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OYSTER MUSHROOM

PRODUCTION GUIDE

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LEA
LOCAL ENTERPRISE AUTHORITY

BUAN CONSULT

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SUMMARY

The oyster mushroom production guide details the oyster mushrooms production process from start to finish including all structural requirements and inputs over a 13-week production cycle. The mushroom common pests and diseases are also identified along with their management measures. Production of oyster mushroom is suitable for all areas of the country as production is done in structures. Where temperature control facilities are available, production can be done throughout the year. This guide is suitable for use by SMME and backyard farmers who have undergone some basic training of mushroom production.

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OYSTER MUSHROOM PRODUCTION GUIDE IN BOTSWANA

SYNOPSIS:
Mushroom production in Botswana is still at infancy stage mainly due to limited knowledge and skills required to successfully run the business. In general mushroom cultivation is new to Botswana and this has resulted in fewer people venturing into the technology. The Government of Botswana pronounced a ban on the importation of mushrooms from 1st July 2024, and now there is a tremendous interest from local farmers to take up mushroom production as a business. There is a huge deficit in the supply of fresh mushrooms and many local farmers want to scale up the production in order to close on the mushroom shortage created by the ban. The main purpose to produce the Oyster mushroom guidelines is to develop a working tool that can be used by new and aspiring Oyster mushroom producers. The guidelines were developed specifically for small and medium scale enterprises to help establish Oyster mushroom cultivation.

Mushroom cultivation in Botswana is still low even though more than two hundred participants have been trained in Oyster mushroom production at Botswana University of Agriculture and natural resources (BUAN) through the Centre for Inservice and Continuous Education (CICE) since 2007. The CICE one-week short course was developed to expose potential and aspiring mushroom farmers on the general principles of mushroom production. The slow uptake in the technology was mainly due to lack of funding to start up the business as most financial institutions in Botswana did not have a funding model for mushrooms. This has however changed as there has being developments recently, some funding institutions are now funding mushroom production projects. The number of people funded is still low, but it is promising. Unfortunately, it is difficult to know the exact number of farmers who have benefited from the funding. Currently, it is difficult to get records of farmers who are producing mushrooms since most of the farmers were producing low quantities.

The demand for mushrooms in Botswana increased in monetary terms from P11 million in 2021 to P14.2 million in 2023. The increasing demand is met through imports with majority (99.89%) of fresh and frozen mushrooms sourced from The Republic of South Africa (WITS,2022). The import data of Mushrooms as per Tables 1 and 2, provide enough evidence for the demand for mushrooms in Botswana.

Table1: Botswana's Mushroom imports for three years

YEAR	2021	2022	2023
IMPORTS (PULA)	11,031,611.10	12,049,663.23	14,283,551.01

Source: Statistics Botswana 2024 (Accessed 09 August 2024)

Table 2: Botswana Mushrooms, fresh or chilled imports by country in 2022

Importer	Partner	Trade Value 1000USD	Quantity (Kg)
Botswana	World	988.88	278 987
Botswana	South Africa	987.81	278 861
Botswana	Namibia	0.75	93
Botswana	Uganda	0.28	11
Botswana	Zambia	0.02	20
Botswana	Zimbabwe	0.02	1
Botswana	China	0.00	1

Source: World Integrated Trade Solutions (2022)

The data provided in Table 1 and 2 does not separate mushroom imports by species and this makes it difficult to know which type of mushrooms are mostly imported. In the future, separation of production by species will be informative for funders and the farming community. The high import bill for this commodity suggest it has an opportunity that's is mainly untapped/ unexplored as a commercial crop, locally. The recent inclusion of this crop in the list of crops banned from being imported into the country also makes it a very viable enterprise for consideration by local farmers.

BACKGROUND ON OYSTER MUSHROOMS

There are many types of edible mushrooms in the world and in Botswana the common naturally occurring edible mushroom is the Termite Mushroom known as Termitomyces species, the local Setswana name is Lebowa la seolo. Apart from the termite mushroom, most local communities regard other mushrooms poisonous and there is a lot of fear around eating or foraging for mushrooms. Some of the common mushrooms locally available in the retail stores are White button mushroom (Agaricus bisporus), Brown button mushrooms (Agaricus bitorquis), King oyster mushroom (Pleurotus eryngii), Shiitake mushroom (Lentinula edodes). Oyster mushrooms are one of the edible and easy to cultivate mushroom types that utilizes locally available farm resources to grow. Many people who are not mycologists often refer to all gilled mushrooms fungi as oyster mushrooms, but the name oyster mushroom is reserved for species in the genus Pleurotus. There are several species of the edible gilled mushrooms in the genus Pleurotus and the most common types are Pleurotus ostreatus, P. sojar-caju (currently named as Lentinus spp), P. ostreatus x P. florida just to mention a few. These types of mushrooms are available in different colours ranging from white, grey and coral based on the strain type. The most common cultivated species in the world is P. ostreatus which has several strains associated with the cultivated types.

WHAT ARE OYSTER MUSHROOMS?

The genus name Pleurotus literally means side ear in reference to the mushroom caps being laterally attached to the substrate (Wikipedia, 2024). Most of the species are found naturally in the tropical and sub-tropical regions of the world occurring as saprophytes on decay woods. However, the cultivated oyster mushrooms can grow successfully and profitably on many cereal stubble or straw substrate. The substrate used is often guided by the naturally or cultivated cereals and grasses available in a region. Common substrates are rice, wheat, maize, sorghum, sawdust and some grasses. In Botswana, research work conducted by Khonga et al, 2007 has shown that sawdust, maize cobs and straw, sorghum straw, pearl millet straw can serve as substrate for oyster mushroom production. Jongman et al. 2013 reported that oyster mushrooms can grow on some grass species such as Cenchrus celiaris, Eragrostis pallens and the water reed Phragmetes sp.

OYSTER MUSHROOMS AS A FOOD SOURCE

Oyster mushroom production is among top ten cultivated mushrooms in the world. Hoa et al. 2015 reported that oyster mushrooms are the third largest commercially produced mushroom in the world. Its popularity is mainly due to its nutritional and medicinal properties as well as the ease in production. Several researches carried out showed that Pleurotus species are a rich source of protein, minerals (P, Ca, Fe, K, and Na) and vitamin (thiamine, riboflavin, folic acid, and niacin (Szbova et al. 2013). Apart from food value, their medicinal value for diabetics and in cancer therapy has been emphasized (Sivrikaya et al. 2002). Numerous mushroom species contain a wide range of metabolites as antitumour, antigenotoxic, antioxidant, antihypertensive, antiplatelet aggregating, antihyperglycemic, antimicrobial, and antiviral activities. The popularity of oyster mushroom production is because of their simple, low cost production technology and high biological efficiency (BE).

REQUIREMENTS TO START AN OYSTER MUSHROOM ENTERPRISE

To start any business enterprise, it is important to ensure that a farmer has studied the market and is aware of its requirements. Oyster mushroom farming is different from other vegetable production methods such as tomato and cabbage production and as such it is highly recommended that mushroom farmers should attend a short training course on the principles of mushroom production before they start production. Mushrooms are fungi and hence their requirements are specific, and it is essential to always maintain sterile conditions to reduce contamination. Basic requirements to start the mushroom business are the following:

i. Land to build the production structures and the sheds.
ii. Structures to produce the mushroom.
iii. Reliable and good source of spawn (mushroom seed).
iv. Good and readily available substrate.
v. Clean water supply.
vi. Electricity and Airconditioning (One can operate a successful business without electricity).
vii. Consumables.
viii. Market access.

LAND REQUIREMENTS

Mushroom production does not require a lot of land. An area of two hundred and fifty square metres (250 sqm) is the recommended minimum area big enough to produce a viable and profitable crop. The area is required to have all your consumables and equipment within reach. The most essential element is determined by the size of the production. Under ideal conditions one requires at least one production structure of about 30 sqm (6m length * 5m wide *2.5m high), a shaded structure of 50 sqm for storage of straw, firewood and drums required for sterilization. A mushroom project for small scale farmer can be done at the backyard building or structures.

MUSHROOM STRUCTURE/S

The design concept can be tailor made for each enterprise. A functional oyster mushroom house should be cleaned at specific intervals. The structures can be constructed using locally available resources such as mud/thatching grass, concrete structures with bricks or stones and modified structures using steel and aluminum metal sheets for roofing. Optimal designs can use grass thatching or corrugated iron sheets for roofing. The critical consideration in a mushroom production structure is to maintain temperature and humidity within prescribed ranges to meet its requirements at different growth stages.

Fig 1: Backyard design with water reed (letlhaka la noka). Pandamatenga
(source Mr. Wylton K. Digangwa)

Fig 2: Converted brick and mortar
(source Mr. Kutlo Mokwena)

Fig 3: Mushroom house using thatching grass panels and gum pole.
(Source: Prof EB Khonga)

Fig 4: Mushroom house from Cold storage
(Source Prof EB Khonga)

Fig 5: Mushroom house with a provision for a shade area or preparation area

Fig 6: Mushroom house design showing the plastic lining on the walls and shelving of the growing room to accommodate multiple production system

Single structure design

One can successfully run an Oyster mushroom business from a one roomed structure. The room can be adapted to function as both the growing room as well as the fruiting room. The only challenge is that the farmer will now be producing mushrooms on a three (3) to four (4) month cycle. Hence, they can only put three (3) production cycles per year depending on energy supply. In Botswana, farmers can successfully produce mushroom from September (Spring) to end of March (Autumn) without electricity, just depending on the weather and they will have to monitor temperature and relative humidity very well. The winter temperature will result in no crop as the spore undergo the dormant (overwintering) phase where there is no supplementation of heat. Where there is electricity an air conditioner can be installed to cater for the winter and summer temperatures, allowing for an additional production cycle.

Normal dimensions for an ideal single room will be 6m length by 5m width and a height of 3m.

Two structures design

Two houses are most preferred for small scale farmers as this allows for continuous production of mushrooms provided the conditions stipulated above are met. One room will serve as the growing room while the other room serves as the fruiting room. In this design, a farmer can continuously produce the mushroom crop for the entire period without a break except for winter where there is no electricity. The only break periods can be scheduled for cleaning and fumigating the rooms to maintain high sterile conditions.

Fig 7. 2 Mushroom houses (Grass Thatched)

Three structures design

This is the most ideal and profitable design for small to medium scale enterprises. The design has high returns as there will be continuous production without the break periods. One room will be a dedicated for spawn running (growing room) while the other two rooms function as the fruiting rooms.

Additional considerations will be for materials used for shelving and hanging of bags. Locally, small and medium scale farmers can use gum poles, timber or aluminum for shelving.

Fig 8. Shelving using wood or iron/steel material

Fig 9. Shelving using wood or iron/steel material

SOURCE OF SPAWN

The spore is the seed of the mushroom and a good sterile and actively growing spawn is required. There are different strains of Oyster mushrooms available in the world and there are mushroom producers within the SADC region. The choice of strain is dependent on what the market demands. The main supplier for mushroom spawn is Sylvan Africa in South Africa.

Caution: Farmers must purchase spawn from a reliable and reputable supplier to avoid purchasing the poisonous or contaminated mushrooms.

WATER SUPPLY

Good and reliable supply of clean water is required for mushroom production. Water is used for soaking the substrate (straw) as well as cleaning of the walls to encourage humid conditions. Clean portable or borehole water is adequate.

CONSUMABLES

Mushroom production requires fewer resources and consumables. It is important to accumulate these consumables before the production can start. The quality of the substrate is essential for ease in production. Something like a rotten straw can hugely disrupt the production cycle due to contamination. Mushroom production is an art that develops with time and practice; hence one perfects the technology with time and observation.

ELECTRICITY (ENERGY SOURCE)

Electricity (solar panel or other forms) supply is an added advantage to allow the farmer to produce throughout the seasons without weather disturbances. Maintaining the proper and constant temperatures during spawn running and fruiting phases is the major limiting factor in mushroom production. A slight fluctuation may result in no mushrooms being harvested.

Farmers can be innovative by designing a custom-made heating element that can reticulate warm water through the pipes in the room to cater for cold days in winter.

Fig 10. Boiler room suppling hot water to the mushroom house
Picture: Annetjie (Kgope Farm)

Take note that farmers can still produce a decent harvest from Spring to Autumn in Botswana without the need for electricity supply. Humidity can be managed by sprinkling water on the floor lined with river sand.

MARKET ACCESS

Farmers need to identify the markets for their produce well in advance to avoid spoilage. The mushroom is more that 85% water and hence it has a shorter shelve life for a fresh crop. Alternatively, mushrooms can be air/sun dried to improve the shelf life. It is important to understand what the market requires well in advance.

MUSHROOM PRODUCTION PROCESS

STEP 1: DETAILED PLANNING

a. Source spawn: Source Oyster mushroom spawn (seed) at least weeks before starting the production. The spawn must be fresh and actively growing in order to be fruitful.

b. Growing Materials: Collect substrate and store in a dry shaded area. Currently in Botswana wheat straw is readily available in most retail shops that sell animal feed. It comes in bales of 50kg or 200-250 kg, Wheat straw does not require chopping as compared to maize straw or other types of substrate.

c. Helping Hands: Ensure to secure extra help for substrate preparation and inoculation steps. Labour requirements frequency will be determined by production system. Oyster mushrooms can be produced on a three to four (3-4) months cycles or can be done on a weekly basis depending on the production and product demand.

Fig 11. Substrate Preparation step is labour intensive.

Equipment: Basic equipment for Oyster mushroom production include 200L oil drums, firewood, steaming cage, drum stand, pvc pipe necks, rubber bands, sanitizer bottles growing bags, gloves (heavy duty and sterile gloves) and others.

Fig 12. 10L drum used for pasteurization.

Fig 13. Modified fire stand made from iron rods.

Fig 14. Custom made cage used for steaming th substrate.

STEP 2: ORDERING SPAWN

Spawn must be secured before substrate preparation and be stored in a cool (23-25 °C), dark place free from contamination. Acquire spawn from a reputable source, the choice of spawn can be determined by the substrate used.

Table 3: Table showing the amount of spawn required to inoculate the substrate based on the spawning rate.

Weight of substrate	100 kg (40 bags)	250 kg (100 bags)	500 kg (200 bags)
Weight of spawn (kg) at 5% spawning rate	5	12.5	25
Weight of spawn (kg) at 10% spawning rate	10	25	50
Shipping Costs (BWP)	1000.00	1500.00	2500.00

[* 2024 prices, subject to change annually.]

The price of Oyster mushroom spawn from the SADC region is in the range of approximately BWP 80.00 to 120.00 per kilogram depending on the strain and species used. Always order an extra 1-2 kg excess to cater for more substrate. Always cater for price fluctuations due to currency exchange rate and value added tax.

Table 4: Table showing the estimate price of spawn based on the total weight of substrate

Weight of substrate	100 kg (40 bags) at P120.00/kg	250 kg (100 bags) at P120.00/kg	500 kg (200 bags) at P120.00/kg
Estimated price at 5% spawning rate	600.00	1500.00	3000.00
Estimated price at 10% spawning rate	1200.00	3000.00	6000.00
Shipping Costs (BWP)	1000.00	1500.00	2500.00

[* 2024 prices, subject to change annually.]

Fig 15. Oyster mushroom spawn in growing on sorghum seed.

Fig 16. Oyster mushroom packaging in bulk

STEP 3: SUBSTRATE PREPARATION

Pleurotus spp. can be cultivated on fermented (composted)or unfermented agro-waste rich in cellulose and lignocellulose. Use of a substrate depends on availability, and semi-arid regions like Botswana the substrates available are:

1. Maize stalks
2. Maize cobs and husks
3. Millet stalks
4. Sorghum stalks
5. Sawdust
6. Wheat straw

An ideal substrate should:

1. Provide good anchorage to the mycelium.
2. Provide good aeration.
3. Have the right water holding capacity.
4. Contain the necessary nutrients.
5. Be selective for the mushroom being cultivated.
6. Be readily available.

PREPARATION OF STRAWS AND CORN COBS AND MUSHROOM PRODUCTION.

CHOPPING

Maize stalks, Sorghum stalks or millet stalks should be chopped into pieces about 2 – 4 cm long. If the pieces are too large, it is difficult for the mycelium to effectively colonize, it is difficult to moisten and is not easy to pack in bags. Chopping can be done by hand using a knife or axe or by using a machine such as a chaff cutter.

Corn cobs should be broken into pieces 2 – 3 cm long using a harmer or hammer mill.

MOISTENING

The substrate should be moistened to 70% moisture content. To remove anti-fungal compounds in saw dust and millet and sorghum stalks, the substrate should be soaked for 12 – 24 hrs. and the red tannins washed off.

FERMENTATION AND SUPPLEMENTS

Supplements to improve the nitrogen content of the substrate can be added before fermentation. Wheat bran (10 – 20%) and lime (1%) can be added to the moist substrate. Addition of lime helps with increasing the substrate pH to about 8-9. The substrate is piled into a cone shaped pile and allowed to ferment for 3 – 4 days. Pleurotus spp can also be grown on a substrate without prior fermentation.

Option 1:

Table 5: Table showing the number of production bags produced based on substrate weight

Substrate weight	100 kg	250 kg	500 kg	1000 kg
Number of bags produced	40	100	200	400

For small scale farmer or a farmer producing without additional amendments to straw. The calculations are based on small bags of 2.5 to 3kg.

Option 2:

Table 6: Table showing the formulation and proportion straw and other additives

Substrate weight	100 kg	250kg	500 kg	1000kg
Wheat straw	90kg	225	450	900
Wheat bran (10 % of straw)	9 kg	22.5	45	90
Wheat bran (10 % of straw)	1kg	2.5	5	10

For farmers with additional amendments to wheat straw to improve Nitrogen content.

PASTEURISATION

Pasteurization can be done in 2-3kg bags or in bulk, both methods are acceptable.
The bags are placed in 210 litre drum in a cage and steamed for 2 – 3 hrs.

Alternatively, the substrate is steamed in bulk in the 210 litre drum and after cooling, the substrate is placed in the bags. It is necessary to wear rubber gloves when handling the steamed substrates to minimize contamination by bacteria from the skin.

Fig 17. Oyster mushroom packaging in bulk

Fig 18. Oyster mushroom packaging in bulk

Place the 210 L drum on a fire stand.
Fill the drum with water up one quarter capacity until the straw is submerged in water
The next day remove the dirty water and placed the wet straw inside the cage and steam in a steel drum.

Preparation of straw before pasteurization.

Fig 19. Cover the drum with a lid and sterilise with steam for 4-8 hrs Allow the straw to cool down and place the straw in a clean room for bagging.

BAGGING

The substrate is placed in plastic bags a little at a time and pressed down. 2 - 3 kg of substrate per bag have been found ideal. The neck of the bag is tied with rubber band or alternatively, PVC piece (3cm diameter) is used as a collar and the plastic is tied around the collar with a rubber band.

STEP 4: SPAWNING

Spawning is done in a clean house or room. 5 – 10% (50-100g spawn per Kg of substrate) spawn is sprinkled on the substrate in the bag. The spawning rate can range from 2 – 10 % depending on an individual. The smaller the spawn the longer it will take the mycelium to colonize the bags. The mouth of the bag is made with a PVC pipe cut into small pieces and the mouth is plugged with cotton wool and tied with rubber band. Alternatively, PVC piece.

(3cm diameter is used as a collar, and plastic is tied around the collar with a rubber band.)

Fig 20. Spawned bags arranged in shelves in a growing room. Indicate the inoculation dates and spawn used on the bags to make it easy to onitor the bags.

STEP 5: SPAWN RUNNING

Bags are placed on shelves and covered with black plastic to ensure darkness. The mushroom house should be closed, and temperature should be 25 – 30 °C. Spawn running takes 14 – 35 days depending on temperature and vigour of spawn. On average 28 days are ideal.

Fig 21. Bagged spawns

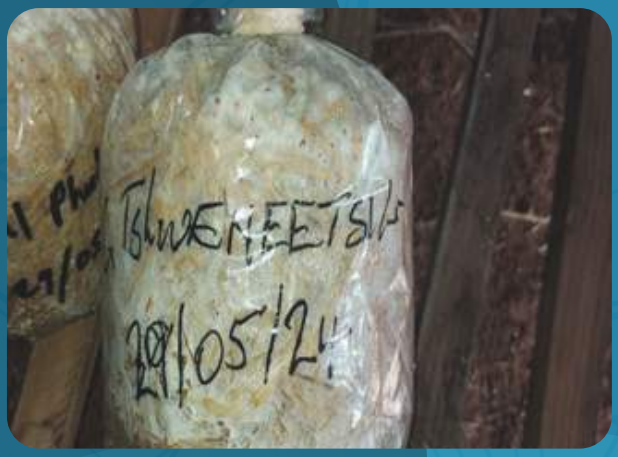

Fig 22. Bagged spawns

STEP 6: MUSHROOM INDUCTION

When spawn running is complete holes are made in the plastic bags to create space for mushrooms to come out. The bags should be hung in timber rafters in the growing mushroom house or placed in shelves. The house is made humid and cool (20 – 26 °C) by sprinkling the floor and walls with water. The house should have enough light during the day to induce pin formation and development of mushrooms.

Fig 23. Bags hanging in the fruiting room. Note that the bags are hanging to allow for easy harvesting and removal of spent bag.

Fig 24. Modification in the fruiting room to allow for light which is required for fruit formation.

Fig 25. Mushroom bags showing the pins and development of the fruits. The bags are hanged to create more space for air circulation.

Fig 26.Pin developing into mushroom (fruit).

Fig 27.Pin developing into mushroom (fruit).

The mushroom doubles in size everyday after the pin development.

Fig 28.Pin developing into mushroom (fruit).

Fig 29.Pin developing into mushroom (fruit).

The mushroom doubles in size everyday after the pin development.

STEP 7: MUSHROOM HARVESTING & PACKAGING

From pinhead to mature mushroom oyster mushrooms normally take about 3 – 4 days. Mushrooms should be picked from a bag without leaving any stubs sticking from the bags. This is achieved by twisting the stalk near the point of emergence. Use of knives to cut mushrooms from the bags is not recommended. Mushrooms are produced in flushes and up to 5 flushes are produced before the substrate is exhausted.

Fig 30. Mature mushroom

Fig 31. Mature mushroom

The stubs are brownish and should be cut off with a knife during processing and packaging.

The mushrooms are packed into punnetts or plastic plates in 200/250g mass and covered with cling wrap with the gills facing upward. Mushrooms should be stored in the fridge until they are consumed.

Fig 32. Packaging in a punnet with gills facing down (left)

Fig 33. Packaging in a punnet with and gill facing up(right)

STEP 8: PRESERVATION OF OYSTER MUSHROOMS

REFRIGERATION

Fresh mushroom can be kept in the fridge (5 –10 °C) for about 7 days. Prolonged storage of oyster mushrooms at low temperature makes the mushrooms to be fibrous and tough. Mycelium also begins to grow between gills and the flavour deteriorates.

DRYING

Oyster mushrooms can be dried in the sun for two to three days and sealed in plastic bags. Dried oyster mushrooms are exported or sold to the local market. The mushrooms can be dried whole or in slices.

FREEZING

Freezing can be done in the home if one cannot use all mushrooms at once. Once frozen the mushrooms should not be allowed to thaw and freeze again. To cook frozen mushroom, one should place the frozen mushrooms directly into the pot without defrosting.

STEP 9: DISPOSAL OF SPENT MUSHROOM BAGS

After completion of harvesting, the mushroom spent bags must be removed from the fruiting rooms and be disposed. The spent bags can be mixed with the compost material for Button mushrooms or dries and/or used as an animal feed due to its high digestibility.

COMMON PROBLEMS DURING SUBSTRATE SPAWN RUNNING

1. Growth of Mycelium very thin and slow
Causes: Substrate lacks nutrients, Substrate too fine, no aeration, excessive amount of rice/ wheat bran creating too fine a structure. (This common in substrates like saw dust).

Solutions: Add right levels supplements, do not chop substrate into very small pieces, create a hole in the centre of bag for aeration and heat exchange.

2. Mushrooms take too long to appear after bag is opened
Causes: Mycelium does not mature, temp too high or too low for fruit body formation, humidity too low, poor ventilation, Spawn too weak/degenerated.

Solutions: Allow mycelium to mature after inoculation, expose to correct temperature, maintain at least 85% RH in the house by frequent watering, Open ventilators, Use reliable spawn.

3. Mushrooms do not grow as large as expected or are deformed

Causes: Spawn weak, insufficient nutrients; too many fruits developing at the same time, nutrients diminishing after several flushes, virus infection.

Solutions: Use reliable spawn; increase supplements; Allow few fruits to develop by opening bags in fewer places; spray substrate with soluble fertilizer, used virus free spawn.

4. Mushrooms rotting before picking
Causes: Fungal or bacterial infection; Insect pest infestation, excessive watering.

Solutions: Discard mushrooms or bag to prevent disease spread, avoid direct watering on developing fruits.

5. Mushrooms long with thin stalks
Cause: Insufficient light.

Solution: Provide sufficient light during the day (for oyster mushrooms).

COMMON PROBLEMS DURING SUBSTRATE SPAWN RUNNING

Pests and diseases adversely affect the mycelium growth and reduce quantity and quality of mushrooms. Outbreak of pests and diseases are directly linked with poor sanitation or improper preparation of substrate.

In mushroom production, prevention of diseases/pest outbreak is better than treating the outbreak because it is difficult to control the problem on the actual mushrooms.

Impact of pests and disease on mushrooms

Pests and diseases affect the mushrooms crop in the following ways:

- By preventing mycelium from colonizing the substrate during spawn running
  eg. Rats/mice consuming spawn before colonization.

- By destroying the plastic and substrate thus contaminating it. This is caused by mice or rats making holes in plastic and destroying substrate. In winter, the mice use the substrate as material for a nesting place.

- By colonizing the substrate faster than mycelium of the mushroom. This is common with fungi such Trichoderma spp which out compete the mushroom for nutrients.

- By production of antibiotics which stop the growth of the mycelium of the mushroom (eg. Bacillus bacteria).

- By feeding on the growing mycelium eg. Mites, insect larvae and parasitic fungi.

- By attacking and damaging the fruit body directly
  eg fungal and bacterial diseases, feeding by cockroaches, larvae and snails.

Identification of Causal Agent

Proper identification or diagnosis of the disease or pest is vital before control measures can be carried out for insects and mites, proper entomological keys or manuals should be used and for fungi and bacteria - proper disease diagnosis manuals should also be used. If possible, the biology of the pathogen or pest should be studied in order to understand how it gains entry and spreads in the house.

Main groups pests and pathogens:

The main groups of organisms which cause problems in mushroom cultivation include insects, mites, nematodes, snails, rodents, parasitic fungi, saprotrophic fungi, bacteria and viruses.

Some groups of pests and diseases affect a wide range of mushroom species while others are specific to specific mushroom species.

PREVENTION OF PESTS AND DISEASES

The best way of preventing diseases and pest in mushroom cultivation is strict hygienic measures. These include the following:

- Cleaning the house after a production cycle before the next.
- Walls inside the house should be washed with water and disinfected with formalin or bleach or steam
- Start picking mushrooms from uninfected substrate.
- Inspect the house from uninfected to old substrate.
- Disinfect picking containers before re-using.
- Keep doors and windows closed or have wire mesh on doors and windows to keep out insects
- Spent compost heap should be far away from the growing rooms or farm or should be burnt.
- Remove aborted or undeveloped pins from the substrate
- Keep floor of house clean, sweep soon after picking to remove fallen mushroom
- Do not leave cut stalks on the substrate or in the house.
- Do not touch sick fruit bodies during picking. Collect them at the end and bury them.
- Remove contaminated bags of substrate as soon as contamination occurs.
- Dip shoes in disinfectant before entering the growing room.

Application of chemical pesticides while mushrooms are growing is not encouraged since the chemical can be adsorbed into the mushrooms. This can adversely affect the safety of mushrooms to the consumer.

MAIN GROUPS OF PESTS AND DISEASES AND THEIR CONTROL

INSECTS

Mycophagous insects feed on mycelium of the mushroom. Some insects are attracted by fermenting smell of substrate to lay eggs and their larvae feed on bacterial but transmit contaminating fungi.

Main genera of mycophagous insects:

- Sciarid flies – Lycoriella spp. The larvae feed on mycelium of fungi. They infest all species of wild and cultivated mushroom.
- Phorid flies (Megaselia spp.) Larvae feed on mycelium

Control: Strict hygiene
Chemical control as a last resort and when there are no fruit bodies.
e.g. Malathion, Dichlorvos and Cypermethrin.

- Termites: Termites can damage substrate as well as feeding on mycelium especially mushrooms cultivated outdoors. Termites are also a problem in grass thatched structures where they damage the thatch grass.

Control – Insecticides applied to floors, treated timber.

MITES

Mycophagous mites are associated with improper pasteurization of substrate and presence of saprotrophic fungi. Some mites feed directly on the fruit bodies and are unsightly to consumers. Once in the fruit bodies, mites are difficult to control.

Control
Spray substrate with malathion, dicofol during spawn running or between flushes.

NEMATODES
Nematodes are associated with too much water in substrate and improper pasteurization of compost. They are not a serious problem in steamed substrates.

PARASITIC AND SAPROTROPHIC FUNGI
Many species of fungi are associated with mushroom cultivation either as saprotrophs or mycoparasites. Diagnosis and identification of fungi is based on spore morphology and genesis and colour of mycelia.

Examples

1 Trichoderma spp (Green mould)
- Trichoderma spp are fast growing fungi on various substrates and they are also parasitic on other fungi. In crop production, Trichoderma spp. are used as biological control agents of various fungal diseases. The fungi are characterized by green coloured spores and mycelium. When the substrate in attacked, the surface turns green. Trichoderma spp attacks oyster, button and other wood inhabiting mushrooms. The pathogen mainly inhibits mycelial growth and causes 100% losses.

2. Verticillium fungicola – Dry bubble disease: The pathogen causes discoloured spots on the cap of button and oyster mushroom. The disease is spread by flies or by hands during picking.

3. Gliocladium spp – Brown rot
Causes discolouration and rot of fruit bodies of oyster, button and shiitake mushrooms.

4. Penicillium spp – Green mould
Substrate competitor and produces antibiotics which stop growth of mushroom mycelium.

Control: Fungicides recommended in mushroom cultivation include Benomyl and Chlorothalonil and these are added to the substrate during wetting for control of Trichoderma, Verticillium and other fungi. Proper pasteurization or sterilization of substrate

BACTERIA
Bacillus spp
Bacillus spp. prevents growth of mycelium during spawn production due to potent antibiotics. The bacteria are associated with too much moisture in the substrate.

Pseudomonas tolaasi (Bacterial blotch)
Bacterial blotch disease causes discoloration of the cap tissue.

VIRUSES
Viral infections have been reported in most cultivated mushrooms. Viruses are associated with deformed or distorted fruit bodies.

RODENTS
Rats and mice damage spawned substrates as they eat the spawn and use the substrate as nesting material. The rodents also introduce fungal and bacteria contamination. This is more common in winter months as the rodents seek warmer places.

Control: Rodent-proofing of house or use of rat poisoned baits.

OYSTER MUSHROOM FINANCIAL PROJECTIONS

Just like in any business it is important for the farmer to keep records such that one can be able to evaluate if the business is financially stable.

Table 7: Required fixed costs for Oyster mushroom production enterprise

Item	Unit	Price per Unit	Qty	Total Cost (BWP)
Straw soaking bins	350L	450	5	2,250.00
Galvanized steel Drums 210L	210L	300	5	1,500.00
Packaging Machine		3000	1	3,000.00
Temperature & humidity gauge		400	4	1,600.00
Building of 3 x Mushroom houses		40000	3	120,000.00
Air conditioner		12000	3	36,000.00
Shelter (50sqm)		25000	1	25,000.00
Plastic cutting machine		1000	1	1,000.00
Weighing scale		2500	2	5,000.00
Straw sterilizing Cage		500	5	2,500.00
		Sub-total		**197,850.00**
		Incidental Costs (10%)		**19,785.00**
		Net-Total		**217,635.00**

[* 2024 prices, subject to change annually.]

The cost for the structures is based on using locally available building material, the price will increase as building is advanced to concrete block and metal shelving is used. The price for air conditioning will be removed if the farmer has no electricity supply to the production area.

Profit Projections

The profit projections are dependent on the size of the enterprise as well as the management practices used by the farmer. Under normal production, the farmer must be at seventy (70) percent biological efficiency to make profit. High standard hygiene standard must be maintained at all time to reduce contamination of the bags.

Biological efficiency = [Fresh weight of mushroom/ (fresh weight of substrate + spawn)] * 100

Example:

Fresh weight of substrate bag (straw + spawn) = 3kg
Fresh weight of harvested mushroom = 1.8 kg
Biological Efficiency (BE) = (1.8 kg/3 kg) * 100
B. E. = 60%

Table 8: Projected oyster mushroom income statement based on different biological efficiency level for single production cycle (Pula).

Gross income		Unit	Unit Price	Qty	1000 kg Substrate		
					50 % BE	70 % BE	80 % BE
Mushroom sales	Punnets	250g	15	2000	30 000	42 000	48 000
Total					**30 000.00**	**42 000.00**	**48 000.00**
Production costs							
Variable costs							
	Mycelium / Spawn (Liter)	Bag	600	4	2400	4000	4000
	Transportation of Spawn	trip	1000	1	1000	1000	1000
	Permits				2000	2000	2000
	Wheat Straw	500KG	800	2	1600	1600	1600
	Wheat Bran x 4 (150kg)	600KG	150	4	600	600	600
	Lime x 4 (50kg)	400KG	100	4	400	400	400
	Urea (50kg)	50KG	400	1	400	400	400
	Plastic bags	1 ROLL	1000	1	1000	1000	1000

	Punnets (100)	Packet	100	20	2000	2000	2000
	Cotton wool	kg	120	5	600	600	600
	Ethanol (99%)	5L	2000	2	4000	4000	4000
	Sterile gloves	box	250	10	2500	2500	2500
	Utility bills (Electricity +water)				2000	2000	2000
	Sub-total				**20 500**		
Labour costs	Casual workers	wage	1800	2	3600	3600	3600
	Manager	wage	3500	1	3500	3500	3500
	Sub-total				**7 100**		
Marketing cost	Airtime	Monthly	300	2	600	600	600
Transport	Delivery	Trip	300	8	2400	2400	2400
	Sub-total				**3 000**		
	TOTAL EXPENSES				**30600**	**30600**	**30600**
	NET INCOME				**-600**	**11 400**	**17 400**

[* 2024 prices, subject to change annually.]

Notes:
Cost estimates are based on just one (1) production cycle which can last up to 13 weeks
Assuming the farmer has four production cycles per year, the income generated will multiply by four

The assumption for the calculated net income is based on a single production cycle which takes thirteen weeks to complete in a single room growing and fruiting house. The annual net income is bound to change if the production is calculated for the whole year. In a year, there will be three production cycles where electricity is not supplied but the production will be four where electricity and air conditioning are available. The farmer must operate at BE > 60% to make profit.

In order to make profits the choice of spawn is crucial, and BE must be increased to more than 75%. In a scenario where the farmer has a growing room and two fruiting rooms, the production can be staggered for every two weeks ensuring continuous production of mushrooms throughout the year. It is possible to put twenty to 24 production cycles in a year, increase consumer confidence and the farmer being able to supply the demand on a weekly basis throughout the year.

TAble 9: Ideal Production Scenario For Oyster Mushroom

Activity	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	WK12	WK13	WK14	WK15	WK16	WK17	WK18	WK19	WK20	WK21
Substrate Preparation																					
Spawn Running																					
Mushr oom Fruiting & Harvesting																					
Room Sterilisation																					
Substrate Preparation																					
Mushroom fruiting & Harvesting																					
Spawn Running																					
Mushroom fruiting & Harvesting																					
Room Sterilisation																					
Substrate Preparation																					
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Room Sterilisation																					
Substrate Preparation																					
Spawn Running																					
Mushroom fruiting & Harvesting																					
Room Sterilisation																					

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