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Utilization of Rice Straw from Sungai Balang, Muar as an Alternative for Oyster Mushroom Production

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Abstract

Rice straw, rich in cellulose and hemicellulose, is a possible alternative sawdust as a nutrient-rich substrate for oyster mushroom cultivation, giving a sustainable and cost-effective media for widespread mushroom production. The objective of this research is to produce oyster mushroom media by using rice straw sawdust, to investigate the effect of different substrate compositions between rice straw and rubber wood sawdust, and to develop a packaging box for rice straw substrate mushroom planting kit. The grown media has been produced with 25%, 50%, and 75% sawdust composition between RW and RS. The substrate with 100% RW and 100% RS were produced as the control samples for comparison. All substrate conditions were produced with the 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 movement, spawn movement, pinhead formation, cap dimension, and yield. The results show that the addition of RS to the RW substrate has accelerated the first pinhead formation compared to 100% RW and 100% RS. The 25% RW + 75% RS mixture had the highest yield which is 270.00g. This optimum composition recorded an average of 3.8cm in stipe length, 8.53cm in cap diameter, and 5.77g in total number of fruiting bodies. The RS 100% produced the low yield with an average of 174.75g and with a stipe length 3.09 cm. Consequently, it has been proven that the substrates combined with RS produced a greater quantity and superior quality of edible mushrooms. Hence, the substrate containing a combination of RW and RS exhibited significant potential as a viable alternative growth medium for cultivating oyster mushrooms. Utilizing rice straw sawdust in the mushroom business can result in enhanced mushroom yields and superior quality, offering potential benefits to both the mushroom and rice straw sectors.

1. Background of Study

One of the most popular varieties of grown mushrooms in the world is oyster mushrooms, which is the common name for the species Pleurotus ostreatus [1]. Oyster mushrooms are the second largest commercially produced mushroom next to Agaricus bisporus globally, especially in Southeast Asia, India, Europe, and Africa. Oyster mushroom cultivation has several advantages over other edible mushrooms, including fast growth under a wide range of temperatures and pH [2]. They also go by the names tree oyster mushrooms and pearl oyster mushrooms. The fungi are grown commercially in many nations and naturally occur on and around trees in temperate and subtropical woods all over the world.

Malaysia's rice production is modest, where the nation can generate about 72% of its rice requirement [3]. Rice straw is a leftover residue from the harvesting of rice. The overall biomass of this residue is affected by several variables, including soil types, nitrogen management, and weather. Depending on the harvesting techniques using stationary threshers or self-propelled combine harvesters, respectively rice straw is heaped or strewn out in the field during harvest. Open-field straw burning has increased dramatically over the last decade due to a lack of options. Sustainable rice straw management options include using rice straw as bedding material for cattle, mushroom cultivation, nutrition in the soil, power generation, and producing materials for industrial uses such as silica and bio-fiber [4]. However, not all options are economically feasible due to the costs of materials produced from rice straw, including transportation costs, being higher than for materials produced from other traditional or existing feedstocks

Oyster mushroom cultivation requires a substrate rich in nutrients. Sawdust is typically used as the substrate for oyster mushrooms. Sawdust is typically utilized by oyster mushroom growers as a planting media. As opposed to sawdust, rice straw contains the same nutrients. 27% hemicelluloses, 39% cellulose, 12% lignin, and 11% dust can be found in rice straw. Monomers of sugar, such as glucose, make up cellulose and hemicellulose. The next planting and tillage are hampered by the rice straw, which is viewed as a compost pile. The rice straw, which is made up of the stems and leaves of rice plants, may be used as a planting medium for white oyster mushrooms. This may help reduce the size of the compost pile.

Rice straws being thrown away regularly is a normal occurrence in the paddy industry. During the evaluation process in an industrial environment, the sawdust that is produced from rice straw is intended to be wasted. On the other hand, rice straw sawdust waste has not been used as a substrate for the development of mushrooms yet. Considering previous investigations concerning the use of various natural fibers, it will be investigated whether or not rice straw sawdust may be used in the cultivation of oyster mushrooms. Rice straw sawdust, which has proven to be a successful base substrate for commercially cultivating oyster mushrooms, serves as the study's control medium. Mushrooms can be grown in a variety of media. It makes it possible to cultivate oyster mushrooms widely. The raw material chosen for the mushroom-growing medium will be sawdust made from rice straw.

Therefore, this study's objectives to produce oyster mushrooms by using rice straw sawdust; to investigate different substrate compositions between rice straw and rubber wood sawdust, and to develop a packaging box for rice straw substrate mushroom planting kit

2. Materials and Method

2.1 Materials Preparation

Rice straws were collected from Sungai Balang, Muar, Johor. Rice straws were dried naturally under the sun. Rice straws were cut in smaller lengths to proceed with the grinding process to produce rice straw sawdust. The creation of samples requires diverse compositions of rice straw sawdust and rubber tree sawdust blended in varying percentages. The rubber sawdust, bran, and agriculture lime were bought from Saifulam Agro Farm, Johor. The liquids were blended, and each substrate was packed in a transparent plastic. PVC collars were utilized to compress and close the bag.

Fig. 1 *Figure of rice straw sawdust*

2.2 Media Substrate Preparation

The creation of samples requires diverse compositions of rice straw sawdust and rubber tree sawdust blended in varying percentages. The rubber sawdust, bran, and agriculture lime were provided by Saifulam Agro Farm, Johor. The liquids were blended, and each substrate was packed in a transparent plastic. PVC collars were utilized to compress and close the bag. As mentioned in Table 1, the materials manufactured include five various combinations of rubberwood sawdust and rice straw sawdust.

As shown in Table 2, the substrates were treated with bran and agricultural lime. All substrates were sterilized at 100°C for 8 hours before the spawning process commenced to destroy all fungi, germs, bacteria, viruses, and pathogenic organisms. Following sterilization, each experimental plastic bag was injected with oyster mushroom spawn on the top of the substrate. They were stored at room temperature in a dark environment. Fig. 2 illustrates the media substrate preparation process including sterilization, spawning, and incubation.

Table 1: *Percentage Composition between rice straw and rubberwood sawdust*

Substrate	Rice straw sawdust	Rubberwood sawdust
A	100%	-
B	-	100%
C	25%	75%
D	50%	50%
E	75%	25%

Table 2: *Substrate material composition weight ratio*

Substrate	Rubberwood sawdust (g)	Rice straw sawdust(g)	Bran(g)	Agriculture Lime (g)
A	4000	-	400	40
B	2000	2000	400	40
C	3000	1000	400	40
D	1000	3000	400	40
E	-	4000	400	40

(a) (b) (c) (d)

Fig. 2 *Figure of media substrate preparation (a) media substrate; (b) sterilization; (c) spawning; and (d) incubation*

2.3 Oyster Mushroom Grown Observation

2.3.1 Mycelium Growth Observation

Mycelium demonstrates a type of locomotion through its growth and expansion, even though it does not possess a nervous system or muscles.. Mycelium growth is facilitated by apical growth. Cell division and elongation occur at the ends of the hyphae, causing them to extend deeper into the substrate. This extension facilitates the mycelium's exploration of its surroundings to locate nutrients, moisture, and optimal conditions for its development and reproduction. The movement of oyster mushroom mycelium refers to the growth and colonization of the fungal mycelium in a substrate, which is essential for the production of oyster mushrooms. The process involves solid-state fermentation, where the fungal mycelium grows through a substrate, typically made of sawdust or other organic materials. Fig. 3 shows the mycelium growth for each condition substrate.

(a) ***50% RS : 50% RW***

(b) ***25% RS : 75% RW***

(c) ***75% RS : 25% RW***

(d) ***100% RW***

(e) ***100% RS***

Fig. 3 *Figure of Mycelium growth in a media substrate (a) 50% RS : 50% RW; (b) 25% RS : 75% RW; (c) 75% RS : 25% RW; (d) 100% RW; and (e) 100% RS*

2.4 Spawn movement, pinhead formation, and production of fruiting bodies

Spawn acts as the medium for mycelium. A pre-inoculated substrate is a medium that is usually made out of grains (such as rye, millet, or other cereals) or other nutrient-rich materials like sawdust. This medium has been colonized by the mycelium of the chosen mushroom species. This mycelium-infused substrate works as the beginning point for mushroom cultivation. The movement of the fruiting body of mushrooms, such as the oyster mushroom, is an interesting process. The growing body, which is the visible part of the mushroom, grows relatively fast compared to plants, sometimes appearing overnight. This rapid growth is due to the cellular growth pattern of mushrooms, where the fruiting body grows by cell enlargement, given enough water and the right external circumstances.

2.5 Data Collection

The amount, as well as the weight and size of the fruit bodies after flowering were utilized to compute the yield of oyster mushrooms of various compositions. These aspects of the calculation data have a vital influence in defining the quality of the oyster mushrooms. A high yield of mushrooms suggests a successful and fruitful cultivation procedure, with numerous healthy and well-formed fruit bodies. A bigger size of fruit bodies can suggest a higher rate of growth and a more strong and mature fruiting structure, which can result in a superior quality of mushrooms. A higher weight of the fruit bodies can suggest a high degree of biomass production and a more substantial fruit body, which can lead to a higher grade of mushrooms.

On the other side, low production of mushrooms or tiny size and weight of the fruit bodies can suggest concerns with the culture process, such as poor substrate quality, contamination, or unsuitable growing conditions. These variables can result in lower-quality oyster mushrooms with less flavor, texture, and nutritional value. Therefore, it is vital to precisely analyze the production, size, and weight of the fruit bodies to accurately determine the quality of the oyster mushrooms. These calculations provide vital information on the effectiveness of the growth circumstances, the choice of substrate composition, and the overall health and productivity of the oyster mushrooms.

Data collected from the process was recorded. For example, the amount, weight, and size of the fruit bodies after sprouting were utilized to quantify the yield of oyster mushrooms of varied compositions. Next, the data that will be recorded is the characteristics of the mushroom produced such as the thickness and the cap diameter.

2.6 Packaging Design Process (Mushroom Growing Kits)

Mushroom growing kits are pre-prepared kits that contain everything you need to grow your mushrooms at home. These kits are designed to make mushroom cultivation accessible to everyone, regardless of their level of experience or knowledge. They will come with all the necessary materials, including spores, substrate, and instructions, making it easy for anyone to grow their mushroom.

The design process for a mushroom growing kit begins with ideation and brainstorming, when designers come up with first concepts using paper-based material selection and sketching or computer tools. The refining and prototyping step is crucial in this process since it entails improving the design and producing a preliminary prototype of the final product. The usage of corrugated paper board is significant in this step as it gives increased strength and durability, making it a crucial component of the kit's packaging. In the final design and production phase, the finalized product is built and ready for distribution after all necessary alterations and upgrades have been made. Before continuing to full-scale production, prototypes of the final product may be required to assess the design and assure optimal performance. Fig. 4 shows the development process of the mushroom growing kit.

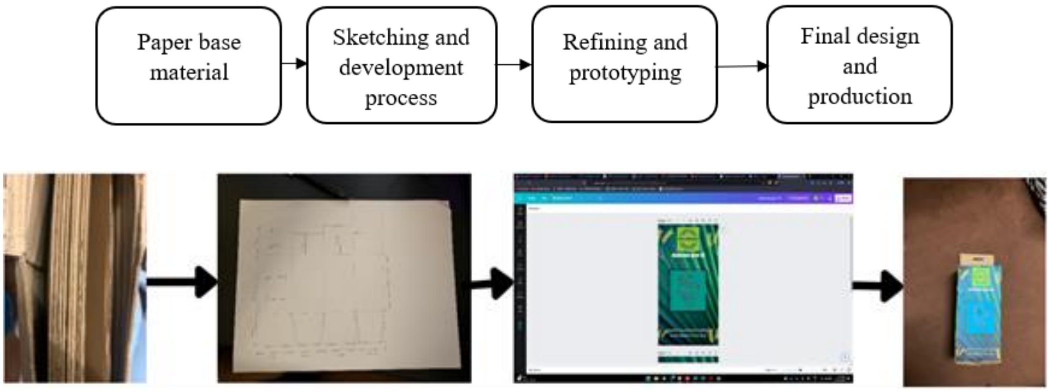

Fig. 4 *Figure of the packaging design and development process for mushroom growing kits*

3. Results and Discussion

3.1 Mycelium Growth of Oyster Mushroom

It can be observed that RW100% shows the fastest growth to reach the maximum growth of mycelium compared to the other substrate which requires 26 days. Meanwhile, the RS100% reaches the maximum growth of mycelium which is required 30 days. The other substrates which are the RW25%+RS75%, RW50%+RS50%, and RW75%+RS25% took 27 days, 28 days, and 29 days to reach the maximum growths of mycelium which is 17cm. The pace of mycelium growth is contingent upon the composition, as illustrated in Fig. 5. The media composition consisting only of rice straw sawdust and rubber wood sawdust exhibited a higher growth rate in comparison to the composition having a mixture of rice straw sawdust and rubber wood sawdust.

Table 3 *Mycelium growth movement observation*

Substrate	Days	7	14	21	25	26	27	28	29	30
RW 100%	mean (cm)	5.10	9.82	12.91	16.61	17.00				
	stdv	0.03	0.05	0.07	0.24	0.00				
RW 25% + RS 75%	mean (cm)	4.19	8.96	11.88	14.90	16.80	17.00			
	stdv	0.08	0.13	0.07	0.12	0.05	0.00			
RW 50% + RS 50%	mean (cm)	3.21	7.69	10.55	13.94	15.86	16.75	17.00		
	stdv	0.03	0.10	0.05	0.06	0.11	0.09	0.00		
RW 75% + RS 25%	mean (cm)	2.81	6.95	9.87	11.99	13.92	15.97	16.65	17.00	
	stdv	0.05	0.05	0.11	0.10	0.07	0.12	0.14	0.00	
RS 100%	mean (cm)	2.11	5.92	8.90	9.87	10.99	12.91	14.54	16.64	17.00
	stdv	0.03	0.13	0.03	0.08	0.12	0.16	0.08	0.17	0.00

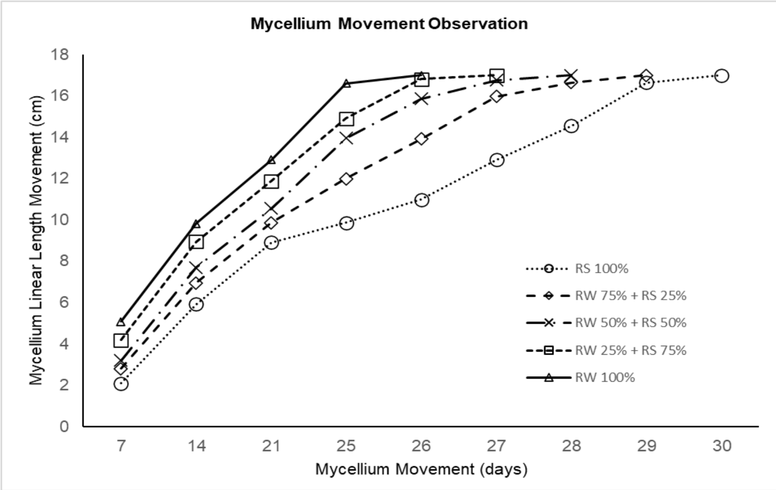

Fig. 5 *Mycelium growth movement observation*

3.2 Spawn Movement, Pinhead Formation, and Fruiting Body Formation

From the observation in Table 4 below, it is shown that RW100% responded well as it took an average day of 26.25 days for spawn movement to complete which is the fastest compared to RS100% which takes an average of 30 days which is the longest among the substrate. Meanwhile, for the pinhead development, the RW25%+RS75% is the quickest to achieve the full development which took an average of 28 days compared to the RS100% which took an average of 35 days which is the slowest among the substrates. Next, fruiting body movement, the RW25%+RS75% was the quickest taking an average of 29 days compared to the RS100% that been the slowest and took an average of 36 days. Research indicates that the time elapsed for complete mycelium colonization, pin-head formation, and the first maturation of fruiting bodies of oyster mushrooms after substrate inoculation can range from 19 to 40.67 days, with some variations based on the specific substrate used [5]. Lastly, the number of fruiting bodies, RW100%, and RW25%+RS75% had the highest average number of fruiting bodies compared to RW50%+RS50% which had the lowest number with an average of 3.

Table 4 *Days of development for mushroom spawn, pinhead and fruiting body*

Substrate Compositions	Sample No.	Total Days for Spawn Movement	Days for Pinhead Development	Days for Fruiting Body Movement	Total Number of Fruiting Body
RW 100%	mean	26.25	32.75	33.75	5.39
	stdv	0.50	0.96	0.96	0.07
RW 25% + RS 75%	mean	27.00	28.75	29.75	5.77
	stdv	0.82	0.50	0.50	0.09
RW 50% + RS 50%	mean	28.25	30.25	31.25	3.79
	stdv	0.50	0.50	0.50	0.15
RW 75% + RS 25%	mean	29.25	31.25	32.25	4.43
	stdv	0.50	0.50	0.50	0.11
RS 100%	mean	30.50	35.50	36.50	4.15
	stdv	0.58	0.58	0.58	0.06

The findings of this research show that each combination has a different total number of fruiting bodies depending on the days and the combination of substances. The rubber wood sawdust responds well to produce a fruiting body compared to the rice straw sawdust and it can be seen when the rubber wood sawdust had a higher percentage in the combination with rice straw. The RW100% had a 5.39 number of fruiting bodies, and RW75%+RS25% had 5.77. Meanwhile, the combination of RW50%+RS50% had 3.79, RW25%+RS75% 4.43, and RS100% had 4.15 in a number of the fruiting bodies as shown in Fig 6.

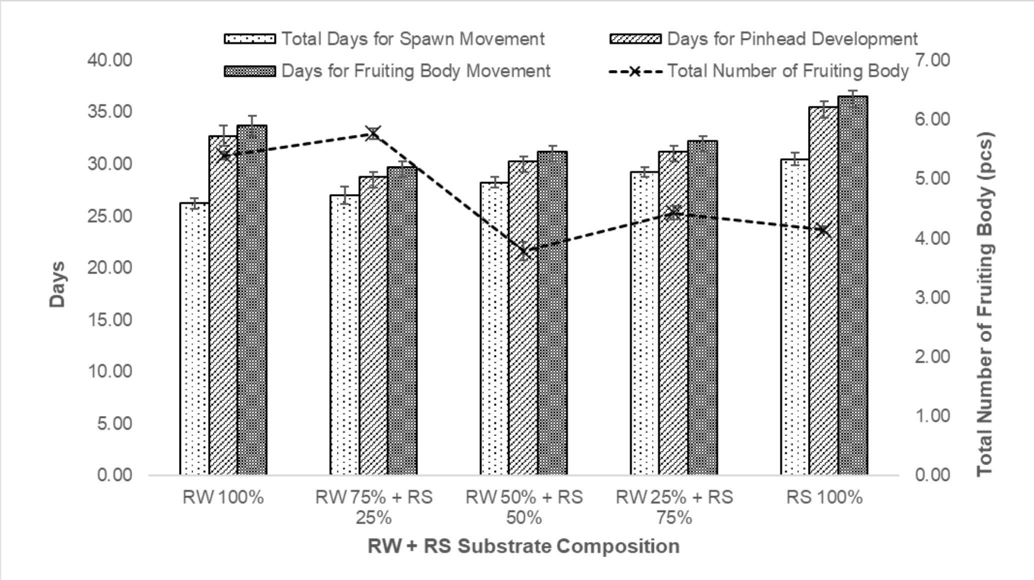

Fig. 6 *Days of development for spawn, pinhead, and fruiting body*

3.3 Mushroom Stipe and Cap Dimension

Detailed information regarding the length and diameter of the stipe, as well as the thickness of the caps and stipes, of the mushrooms that were collected can be found in Table 6. Fig. 6 illustrates the fruit bodies of P. ostreatus that were grown on a range of substrates. During the experiment, it was discovered that the stipe length and cap diameter of P. ostreatus that had been cultivated on various substrate compositions were significantly different from one another. The composition of RW75%+RS25% produced the largest cap diameter compared to the other composition. According to Hultberg et al. [6], the size of the cap is determined by several of elements, some of which include the characteristics of the particular organisms, the growing conditions, and the kind of substrate that is utilized. In addition, recent studies have demonstrated that the diameters of the caps of oyster mushrooms can vary anywhere from 41 mm to 71.5 mm, depending on the particular conditions and the kind of substrate that they are grown on. Because of this, the diameter of the cap of oyster mushrooms can vary quite a little, but mature caps are often quite enormous, with diameters ranging from a few inches to several inches respectively.

Table 5 *Mushroom stipe and cap dimension for different substrate composition*

Composition		Stipe Length (cm)	Stipe Thickness (cm)	Cap Diameter (cm)	Cap Thickness (cm)
RW 100%	mean	3.28	2.14	7.53	0.61
	stdv	0.03	0.03	0.04	0.01
RW 25% + RS 75%	mean	3.81	2.52	8.53	0.68
	stdv	0.06	0.06	0.07	0.02
RW 50% + RS 50%	mean	3.64	2.36	7.88	0.65
	stdv	0.04	0.04	0.08	0.01
RW 75% + RS 25%	mean	3.44	2.25	7.66	0.63
	stdv	0.05	0.04	0.05	0.01
RS 100%	mean	3.09	1.95	7.07	0.55
	stdv	0.06	0.06	0.08	0.03

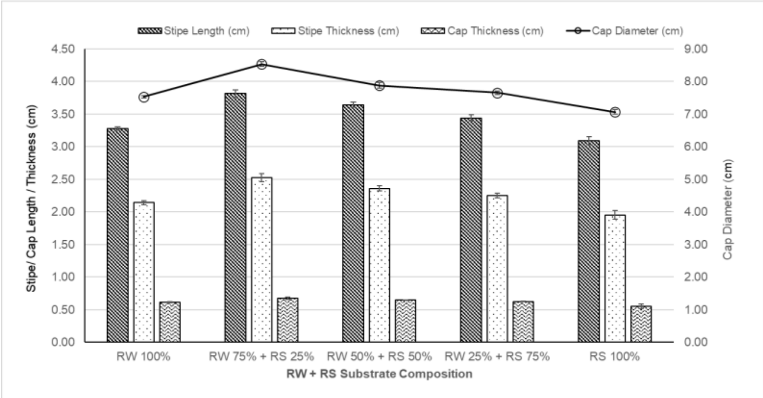

Fig. 7 *Mushroom stipe and cap dimension for different substrate compositions*

3.4 Weight and Total Yield of Different Substrate Compositions

Table 6 shows that RW25%+RS75% composition produced the maximum average total yield in 2 flushes which is much greater than a single substance can be produced. Research has shown that the biological efficiency (BE) of oyster mushrooms grown on different substrate compositions can range from 36.27% to 50.14%, with some substrate formulas being more suitable for higher mushroom yield. The weight and total yield of oyster mushrooms can be influenced by various factors. 161 g in the first flush and 109 g in the second flush, the mixture of RW75% and RS25% has the maximum yield per flush, as shown in Fig. 8. This mixture also has the highest yield overall. While the RS 100% had the lowest value in terms of yield per flush, with 119.00g in the first flush and 65.75g in the second flush. Based on these findings, the composition of the substrate combination has the potential to have a considerable influence on the yield that is achieved with each flush.

Table 6 *Mushroom weight and yield for different substrates composition*

Sample No.		First Flush (g)	2nd Flush (g)	Total
RW 100%	mean (cm)	134.25	74.25	208.50
	stdv	2.99	4.65	6.95
RW 25% + RS 75%	mean (cm)	161.00	109.00	270.00
	stdv	2.58	6.38	8.76
RW 50% + RS 50%	mean (cm)	152.50	90.75	243.25
	stdv	3.11	5.12	5.91
RW 75% + RS 25%	mean (cm)	143.75	83.50	227.25
	stdv	3.50	3.70	5.32
RS 100%	mean (cm)	119.00	65.75	184.75
	stdv	3.37	1.71	2.63

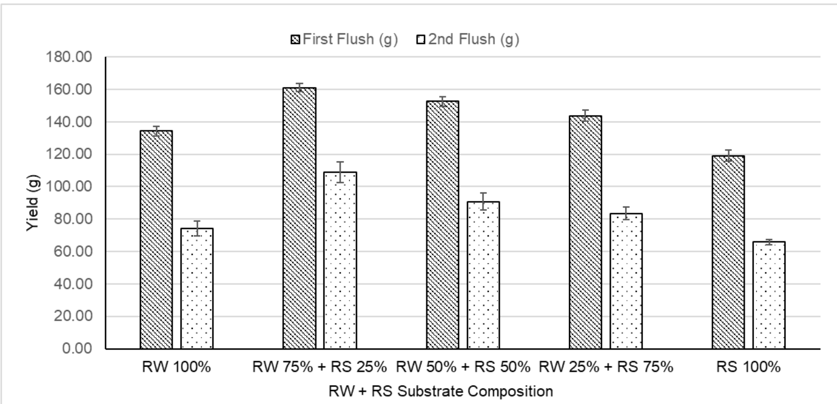

Fig. 8 *Mushroom weight and yield*

3.5 Mushroom Growing Kit Result

A mushroom cultivation kit is a practical bundle that includes all the required ingredients for cultivating mushrooms in the comfort of one's own home. Usually, it comprises of a foundation material such as sawdust, grain, or compost which has been infused with mushroom spores or mycelium (the reproductive component of a fungus. These kits often include instructions and occasionally a humidity tent or bag to produce the best conditions for mushroom production. These kits are meant to develop oyster mushroom as indicated in Fig. 9.

Fig. 9 Mushroom growing kit packaging

4. Conclusion and Recommendations

This study aimed to produce a rice straw-based medium for growing oyster mushrooms due to its rich nutrients. Scientifically proven as an effective substrate, rice straw provides an optimal environment for mushroom growth. Its nutrient abundance supports mycelium colonization and mushroom fruiting. Proper moisture, pH, and temperature are crucial for maximizing yield and quality. The research shows promising yields and highlights the relationship between cultivation management and product quantity or quality. The finding of this research observed that the addition of rice straw inside the current rubberwood material shows an increase of mushroom growth. In conclusion, implementing rice straw sawdust in the mushroom industry, especially in Malaysia is very promising.

The first recommendation is to implement precise monitoring systems for temperature, humidity, and airflow. The regulation of this is essential to maximize the development and quality of the mushrooms. Next is to discover which oyster mushroom strains are most effective when grown on rice straw by experimenting with a variety of oyster mushroom strains. To evaluate yield, quality, and adaptability, comparative studies should be carried out.

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