglog ring because the mycelium growth is not perfect so that the new mycelium can grow optimally into pinheads only in the area around the ring. In addition, chamber conditions and air circulation also affect the growth of stalk length. Air circulation needs to be considered because, during the growth period, mushrooms need oxygen. However, based on the test results Significant Difference (LSD) formula S_0 is not significantly different from the formula S_{2b} so that it can be said that the formula S_0 and formula S_{2b} are just as good.

After doing the analysis using zero-one integer programming, then it is weighted with an evaluation matrix as a decision-making tool. Table 17 described the results of the evaluation of the matrix on the mushroom planting media formula.

From the results of the evaluation matrix below (Table 17), it can be seen that the largest total performance value is 32%, namely alternative E or formula S_{2b} (baglog with a composition of 75% fan open end). This could be due to the formula S_{2b}, the planting media contained cellulose with the highest percentage of 66.7% and lignin with the smallest percentage of 10.5%. The greater the percentage of cellulose in the planting media, the more nutrients are needed for fungi to grow and develop so that growth can run optimally.

Table 17. Matrix Evaluation Analysis Results

No.	Alt.	Criteria					Total (%)	Note
		I	II	III	IV	V		
		30%	10%	10%	45%	5%		
1.	Alt. A	2/10	3/10	3/10	3/10	4/10	27.5	Index
		6	3	3	13.5	2		Weight
2.	Alt. B	0/10	4/10	4/10	0/10	0/10	8	Index
		0	4	4	0	0		Weight
3.	Alt. C	1/10	3/20	2/10	1/10	1/10	11.5	Index
		3	1.5	2	4.5	0.5		Weight
4.	Alt. D	3/10	3/20	1/20	2/10	2/10	21	Index
		9	1.5	0.5	9	1		Weight
5.	Alt. E	4/10	0/10	1/20	4/10	3/10	32	Index
		12	0	0.5	18	3/2		Weight

4. CONCLUSIONS

4.1 Conclusion

From the research that has been carried out, it is concluded that cotton waste has the potential to be used as the basic material for white oyster mushroom planting media, it is proven that oyster mushrooms can grow and develop in planting media based on cotton waste accompanied by degradation of cellulose and lignin content in all formulas of planting media. After knowing that cotton waste has potential as a mushroom planting media, cotton waste is then processed into a planting media with different formulas to find out its effect on the growth of white oyster mushrooms. After doing the research, it can be seen that the formula of the growing media affects the growth of white oyster mushrooms, especially on the parameters of mycelium fulfillment time, wet weight, and stalk length. The best formula for growing white oyster mushroom is a 75% open end fan + 25% sengon wood powder + 200 gram rice bran + 10 grams lime (S_{2b}).

4.2 Suggestion

One of the important aspects of this research is to determine how much the nutrient changes in the media from before use to after being used as a planting media. On this basis, it is necessary to conduct further research on changes in other nutrients contained in the planting media of cotton waste. In addition, it is necessary to conduct further research on the effect of planting media made of 100% dropping and/or fan open end on the growth of white oyster mushrooms.

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