

# Waste Management Practices for Mushroom Cultivation in Malaysia

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## ABSTRACT

Mushroom cultivation can be considered one of the best presentations of sustainable and circular economy activities. The growth substrate used for mushroom cultivation consists of other agricultural waste and its post-harvested waste. The waste product, Spent Mushroom Substrate (SMS), could also be used for animal feeding, plant fertilizer, and feedstock for biogas. It is then essential to determine whether the SMS produced is being used for other purposes to ensure that mushroom agriculture activity is a sustainable and circular economy activity. Therefore, this study explores the mushroom industry's waste management practices in the Malaysian context. A cross-sectional survey was conducted on 89 mushroom farmers. The results found that 60.7% of them manage SMS eco-friendly while only 16.9% handle plastic waste eco-friendly. This finding indicates that not all mushroom cultivation in Malaysia can be considered a sustainable and circular economy activity. Therefore, strategies should be formulated to increase the sustainable approach to managing SMS, such as workshops or providing comprehensive infrastructure and networks.

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## 1. Introduction

The circular economy promotes social, economic, and environmental sustainability by emphasising a closing loop and cleaner production by using reduce, reuse, recycle (3R), and recovering material (Dorr et al., 2021). This type of economy builds upon the previous concept of the linear economy based on "take-produce-consume- discard". The cultivation of mushrooms is an excellent illustration of the potential circular economy symbioses (Dorr et al., 2021). This is because the media used for mushroom cultivation is obtained from other agricultural wastes such as cotton waste, rice straw, sawdust, and oil palm empty fruit bunches, etc (EFB) (Hanafi et al., 2018; Mohd Zainol, Mah Hussin, & Ghazali, 2019; Umr et al., 2021). Whereas post-harvest waste, the spent mushroom substrate (SMS) is high in nutrition and can be used for other purposes. The mushroom cultivation process is built upon this closing loop of reuse and recycling material in both cultivation and post-harvest, which indicates that mushroom cultivation activities open high opportunities for a circular and sustainable agriculture industry.

However, the question of whether the production and consumption of mushrooms are sustainable and circular in the Malaysian context was raised due to the poor agricultural waste of the mushroom industry. The abundant spent mushroom substrate (SMS) is generated in the mushroom farm post-harvesting cycle, as each kilogram of mushroom produces 5 kg SMS (Hafifah & Hanafi, 2018; Mohd Zainol, Davis, Che Rose, Jabil, & Mazdi, 2016). Previous studies showed that the current SMS management disposal in Malaysia is not environmentally friendly, such as burning, landfill disposal, or composting (Mat Zainol, Mah Hussin, & Ghazali, 2019; Phan &

Sabaratnam, 2012). The farmers resorted to such strategies due to their convenience and low cost (Chang & Wasser, 2017; Mat Zainol et al., 2019; Naresh, 2013). Consequently, these brought adverse environmental effects, such as the emission of unpleasant odours and contamination of the soil and nearby water sources. Eventually, these problems lead to potential risks to population health. Unlike the palm oil industry, no standard management practice is established for the mushroom industry. Therefore, it is essential to have a standard or best practice for waste management in the mushroom industry to provide avenues for mushroom growers to be part of the sustainable and circular economy industry. Before proposing this standard, it is essential to determine the current waste management practice in the industry.

## 2. Literature Review

Edible mushrooms are fungi with great nutritional value and low-calorie content. Mushrooms are cultivated for consumption, medicinal and pharmaceutical purposes. Mushroom is identified as high-value commodities; it has the potential to be developed (Ministry of Agriculture and Food Industries, 2021). The mushroom industry in Malaysia has a promising future in Malaysia as the demand and production rate are estimated to increase by at least two-fold in the past decade. The market for fresh and processed mushrooms is expected to grow from 1.0 kilograms in 2008 to 2.4 kilograms per capita in 2020. The production rate was also estimated to increase to 67% by 2020 (Kementerian Pertanian dan Industri Asas Tani, 2011). By 2025, that number may exceed 50 million tonnes (Singh, Kamal, et al. 2021). Presently, Malaysia commercially grows 17 different types of mushrooms. The oyster mushroom is the most widely cultivated mushroom due to its ease of growing and can be cultivated in low land.

Approximately 80% of mushroom producers are small-scale growers (Haimid, Rahim, & Dardak, 2013). The export value for mushrooms in Malaysia is determined to rise to RM 300 million in 2020. This increment is parallel to the global scale, where consumption and production of mushrooms are expected to increase annually by two-fold (Grimm & Wösten, 2018). The high output and use in this industry led to a question of whether these processes are sustainable. With this increased production and consumption rate, the long-standing issue of managing waste from this industry has become more critical than ever.

One of the most significant wastes in the mushroom cultivation industry is the spent mushroom substrate (SMS). An average Malaysian farm producing 100 tonnes of fresh mushrooms annually has produced 438 tonnes of SMS (Phan & Sabaratnam, 2012). SMS in Malaysia is mainly disposed of through landfilling, composting with animal dung, spreading on land, burying, and burning (Leong, Ma, et al., 2022; Phan & Sabaratnam, 2012; Umor et al., 2021). Another significant waste in this industry is mushroom plastic bags. Most of this type of waste is discarded through unsustainable methods like on-site burning, on-site burial, landfill disposal, and illegal dumping (Galati & Scalenghe, 2021). As a result, these will negatively impact the environment, including releasing an unpleasant odour and contaminating the soil and nearby water supplies. These issues will eventually pose potential threats to the general public's health.

Interestingly, the mushroom cultivation industry is often considered an industry with a high potential for circular economy symbioses (Dorr, Koegler, Gabrielle, & Aubry, 2021). Circular economy builds upon the previous concept of the linear economy based on "take-produce-consume- discard". Instead, this paradigm emphasizes closing the loop and cleaner production through reducing, reusing, recycling (3R), and recovering material (Dorr et al., 2021). The mushroom cultivation process can apply this close-loop concept as it used waste for the cultivation process, while the post-harvest waste can be used for other purposes. For the cultivation process, the growing media of mushrooms is taken from other different agricultural wastes, including cotton waste, rice straw, sawdust, oil palm empty fruit bunches, etc (Hanafi et al., 2018; Mohd Zainol, Mah Hussin, & Ghazali, 2019; Umor et al., 2021). Whereas the post-harvest waste, such as SMS can be used for other agricultural purposes such as fertilizer and soil remediation on mushroom farms (Umor et al., 2021). Meanwhile, mushroom bags can be recycled and reused (Galati & Scalenghe, 2021). However, the current waste management disposal is not environmentally friendly and does not follow the closing loop concept in the circular economy activity.

Therefore, there is a need for a standard or guideline for waste management practice in mushroom cultivation activity. Previously, most of the guidelines in the agricultural sectors were top-down approaches which often encountered problems with implementation as the institutions struggled in dealing with their limitation, such as low level of awareness amongst their officer, bureaucracy, and inefficient management (Mohd Zainol, Buang, Che Rose, Aznie, Jabil, & Marzuki, 2015). Thus, instead of using guidelines from the top-down level, the bottom-up approach shall be used to formulate a standard guideline. Such guidelines will include the current good practice of the operators and integrate their indigenous knowledge. Thus, this study proposes to examine the current waste management practices in mushroom agriculture among Malaysian growers. Although a study conducted a similar survey (Mohd Zainol et al., 2019), the sample used was limited to certain states in Malaysia. This study will be using a representative sample of Malaysian mushroom growers.

### 3. Methods

The study employed a cross-sectional survey of Malaysian mushroom farmers. Purposive sampling was used in this study, as the study specifically targets farmers involved in mushroom cultivation activities. The mushroom cultivators must grow their mushrooms and be involved in marketing activities, still active in the mushroom business. They are ineligible if they sell and create mushroom bags. The Headquarters of the Department of Agriculture, Malaysia, provided the database of mushroom growers. Based on this database, a total of 212 respondents were contacted; nevertheless, only 89 of them participated in the survey. This study utilised two modes of the survey: telephone and an online survey.

The respondents were initially contacted via phone calls. However, due to the low responses, the study used an online survey, sharing the survey form link via WhatsApp with the respondents. This approach has increased the number of respondents and sped the data collection process. Further, an online survey gives flexibility to the respondents as they may complete the study whenever they have free time online (Evans & Mathur, 2005). The timeframe of the survey is between May to July 2022. The survey was adapted from Mohd Zainol et al. (2019). This study expands the previous study's sample size, including all growers in Peninsular Malaysia. The data collected were descriptive. SPSS statistics software was used to calculate the frequency of mushroom growers that practice sustainable and unsustainable mushroom waste and the techniques used in handling mushroom waste. Some mushroom growers use more than one method in handling SMS and mushroom plastic waste.

### 4. Results

89 out of 212 participated in the survey, based on Figure 1, where 73% were male, and 27% were female. Most mushroom growers are in the 31-40 age group. 66.3% are full-time mushroom growers. Johor (31.5%), Perak (16.9%), and Negeri Sembilan (15.7%) are the top three states with the most mushroom growers. Grey Oyster (65.95) is the most cultivated type of mushroom.

Table 1. The demographic of Mushroom Cultivators

	Number (n=89)	Percentage (%)
<b>Profile</b>		
<b>Gender</b>		
Male	65	73
Female	24	27
<b>Age Group</b>		
Under 30 years old	9	10.1
31-40 years old	29	32.6
41-50 years old	24	27.0
51-60 years old	19	21.3
61 years old and above	8	9.0
<b>Employment Status in Mushroom Farming</b>		
Part Time	30	33.7
Full Time	59	66.3
<b>States</b>		
Johor	28	31.5
Perak	15	16.9
Negeri Sembilan	14	15.7
Kelantan	12	13.5
Terengganu	8	9.0
Melaka	7	7.9
Perlis	5	5.6

#### 4.1 Spent Mushroom Substrate (SMS) Waste Management

The result in Figure 2 indicated that most mushroom growers practice sustainable waste management for SMS (60.7%). According to Figure 3, most growers—45 out of 89—utilise SMS as fertiliser, making it the most widely used approach.

Table 2. Methods Of Managing SMS

SMS Management Methods	Number (n=89)	Percentage (%)
Sustainable	54	60.7
Unsustainable	35	39.3

Table 3. Sustainable Ways of Managing SMS

Sustainable Techniques Managing SMS	Number (n=76)	Percentage (%)
Fertilizer	45	60.7
Sell/Give to Other Parties	35	59.2
Medium Reuse Recultivating Other	20	26.3
Mushrooms/ Crops	9	11.8
Others	2	2.6

#### 4.2 Mushroom Plastics Waste Management

However, the survey results show that for most mushroom farmers, 74 out of 89 still use unsustainable methods in managing mushroom plastic bags (Table 4). Table 5 shows that 38 out of 89 growers handle mushroom plastic trash through burning, the most used method.

Table 4. Methods For Managing Mushroom Plastic Waste

Mushroom Plastics Waste Management Methods	Number (n=89)	Percentage (%)
Sustainable	15	16.9
Unsustainable	74	83.1

Table 5. Unsustainable Ways of Handling Plastic Mushroom Waste

Unsustainable Techniques Managing Mushroom Plastic Waste	Number (n=83)	Percentage (%)
Burning	38	45.8
Dumping At the Garbage Disposal Site	34	41.0
Burying In the Ground	4	4.8
Others	7	8.4

## 5. Discussion

This study conducted a cross-sectional survey on 212 mushroom growers in Peninsular Malaysia. A total of 89 respondents participated in this study. The result of this study showed that most mushroom growers practice sustainable waste management for SMS (60.7%) which contradicts previous studies that showed many farmers tend to handle SMS waste in unsustainable methods (Leong, Ma, Chang, & Yang, 2022; Phan & Sabaratnam, 2012; Umor et al., 2021). However, this study showed a similar finding to other studies as most respondents opted to recycle SMS as fertilisers (Hu, Di, Liang, Liu, & Zhang, 2022). However, the production of fertiliser may cause several difficulties in the long run. The farmers may experience financial implication as the cost to hire labours and the use of new technology will add to their current expenditure, especially when SMS reach a substantial size and composting space becomes scarce. As a result, finding other ways to manage a big volume of SMS, such as integrating a company that produces organic fertiliser, may be necessary. This can help farmers to handle SMS effectively and lessen their burden. This study also found that only a small percentage of them reuse SMS for recultivating their crops. To date, many studies have been done to increase the nutrient of SMS waste for it to be reused and close the loop. It is suggested that other stakeholders, such as MARDI and the Department of Agriculture, promote this type of waste management for the farmers. Knowledge-sharing sessions such as workshops and online support groups can be used to promote other sustainable waste management in this mushroom industry.

One of the significant findings in this study is that most of the respondents chose to manage the mushroom plastic waste in non-sustainable methods. Not only are these methods harmful to the environment and public health, but they also indicate that the mushroom industry in Malaysia is not part of a circular economy. In contrast to SMS, where its waste can be reused and recycled, there should be a guideline for mushroom growers to follow in managing plastic waste. For example, the farmers should be working together with the local authorities to place the waste in the recycling centre effectively.

## 6. Conclusion

In conclusion, Malaysia has enormous potential for the mushroom industry to become a circular economy. However, with the current practices among mushroom farmers in Malaysia, many gaps should be addressed for this industry to be a circular economy activity and sustainable agricultural activity. Putting into effect practical best practices in management could aid in the growth and circular economy promotion of the mushroom industry. Nevertheless, our study found that most farmers have already practiced a sustainable approach to managing SMS waste by converting it to fertilisers. Many other initiatives are recommended to involve stakeholders such as DoA, MARDI, and local authorities to promote and enhance sustainable waste management practices in the mushroom cultivation industry.

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