Description

SporeAttic Mushrooms is a startup commercial gourmet mushroom farm in Bozeman Montana. They partnered with Three Hearts Farm to build their mushroom cultivation facility and officially hit the market in October 2020. Today, they sell a wide variety of specialty mushrooms to local restaurants, farmer's markets and local grocery stores. SporeAttic specializes in a wide variety of Gourmet Mushrooms including Oysters, Lion's Mane, King Trumpets, and Chestnuts.

Challenge

SporeAttic produces about 850-1000 pounds of mushrooms per week. Each strain is grown on defined substrate conditions. Substrate that are being used are the following: hardwood pellets, soy hulls and water. They are bagged all together in 10- or 12-pound unicorn breathable bags depending on the strain. After sterilizing the bags, they can be used. Each strain is also grown in seed bags (oats, barley, etc.) prior to inoculation. Each strain will be inoculated using colonized seeds as an easy transferring method. On average, inoculated bags would stay in the incubation rooms for about 14 days. When the mycelium growth colonized the bag, they are ready to be transferred to the grow room. In the transition from incubators to the grow room, operators make a cut in the bags allowing them a higher air exchange in the grow room, and the fruiting body to come out. On average, bags would stay in the grow room for about 12-14 days. After the growth period, the blocks are collected for harvesting. Unlike most strains, some (lion’s main in this company) will be put back in the grow room for the second flush. At this point, the harvested blocks are considered “spent” blocks and will be discarded as waste.

The “spent” blocks will be de-bagged and stored in bins outside of the facility. The first issue of discarding the “spent” blocks is the space to store them, even temporarily. For instance, at the production rate of 850 pounds/week, 3,400 pounds of “spent” bocks are being produced. The second issue is the odor that being produce, especially to the neighboring businesses. The fastest, and easiest approach to eliminate this problem would be discarding them as landfill. This approach can be costly for the business in terms of storage and transportation to the closest dumpster. Currently, SporeAttic and similar size mushroom companies give away their mushroom spent blocks to neighboring farmlands. The farmers compile the mushroom spent blocks with other composting material and use them as compost. They also use them as mulch in their farming. This approach can be beneficial if the mushroom companies are in proximity of farmlands who are willing to take the mushroom spent blocks on regular basis. On the other hand, the amount of mushroom spent blocks produced, and the farming season can be named as some of the potential disadvantages of this approach. For this approach to be fully effective with not additional costs for the mushroom business, neighboring farmlands must be willing to take all the mushroom spent blocks in all seasons.

As an intern, I have been tasked with addressing the challenge of managing mushroom spent blocks, which amount to 3400-4000 pounds weekly on average.

Proposed and tested solutions

To tackle the spent mushroom block issue, I divided my investigation into two main categories: **1. Short-term solutions 2. Long-term solutions**.

The short -term plan was focused on investigating low-cost immediate solutions to this issue. To do that, I designed simple growth experiments where I re-used the spent mushroom blocks as substrate to growth mushrooms.

For the long-term solutions, I proposed several methods coupled with cost-benefit analysis for each solution including: **1. Composting Business 2. Mulching Business 3. Pellet production**

My initial experiment on reusing spent blocks as substrate for mushroom growth yielded positive results, demonstrating potential for reducing waste and substrate costs. However, recognizing that this is not a long-term solution, I explored composting and mulching as alternatives. Composting could involve selling spent blocks to composting companies or establishing an on-site composting operation, each with its own set of costs and benefits. Similarly, repurposing spent blocks into mulch or pellets present viable business opportunities, necessitating investment in equipment, site preparation, and marketing.

Following one of the main goals of this program; **aiming to reduce or eliminate waste**, the Waste Management Hierarchy (Figure_1) was the core of my strategy to tackle this project's challenge. Re-using and Recycling the spent mushroom blocks fit perfectly with the Waste Management Hierarchy, avoiding the least preferable method, disposal.

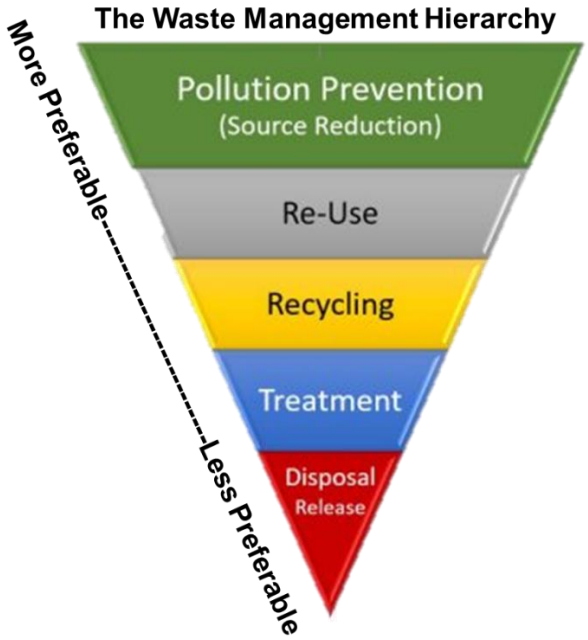

Figure 1: Adopted from EPA's waste management 2022 highlights: https://www.epa.gov/trinationalanalysis/waste-management

Re-using spent mushroom blocks

It is not clear how much of the initial substrate is used by the time mushrooms are harvested after one cycle. **To investigate that, I designed simple growth experiments in different conditions to assess if spent substrates can be used again with/without using new substrate**. This method (if applicable in large scale) can potentially slow down the rate of using new substrate and producing solid waste. In the growth experiments, three main conditions were investigated:

1. **Second flushing**: Using spent blocks directly after harvesting-no treatment
2. **Direct use**: using spent blocks as substrate to grow a new cycle
3. **Mix**: Using 1:1 ratio of spent blocks, and new substrate

The growth experiments were tested using only two strains including Oyster and Lion's Main and each condition was done in triplicates. In parallel, normal production bags with the same strains were being monitored to create a baseline weight profile to be used in yield calculations. As it can be seen in the bar charts (Figure_2), condition_1 achieved the yields of 55% and 65% for the Oyster and Lion's Main respectively. In condition_2, higher yields of 65% and 84% were achieved in the Oyster and Lion's Main respectively. Condition_3 however, resulted in the highest yields of 96%, and 104%, respectively. The growth experiments showed that re-using spent mushroom blocks can result in reasonable yields even when used by itself to produce additional cycles. However, re-using spent mushroom blocks in combination of new substrate in a 1:1 ratio resulted in almost similar amounts of mushroom as the baseline (100% new substrate). It is important to acknowledge that these experiments need to be done in larger scales including all the strains used at the company to be able to make definitive conclusions. Additionally, accepting the process of re-using spent mushroom blocks by the company can be challenging in terms of applicability and sanitary reasons.

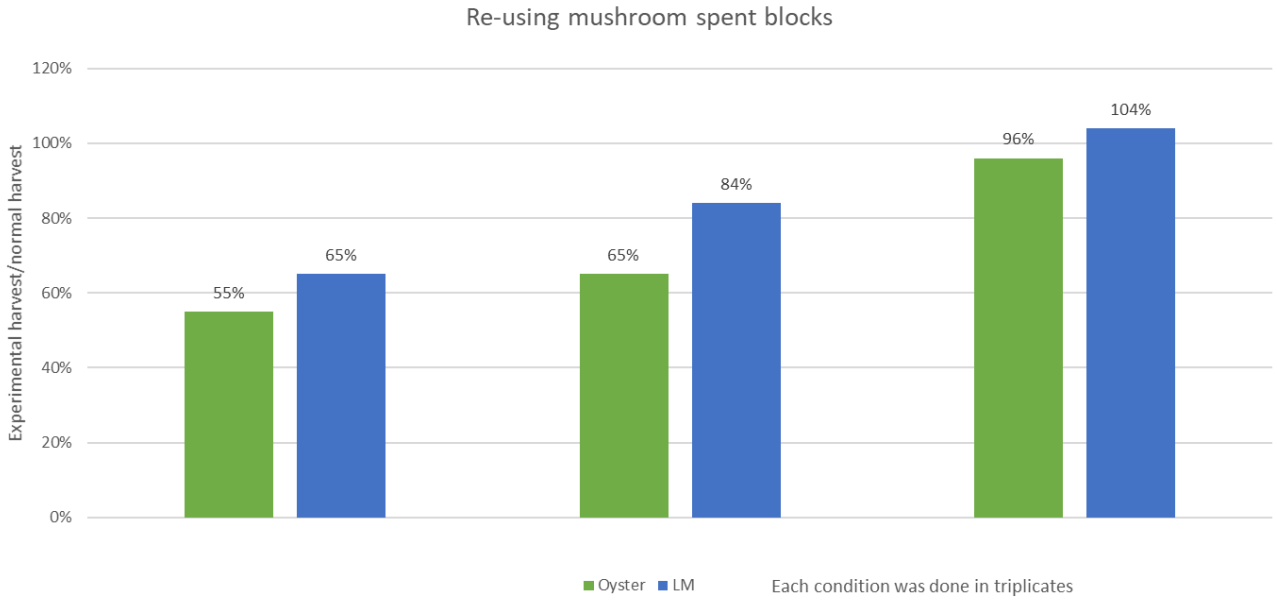

Figure 2: Production yield of re-used spent mushroom blocks in three conditions explained above.

Recycling spent mushroom blocks

As it was explained earlier, spent blocks consist of used and unused wood and soy hull pellets, in addition to fungal mycelium and water. This approach consists of collection of spent blocks, and additional processes to create value -added products. I performed cost-benefit analysis of the following processes which you can see an overview of in the Table_1. The following approaches were investigated in this part of the project: 1**. Composting**, **2. Sell to composting facilities**, **3. Mulching**, **4. Spent Block pellet production**. Requirements, financial considerations and implementation challenges for each approach can be found in Table_2.

Table 1: An overview of cost-benefit analysis of potential long-term solutions to the spent mushroom blocks

Approach	Requirements	Financial Considerations	Implementation
Composting	Space, composting equipment, personnel	Initial investment, operations	Cost-benefit analysis
Sell to composting facilities	Potential buyers, pricing and delivery terms	Transportation costs	Market research, pricing strategy, logistics
Mulching	Space, shredding and packaging eq	Initial investments, operations	Cost-benefit analysis
MSB pellet production	Space, pellet mill machine, packaging eq	Initial investments, operations	Can be used as fuel, additional cycles

Conclusion and Recommended P2 actions

The spent mushroom block's physio-chemical properties, its high content of bioactive compounds, and readily available macro- and trance elements make it a potential candidate for several agricultural applications. Therefore, recycling them with the purpose of creating value added products such as compost, mulch, and pellets would essentially eliminate this growing waste stream. On the other hand, re-using the spent mushroom blocks can also be used to reduce the rate of waste production. With that, Table_2 goes over the **recommended P2 action items** and potential annual reductions in resources coupled with some of the implementation barriers.

Table 2: Recommended P2 action items, Annual Reductions, and Barrier to implement each investigated approach

Recommended P2 actions	Annual reductions	Barrier to implement
Re-using mushroom spent blocks	50% reduction of raw materials (HW, soy), 30-40% reduction of water	Re-designing workflow, more data to support the claims
Re-purposing spent blocks	Complete elimination of waste by creating value-added products	Initial investments, cost-benefit analysis
5S and Lean practices	Reduction in overproduction and defects	Future employee training

Acknowledgments

Jenny Grossenbacher
Barbara Watson
Alistair Stewart
Wan-Yuan Kuo

Benjamin Deuling
Becca Finch