Utilization of Tofu Industry Waste and Banana Plant Waste for Growing Medium of Brown Oyster Mushrooms (*Pleurotus cystidiosus* [Jacq. Fr.] P.Kumm.)

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Abstract. Brown oyster mushroom is one of the consumption mushrooms with high economic value, so it is important to be cultivated commercially. Several types of plant and industrial wastes, such as dried banana leaves and tofu dregs, are available abundantly in the field. The waste has the potential to be used as medium for growing consumption mushrooms. This is because dried banana leaves and tofu dregs contain enough nutrients needed for the growth and development of oyster mushrooms. The study aimed to determine the growth response and yield of brown oyster mushrooms by giving various doses of dried banana leaves and tofu dregs flour. The research was carried out using factorial completely randomized design. First factor: dosage of tofu flour: 50 g per baglog, 150 g per baglog, and 250 g per baglog. Second factor: dosage of dried banana leaves, without dried banana leaves, 100 g dried banana leaves per baglog, and 250 g dried banana leaves per baglog. The results showed that the treatment of addition of tofu dregs flour with dried banana leaves interacted very significantly in the number of mushroom caps, diameter and thickness of the caps, the length of the mycelium, the fresh weight of the fungus, and biological efficiency.

Keywords: Biological efficiency, fungus, nutrient, waste.

1 Introduction

Brown oyster mushroom (*Pleurotus cystidiosus* [Jacq. Fr.] P.Kumm.) is a type of consumption mushroom that is popular with the public. Brown oyster mushrooms usually grow wild in nature and have not been widely cultivated. Oyster mushrooms are highly nutritious, have vitamin B, C and D, and that carry numerous medicinal benefits [1]. Brown oyster mushrooms have the advantage of thicker caps and longer shelf life [2].

Brown oyster mushroom has not been widely cultivated but the market demand for oyster mushroom continues to rise. Sawdust is a staple used as a growing medium in producing the fungus. Wood sawdust is a place to grow oyster mushrooms classified as fungi using cellulose, hemicellulose, and lignin that can break down and use it as a carbon source [3].

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Kind of growing media is very important because it can affect the results of oyster mushrooms later. Brown oyster mushroom media used must contain nutrients needed for growth and production including lignin, carbohydrates (cellulose and glucose), protein, nitrogen, fiber and vitamins. Other factors that influence the growth of brown oyster mushrooms are temperature, humidity, light intensity and pH. Tofu waste and dried banana leaves are potential wastes to be used as additional growth media for consumption mushroom production.

Tofu waste is a waste from tofu processing. Tofu waste contains substances such as carbohydrates, proteins, fats, minerals and vitamins. Protein functions to stimulate mycelium growth, while fat is used as an energy source to break down carbohydrates, protein, minerals and vitamins. Tofu waste can provide earlier yields, more fruit bodies and increase fruit weight, so that at harvest time the results are better and more profitable [4].

Dried banana leaf contains hemicellulose so that it can be used as a mushroom growing media. The organic components of banana leaf (g per 100 g dry weight) are cellulose 11 g; hemicellulose 20 g; lignin 18.12 g; total C 51, and C/N ratio 29.45. Leaf waste is the best growing media for mushroom compared to other agricultural wastes such as coffee skins, reeds, and straw [5]. The addition of banana leaves waste to the wood sawdust base medium could increase the fresh weight of the white oyster mushroom fruit body. The contents of dried bananas consist of 16.0 % dry matter, 2.3 % crude protein, 3.7 % crude fiber, 6.0 % fat and 1.9 % ash content two strains *Volvariella volvacea* [(Bul.) Singer,1951] showed their highest production on banana leaves waste, with biological efficiencies of 43 % and 72 % [6]. Seeing the potential of tofu industry waste and banana plants waste, it is important to research, its use as an additional growth medium for consumption mushrooms including brown oyster mushrooms.

2 Materials and methods

The study was conducted using a Completely Randomized Design (CRD) compiled factorially with two treatment factors, repeated four times.
First factor: Addition of tofu waste flour (A) consisting of three test levels, namely:

A1: 50 g tofu dregs flour per baglog
A2: 150 g tofu dregs flour per baglog
A3: 250 g tofu dregs flour per baglog

Second factor: Addition of dried banana leaves (D) consisting of three test levels, namely:
D0: without dried banana leaves
D1: 100 g dried dried banana leaf per baglog
D2: 250 g dried dried banana leaf per baglog.

Tofu industry waste in the form of tofu dregs is dried in an oven at 105 °C for 2 d. Tofu dregs that have been dried mashed. Waste of banana plants in the form of dried banana leaves that are cut into small pieces so that it is easily inserted into plastic. The initial weight of the media grew by 800 g.

The research data included observations of the growth of brown oyster mushroom mycelium (cm), number of mushroom caps, mushroom caps diameter (cm), thickness of oyster mushrooms (mm), fresh weight of mushrooms (g), biological efficiency (%), and nutrient content analysis of tofu dregs. Harvesting is done four times. Specifically biological efficiency was measured after eigth times of harvest.

The data obtained were then analyzed statistically using analysis of variance. To find out the effect of whether or not the F test level of 5 % and 1 % is used. If the F test results show a significant effect, then proceed with the Duncan Multiple Range Test.

3 Results and discussion

3.1 Mycelium growth

The data analysis showed that there were significant interactions at (8, 16, 24, 32 and 40) d after inoculation (DAI) on mycelium growth. The mean mycelium length is shown in Table 1.

Table 1. Average length of brown oyster mushroom mycelium due to addition tofu dregs flour and dried banana leaves (8 to 40) d After Inoculation (DAI)

Treatment	Mycelium growth (cm)				
	8 DAI	16 DAI	24 DAI	32 DAI	40 DAI
50 g flour, 0 g leaves	0.63 bc	2.77 ab	6.16 ab	8.91 a	17.00 b
150 g flour, 0 g leaves	1.23 cd	5.26 d	8.91 d	11.94 bc	16.67 b
250 g flour, 0 g leaves	0.00 a	4.16 cd	8.71 d	13.63 c	17.00 b
50 g flour, 100 g leaves	2.30 e	7.51 e	12.60 e	17.00 d	17.00 b
150 g flour, 100 g leaves	1.48 d	4.76 cd	9.76 cd	13.06 c	17.00 b
250 g flour, 100 g leaves	0.00 ab	3.51 bc	8.42 cd	13.09 c	17.00 b
50 g flour, 250 g leaves	1.02 cd	3.63 bc	6.82 cd	9.66 ab	17.00 b
150 g flour, 250 g leaves	0.00 ab	2.30 a	5.34 a	8.79 a	15.99 a
250 g flour, 250 g leaves	0.00 ab	2.26 a	5.42 ab	10.29 ab	16.03 a

Numbers with the same letter in the same column are not significantly different according to the Duncan 0.05 test.

The 50 g tofu dregs flour and 100 g dried banana leaf treatment can accelerate the growth of fungal mycelium, so that at the age of 32 DAI mycelium fungi have filled the baglog. The addition of tofu waste flour and dried banana leaves on the mushroom growing media had a positive effect. Growth of oyster mushroom mycelium spread is influenced by nutrient content in the growing media. High protein content of 21.56 % in tofu dregs indicates that the nitrogen content is also high so that the growth of mycelium becomes thick and compact (Table 2). Tofu waste contains carbohydrates, protein, fat, minerals and vitamins [7]. added that protein functions to stimulate mycelium growth.

Crude fiber in tofu dregs can increase the rate of mycelium spread, so it can supply the nutrients needed by the growth of fungal mycelium.

Table 2. Analysis of nutrient content of tofu waste

Protein	Crude fat	Crude fiber	Dry matter	Water content	Ash
21.56 %	9.8 %	25.81 %	96.14 %	62.32 %	4.03 %

3.2 Number of mushroom caps

The results of the analysis of variance showed a real interaction between the treatment of the amount of tofu dregs flour with dried banana leaves on the number of mushroom caps. The average number of caps for each treatment is presented in Table 3.

Table 3. Average number of brown oyster mushroom caps due to addition of tofu dregs flour and dried banana leaves.

Treatment	Number of mushroom caps				
	Harvest I	Harvest II	Harvest III	Harvest IV	Average harvest
50 g flour, 0 g leaves	3 a	5 a	3 a	3 a	4 a
150 g flour, 0 g leaves	4 a	7 ab	5 a	4 ab	5 a
250 g flour, 0 g leaves	4 a	6 a	4 a	4 ab	4 a
50 g flour, 100 g leaves	4 a	7 ab	5 a	4 ab	5 a
150 g flour, 100 g leaves	4 a	6 a	4 a	4 ab	4 a
250 g flour, 100 g leaves	9 b	9 b	7 b	6 b	8 b
50 g flour, 250 g leaves	4 a	6 a	4 a	4 ab	4 a
150 g flour, 250 g leaves	5 a	7 ab	5 a	4 ab	5 a
250 g flour, 250 g leaves	4 a	6 a	4 a	3 a	4 a

Numbers with the same letter in the same column are not significantly different according to the Duncan 0.05 test.

The treatment of adding 250 g of tofu dregs flour and 100 g of dried banana leaves is able to provide sufficient nutrition so that it can form more primordia which will later become more fruit bodies. Nitrogen functions to form proteins, and builds enzymes for the growth of the fungus fruit caps. The crude fiber content of 25.81 % in tofu waste flour (Table 2) can increase the production of cellulose enzymes so that cell formation occurs. The dried plants leaves contain high levels of hemicellulose and lignin [8].

Low or insufficient nutrient content can cause a less optimal growth of the primordial caps, making the growth in the number of caps to be small. The use of different planting media composition affects the physical quality of the oyster mushrooms produced [9].

3.3 Mushroom caps diameter

The results of the analysis of variance showed a very real interaction on the diameter parameters of the brown oyster mushroom caps. The average yield of each treatment is presented in Table 4.

Table 4. Average diameter of brown oyster mushroom cap due to addition of tofu dregs flour and dried banana leaves

Treatment	Caps diameter (cm)				
	Harvest I	Harvest II	Harvest III	Harvest IV	Average harvest
50 g flour, 0 g leaves	8.58 c	7.42 f	6.76 c	5.60 d	7.09 e
150 g flour, 0 g leaves	6.97 abc	5.97 cde	5.77 b	5.18 bcd	5.97 cd
250 g flour, 0 g leaves	7.72 bc	6.25 de	5.06 a	4.33 a	5.84 bcd

(Continued on next page)

Table 4. Continued

Treatment	Caps diameter (cm)				
	Harvest I	**Harvest II**	**Harvest III**	**Harvest IV**	**Average harvest**
50 g flour, 100 g leaves	6.06 ab	6.08 cde	5.71 ab	5.13 bcd	5.74 bcd
150 g flour, 100 g leaves	6.01 ab	5.83 bcd	5.44 ab	4.56 abc	5.46 abc
250 g flour, 100 g leaves	5.50 a	5.32 ab	6.67 c	5.32 cd	5.70 abc
50 g flour, 250 g leaves	5.51 a	5.07 a	5.63 ab	4.75 abc	5.24 a
150 g flour, 250 g leaves	5.88 a	5.79 bc	5.37 ab	4.50 abc	5.39 ab
250 g flour, 250 g leaves	8.44 c	6.56 e	5.50 ab	4.67 abc	6.29 d

Numbers with the same letter in the same column are not significantly different according to the Duncan 0.05 test.

The treatment of adding 50 g of tofu dregs without the dry banana leaf has the highest diameter. This is allegedly because it is influenced by the number of caps formed. The 50 g tofu flour treatment without dried banana leaves has a smaller number of caps but the widest caps diameter. This shows that the growth of the caps is more maximal and the width of the caps is not crowded. The 50 g tofu dregs flour and 250 g dried banana leaves treatment has a relatively small diameter because the number of caps produced is quite large and crammed together to make the mushroom caps less optimal growth. The more mushroom caps that grow generally the smaller the diameter of the caps produced.

3.4 Thickness of mushroom caps

The results showed a significant interaction in the 1st to 4th harvest of the mushroom caps thickness. The average caps thickness of each treatment is presented in Table 5.

Table 5. Average thickness of brown oyster mushroom caps due to the addition of tofu waste flour and dried banana leaves

Treatment	The thickness of caps (mm)				
	Harvest I	**Harvest II**	**Harvest III**	**Harvest IV**	**Average harvest**
50 g flour, 0 g leaves	8.67 c	8.76 e	8.09 e	6.93 d	8.11 c
150 g flour, 0 g leaves	6.13 a	7.31 c	7.10 c	6.51 bcd	6.76 ab
250 g flour, 0 g leaves	7.33 ab	7.59 cd	6.39 cd	5.66 a	6.74 ab
50 g flour, 100 g leaves	7.11 b	7.41 cd	7.04 cd	6.46 bcd	7.01 b
150 g flour, 100 g leaves	7.07 b	7.16 bc	6.78 bc	5.90 abc	6.73 ab
250 g flour, 100 g leaves	6.56 ab	6.66 ab	8.00 ab	6.65 cd	6.97 ab
50 g flour, 250 g leaves	6.57 b	6.40 a	6.97 a	6.08 bcd	6.51 a
150 g flour, 250 g leaves	6.94 ab	7.12 bc	6.70 bc	5.82 ab	6.64 ab
250 g flour, 250 g leaves	6.66 ab	7.90 d	6.84 d	6.00 abc	6.85 ab

Numbers with the same letter in the same column are not significantly different according to the Duncan 0.05 test

The thickness parameter of the 50 g tofu dregs treatment cap without dried banana leaves has the highest caps thickness with an average total value of 8.11 mm. That is because in the growth of the number of fruit bodies, 50 g of tofu flour without tofu leaves produce a little and wider fruit caps so that the fungus can produce carbohydrates in sufficient quantities for vegetative growth. The more the number of caps, the thinner the caps thickness will be, causing the mushroom caps to be less than optimal. Mushrooms grow to form clumps, where if a large number of caps are formed in a clump, it will affect the diameter and thickness of the caps, ie the caps gets smaller.

3.5 Mushroom fresh weight and biological efficiency

The results showed a significant interaction between the addition of tofu dregs and dried banana leaves to the total fresh weight of mushrooms and biological efficiency. The average total fresh weight of mushrooms is presented in Table 6.

Table 6. Average fresh weight of brown oyster mushrooms due to addition of tofu dregs flour and dried banana leaves

Treatment	Fresh weight (g)	Biological efficiency %)
50 g flour, 0 g leaves	121.67 a	46 d
150 g flour, 0 g leaves	173.89 bc	55 ef
250 g flour, 0 g leaves	178.89 c	51 e
50 g flour, 100 g leaves	152.78 abc	48 de
150 g flour, 100 g leaves	137.78 ab	39 b
250 g flour, 100 g leaves	230.00 d	57 f
50 g flour, 250 g leaves	145.00 abc	40 b
150 g flour, 250 g leaves	168.33 bc	42 bc
250 g flour, 250 g leaves	132.78 a	31 a

Numbers with the same letter in the same column are not significantly different according to the Duncan 0.05 test.

Nutrients available in growing media that can be absorbed by the fungus will be able to increase the fresh weight of the fungus. The protein content in tofu dregs is thought to be able to add nutrients to the mushroom media. The cellulose and hemicellulose content in dried banana leaves can also stimulate tissue formation which affects the fresh weight of oyster mushrooms produced. It was suspected that mushrooms have sufficient energy reserves because the elements contained in baglog are evenly decomposed at the time of fruit body formation, thus affecting the fresh weight of mushrooms. The nutrients available in the growing media that are able to be absorbed by the fungus will be able to increase the fresh weight of the fungus. High protein content in tofu dregs increases the amount of nitrogen in the growing media so that it can spur the growth of white oyster mushroom mycelium. High nitrogen causes the growth of mycelium which is thicker and more compact [10].

The addition agricultural waste (leaves) to the base medium of wood sawdust can increase the fresh weight of the oyster mushroom body [11]. Nutritional requirements for oyster mushrooms are a source of carbon, nitrogen, and phosphate [12].

The higher the value of biological efficiency, the higher the production obtained and the more efficient use of the media by oyster mushrooms [13]. The treatment of adding 250 g flour and 100 g leaves has the best thickness of mycelium, which is dense and thick, mycelium which grows very thick can utilize the nutrients contained in the media well and efficiently. A good mycelium is mycelium that looks white like cotton, dense, and grows attached [14]. In the treatment with a higher total fresh weight of mushrooms, the biological efficiency value will also be higher.

4 Conclusion

The interaction of the treatment of the addition of tofu dregs with dried banana leaves significantly affected the growth of mycelium, the number of caps, caps diameter, caps thickness, fresh weight, and the biological efficiency of brown oyster mushrooms. The treatment of adding 250 g of tofu dregs with 100 g dried banana leaves is a better treatment than others, which is shown with the highest fresh weight and biological efficiency.

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