Progress in Engineering Application and Technology Vol. 4 No. 2 (2023) 531-539
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PEAT

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Utilization of Bamboo Sawdust as Oyster Mushrooms Grown Media

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DOI: https://doi.org/10.30880/peat.2023.04.02.053
Received 15 January 2023; Accepted 11 February 2023; Available online 11 February 2023

Abstract: The rapid increase in the *Pleurotus ostreatus* (oyster mushroom) growing industry in Malaysia requires the supply of suitable alternative materials as growing media other than rubber wood sawdust (RS). Thus, this study is conducted to observe the potential of bamboo sawdust (BS) from Betong (*Dendrocalamus asper*) variety as an alternative substrate for the cultivation of oyster mushroom which currently uses sawdust from the rubber trees. The grown media has been produced with 25%, 50% and 75% sawdust composition between BS and RS. Substrate with 100% BS and 100% RS were produced as control samples for comparison. The mushroom kit packaging for BS media-based substrates is successfully developed in this study. All substrate compositions were produced with addition of 10% bran and 1% agricultural lime. In the oyster mushroom cultivation, media bagging, sterilizing, spawning, incubation, and substrate harvesting were conducted. The study also observed in mycelium development, spawn run, pin head formation, and yield. The results shows that the addition of BS into the RS substrate has accelerated the first pinhead formation compared to 100% RS and 100% RS. Substrate with 25% RS + 75% BS mixture has the highest yield in terms of mean stipe length, which was 17.76 cm. This optimum composition recorded the average fresh weight of 123.28 g and average number of fruiting bodies of roughly 5.53. With a stipe length of 6.14 cm, the BS100% substrates produced the lowest total yield (89.04 g). As a result, it has been demonstrated that the substrates mixed with BS generated more edible mushrooms in terms of number and quality. Therefore, the substrate with combination of BS and RS demonstrated a high potential as an alternate grown media for the development of oyster mushroom. The use of bamboo sawdust in the mushroom industry can lead to increased yields and improved quality of mushrooms and could be advantageous to the mushroom and bamboo industries.

Keywords: Betong Bamboo, Rubber Sawdust, Oyster Mushrooms, Growth media

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1. Introduction

Oyster mushrooms are commonly ingested as a cuisine. Mushrooms can be grown in a variety of media. Mushrooms can live in a microbe, parasitic, or fungal state. The majority of farmed mushrooms are capable of accumulating, which means they thrive on natural matter generated by plants or animals. In nature, they grow on leaf litter, animal waste, and dead trees planks. [1]. According to Data Bridge Market research, the oyster mushroom market is expected to be growing at a growth rate of 6.70 percent in the forecast period of 2021 to 2028. The mushroom processing sector is attracting a rising number of entrepreneurs, particularly young individuals who are encouraged to invest and become involved in the industry [2].

Mushrooms can be cultivated in a variety of media. It makes it possible for the oyster mushroom to be widely cultivated in Malaysia, the high demand for sawdust in other industries has a negative impact on mushroom farmers' desire to acquire the important raw material for mushroom cultivation. As a possible solution, betong bamboo is proposed as a rapidly growing and locally available source that suitable for oyster mushroom growth media.

According to Abdullah Siam [3], Mainland Malaysia is the habitat to around 63 bamboo species, but only thirteen species are known to be used for industrial. In the context of mushroom cultivation, the morphology of bamboo fiber may influence the quality of the mushrooms in a few different ways. Oyster mushroom is a mushroom that can thrive on a wide range of organic substances [4]. This fungus might be created from any agricultural waste containing cellulose and lignin. Bamboo sawdust (BS) has the possibility to be an option medium in the production of oyster mushrooms due to its usual lignocellulosic composition (% dry matter base) of 73% cellulose, 12% hemicellulose, 28% lignin, and 1.5% ash [5].

Therefore, this study objectives to produce oyster mushroom media by using Betong (Dendrocalamus asper) bamboo sawdust; to investigate the effect of sawdust percentage between bamboo and rubber wood sawdust on the oyster mushroom growth and to develop a packaging box for oyster mushrooms planting kit.

2. Materials and Methods

2.1 Sample preparation

The preparation of samples required various compositions of bamboo and rubber tree sawdust mixed in various percentages. The rubber sawdust, bran and agriculture lime were acquired from Saifulam AgroFarm, Johor. It should be acknowledged that the mixed composition ratio of (100:10:1) was provided by Saifulam Agrofarm. The mixtures were combined, and each substrate was put in a transparent plastic. PVC collars were used to compress and shut the bag. As stated in Table 1, the materials manufactured comprise of five distinct mixtures of rubber sawdust and bamboo sawdust.

Table 1: Composition of substrates

Substrate	Composition of substrate	
	Betong Bamboo Sawdust (BS)	Rubber wood sawdust (RS)
A	100%	-
B	-	100%
C	50%	50%
D	25%	75%
E	75%	25%

2.2 Substrate preparation

As shown in Table 2, the substrates were supplemented with bran and agricultural lime. All substrates were sterilised at 100°C for 8 hours before the spawning process started to eradicate all fungus, germs, bacteria, viruses, and pathogenic organisms. Following sterilization, each experimental plastic bag was injected with oyster mushroom spawn in the top of the substrate. They were stored at room temperature in a dark room.

Table 2: Ratio for each substrate

Substrates	Rubber Sawdust (g)	Bamboo Sawdust (g)	Bran (g)	Agriculture Lime (g)
RS100%	4000	-	400	40
RS50%+BS50%	2000	2000	400	40
RS75%+BS25%	3000	1000	400	40
RS25%+BS75%	1000	3000	400	40
BS100%	-	4000	400	40

2.3 Growth conditions

2.3.1 Mycelium growth

The quality of the substrate, the presence of competing micro-organisms, and the temperature and humidity of the growing environment are all elements that might influence the rate and success of oyster mushroom mycelium growth. Proper substrate sterilization and the maintenance of ideal growing conditions can assist to assure effective mycelium development and mushroom output. Figure 1 shows the mycelium growth for each condition of substrates.

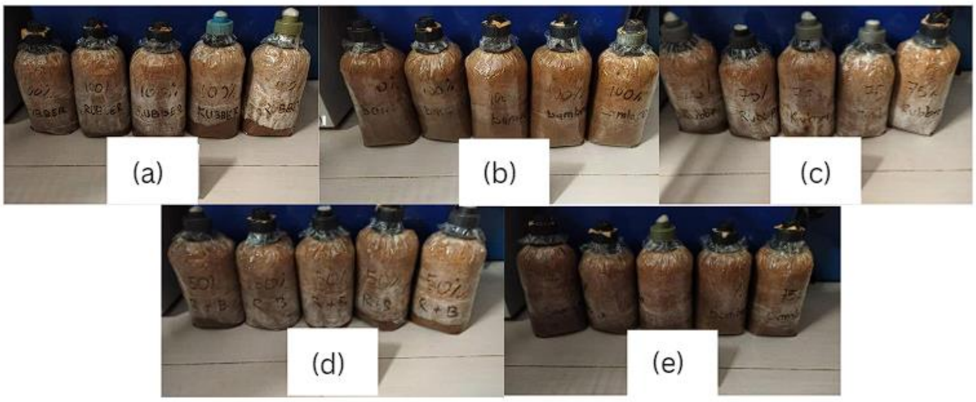

Figure 1: Mycelium growth for each condition (a) RS 100%, (b) BS 100%, (c) RS 75%+BS 25% (d) RS 50%+BS 50% (e) RS 25%+BS 75%

2.3.2 Spawn movement, pinhead development, and production of fruiting bodies

Spawn movement is the process of transferring the spores or spawn to a substrate, such as a mixture of nutrients and water, and allowing it to grow and colonize the substrate. This typically involves incubating the substrate in a controlled environment to create the ideal conditions for the spores to germinate and grow.

2.4 Data collection

The quantity, as well as the weight and size of the fruit bodies after blooming were used to calculate the yield of oyster mushrooms of various compositions. These characteristics of the calculation data play a significant role in determining the quality of the oyster mushrooms. A high yield of mushrooms indicates a successful and productive cultivation process, with many healthy and well-formed fruit bodies. A larger size of fruit bodies can indicate a higher rate of growth and a more robust and mature fruiting structure, which can result in a better quality of mushrooms. A higher weight of the fruit bodies can indicate a high level of biomass production and a more substantial fruit body, which can contribute to a higher quality of mushrooms.

On the other hand, a low yield of mushrooms or small size and weight of the fruit bodies can indicate issues with the cultivation process, such as poor substrate quality, contamination, or inadequate growing conditions. These factors can result in lower quality oyster mushrooms with less flavor, texture, and nutritional value. Therefore, it is crucial to accurately calculate the yield, size, and weight of the fruit bodies to accurately assess the quality of the oyster mushrooms. These calculations provide valuable information on the effectiveness of the growing conditions, the choice of substrate composition, and the overall health and productivity of the oyster mushrooms.

The average values of the measurements from the numerous conditions of substrate were computed. Growth characteristics such as the quantity of fruit bodies, stipe thickness and length, cap diameter and thickness were measured and computed. Direct counting of fruit bodies on each substrate was used to determine the number of fruit bodies. All measurements were taken in centimetres (cm) with a vernier calliper, through one side of the stipe throughout the pointed tip to the other, as seen in Figure 2.

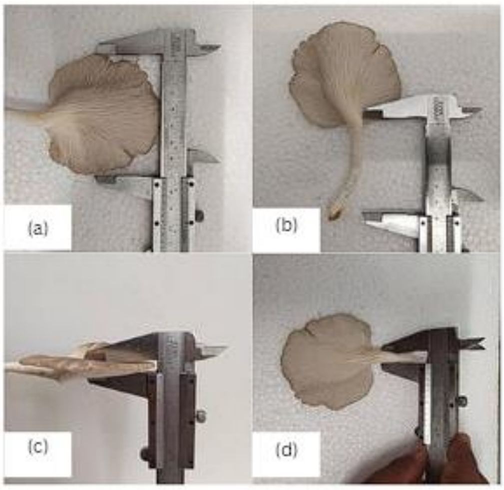

Figure 2: Measurement using vernier caliper (a) cap diameter, (b) stipe length, (c) cap thickness, (d) stipe thickness

2.5 Packaging design process (mushroom growing kit)

The design process for a mushroom growing kit begins with ideation and brainstorming, where designers come up with initial concepts through paper-based material selection and sketching or computer software. The refining and prototyping stage is critical in this process as it involves refining the design and constructing a rough version of the final product. The use of corrugated paper board is important in this stage as it provides added strength and durability, making it a crucial component of the kit's packaging. In the final design and production phase, the completed product is manufactured and ready for distribution after all necessary changes and improvements have been made. Before proceeding to full-scale production, prototypes of the final product may be required to evaluate the design and ensure proper performance. The use of corrugated paper board in the final product design adds to the strength and durability of the kit, making it an essential part of the mushroom growing kit development process as show in Figure 3.

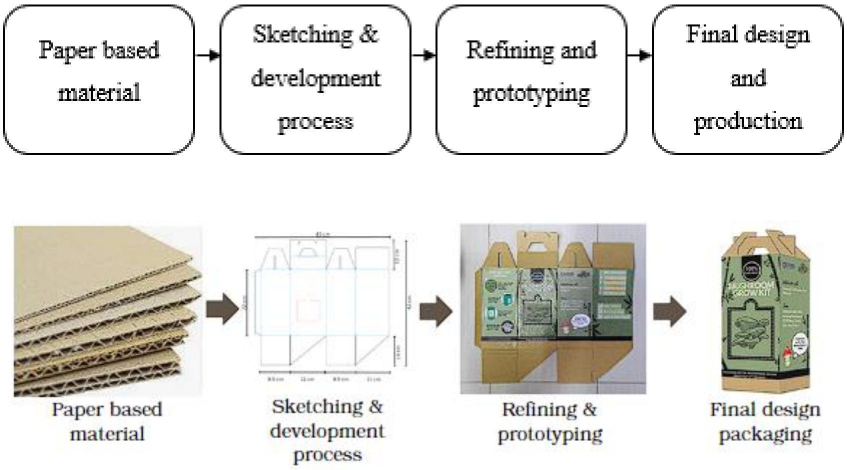

Figure 3: Mushroom growing kit design process

3. Results and Discussion

3.1 Mycelium growth of oyster mushroom

The rate of mycelium growth varied depending on the media composition, as shown in Figure 4. A media composition of rubber wood sawdust and bamboo sawdust grew faster than media containing only one carbon source, such as 100% bamboo and 100% rubber. Mycelium covered all bags surface at the average of 26-29 days. Verma [6] , stated that the molecular structure of the media may impact mycelia growth.

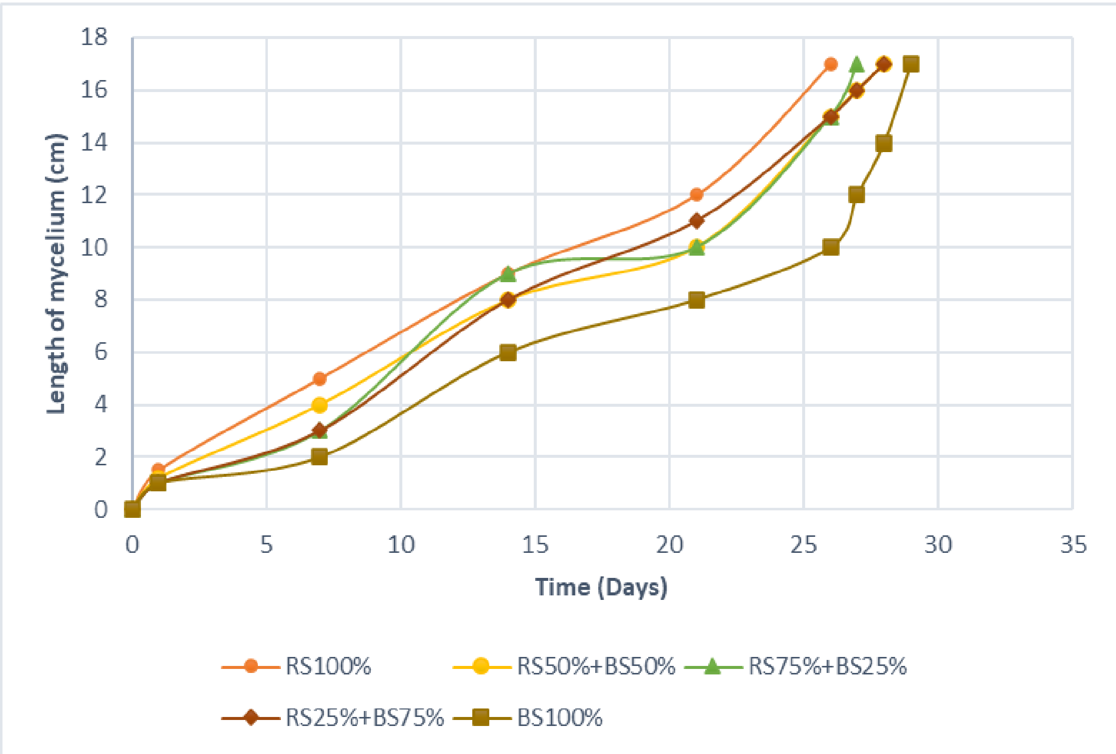

Figure 4: Mycelium growth of oyster mushrooms

3.2 Spawn movement, pinhead development, and production of fruiting bodies

According to the findings of this study, bamboo sawdust reacts effectively when combined with rubber sawdust, since it required 27 days and 28 days for a mix of RS 25%+BS 75%, RS 75%+BS 25%, and RS50%+BS 50%, respectively, whereas BS 100% sawdust took a long time to fully colonise, as shown in Table 3.

The pinhead development occurs during the second stage of the growth of mycelium during mushroom cultivation. As shown in Table 3, the days required for the pinheads development was reduced in 29 days and 31 days for mixture of RS25%+BS75%, RS75%+BS 25% and RS50%+BS 50% respectively, when compared to the 33 days needed for pinheads development using only rubber sawdust [7], It was stated that the pinhead development of oyster mushroom required around 6 and 7 days.

Table 3: Days for spawn movement, pinhead development, and fruiting body formation on various substrates

Substrates	Days for spawn movement	Days for pinhead development	Days of fruiting body formation	Total number of fruiting bodies
RS 100%	26.4 ± 0.54	33.6 ± 0.54	34.6 ± 0.54	5.33 ± 0.08
RS50%+BS 50%	28.6 ± 0.54	31.4 ± 0.54	32.2 ± 0.84	3.83 ± 0.02
RS75%+BS 25%	27.6 ± 0.89	30.6 ± 0.54	31.8 ± 0.84	4.08 ± 0.07
RS25%+BS75%	27.4 ± 0.89	29.6 ± 0.89	30.2 ± 0.84	5.53 ± 0.06
BS 100%	29.8 ± 0.83	36.4 ± 0.54	37.6 ± 0.89	4.30 ± 0.44

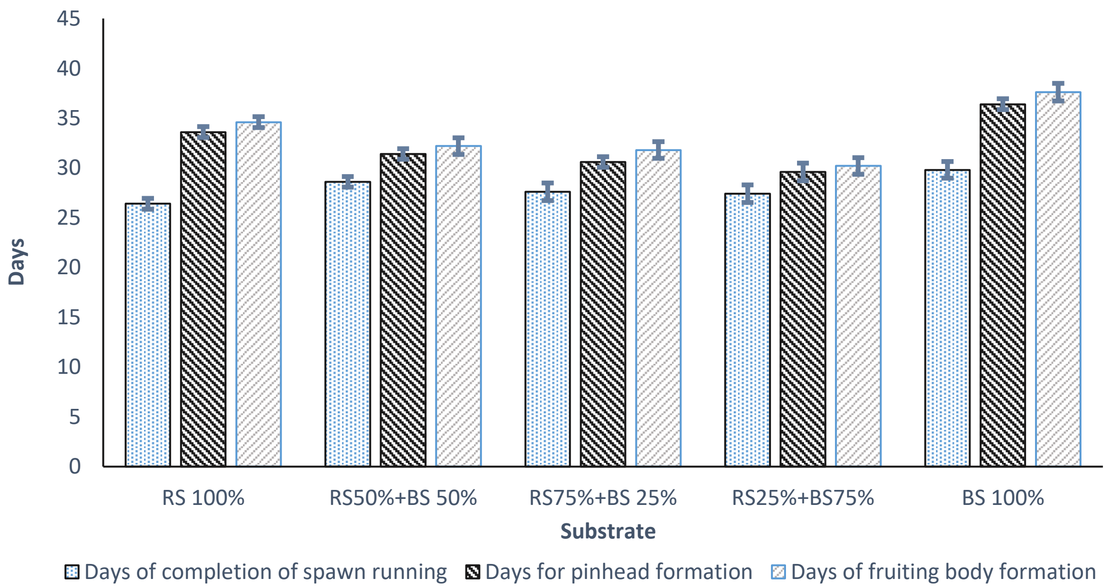

Figure 5: Days for completion of spawn running, pinhead formation, and fruiting body formation on different substrates in bar chart

Yamauchi [8] found that fruiting body development takes 3-6 weeks following pinhead formation. It differs well with data obtained, which reveal that the fruiting body development took 2-3 days following the pinhead formation in RS25%+BS75%, RS75%+BS 25%, and RS50%+BS 50%, as shown in Table 3. This shows that the utilization of bamboo sawdust in the cultivation of oyster mushrooms could really enhance a more rapid growth rate in the mushrooms. Figure 6 illustrates the fruiting bodies of each composition of substrates.

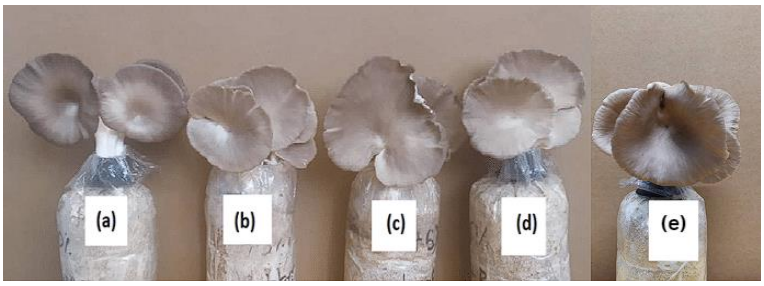

Figure 6: Fruiting development of oyster mushroom. (a) RS100%, (b) RS50%+BS 50%, (c) RS25%+BS 75%, (d) RS75%+BS 25%, (e) BS100%

3.3 Total length, diameter, and thickness of fruiting bodies of mushroom on different mixtures

The composition consisting of RS25%+BS 75% produced the longest stipe at mean 17.76 centimeters, while the length of the stipe produced by bamboo sawdust alone was the shortest at 6.14 centimeters (Table 4). Samuel [9] reported the length of the stipe can be used to determine the overall quality of the oyster mushroom. According to Mondal [10], the quality of the mushrooms decreases as the stipe length increases. The pattern of outcomes varied depending on the thickness of the stipe. The mixture of RS25%+BS 75% yielded the greatest mean stipe thickness of 3.60 cm and the maximum levels for cap diameter and thickness of 18.63 cm and 2.52 cm, respectively. On average, the substrates yielded mushrooms with superior physical attributes than the unmixed mixture substrates. It is probable that the abnormally high carbon to nitrogen ratio observed in these substrates.

Table 4: Total length, diameter, and thickness of fruiting bodies of mushrooms on different mixtures.

Substrates	Stipe length (cm)		Stipe thickness (cm)		Cap diameter (cm)		Cap thickness (cm)	
	Mean	**STDV**	**Mean**	**STDV**	**Mean**	**STDV**	**Mean**	**STDV**
RS 100%	12.39	11.32	2.74	2.51	14.96	14.10	1.90	1.73
RS50%+BS 50%	12.64	11.66	2.65	2.53	14.61	13.62	1.91	1.74
RS75%+BS 25%	12.74	11.66	2.29	2.12	14.61	13.62	2.06	1.94
RS25%+BS 75%	17.76	10.00	3.60	2.14	18.63	10.93	2.52	1.42
BS 100%	6.14	8.66	1.51	2.10	9.90	13.68	1.26	1.73

3.4 Weight and total yield of different mixtures

Table 5 shows that RS25%+BS75% mixtures produced maximum average yield in 2 flushes resulted 123.28 g in total yield, which higher than the single substrates. This is coincided to the findings of Shashirekha and Rajaratnam [11], discovered that mixed substrates had a better yield than single substrates. The increased yield reported in the mixed substrate might be attributed to the substrate's strong physical and chemical properties. The highest yield per flush is seen in the mixture of RS25%+BS75% with 62.18 g in the first flush and 61.10 g in the second flush. While, BS 100% and RS 100% have the lowest yield per flush with 44.16 g and 48.78 g respectively in the first flush and 44.88 g and 50.91 g respectively in the second flush. It is also notable that the yields of the mixtures

RS50%+BS50% and RS75%+BS25% are relatively consistent across the two flushes. Overall, these results composition of the substrate mixture can have a significant impact on the yield per flush.

Table 5: Weight and average yield of different substrates

Substrates	Average yield per flush (g)		Total yield in 2 flushes (g)
	1	2	
RS 100%	48.78 ± 4.63	50.91 ± 1.32	99.69
RS50%+BS50%	52.12 ± 5.09	52.79 ± 5.40	104.91
RS75%+BS25%	53.70 ± 6.27	51.46 ± 6.65	105.16
RS25%+BS75%	62.18 ± 14.43	61.10 ± 0.74	123.28
BS 100%	44.16 ± 8.13	44.88 ± 8.92	89.04

3.5 Mushroom grow kit result

A mushroom grow kit is a ready-to-use package of products and instructions for cultivating mushrooms at home. These kits generally include mushroom block kit, a growth medium, and instructions for establishing and maintaining the grow environment. These kits are designed to cultivate oyster mushroom as shows in Figure 7.

Figure 7: Sample mushroom grow kit result

4. Conclusion

The current study discovered that the oyster mushroom grown media from Betong (*Dendrocalamus Asper*) bamboo sawdust which is rich in nutrients level and can be used as a substrate for producing oyster mushrooms. The current study found that the mixed sawdust between rubber sawdust (RS) and bamboo sawdust (BS) performs better especially for the RS25%+BS75% substrate than unmixed substrate in terms of growing performance, and weight with 30 days, 123.28 g, respectively. Increasing the quantity of BS in the RS substrate mixture results in the quickest mycelium rate, pin head development, and fruiting body formation. Based on these findings, it can be concluded that bamboo sawdust can utilized as a starting material for oyster mushroom production. In the future, Betong bamboo sawdust research might be implemented in Malaysia which have subtropical climates, to expand their use.

Acknowledgement

The authors like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for its support. The authors would also like to thank Mr. Noorsaiful Amri Suloh of Saifulam Agro Farm in Benut, Johor, Malaysia, for his assistance and facilities.

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