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Effect of Media and Temperature Variations on Growth and Protein Content of White Oyster Mushroom (*Pleurotus ostreatus* (Jacq.) P. Kumm)

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Abstract:
Background*: The main planting medium in mushroom cultivation is sawdust. Wood sawdust is easy to obtain and relatively inexpensive. The mixture of media greatly affects the growth of white oyster mushrooms. White oyster mushrooms can grow on a variety of agricultural waste. Utilization of waste wood sawdust, rice husks, corn cobs and bagasse can help oyster mushroom farmers to farm white oyster mushrooms to make it more economical in production costs.*

Materials and Methods*: This study aims to determine the effect of media and temperature variations and their interaction on growth and protein content of white oyster mushrooms. The design used was Factorial RAL (RALF) with two factors being tested, namely the media factor (Factor-A) and the temperature factor (Factor-B). Data analysis using ANOVA.*

Results*: The results showed that variations in media and temperature could increase the growth of white oyster mushrooms.*

Conclusion: *The conclusion of the study showed that there was a significant effect on the growth of white oyster mushrooms, and there was an interaction between the two.*

Key Word*: White Oyster Mushroom, Media and Temperature Variations, Interaction.*

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I. Introduction

Mushrooms are plants that are often found in the wild. Mushrooms can grow easily on logs or piles of organic waste and have a high adaptability to the environment. One of the mushrooms consumed by the people of Indonesia is white oyster mushroom. The main nutrients needed by white oyster mushrooms are carbon and nitrogen. Carbon is needed a lot for metabolic activities as a producer of energy in the form of long sugar chains, namely cellulose and lignin, while nitrogen is used in the synthesis of proteins that make up cells[1].

The nutritional content of white oyster mushrooms per 100 grams of dry weight is 128 calories, 16 grams of protein, 0.9 grams of fat, 64.6 mg of carbohydrates, 51 mg of calcium, 6.7 mg of iron, 0.1 mg of vitamin B. Complete nutrients needed by oyster mushrooms include carbohydrates (*cellulose*, *hemicellulose* and *lignin*), protein (*urea*), fat, calcium carbonate minerals[2].

Protein is a compound that is needed in the human body as a substance that supports growth and development. Protein is also a source of energy and body regulator[3]. The protein content of white oyster mushrooms in every 100 grams is 27%[4]. The growing medium occupied can affect the protein content of white oyster mushrooms.

The main growing medium in mushroom cultivation is sawdust. Wood sawdust is easy to obtain and the price is relatively cheap. Sawdust is a sawdust waste which is quite abundant and its use is not optimal. To increase the economic value of sawdust and reduce pollution, sawdust can be used as a growing medium for mushroom cultivation[5].

Wood sawdust is used as the basic material for making planting media (baglog) which contains carbohydrates, organic fibers (*cellulose* and *hemicellulose*) and lignin which are needed by fungi to grow and develop. Sawdust planting media contains more cellulose. The use of sawdust as a growing medium has a significant effect on the growth of white oyster mushrooms[6].

Other media materials that can be used to supplement the content of elements needed by white oyster mushrooms are rice husks, corn cobs and bagasse. Rice husk contains 32-47% cellulose, 19-27% hemicellulose, 5-24% lignin and 7.80% crude protein[7]. Corn cobs contain 40% cellulose, 29% hemicellulose, 13% lignin and 2% silica[8]. Bagasse contains 40-50% cellulose, 23-35% hemicellulose and 18-24% lignin[9]. The content of cellulose, hemicellulose and lignin contained in the growing media can help the growth of white oyster mushrooms.

The growth of white oyster mushrooms is influenced by environmental factors such as pH, temperature, humidity and light. The optimum temperature for mycelium and fruit body growth is different. The optimal temperature for mycelium growth is 25°C while the optimal temperature for fruit body growth is 17-23°C[10].

Mixed media greatly affects the growth of white oyster mushrooms, the results of research by Nur & Oktavia (2019) stated that white oyster mushroom mycelium can grow on mixed media of sawdust, rice husks and rice straw. Optimal growth of 30.60 gram cm/ 30 days[11]. Good media mix according to Arif (2014), states that the percentage mix of bagasse 42% and 42% corn cob powder can influence the speed of mycelial growth with a mean of 1.99 cm and the greatest productivity of the body that is 89.11 grams[12.] The combination of bagasse and rice husk media gave the best response to the growth of white oyster mushrooms in terms of mycelium growth speed, relative growth time of the ovule, maximum diameter of fruit cap and harvest weight per baglog, and the combination of bagasse and corn flour media gave the best response on quality. fruiting bodies supported by the number of fruit bodies and the best fruit body weight, as well as the diameter of the fruit cap and a high index of the ratio of weight to diameter of the fruit cap[13]. White oyster mushrooms can grow on various agricultural wastes[14].

Based on the background of the problem above, it shows that the utilization of waste wood sawdust, rice husks, corn cobs and bagasse can help oyster mushroom farmers to farm white oyster mushrooms to be more economical in production costs. However, the required temperature variation with the addition of the various media above has not been carried out to see the protein content of white oyster mushrooms. Therefore, it is necessary to do research on "The Effect of Media and Temperature Variations on Growth and Protein Content in White Oyster Mushrooms (*Pleurotus ostreatus* (Jacq.) P. Kumm)"

II. Material And Methods

This research uses a quantitative approach with the type of applied research (experimental), applied research is research based on problems that develop in society which aims to solve problems and the results can be used for the benefit of the community.

Study Design: Factorial Design (RALF) with two factors tested, namely the media factor (Factor-A) and temperature factor (Factor-B).
Study Location: White Oyster Mushroom Cultivation Business, Ulee Pusong Village, Kutablang District, Bireuen Regency and in the Science Laboratory Nutrition and Feed Technology, Faculty of Agriculture Unsyiah.
Study Duration: April-June 2021.
Objek penelitian: White oyster mushroom grown on 24 growing media.
Parameter Penelitian: Number of mushrooms, mushroom diameter, wet weight, dry weight, moisture content and protein content.

Procedure methodology: The data collection technique used in this study is observation, which is a data collection technique by directly observing the object under study, namely white oyster mushrooms. Fungal growth data were measured every day. Observational data collected in the study were as follows, namely harvest time of each baglog (days after planting), number of mushroom fruiting bodies per baglog, mushroom fruiting body diameter (cm) per baglog, wet fruit body weight (grams) per baglog, body weight dried fruit (grams) per baglog and water content of white oyster mushrooms (%). Then after the study was completed for 30 days, the protein content of the white oyster mushroom was tested and using the Kjeldahl method to analyze the protein content of the white oyster mushroom and the samples used were fresh mushroom samples.

Statistical analysis

When performing data analysis, you must first do a tabulation. Tabulation is the preparation of data in the form of a table so that the next step can be done. The data obtained were analyzed using the Analysis of Variance Test (ANAVA) with the following formula:

$$Yij = \mu + \alpha i = + \beta j + \alpha\beta ij + \varepsilon ij$$

Description:
Yij : Variable to be analyzed
M : average common
Ai : Effect factor-a level of i

Bj : Effect factor-b level j
Aβij : Effect of the interaction between the factor-a and factor-b
εij : Error

To accept and reject the hypothesis, the F test level ($\alpha = 0.05$) is used with the following conditions:

a. If F count ≥ F table then the research hypothesis (Hr) is accepted.
b. If F count < F table then the research hypothesis (Hr) is rejected.

If the analysis of variance shows a significant difference, further tests are carried out to determine the difference between one treatment and another, determined based on the coefficient of variance (KK), namely:

$$KK = \frac{\sqrt{KTG}}{Y} x\ 100\%$$

Description:
KK : Coefficient of diversity
KTG : Middle square of error
Y : Average in the experiment

III. Result

Number of White Oyster Mushrooms

Based on the results of the study in Table 1 shows that different media and temperatures can produce different amounts of fungi as well. The highest number of mushrooms was at temperature A (without lamp with a temperature of 27-28^{o}C) namely P2 with an average of 11.33. While the fewest amount of mushrooms is P0 with an average of 8. The number of mushrooms at most at temperatures B (5 watt powered lamp with a temperature of 28-30 $^{\circ}$C) is P2 with an average of 9.33. While the least number of mushrooms is P0 with an average of 6.

Table 1. Average Number of White Oyster Mushrooms

Temperature	Treatments	Day							Number of mushrooms
		1	2	3	4	5	6	7	
A	P0	6	8,33	8,33	8,33	8,33	8,33	8,33	8
	P1	7,33	9,67	9,67	9,67	9,67	9,67	9,67	9,33
	P2	9,33	11,67	11,67	11,67	11,67	11,67	11,67	11,33
	P3	7,67	10,33	10,33	10,33	10,33	10,33	10,33	9,95
B	P0	6	6,00	6,00	6,00	6,00	6,00	6,00	6
	P1	7,33	7,33	7,33	7,33	7,33	7,33	7,33	7,33
	P2	9,33	9,33	9,33	9,33	9,33	9,33	9,33	9,33
	P3	7,67	7,67	7,67	7,67	7,67	7,67	7,67	7,67

Effect of media and temperature variations on the growth of white oyster mushrooms for 7 days for the utilization of saw waste, rice husks, corn cobs and bagasse can be reviewed by the ANOVA test. The ANOVA test results showed that there was a significant difference in the number of white oyster mushrooms between treatments. In accordance with the decision-making criteria to accept Hr if F count ≥ F table at the 5% level ($\alpha = 0.05$), then the hypothesis is accepted and can be continued with the Advanced Test, namely Duncan's Test. While the results of the ANOVA test for the interaction between the media and temperature showed that there was no significant interaction on the number of white oyster mushrooms between the two. In accordance with the decision-making criteria to reject Hr if F count ≤ F table at the 5% level ($\alpha = 0.05$), then the hypothesis is rejected.

White Oyster Mushroom Diameter

Based on the results of the study in Table 2 shows that at different media and temperatures can produce different mushroom diameters as well. The highest mushroom diameter at temperature A (without lamp with a temperature of 27-28^{o}C) is P2 with an average of 6.60 cm. While the lowest number of mushrooms was P0 with an average of 4.38 cm. The highest mushroom diameter at temperature B (5 watt lamp with a temperature of 28-30 ^{o}C) is P2 with an average of 4.76 cm. Meanwhile, the lowest mushroom diameter was P0 with an average of 4.26 cm.

Table 2. Average White Oyster Mushroom Diameter

Temperature	Treatments	Day							Diameter of mushrooms (cm)
		1	2	3	4	5	6	7	
A	P0	1,13	2,07	3,13	4,43	5,67	6,60	7,63	4,38
	P1	1,27	2,33	3,40	5,50	6,37	7,17	8,43	4,92
	P2	1,57	2,53	4,27	6,73	8,42	10,43	12,27	6,60
	P3	1,27	2,37	3,60	5,77	7,77	8,53	10,83	5,73
B	P0	1,23	2,23	3,33	4,23	5,30	6,27	7,20	4,26
	P1	1,33	2,37	3,37	4,50	5,47	6,37	7,37	4,40
	P2	1,83	2,87	3,60	4,73	5,67	6,77	7,83	4,76
	P3	1,57	2,63	3,53	4,43	5,60	6,70	7,40	4,55

Effect of media and temperature variations on the growth of white oyster mushrooms for 7 days for the utilization of saw waste, rice husks, corn cobs and bagasse can be reviewed by ANOVA test. The results of the ANOVA test showed that there was a significant difference in the diameter of the white oyster mushroom between treatments. In accordance with the decision-making criteria to accept Hr if F count ≥ F table at the 5% level ($\alpha = 0.05$), then the hypothesis is accepted and can be continued with the Advanced Test, namely Duncan's Test. While the results of the ANOVA test for the interaction between the media and temperature showed that there was a significant interaction in the diameter of the white oyster mushroom between the two. In accordance with the decision-making criteria to accept Hr if F count ≥ F table at the 5% level ($\alpha = 0.05$) then the hypothesis is accepted.

Wet Weight, Dry Weight and Moisture Content of White Oyster Mushroom

Based on the results of the study in Table 3 shows that different media and temperatures can produce different wet weight, dry weight and moisture content of mushrooms. The highest wet weight of mushrooms was at temperature A (without lamp with a temperature of 27-28^{o}C) namely P2 with an average of 31.03 grams. While the lowest wet weight of mushrooms was P0 with an average of 25.97 grams. The highest wet weight of mushrooms at temperature B (5 watt lamp with a temperature of 28-30 ^{o}C) is P2 with an average of 26.80 grams. Meanwhile, the lowest wet weight of mushrooms was P0 with an average of 22.37 grams.

The highest dry weight of mushrooms at temperature A (without a lamp with a temperature of 27-28^{o}C) is P2 with an average of 15.80 grams. Meanwhile, the lowest mushroom dry weight was P0 with an average of 13.00 grams. The highest dry weight of mushrooms at temperature B (5 watt lamp with a temperature of 28-30 ^{o}C) is P2 with an average of 13.77 grams. Meanwhile, the lowest mushroom dry weight was P0 with an average of 11.77 grams.

Mushroom moisture content was highest at temperature A (without lamp with a temperature of 27-28^{o}C) namely P1 with an average of 50.00%. While the lowest water content of mushrooms is P3 with an average of 46.09%. The highest moisture content of mushrooms at temperature B (5 watt lamp with a temperature of 28-30 ^{o}C) is P2 with an average of 48.63%. While the lowest water content of mushrooms is P0 with an average of 47.38%.

Table 3. Average Wet Weight, Dry Weight and Moisture Content of White Oyster Mushroom

Temperature	Treatments	Wet wight (gr)	Dry weight (gr)	Water content (%)
A	P0	25.97	13.00	49.94
	P1	27.43	13.72	50.00
	P2	31.03	15.80	49.07
	P3	27.40	14.37	46.09
B	P0	22.37	11.77	47.38
	P1	23.43	12.20	47.93
	P2	26.80	13.77	48.63
	P3	24.73	12.83	48.11

The effect of media and temperature variations on the growth of white oyster mushrooms for 7 days for the utilization of saw waste, rice husks, corn cobs and bagasse can be reviewed by the ANOVA test. The results of the ANOVA test on the media showed that there was no significant difference in the wet weight of white oyster mushrooms between treatments. In accordance with the decision-making criteria to reject Hr if F count ≤ F table at the 5% level ($\alpha = 0.05$), then the hypothesis is rejected. The results of the ANOVA test on temperature showed that there was a significant difference in the wet weight of white oyster mushrooms between treatments. In accordance with the decision-making criteria to accept Hr if F count ≥ F table at the 5% level ($\alpha = 0.05$) then the hypothesis is accepted. While the results of the ANOVA test for the interaction between the media and temperature showed that there was no significant interaction on the wet weight of white oyster mushrooms between the two. In accordance with the decision-making criteria to reject Hr if F count ≤ F table at the 5% level (α = 0.05), then the hypothesis is rejected. The results of the ANOVA test showed that there was a significant difference in the dry weight of white oyster mushrooms between treatments. In accordance with the decision-making criteria to accept Hr if F count ≥ F table at the 5% level (α = 0.05), then the hypothesis is accepted and can be continued with the Advanced Test, namely Duncan's Test. While the results of the ANOVA test for the interaction between the media and temperature showed that there was a significant interaction on the dry weight of white oyster mushrooms between the two. In accordance with the decision-making criteria to accept Hr if F count ≥ F table at the 5% level (α = 0.05) then the hypothesis is accepted. The results of the ANOVA test showed that there was no significant difference in the water content of white oyster mushrooms between treatments. In accordance with the decision-making criteria to reject Hr if F count ≤ F table at the 5% level (α = 0.05), then the hypothesis is rejected. While the results of the ANOVA test for the interaction between the media and temperature showed that there was no significant interaction on the wet weight of white oyster mushrooms between the two. In accordance with the decision-making criteria to reject Hr if F count ≤ F table at the 5% level (α = 0.05), then the hypothesis is rejected.

White Oyster Mushroom Protein Content

Based on the results of the study in Table 4 shows that at different media and temperatures can produce different mushroom protein content as well. The highest mushroom protein content was at temperature A (without lamp with a temperature of 27-28^{o}C) namely P2 with an average of 15.92. While the lowest mushroom protein content was P0 with an average of 12.83. The highest mushroom protein content at temperature B (5 watt lamp with a temperature of 28-30 ^{o}C) is P2 with an average of 13.77. While the lowest mushroom protein content was P0 with an average of 11.77.

Table 4. Average Protein Content of White Oyster Mushroom

Treatments	Temperature A	Temperature B
P0	12.83	11.77
P1	13.95	12.20
P2	15.92	13.77
P3	14.91	12.83

The effect of media and temperature variations on the growth of white oyster mushrooms for 7 days for the utilization of saw waste, rice husks, corn cobs and bagasse can be reviewed by the ANOVA test. The results of the ANOVA test showed that there was a significant difference in the protein content of white oyster mushrooms between treatments. In accordance with the decision-making criteria to accept Hr if F count ≥ F table at the 5% level (α = 0.05), then the hypothesis is accepted and can be continued with the Advanced Test, namely Duncan's Test. While the results of the ANOVA test for the interaction between the media and temperature showed that there was a significant interaction in the diameter of the white oyster mushroom between the two. In accordance with the decision-making criteria to accept Hr if F count ≥ F table at the 5% level (α = 0.05) then the hypothesis is accepted.

IV. Discussion

Growth of White Oyster Mushrooms

Based on the ANOVA test and Duncan's test, it was shown that the variation of media and temperature on the growth of white oyster mushrooms had a significant effect on the treatment parameters which included the number, diameter, wet weight, dry weight and moisture content of the white oyster mushroom. cultivated for 30 days. The results showed a significant difference to the growth of white oyster mushrooms and there was a significant interaction with the growth of white oyster mushrooms. The highest growth was in P2, followed by P3, P1 and the lowest was in P0. P2 media is very effective for growing white oyster mushrooms. The composition of the media in the P2 treatment consisted of 450 g of sawdust, 450 g of corn cobs and 100 g of kaptan. The addition of the composition with the required nutrients for white oyster mushrooms in a variety of media can increase the number and diameter of these mushrooms. This is consistent with the statement Steviani (2011), that the media formulations and addition of other elements required by the appropriate fungus can increase productivity, efficiency and effectiveness considerations[15.] This is consistent with the statement of Sari (2020), that in general the addition of corn cobs to the growing media can increase the diameter of the resulting mushroom hood and proportional between the diameter and composition of corn cobs, corn cobs so the addition can improve the quality of the resulting diameter hood[16.] This is consistent with the statement Assan (2014), that the proportion of corn cob cellulose, hemicellulose and lignin is right for growth rate *mycelium*17.

Corncob flour can be used as a nutritional supplement for mushrooms. Flour corn cobs contain carbohydrates which plays an important role in the growth *of mycelium* faster, primordia will develop into a mushroom stalk and hood, the more the mushroom body and wider hood per clump mushroom fungus will produce a high wet weight[18.] Goodgrowth *mycelium* will result in a good growth in diameter, wet weight and number of mushroom bodies per group. This is consistent with the statement of Arif (2014), that the corn cob powder mixture has a growth speed of mycelium and fruiting bodies greatest productivity[12].

Corn cobs are one of the most widely available lignocellulosic wastes in Indonesia. Lignocellulosic waste is agricultural waste containing cellulose, hemicellulose and lignin. Each is a compound that can potentially be converted into other compounds biologically. High cellulose content and low lignin content in corn cobs make the composting process run smoothly in the media19.

The lowest growth was found in P0 media consisting of 900 gr sawdust and 100 gr kaptan. This is in accordance with Hartati's (2010) statement, that the corn cob media has a softer structure so that the time required for the media weathering process is faster when compared to sawdust. Lignin is a complex polymer that existed at the plant, including on wood, lignin function itself is a component of the bond between the cell and the cell wall reinforcement on wood[20.] Mushrooms have lignolytic enzymes to digest lignin in wood, but in the composting process, the lignin in wood is very difficult to be digested by microbes than cellulose[21.] Therefore media with the addition of corn cobs is more effective than media from sawdust because the composting process is better because it has a lower lignin content.

The best growth was found in media with temperature A. The temperatures used in this study were temperature A (without lamp at 27-28^{o}C) and temperature B (5 watt lamp at 28-30^{o}C). This is in accordance with Amelia's statement (2017), that the temperature generated in the treatment using direct sunlight and light from the lamp has a significantly different effect, while between a 5 watt lamp and a 15 watt lamp it does not have a significantly different effect on temperature. generated[22]. The growth *mycelium* of oyster mushrooms is also highly dependent on physical factors such as temperature, humidity, light, pH of the growing media, and aeration. Oyster mushrooms can produce fruiting bodies optimally at a temperature range of 26-28^{o}C, while *mycelium* growth reaches optimal growth at a temperature of 28-30^{o}C[23]. According to the Ministry of Agriculture (2012), the temperature required for fruit body growth is 22-28^{o}C[24]. High temperatures can cause the growth of fruit bodies to not grow optimally. This is due to the faster evaporation of the growing media[25].

Temperature B is also not bad for the growth of white oyster mushrooms. This is in accordance with the statement of Susilawati (2010), that a temperature of 28-30^{o}C is a warm temperature and is still classified as a warm humid temperature, so the *mycelium is* able to grow well. At a temperature of 18-20^{o}C, the growth of mycelium is very slow. This is because the incubation temperature is not in accordance with the growth of *mycelium*[23]. A temperature of 20^{o}C is more suitable for cultivating oyster mushrooms than growing *mycelium*. While at a temperature of 38-40^{o}C is a very warm temperature in the growth of *mycelium*, so that at that temperature there are variations in growth but do not last long to the optimal limit of growth *mycelium*, this is because the temperature has exceeded the optimum temperature limit for fungal growth, causing low quality and growth *mycelium*[26].

Protein Content of White Oyster Mushrooms

Based on the ANOVA test and Duncan's test, it was shown that variations in media and temperature on the growth of white oyster mushrooms had a significant effect on the protein content of white oyster mushrooms cultivated for 30 days. The results showed that there was a significant difference in the protein content of white oyster mushrooms, where the highest protein content was in P2 media while the lowest protein content was in P0 media. This is consistent with the statement Oktasari (2015), that the high protein content in the addition of flour corn cob corn cobs have caused in the element potassium, vitamins, phosphorus and nitrogen that can increase the protein content of white oyster mushroom[27.] This is in accordance with the statement of Ginting (2013), that the low protein content in P0 media is due to the fact that the wood powder only has 49.40% cellulose, 24.59% hemicellulose, 26.8% lignin, 15.6% pentose, 0 ash. 6% and silica 0.2%. The growth of white oyster mushrooms requires nitrogen (N), phosphorus (P) and potassium (K) as basic needs that must be met, this causes P0 media to have lower protein content than P2 media. In addition to meeting the nutritional needs of fungi, N, P and K will affect the level of nutrient content in mushrooms, one form of the protein[28]

V. Conclusion

The media variation had a significant effect in increasing the growth of white oyster mushrooms including the number, diameter, wet weight, dry weight, water content and protein content of white oyster mushrooms. Variations in temperature have a significant effect on increasing the growth of white oyster mushrooms including the number, diameter, wet weight, dry weight, water content and protein content of white oyster mushrooms. Variations in media and temperature interacted significantly in increasing the growth of white oyster mushrooms including diameter, dry weight and protein content of white oyster mushrooms.

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