OYSTER MUSHROOM CULTIVATION
(basic guidelines)
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Oyster mushroom cultivation has the potential to convert agricultural waste into a protein-rich nutritional product, because not only can these mushrooms be produced from locally available agricultural waste products such as corncobs, bean straw, wheat straw, millet and sorghum straw, as well as seed hull, veld grass, etc., but the spent mushroom substrate (everything that remains after harvesting) can also be utilized as compost or fodder for goats and cattle. Furthermore, it is possible to build the infrastructure for production from available material such as grass, straw or mud.

For quite some time now the Ministry of Agriculture, Water and Forestry has worked hard to make the cultivation methods user-friendly. We have presented many practical training workshops to a vast number of interested communities and individuals in Namibia. To date, since 2003, the number of trained personnel have increased and some have even taken up mushroom cultivation as part of their farming activities.

Following the training and information dissemination, many people still approach the Ministry’s offices looking for mushroom-related information. This brochure has been compiled to make this much sought-after information available to everyone. The technology has been simplified to make oyster mushroom farming ideal for rural and peri-urban dwellers, retired workers, pensioners and youth groups. In addition, the cultivation of mushroom generates income and job creation due to the labour-intensive nature of the cultivation.

Mushrooms are also well-known for their nutritional value. Most mushrooms have medicinal value with a definite effect on blood
pressure, tumours and viruses. Edible mushrooms are very nutritious being rich in high quality protein and all nine essential amino acids, and vitamins such as thiamine (B1), riboflavin (B2), niacin (B12), biotin and ascorbic acid. Mushrooms are also well-known for their good supply of high quality crude fibre, folic acid and minerals such as phosphorus, potassium, calcium and other such as zinc, iron and magnesium. With the little fat content of 1 % to 8 % on dry weight, they are low in cholesterol, have little sugar and no starch and for these reasons are also ideal for diabetics and those with weight problems.

And with these words I not only wish you every success with your mushroom farming activities, but in all your other farming endeavours as well. May you thrive in your communities and taste the sweetness of achievement as your farming activities grow and prosper.

MR. ANDREW NATANGWE NDISHISHI
Permanent Secretary
Ministry of Agriculture, Water and Forestry
INTRODUCTION

Only recently has the cultivation of exotic mushrooms become a practical endeavour. Mushroom cultivation is very easy, but does, however, require a willingness to learn, hard work and an adherence to some well-defined guidelines. Most importantly, mushroom growers continually need to access accurate information and state of the art technology. With this technology mushroom production can be pursued throughout the year.

Nutritional qualities

Mushrooms are rich in protein that constitutes all of the amino acids. They are high in unsaturated fatty acids and low in cholesterol, high in fibres and rich in vitamins and minerals, and can be used as a meat substitute, especially for people who suffer from gout. Some mushrooms (e.g. *Garnodema lucidum*) are also well-known for their medicinal qualities.
1. Spore culture/tissue isolation and preparation

Tissue isolation is a method that makes use of a fruit body that has the ability to grow into mycelia to gain a genuine strain. A piece is cut from the internal fruit body of a mushroom and laid on a Potato Dextrose Agar (PDA) media in a Petri dish.

Material needed

1. Potato Dextrose Agar or Malt Extract Agar
2. Distilled or clean water
3. A measuring cylinder
4. Petri dishes or clear, flat bottles
5. A pressure cooker or autoclave (or even a 200 liter drum to be used for pasteurization)
6. Pure culture from a research laboratory or other reliable source
7. Alcohol (ethanol) or methylated spirits
Method

Step 1: Dissolve 39 g of Potato Dextrose Agar or 50 g of Malt Extract Agar in 1 liter distilled or clean water.

Step 2: Boil until completely dissolved (it turns yellowish and translucent).

Cook the Potato Dextrose Agar solution to dissolve it – once dissolved it turns yellowish and clear (note the colour of the solution in the bottle on the right-hand side)
Step 3: Pour into clean bottles and autoclave at 121 °C for 15 minutes to sterilize the solution. Alternatively cook the bottles in a pressure cooker or steam in a drum for 2 hours.

Research technicians and trainees sterilizing the PDA solution in a drum

Removing the pasteurized PDA solution from the drum after 2 hours
Step 4: Pour the hot solution in Petri dishes or clear flat bottles to about 2.5 cm from the bottom. Cover the Petri dishes or plug the bottles with cotton wool and let them cool to solidify.

Step 5: Clean the area where you are going to work, as well as the apparatus with 75% alcohol (ethanol) or methylated spirits.

Step 6: Aseptically, cut a piece from the pure culture and with the mycelia side facing down, place it on the now solidified PDA in the Petri dishes or bottles.

Step 7: Replace the Petri dish covers or cotton wool plugs on the bottles and seal with para-film.

Step 8: Leave the filled Petri dishes (or bottles) in a cool, dark place at room temperature and in 10 to 15 days the mycelia will cover most of the surface of the agar. Place cultures that are not going to be used in the fridge at 4 °C for future use.
2. Spawn-making

Spawn is made from the pure culture that was prepared in the previous section. Spawn can be seen as the “seed” of the mushroom. The purpose of spawn-making is to culture strains with good qualities: they should be genuine, grow vigorously and in large quantities. This is usually the second stage in mushroom cultivation and it is here where primary mycelia grow into secondary mycelia which are regarded as strong. Strong mycelia have the ability to decompose and are regarded as high yielding and of good quality.

Matured spawn ready for use

Material needed

1. Grain like sorghum, wheat, millet or maize
2. A pressure cooker or autoclave (or even a 200 liter drum to be used for pasteurization)
3. Firewood
4. Chalk or Building/Agricultural lime (optional)
5. Wheat bran
6. Sterilizable bottles
Method

Step 1: Soak the grain for 5 hours in boiled hot water or until it has soaked up enough water. The optimal moisture content for spawn mycelia invasion is 40 % to 70 %. Grain can also be pre-boiled if too hard, but avoid cooking it. The kernel should stay intact and not be broken.

Step 2: Remove the grain from the water and drain to remove all excess water. Fill clean, sterile bottles two thirds of the way with the soaked grain and close the bottles only slightly (partially).
Step 3:
Autoclave the bottles at 121 °C for 15 minutes or cook in a pressure cooker for 20 minutes – or alternatively steam them in a 200 liter drum for 2 hours. This is an important sterilization step.

Step 4:
Let the bottles with grain cool down.

Step 5:
Inoculation should be done under proper sterile conditions to avoid contamination. It is therefore very important to also sterilize all working utensils. Dip spatulas in alcohol (ethanol) or methylated spirits and then sterilize them with flames.

Step 6:
Depending on the size of the bottle, cut 3 to 4 pieces of culture from the Petri dish, mix these pieces thoroughly with the grain and loosely replace the cap.
Step 7:
After inoculation, the bottles are kept in a cool, dark place at room temperature until the mycelia grow through the grain. The grain will turn white and mycelia will be seen throughout the bottle. This process takes about 3 to 4 weeks maximum. If not used immediately, the fully invaded bottles should be stored in a refrigerator (4 °C) or at a cool temperature. The spawn can live for up to 6 months in a refrigerator.

Old or spoiled spawn will turn yellow or dark and should not be used. It also has a bad odour which is easily recognised (by colour and smell). A healthy spawn culture is white and has the same pleasing smell mushroom fruit has. It also grows with a healthy vigour.
3. Substrate preparation/composting

This process is called composting and the final product is called compost of the prepared substrate. Substrates should be sterilized soon after they have been soaked in water to prevent the material from acidification. The recommended compost material should consist of a 70 % water content and an NPK ratio of 13:4:10 (1,98 % N, 0,62 % P and 1,5 % K) on the dry weight if possible.

Material needed

1. Millet seed hull
2. Straw from maize, millet, sorghum or grass, cowpea or cotton stems and branches, etc.
3. A scale
4. Optional: lime (acid builds up when substrates are left too long before the pasteurization process takes place – lime neutralizes the acid)
Method

Step 1:
All raw material to be used should be cut into smaller pieces of about 1 cm to 5 cm long first.

Step 2:
Weigh the dry substrate to determine the bioconversion or efficiency if possible. If not, this step may be ignored.

Step 3:
Soak the substrate in water until it is saturated (or spray it with water – while it is spread out on the floor – until it is soft enough).

Step 4:
Drain excess water to an optimal moisture content of about 50 % to 70 %.

Step 5:
This step is optional: Mix the substrate with 1 % to 1.5 % lime (percentage of dry weight of the substrate) – or skip and go to Step 6.

Substrate preparation (mixing with Agricultural lime – optional)
Step 6:
Pack the substrate preferably into clear plastic bags and tie them; then sterilize in an autoclave for 15 minutes at 121 °C or steam for 2 hours in a drum.

Participants filling the plastic bags with substrates

Steaming (pasteurizing) the substrates in a modified drum for 2 hours
Step 7:
Let the substrate cool down and inoculate with spawn under clean, sterile conditions. A clean bench or table in a closed room can be used for this purpose.

Technicians practising inoculating (planting in) of the substrate

Step 8:
Spread a tablespoon of the spawn in the bag with the substrate.

Step 9:
Tie the inoculated bags loosely to allow a small amount of $O_2$ (oxygen) to enter.

Step 10:
Keep the inoculated bags in a cool, dark room at room temperature until fully covered with the white mycelia. In cases where there is contamination (usually by penicillin), a green colour can be seen through the clear plastic bags (sometimes even brown or black in colour). Such bags should be removed or discarded to avoid a smell developing and contamination of the full house. Substrates in that condition could, however, be dried and steamed for reuse by following the same procedures as above.
4. Vegetative phase

Inoculated bags should be placed in a cool, dark place at room temperature until they are fully invaded by the mycelia.
5. Fruiting phase

Once the bags are fully invaded by the mycelia, they must be moved to a room where the temperature and humidity can be controlled. Sprinklers or pipes with nozzles can be installed to provide the moisture. Slits are made through the bags to allow the mushroom heads space to grow out.

For oyster mushroom growth the temperature in the fruiting house/room should range between 15 ºC to 35 ºC. The first fruiting appears in 4 to 8 weeks from the day the bags are inoculated and it takes about 5 days for the mushrooms to grow to their full size. Harvesting can then start.

The types of mushroom currently available at the Ministry are *Pleurotus ostreatus*, *P. sajor caju*, *P. florida*, *P. corn* and *P. eringi.*
6. Maintenance of a mushroom house

A mushroom house should be kept free from insects and rodents. The house should also be almost airtight, allowing only a minimum air to filtrate. Humidity of at least 60 % or more should be maintained inside a fruiting house to support mushroom development and growth. Oyster mushrooms prefer a temperature of between 15 °C to 35 °C.

The house floor should be kept wet at all times and the walls sealed with a layer of plastic to conserve moisture and maintain humidity. Spray the bags with water three times a day, but in an area where water resources are limited, watering once in the morning and once in the afternoon will also do, as long as the humidity is well-maintained.
After the fruit bodies have appeared, watering should continue, but avoid wetting the fruiting body of the mushroom directly as they will absorb water like sponges.

When the outside environment is too wet, especially during the rainy season, mushroom houses can be opened at night to allow air circulation. This will help to dry some unwanted fungus in the house. Fumes from insect repellent plants such as bitter bush or edimba (*Blumea garipinum*), can be used when insects infest the house.

Mushroom houses at Omahenene (top) and Mannheim research station (bottom)
How is lime calculated?

If you for example use:
8 kg soaked wet material (straw, sawdust, cotton straw, etc.) and
8 kg dry material (millet dust, cowpea or grass), and
mix both together to make a total of 16 kg material,
1 % to 1,5 % lime should be mix in, as stated before.

Calculation: \[
\frac{1,5 \times 16}{100} = 0,24 \text{ kg}
\]
\[
= 240 \text{ g of lime that should be mixed in}
\]

Further information can be obtained from:

Ministry of Agriculture, Water and Forestry
Directorate of Research and Training
Division Plant Production
Government Office Park
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Namibia

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Useful reference material


