SENIOR CAPSTONE/
SENIOR DESIGN EXPERIENCE
2024

Oyster Mushroom Cultivation

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Background

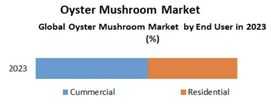
Growing demand for healthy, sustainable food drives attractive oyster mushroom market.

Oyster Mushroom Market Size

2023	2030
US$ 54.34	US$ 84.33

Market Size in billion

7.6 % CAGR
Oyster Mushroom Market to grow at a CAGR of 7.6 % during 2024-2030



Oyster Mushrooms

Oyster mushrooms are prized for their delicate flavor and versatile culinary applications, boasting a mild, nutty taste and a firm, meaty texture.

Objective

Our oyster mushroom production plants and business model prioritize profitability while minimizing environmental impact through efficient operations and sustainable sourcing practices.

Ethics, Competitors, US Market

FAIR LABOR PRACTICES | SUSTAINABLE CULTIVATION METHODS | RESPONSIBLE MATERIAL SOURCING | INNOVATIVE CULTIVATION TECHNIQUES | BRANDING FOR CONSCIOUS CONSUMERS

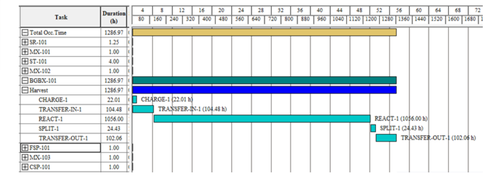
Annual Production, USA	~30,000 tons 2022	1500 tons Our production goal	Large-Scale Producers	The Green Yard, Bonduelle, Monaghan Group
Market Costs and Pricing	~$11.45/kg US Oyster Mushrooms	& $1.58/kg Raw Materials $	Med-Scale Producers	Monterey Mushrooms, CMP Mushrooms, Highline Mushrooms, Carolina Mushroom Farm
Per Capita Consumption, USA	3.65 lb Fresh Mushrooms	→ 1.54 lb Oyster Mushrooms	Regional Producers	R&R Cultivation, Smallhold, Ellijay Mushrooms

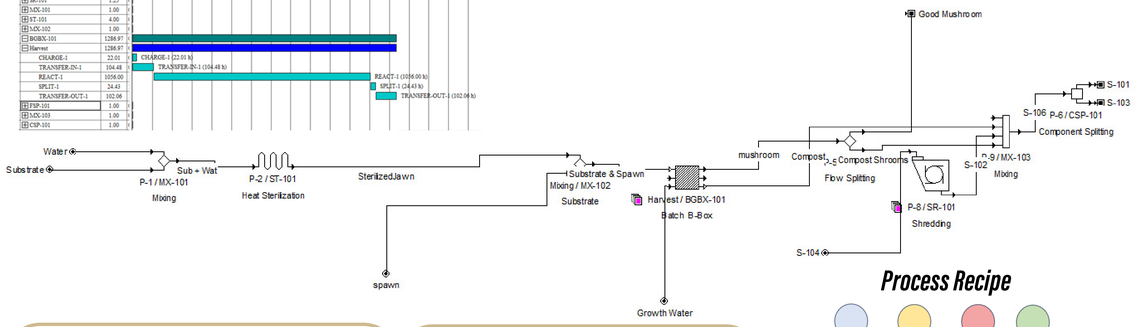
Experimental design

Process Overview:

- **Three major unit operations**:
  - Sterilization
  - Growth & Harvest
  - Composting
- **Sterilization:** Find the optimal method and conditions for an autoclave to effectively sterilize substate.
- **Growth & Harvest:** Determine the optimal environmental and timing conditions to harvest mushrooms at a most profitable rate in terms of yield, sales, and product quality.
- **Composting:** Determining the ideal nutrient concentrations to ensure healthy grow of microorganisms within the mixture

Production Process





Sterilization

- **Output**: Sterilized wheat straw for various uses.
- **Resources**: 1535 tons wheat straw, 4725 m^3 water, 8.5 kW/h electricity/ton, 48,750 kg steam/ton.
- **Soaking**: 24-hour soak in 50-60°C water.
- **Sterilization**: Autoclaves at 15 psi (121°C) for 45 mins.
- **Quality Assurance**: Second 45-min sterilization cycle.

Harvest

Harvest Scheduling
- 3 flush cycles harvested/batch
- 1 week fruiting between harvests

Harvest Data Estimates
- ~62.5% of product harvested in flush 1
- ~25% of product in flush 2
- ~12.5% of product in flush 3
- 242 man hours/flush per room to harvest (8hrs/person w/ 32 ppl)

Mixing

Process Scheduling
- Used to mix sterilized substrate and solid mycelium spawn
- Streams combined in growth trays for placement in growth rooms

Stream Composition
- 18.9% Spawn (w/ mycelium)
- 81.1% Sterilized substrate (dry)

Composting

Unit Process
- Incorporating mushrooms from harvesting to reinvigorate the following compost batches
- Water from sterilization
- Three different phases: Mesophilic, Thermophilic, Maturation and cool-down

Growth

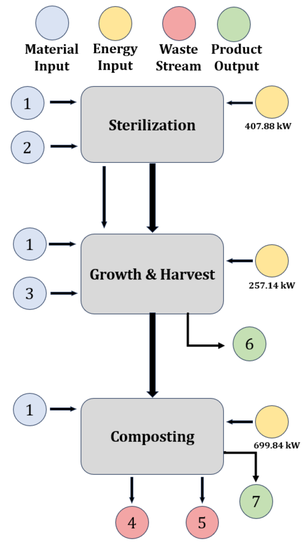
Growth Scheduling
- Incubation period: ~23 days
- Fruiting period: ~21days
- Cleaning period: 1 day (automated)

Operation Conditions
- Temperature: 19°C
- Humidity: 90%
- Airflow Exchange: 9 times/hr

Operation Data

- 4 Identical Production Rooms
  - 8 batches/yr per room
  - 32 batches/yr total
- Batch Time: ~44 days
- Plant Operation: 360 days/yr
  - 8 hrs labor/day
- Labor Costs per kg product
  - $1.07/kg mush | $0.18/kg comp

Process Recipe



Stream	Component	kg/batch
1	Water	1,601,668
2	Substrate	43,520
3	Spawn	10,142.61
4	Waste Water	45122.32
5	Residual Waste	54,153.75
6	Mushroom Product	43,520
7	Compost Product	51,180

Total Production Rate

1,392,640 kg/yr mushroom
1,637,772 kg/yr compost

Power Consumption

43,675 kW/year

Raw Material Requirement

1,392,640 kg/yr dry substrate
324,563.5 kg/yr spawn
51.253*10^6 kg/yr water

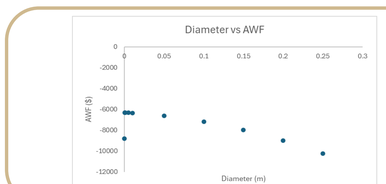
Waste Production

1,443,914 kg/yr water
1,732,919.15 kg/yr residual

Process Optimization/Controls

Batch Size/Autoclaves

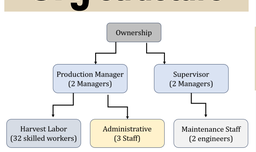
Optimal batches: 10
Optimal batch size: 0.5 m^3
Optimal autoclaves: 12
Max AW: $4,924,308.80
Controls: RTD, Pressure Transducer, Valves, Boiler, Pump, Motor, Proximity Sensor



Water Recycling

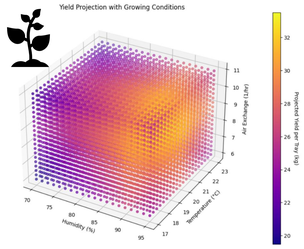
Reuses: 86,990.32 L/day
Initial investment: ~$700,000, yielding quick savings.
Components: pre-filtration, ultrafiltration, UV disinfection.
Benefits: Water efficiency, streamlined operations, sustainability.

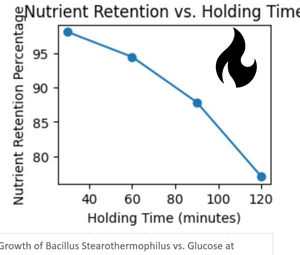
Org structure



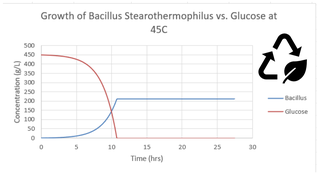
Labor Breakdown:
- Harvest Labor: $52.94/hr
- Administrative budget: $179, 091/yr
- Supervisor & maintenance: $305k/yr
- Manager budget: $179,091/yr

Experimental Results





Performance curves were validated and used to make decisions regarding processing conditions.



Economic Analysis

Total Product Cost

$5.943 million/year

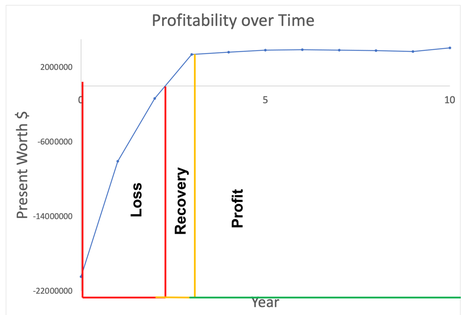
Manufacturing Cost

$4.336 million/year

Total Capital Investment

$20.46 million

Profits expected in Year 4



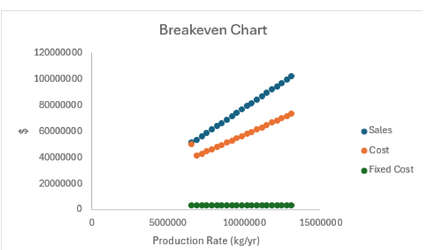
Assumed Sale Price

$7.8/kg (average of products)
$11.45/kg mushroom
$0.7147/kg compost

Breakeven Point

50% capacity

Breakeven occurs at 0.65 million kg/year



Future Improvements

- Closed-loop nutrient cycling enhances sustainability in mushroom production.
- Reintroducing leachate stream improves compost quality and reduces costs.
- Revitalize Spent Mushroom Compost
- Alternative Substrate impact on Yield
- Alternative Sterilization techniques (chemical/heat exchanger)

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