Mushroom Production for Sustainable Livelihoods

Production Manual

PRACTICAL ACTION
Technology challenging poverty

FOREWORD

This manual is a culmination of Practical Action Southern Africa's work in Chakohwa were the organisation implemented the Mushroom Production for Sustainable Livelihoods project. The project worked with the Chakohwa Community-Based Organisation (CCBO) in Chimanimani District of Manicaland province. The aim of the project was to provide income earning opportunities for HIV and aids orphans and their carers. Mushroom production was one of the key activities identified that the community engaged in addition to other horticultural, soap making and small ruminant rearing activities.

The manual is intended as a training and information guide tool for those seeking to venture into oyster mushroom production and those already engaged in mushroom production and would like to improve their skills.

It will provide a comprehensive description of oyster mushroom production to small-scale farmers who seeking to be involved in such a venture. For farmers to understand more about mushrooms as fungi, a general description of mushroom biology and mycology is also provided in Chapter 2 of this manual. Chapter 3 summarises oyster spawn production, whilst Chapter 4 summarises the materials and methods used for producing oyster mushrooms, humidity and temperature control, pests and diseases and their control; harvesting, grading and packaging. Proper hygiene regimes required for successful mushroom production will be highlighted at different production stages. Marketing the final mushroom or value added product is covered in Chapter 5.

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Front Cover Picture; Oyster mushroom production in Chakohwa, Manicaland Province,

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CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Zimbabwe's mushroom industry is fast growing as more and more smallholder farmers develop a keen interest in growing gourmet mushrooms for a hobby or as a small business. Due to interest in their culinary, nutritional, and health benefits, the popularity of consuming mushrooms in the Zimbabwean diet is continuing to increase. Today, many retail outlets in Zimbabwe sell a variety of mushrooms, common button (*Agaricus bisporus*) mushrooms, shiitake (*Lentinus edodes*) mushrooms and several forms oyster (*Pleurotus* species) mushrooms.

However, as fungi, mushrooms have life cycles very different from those of green plants thus their production is labour and management- intensive. Therefore, it takes a considerable amount of knowledge, research, planning, and capital investment to set up a tremendous production system.

1.2 BENEFITS ASSOCIATED WITH MUSHROOM PRODUCTION

There are a number of benefits associated with mushroom production. These are highlighted below;

Health Benefits

Many people are intrigued by mushrooms nutritional and medicinal properties. Consumption of mushrooms offers a good nutrition since they are rich in protein, vitamin, and minerals.

In addition to this, mushrooms have medicinal attributes such as boosting health; lowering the risk of cancer, liver ailments; promoting immune function; warding off viruses, bacteria and fungi; reducing inflammation; combating allergies; help in balancing the blood sugar levels and supporting the body's detoxification mechanisms.

Smallholder farmers are developing a keen interest in mushroom growing.

Waste Management

- Assist in management and economic utilisation of inedible farm organic wastes are used as growing media for edible fungi.
- Spent compost/growing media is important source manure for crop production although on a small scale.
- Generation of income through sale of product. In addition to this, mushrooms have high returns on every dollar invested**.**
- Employment creations as opportunities are created at the production level and along the distribution chain**.**
- Mushrooms production offer opportunities for crop diversification to farmers.

1.3 CHOOSING A MUSHROOM SPECIES

There are several factors that should be considered before entering into the mushroom production business and these are as follows;

- Market Analysis
- Capital Outlay and Facilities Available
- Substrate Supply
- Technical Know-how
- Facility or Environment available

Step I – Market Analysis

A careful analysis of potential markets for a particular species is usually the first step in deciding whether to raise mushrooms for sale. Mushrooms ought to be grown in areas positioned within easy access of markets. Production efficiency will become increasingly important as the market becomes even more competitive.

Step II – Facility or Environment Available

It is imperative to consider the kind of facilities or environment available for mushroom production. Environmental conditions such as high temperatures (above 28^{o}C) and low relative humidity (below 85%) are not suitable for spawn or mushroom production. These affect production at different developmental stages and significantly reduce the total harvestable index of mushrooms. Labour sources should be easily available or nearer the production site and the environment should be suitable for mushroom production.

Step III– Technical Know-how

Indoor mushroom production demands a much higher level of knowledge and skill to manage the life cycle of the fungus i.e. continuous monitoring and timely manipulation of environmental conditions. It is important to note that different mushrooms require different expertise in substrate preparation and production

Step IV – Substrate Supply

The choice of mushroom species to raise in a particular area depends on waste material readily available for use as growing media. Growing media can also be sourced from substrate suppliers.

Step V - Capital Outlay

It is important for a farmer to consider the cost for buying necessary equipment required to produce a particular mushroom. Some mushrooms require a high capital outlay for commercial production purposes whilst others can be produced in simple structures.

According to this criterion, oyster mushrooms are the best for most novices as they are relatively easy to grow.

1.4 SPECIES FOR BEGINNERS

Oyster (*Pleurotus ostreotus)* mushrooms are a good choice for beginning mushroom cultivators because they are easier to grow than many of the other species. They can be grown on a small-scale with a moderate initial investment and thrive quite well under less controlled environments. There is no need for electrically driven humidifiers, air conditioners, or cold rooms. A farmer needs at least one simple growing house to be able to harvest mushrooms continuously. Further more, oyster mushrooms can be grown on a wide variety of simple high-cellulose crop waste materials. Some of these materials do not require sterilization, only pasteurization, which is less expensive instead of the costly and complex compost preparation as in the case of button (*Agaricus species*) mushrooms. Another advantage of growing oyster mushrooms is that a higher percentage of the substrate converts to fruiting bodies, increasing the potential profitability.

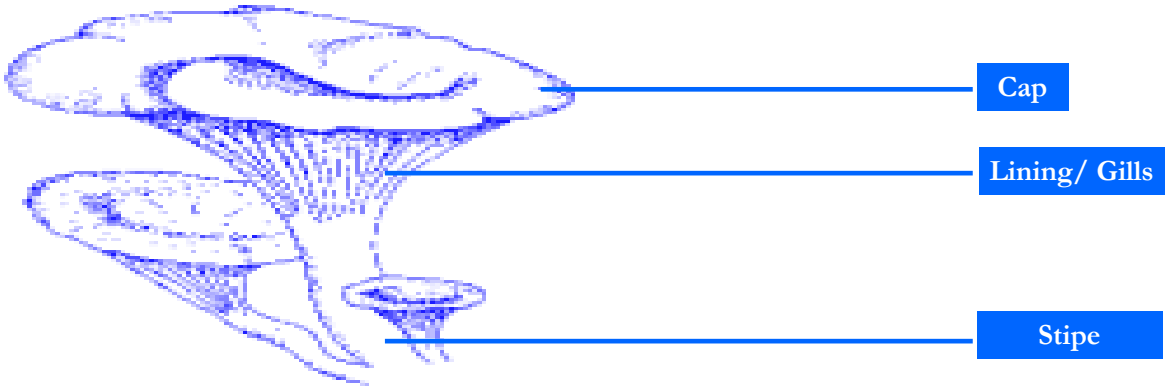
Oyster mushrooms are a good choice for beginners

CHAPTER 2

2.1 WHAT IS A MUSHROOM?

All fungi form the so-called hyphae, tiny threads that originate from spores. These spores get to the sexual stage where large spore (bigger than 10mm) will develop into the fruiting body, the mushroom. A **mushroom** is the reproductive or edible fleshy fruiting body of certain fungi, which may be gathered wild or grown under cultivation. Just like the apple on a tree, mushrooms are the "fruits" of these fungi. The actual organism that produces mushrooms is called **MYCELIUM**, a strand like mass of white cells found in the growing substrate that may be a dead tree stump, a live tree, or organic material in the soil. Figure 1, shows the structural composition of a mushroom; the cap, lining, and the stipe.

Figure 1: Structural composition of mushroom



The lining/gills form the mushroom's reproductive hymenium part and is the one that bears reproductive spores.

As a group, fungi can grow on almost any carbon source (a substrate). Most of the fungus goes unseen as it colonizes and absorbs nutrients from wood, fallen leaves, organic matter in soil, etc. Fungi reproduction depends on the existence of specific environmental conditions, especially the moisture or humidity level, the temperature, and the availability of nutrients. Optimum conditions vary among species. Under the right conditions "fruiting" occurs and the mycelium produces mushrooms. When mature, the mushrooms release millions of spores into the environment for further propagation of the species.

2.2 MUSHROOM TAXONOMY AND CLASSIFICATION

Mushrooms can be roughly divided into four categories

- Those that are fleshy and edible fall into the edible mushroom category e.g. *Agaricus bisporus, Lentinus edodes, Pleurotus ostreas* e.tc;
- Mushrooms are considered to have medicinal attributes, hence referred to as medicinal mushrooms e.g. *Garnoderma lucidum*;
- Those which are proven to be or suspected to be poisonous and hence called poisonous mushrooms e.g. *Amanita phalloides*;.
- A miscellaneous group that consists of a large number of mushrooms, whose properties remain less defined. These may be tentatively grouped as other mushrooms.

- 2.2.1 The Ecological Habitats and Breeding Selection of Mushrooms

Ecological Attributes			Important Genera	Fruiting by Artificial Cultivation
Non- Mycorrhizal Mushrooms	Above ground	Wood	*Pleurotus, Auricularia Lentinus, Tremella, Hericium, Pholiota Kuehneromyces*	EASY ↑ DIFFICULT
		Straw	*Volvariella*	
	On Earth	Dung	*Coprinus, Agaricus, Agrocybe, Stropharia*	
		Soil	*Lepiota, Dictyophora, Lepista, Melanoleuca, Morchella*	
		Insects	*Cordyceps, Termitomyces*	
Ectomychorrhizal mushrooms	With roots	Mycchorhizal	*Tricholoma, Ramaria, Cantnarellus, Boletus, Suiluss, Gomphidus, Lactarius, Russsula , Amanita, Cortinarius, Rhizopogon, Terfezia*	

Souce: Chang 1991.

2.2.2 Edible Mushrooms

Edible mushrooms account for about 50% of the total production of micro fungi (Chung and Miles, 1992). Edible mushrooms are generally classified into three types according to their growing characteristics.

Parasitic Mushrooms
Parasitic mushrooms attack a living host plant, usually a tree, and eventually kill it. They may also be found growing on dead trees, but they probably started growing while the tree was alive and contributed to its demise. An example of a parasitic mushroom is the Honey mushroom (Armillaria mellea). This type of mushroom can be cultivated but will require a living host. Some parasitic mushrooms also function as saprophytes (described below).

Armillaria mellea.

Boletes

Mycorrhizal Mushrooms
Mycorrhizal mushrooms form a symbiotic (mutually beneficial) relationship with the roots of trees or bushes and this is one of the reasons why forests are often generous to mushroom hunters. In fact, the root tips of all plants are coated with a fungus which breaks down the organic matter in the soil and makes it available to the plant. The plant in turn produces sugars and exchanges these with the fungus. Some of these symbiotic fungi produce mushrooms. Examples include the Matsutake, Boletes, Truffles, Chanterelles, and Amanitas.

Cultivation of this type of mushroom requires the other half of the symbiotic relationship, which is the live tree. It is almost impossible to establish this symbiotic relationship under controlled conditions on a commercial basis. However, success has been achieved with truffles whereby a grower inoculated the roots of small oaks with the mycelium, planted them, and then waited for more than ten years before harvesting the truffles.
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Saprophytic Mushrooms
Saprophytic mushrooms live on dead organic matter such as dead trees, stumps, old roots, grass, straw, compost, etc. Mushrooms in this group are those that are successfully cultivated including Shiitake, Oyster, Champignons or White Button mushrooms (Agaricus spp.), Portobello, Enokitake, Reishi, Maitake, Paddy Straw mushroom, and many others.

All of these types of mushrooms play roles in ecosystems throughout the world. One of the key roles that mushrooms play in natural systems is the decomposition of dead organic matter. Decomposition is accomplished by a succession of saprophytic fungi.

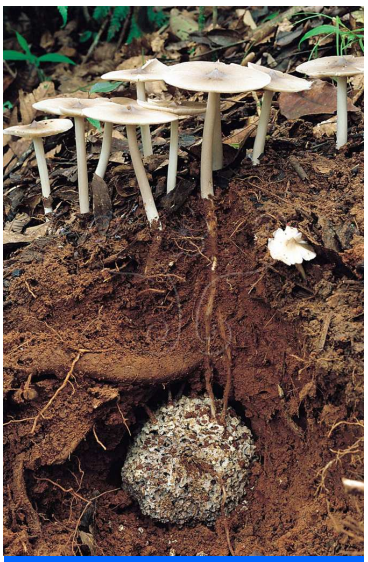
2.2.3 Edible Mushrooms in Zimbabwe

There are five main types of edible mushrooms in Zimbabwe. These are:

Termitomyces (termite fungi)

These are always associated with termite nests. All known species in this group are edible. The caps (fruits) vary from white to pale brown and from smooth to rough peeling. There may be a ring on the stipe, but there is no volva. The base of the stipe extends into a root-like structure (pseudorhizum). The gills are white to cream in most of the species. The common species include:

Termitomyces Species	Cape Size	Colour
T. letestui (Shona: Dari)	Diameter than 20cm	Greyish
T. dypeatus (Shona: rusutwe)	Diameter between 4 to 10cm	Golden brown
T. schimperi (Shona: Huvhe)	Diameter up to 30cm	Creamy white
T. titanicus (Shona: Muravatsuro)	Diameter as large as 100cm	Greyish in colour
T. microcarpus (Shona: ruku-vhute)	Stipe is 0.5-2cm	



Termitomyces .

NB: *Species in this group should be baked before eating to avoid stomach upsets. Most of the members grow as wild species. Not much work has been done to culture them in vitro.*

Cantharellus (Chantereless)

These are generally known as apricot fungus. They have gills with ridges on the underside of the cap and a sweet, fruit odour. They should be washed well as grit tends to collect between the ridges, and are then dried or eaten fresh rather than fried. Members include:

Cantharelles Species	Cape Size	Colour
C. pseudocibarius (Shona: Tsvuketvuke)	2 cm in diameter	Bright Orange
C. cibaricus	2-9cm diameter	Ochreous yellow
C. longisporus	2-5cm diameter	Pink-orange

Cantharellus

Agaricus (Agaricus)

This is commonly called white button and is commonly found in fields and pasture. Strains of this mushroom group have been successfully cultivated, unlike most of the wild mushrooms. It is also called fields' mushrooms since most species appear fairy rings in crop fields. The genus constitutes the oldest known edible mushrooms. These include:

Agaricus Species	Cape Size	Colour
A. bisporus	6-12 cm in diameter	White
A. avensis	25cm diameter	White
Leucoagaricus crustaceus	4-10cm diameter	White

Agaricus

Amanitas

This is the most popular mushroom in the country, particularly *Amanita zambiana.* This is prevalent in miombo woodland. It occurs mainly during the rainy season, and is a common sight on the roadsides. Another commom species *Amanita pantherina* causes most common cases of poisoning in Zimbabwe due to its similarity with the edible *Amanita nibescens*. The poisonus form is normally associated with pine and Eucalyptus plantations. The most common members include:

Amanita Species	Cape Size	Colour/ Characteristic
A. nibescens	5-15 cm in diameter	Warts are grey, but not striated *A. pantherina* is striated.
A. Zambiana (Shona: Nhedzi)	30cm diameter	Characterised by a sticky top

Boletes

These are spore fungi, which are edible after cooking. Most are brown in colour and the cap diameter can be as large as 50 cm. Most of the boletes grow in symbiotic association with conifers and are a common part of the forest ecosystem in the Eastern Highlands forest plantations. The most common include:

Boletes Species	Cape Size	Colour/ Characteristic
B. edulus	5-25 cm in diameter depending on strain	Flesh is whitish yellowish
Strobilomyces (English: Tortoise Shell; Shona: Mbirikamba)	Up to 12cm diameter	Rough black to brown scales. Stipe is cream with black granulated spots. Mushroom is initially white, but turning black at maturity

Boletes

Parasols;

There are two similar species in this group which are similar in size and shape during early development stages of growth, thus care should be taken when collecting the mushrooms.

Species	Cape Size	Colour/ Characteristic
Macrolepiota zeyhere	5-15 cm in diameter	Edible species with white and brown scales.
Chlorophylum molybdites	10-25 cm diameter	Poisonous species and can be lethal.

Parasols

Coral Fungi

The edible coral fungi (Clavulina cristata) has a greyish-white, coral like growth in litter of miombo woodlands. They often grow up to 6cm in clusters.

2.2.4 Commonly Cultivated Species in Zimbabwe

It has been consistently difficult to cultivate most wild mushrooms. However, years of extensive research have managed to cultivate different species. Manipulation of growing environment has resulted in cultivation of different types of mushrooms across divergent agro-ecological zones. In essence mushrooms thrive well under controlled environments. Some of the most commonly cultivated mushrooms include:

Volvariella

The mushroom is creamy white in colour; the caps ranging from 5-10 cm in diameter. The mushrooms can grow to a height of 10 cm, and occur in clusters. The fruiting bodies emerge as if they were rupturing from a cocoon. Straw is the common substrate utilised in raising the mushroom. Farmers often bundle the grass materials, erect it and inoculate with mushroom mycelia. The grass bundles can be oriented to maximise space utilisation under limited space. After inoculation, the mushrooms can be harvested after two weeks, and flashes normally occur at three day intervals.

Pleurotus

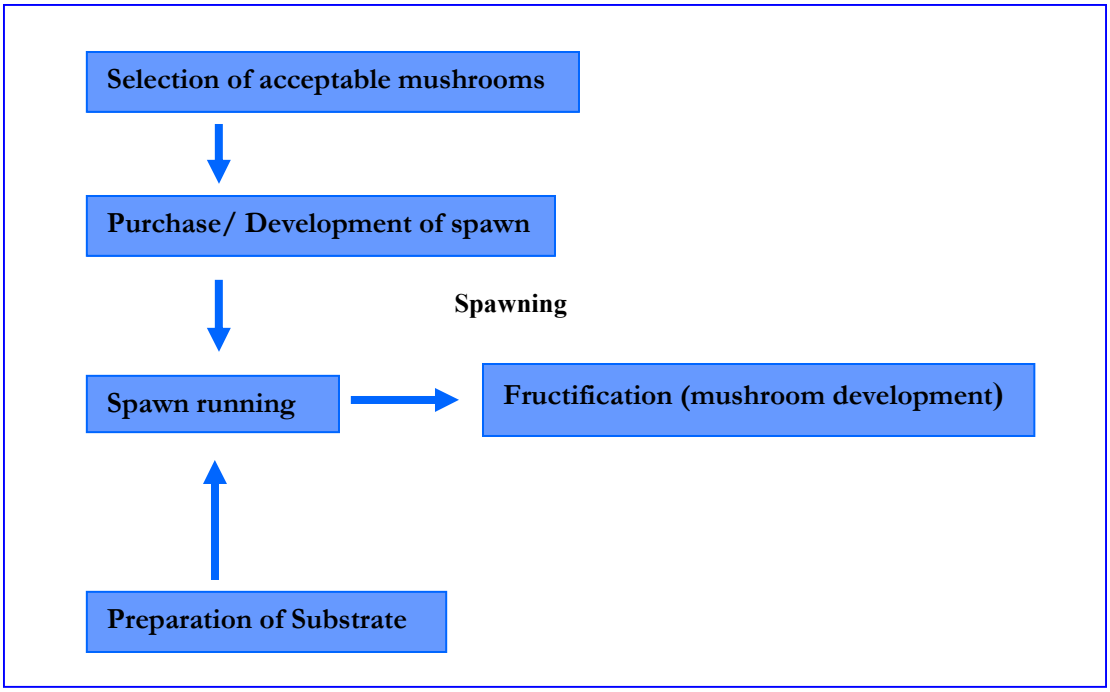
It is commonly called the abalone or oyster mushrooms. Oyster mushrooms can be grown using the tray, bottle or plastic culture technique. The mycelium is inoculated into the plastic bags or wooden trays containing the crop residues. The mycelia will colonise the fruiting bags or trays utilising the substrate contained therein. If using the plastic culture, the plastic bags are punctured to allow for emergence of fruiting bodies. The mushroom fruits appear 10-15 days after inoculation, through the openings available on the fruiting bodies. It is not apparent whether the extent of fruiting requires an optimum area in openings for maximum yield, although it is apparent that for high yields, a high number of openings should be made available on the fruiting bags. The first three flushes are the most productive. The cap and a small section of connected stem are usually harvested before the caps are fully expanded.

Auricularia

This is also called the black ear fungus. The cultural practices in raising Auricularia are similar to those of *Pleurotus*.

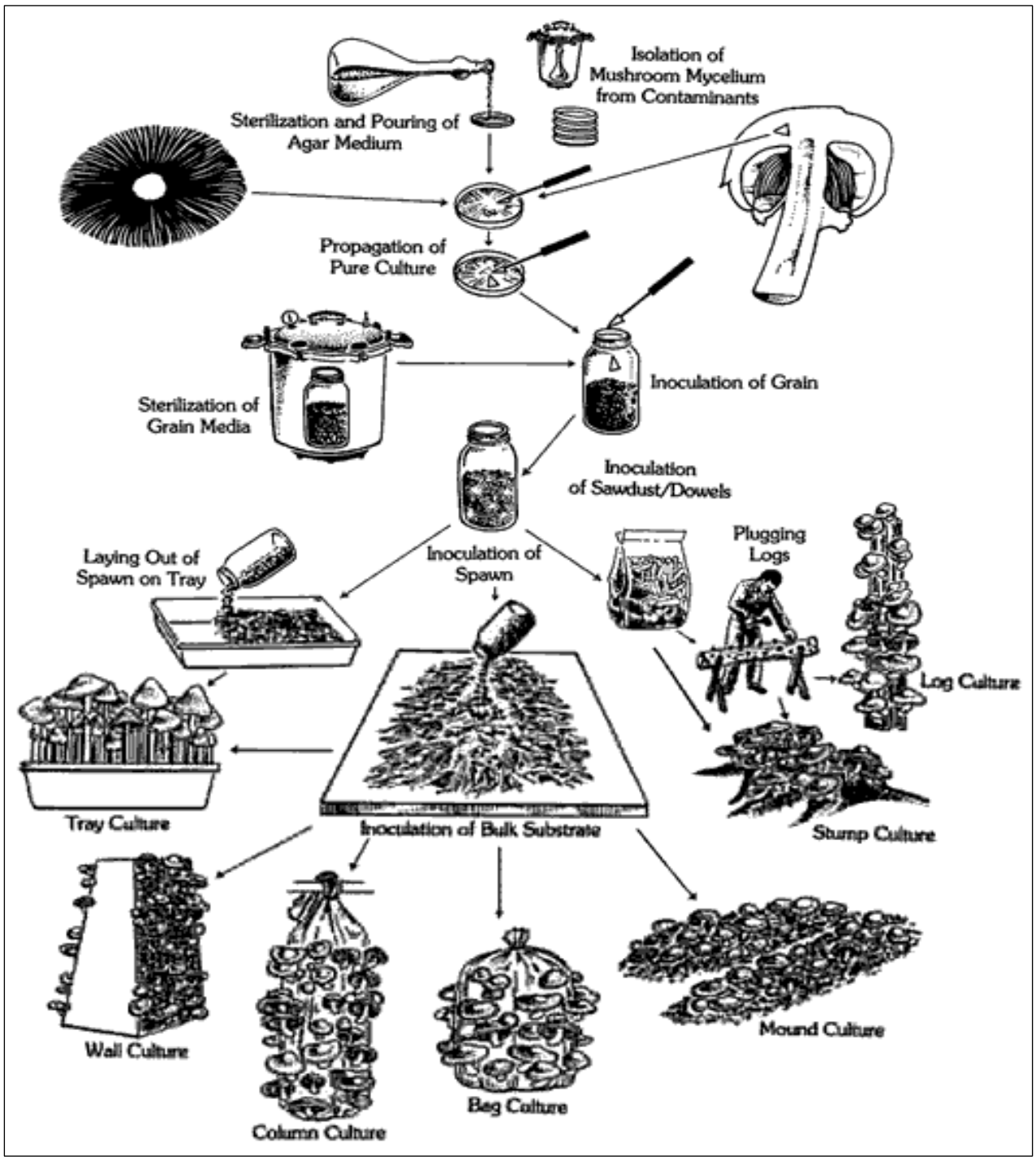
In summary, the table and figure 1 below summarises the major phases involved in mushroom production from spawn production to culturing of mushrooms using different methods.

Major Phases



Source: Chang 1991

Figure 1. Phases involved in spawn production



Source: www.fungi.com by Paul Stamets

CHAPTER 3

3. SPAWN PROPAGATION

Over the years, scientists researched into the production of mushroom seed now called spawn in scientific terms. The production of seed came as a good idea as it provides a very profitable business to individuals and entrepreneurs engaging into spawn or mushroom production as a business. However, it is important to note that spawn making is rather a complex task and not feasible for the common mushroom grower. This is because spores are likely to yield a new strain and performance would be unpredictable. For beginners it is normally recommended to buy spawn from commercial suppliers due to difficulties experienced in propagating a pure culture and expensive capital equipment required to set up a laboratory.

Spawn of various oyster mushroom species may be purchased from commercial spawn makers who usually provide instruction for its use. In Zimbabwe, spawn is commercially available from specialist spawn producers (Annex 2).

3.1 What is Spawn?

Like the seed of crop plants, mushroom cultivation starts from spawn, the vegetative material. Kligman defined spawn as merely the vegetable mycelium from a selected mushroom grown in convenient medium. Sinden stated that vegetative growth is called the mycelium and the material used to plant the compost is called the substrate**,** therefore spawn consists of mycelium and the supporting medium. In the mushroom industry, both the vegetative body (mycelium) of the mushroom, which consists of a mass of white fine threads (hyphae) and the planting material, which consists of the mycelium and its substrate, are called **spawn (**Chang, 1993).

3.2 The Laboratory Process

Spawn production is carried out in the laboratory. The laboratory provides optimal conditions for performing experiments and the environment can be altered to favour growth of species under investigation while at the same time eliminating other organisms seen as potential competitors.

3.3 The Laboratory

This is a room designed for carrying out experiments and other processes in an environment that is selective. It is furnished with laboratory equipment needed for such procedures. The room should be well ventilated with running tap water available. All equipment must be placed in their designate positions and always kept free of dust. Consumables must be kept in cupboards under lock. All this is done to ensure safekeeping of the laboratory and minimising damage both to the equipment and humans.

Safety is the paramount aspect when working in the laboratory so the laid down procedures should be followed to avoid accidents, loss of equipment and damage to the laboratory.

3.3.1 Equipment and Consumables used in the Laboratory

DESCRIPTION	USE
Pressure Cooker	These are electric gadgets used for sterilisation and boiling substrate.
Weighing balance	Used for measuring Potato Dextrose Agar (PDA) and substrate
Measuring Cylinder	For measuring liquid during preparation
Beakers	For transference of liquid during preparation
Spatulas	For scooping the media
Forceps	For interesting innoculum
Blades	For cutting
Autoclavable bags	Packaging plastic bags
Petri dishes	For PDA cultures
Burners	For heating up the environment
Stove	For autoclaving process
Fridge	Storage of cultures and spawn
Buckets and dishes	For soaking and cooling of wheat
Potato Dextrose Agar	Medium for initial mycelia cultures
Alcohol	Disinfectant/fuel
Fomaldehyde	Fumigant
Methylated spirit	Disinfectant/fuel
Distilled water	For laboratory use
Jik	Hygiene liquid
Cotton wool	Plugs or bag opening
Mutton cloth	Wiping cloth or wick
Spraying gun	Fumigant spraying container
Cotton string	For tying bag opening

3.3. 2 Ascepsis *(reducing or eliminating contaminants)*

The laboratory is a very sensitive area that requires much attention and care. The floors must be kept clean; any spillages should be wiped immediately. People with knowledge should do operation of machines. Any accidents should be reported immediately and first aid should be administered. During work, wash your hands and disinfect the workbench, during inoculation, talking is not allowed because you are likely to contaminate your work with bacteria from your mouth.

Make sure the benches are lit 2-5 minutes before staring your work and continually disinfect the workbench and your hands as you progress with work. Heat the inoculating instrument until red hot and cool before contact with innoculums.

CAUTION: No laboratory consumables should be tested by mouth because they are hazardous to health.

3.4 SPAWN MAKING PROCESS

3.4.1 Preparation of Mother Cultures

3.4.1.1 Preparation of Potato Dextrose Agar (PDA)

- Prepare PDA as directed on the container.
- Autoclave PDA in a pressure cooker for 30 minutes to one hour.
- Disinfect the bench together with your hands and put on the flame.
- Take the PDA out of the pressure cooker while still hot.
- Pour the PDA in petri dishes, flame the opening of the bottle regularly as you pour.
- Close the lid of the petri dish after pouring, repeat to the remaining dishes.
- Leave the dishes to cool and then solidify.
- If not for immediate use, wrap the dishes with a cling wrap and store in a fridge.

3.4.1.2 Innoculation of PDA

- Wipe the bench with a disinfectant and also disinfect your hands.
- Take a piece of mushroom fruit of known type, gently spray it with a disinfectant and place it in a sterile petri dish.
- Dip your blades in a disinfectant.
- Take out the blade, flame it and leave it to cool for a short time.
- Dissect the mushroom fruit.
- Using flamed forceps, pluck out a piece from the white fluffy middle part of the fruit.
- Open the lid of the petri dish with one hand and the other hand dropping the piece in the media and quickly close the dish.
- Incubate in a dark disinfected cupboard with the dish placed up side down for 3-7 days monitoring the development.
- On complete colonisation, cover with cling wrap and put in the fridge.

3.4.2 Preparation of Grain Master Cultures

3.4.2.1 Preparation of Substrate

The substrates normally used for spawn production is wheat, rye or sorghum grain.

1. Put the wheat into a bucket about half full, and add water.
2. Clean the wheat by removing suspended particles thus cleaning the substrate.
3. Soak the clean wheat in water for 8 hours (or overnight) for softening.
4. Mix the wheat with calcium sulphate (gypsum) at a rate of 50g per kg of wheat (5%). Calcium sulphate is for pH regulation
5. Weigh the wheat into 500g and pack in bottles or packets.
6. Autoclave for 45 minutes to 1 hour and leave the substrate to cool in their bottles/packets.

3.4.2.2 Innoculation of Grain

1. Disinfect the bench together with your hands and put on the flame.
2. Place the bottles/packets on the bench and take out prepared dish with innoculum of mother culture.
3. Dip the blades and forceps into the disinfectant.
4. Flame the blade and open the petri dish. Cut pieces 3 to 4 per bottle.
5. Flame the forceps and pick the piece, drop it in the bottle/packet and quickly close the lid, make the pieces 3 or 4 per bottle. Note that this process has to be done asceptically.
6. Gently shake the bottle to disperse innoculum.
7. Incubate in a disinfected dark cupboard for 5 – 10 days.
8. On complete running, put in the fridge.

These are the grain master cultures used for propagation.

3.4.3 Propagation for Commercial Purposes (Multiplication)

3.4.3.1 Preparation of Substrate

Preparation of grain is the same as for preparation of grain master culture.

1. Put the wheat into a bucket about half full, and add water.
2. Clean the wheat by removing suspended particles thus cleaning the substrate.
3. Soak the clean wheat in water for 8 hours (or overnight) for softening.
4. Mix the wheat with calcium sulphate (gypsum) at a rate of 50g per kg of wheat (5%). Calcium sulphate is is for pH regulation
5. Weigh the wheat into 500g and pack in bottles or packets.
6. Autoclave for 45 minutes to 1 hour and leave the substrate to cool in their bottles/packets.

3.4.3.2 Innoculation of Grain

1. Disinfect the bench together with your hands and put on the flame.
2. Place the bottles/packets on the bench and take the grain master.
3. Dip the forceps in a disinfectant.
4. Flame the forceps and lid of the bottle.
5. Open the bottle and scratch the surface of the mycelia to separate the grains.
6. Put about 15 – 20 grams into the prepared media bottles/packets.
7. Gently shake the bottle to disperse innoculum.
8. Incubate in a disinfected dark cupboard for 5 – 10 days.

NB: Important Points to Consider during Innoculation.

- Make sure the cupboards are thoroughly disinfected.
- Arrange bags in such a way that they are not stacked on top of each other, this retards growth through lack of enough air circulation.
- Keep the incubating cupboards as dark as possible, they must not be frequently opened.
- Gentle mixing may be administered if growth is concentrated on a particular area.

9. On full colonisation, the fully-grown spawn with no signs of contamination is transferred in to the fridge of not less than $0^{o}C$ for long-term storage.

This is your spawn ready either for use or for market. If the spawn is contaminated, it should be discarded as soon as it is identified.

Recommended Spawn	Contaminated Spawn
• Has a uniform white colour with no or little deviations • Vigorous growth • Absence of unpleasant odours. • Reasonable moisture content.	• Green colour is contamination by penicilium species. • Any other colour seen to be progressing in size. • Retarded growth of the mycelia. • Decomposition of the substrate. • Completely failure to grow.

3.4.3.3 Disposal of Contaminated Spawn

Contaminated spawn and all laboratory disposals should be carefully disposed. Contaminated spawn should be thrown together with the plastics into a rubbish pit situated about 500m away form the laboratory. Containers should not be used for any other purposes because the chemicals which they contain are very dangerous.

3.5 RECORD KEEPING

For commercial businesses purposes there should always be an inventory of equipment. Any damages and losses should be recorded. The process of spawn production should be well recorded. Records of quantity of consumables used and production rates should always be updated. This helps in measuring the profitability of the business and makes it easy to track the probable causes of contamination. On innoculation, stickers bearing the production number should be on each bag. This is the number that is entered in to the daily production book.

SUMMARY

This Chapter gave a summary of production stages involved in manufacturing of spawn. Chapter 4 details oyster mushroom production stages, stating the hygiene regimes required for successful production at different stages.

CHAPTER 4

This chapter will highlight the major requirements for oyster mushroom production; raw materials, building design, and major considerations required for successful mushroom production. Information on commercial oyster mushroom cultivation is incorporated at some production stages.

4.1 GROWING OYSTER MUSHROOM

Production of oyster mushrooms demands a much higher level of knowledge, continuous monitoring, and timely manipulation of environmental conditions. As a mushroom grower, you must be prepared to face sporadic fruiting, invasions of "weed" fungi, insect pests, and unreliable market prices.

4.1.1 Raw Materials for Oyster

Mushroom production requires a number of raw materials. At small scale some of the major inputs required are highlighted below.

1. Mushroom Production house
This is where the mushrooms are produced and design depends with resources available.

2. Growing Media
There are several media that can be used as substrate and these depend on mushroom specie to be produced. These can be purchased locally depending on availability.

Oyster mushrooms growing on cotton waste substrate.

3. Spawn (mushroom seed)
Since the Zimbabwean mushroom industry is based on small-scale production, most growers obtain spawn from a few reliable spawn producers in the country.

4. Plastic/mushroom growing bags/ Trays
Plastics are purchased from specialist manufacturers, hard wares or retail shops. Euro Plastics supplies recommended plastics for mushroom production in Zimbabwe. Trays can be made from metal sheets or wood.

Mushroom growing bags.

Mushroom growing trays.

5. Knapsack Sprayers
Used for irrigation purposes in the mushroom production house. These act like humidifiers at small scale as they provide fine mist of water molecules that caters for the growing mushroom moisture requirements.

7. Harvesting Trays
This is where harvested mushrooms are placed before grading and scaling.

8. Scale
Required for weighing harvested mushroom and record keeping.

OTHER REQUIREMENTS FOR SMALL SCALE PRODUCTION
9. Cane Knives/Grinding Machines
Used for growing media e.g. grass substrates that have a larger surface area for colonisation and needs to be reduced in size.

10. Plantation Wood, Drums and Forks
Used only where there is need to make fire for pasteurisation of growing media. Drums are containers where pasteurisation of growing media takes place. Forks are used for turning grass straw when pasteurising.

11. Watering Cans
Needed for fetching water in areas where water is scarce.

12. Pest and Diseases Control
Flytrap mixtures (liquid Malathion mixed with sugar and water) are the only pest control method that can be used in mushroom production. Diseases infections are only controlled following internal quality management procedures and strict adherence to proper hygiene regimes.
Annex 1 gives the consumables list for structural requirements for construction of simple thatched oyster mushroom production house.

4.1.2 Building design

Mushrooms are grown in specially constructed sheds. Existing farm buildings can be used, but require major modifications and even then, still have some limitations. There is no standard size or design of buildings for mushroom culture. Factors to include when planning include construction costs, machinery space requirements, tray or bed size, stacking design etc. Doors must be designed to suit all machinery and equipment that is used. Windows are not required. Although mushrooms do not require complete darkness to grow, do not allow direct sunlight to reach the beds. Any electrical equipment installed must be able to withstand high humidity. Buildings should be rodent-proof.

Cement floors with adequate drainage are required to allow for ease of cleaning and hygiene operations. Flat roofs should have sufficient slope to prevent condensation from dripping onto the beds. Insulation (commonly polystyrene panels at large scale or thatch at small-scale) prevents temperature fluctuations and increases the energy efficiency of the air conditioning.

Good ventilation to supply a constant flow of fresh air and prevent carbon dioxide build-up is essential. Ventilation units should be fully adjustable in terms of circulation volumes and include a filter (gauze wire normally used at small-scale) which will prevent entry of insects and airborne spores. The filters should be cleaned regularly. Do not recycle unfiltered air between different growing rooms. If using trays or shelves, they should be arranged to allow ease of air circulation.

Two systems are currently used. The one-zone system where spawn run and cropping are done in the same room, and the two zone system where separate rooms are used for some production stages. The second option requires a larger turnover to cover extra capital expense.

4.2 OYSTER MUSHROOM AND PRODUCTION STAGES

Oyster mushroom production stages involves a cycle that takes about 15 weeks (from start to finish) as will be described in this chapter. These production stages are as follows;

1. Choosing a growing medium.
2. Pasteurising or sterilizing the medium.
3. Seeding the beds with spawn (material from mature mushrooms grown on sterile media).
4. Maintaining optimal temperature, moisture, and other conditions for mycelium growth and the conditions that favour fruiting (This is the most challenging step.).
5. Harvesting, packaging, and marketing the mushrooms.
6. Cleaning the facility and beginning again.

4.2.1 Choosing a Growing Medium (Substrate)

Mushroom production is completely different from growing green plants. Mushrooms do not contain chlorophyll and therefore depend on other plant material (the "substrate") for their food. Generally, each mushroom species prefers a particular substrate/growing medium, although some species can grow on a wide range of materials. Oyster mushrooms can be cultivated on a wide range of plant wastes often enclosed by plastic bags and production efficiency depends on substrate chosen. Oyster is commonly grown on sterile straw from wheat or a wide variety of high-cellulose/carbon waste materials with high conversion efficiency (usually 75 % and above) for optimum mycelium growth. The following materials can be used as substrate for producing oyster mushrooms;

- Wheat/ Rice/ Barley/ Oat straw
- Maize/ Sorghum/ Millet stover
- Milled maize cobs
- Soya bean hay/ empty pods
- Cotton wastes/ seed hulls
- Saw dust

Members of the Chakohwa Community Based Organisation preparing substrate.

4.2.2 Pasteurising or Sterilizing the Growing Medium

The crop residues are autoclaved or steam sterilised under large-scale production. On a small scale, the growing media can be pasteurised using boiling water. These processes are meant to kill other fungal and bacterial contaminants contained in growing media, which may actively compete with the desired mushrooms specie under cultivation. Contamination of substrate will result in lowering of the potential yield.

At small scale pasteurisation is normally done in drums and substrate is boiled for 1 – 2 hours depending on the type of substrate. In autoclaving, the substrate is placed in the plastic and heated in the autoclave for a minimum period of 2 hours. If large-scale production is desired, high-output autoclaves or more than one autoclaves would have to be used.

The following points should be noted for successful pasteurisation of growing media;

- Avoid over or under pasteurisation of the growing media.
- Pasteurised substrate should be cooled to the correct temperature (avoid over/under cooling) as this can adversely affect colonisation of growing media.
- Cooling of pasteurised substrate should be done under aseptic conditions to avoid recontamination.
- All equipment should be thoroughly cleaned after each use and pasteurisation should be carried out in sterilized drums.

Sterilization of substrate through boiling.

4.2.3 Acquiring Spawn and Spawning

4.2.3.1 Spawn

This is the mushroom propagating material containing mushroom spores with a mixture of other materials to promote spawning as mentioned in Chapter 3. Spawn to be used for mushroom production should either be produced by the cultivator or purchased from a reliable commercial mushroom spawn supplier. Purchased spawn should be first generation (non senescent), virile (non degenerated spawn) and pure (free from contaminants) as this is absolutely critical. Good quality spawn smells like mushrooms. Once purchased, spawn should be mixed with the growing media as soon as possible. However it can be stored at 15-20^{o}C for several days or at 2^{o}C for several weeks. Excessive temperatures or rapid temperature changes adversely affect spawn performance.

4.2.3.2 Spawning - Seeding the Beds with Spawn

Spawning is the inoculation of substrate/growing medium. After the substrate is prepared and sterilized in the plastic bag or other suitable container, spawn is aseptically added to avoid recontamination of substrate.

In most mushrooms species, spawn is added at a rate of 2.5% or more of the dry weight of the substrate. In oyster mushrooms the spawning rate is 5% of the wet weight of substrate.

After this, the bag is hermetically sealed, the spawn should be evenly distributed throughout the growing media by shaking the bag lightly or using the mechanical method of hand mixing.

NB: Plastic bags used for growing oyster mushrooms should be sterilised before spawning. Secondly, more innoculum points, available from increased spawn levels, would provide faster substrate colonisation and thus, more rapid completion of the production cycle.

Mushroom bags must be sterilized before spawning

4.2.4 Spawn Run

Spawn run is the complete colonization of a suitable substrate following inoculation of the substrate, called spawning. Depending on the species of oyster mushroom, the substrate is usually fully captured by the mycelium within 2 to 6 weeks. Spawn run temperatures should be 21-24° C with high humidity (95-100%). Penetration of light during this stage should be kept minimum.

The mycelium—tiny threads will grow throughout the substrate and collect nutrients by breaking down the organic material. This is the main body of the mushroom. The part of the organism that we see and call a mushroom is really just the fruiting body.

4.2.5 Pinning

Pinning is the stage of growth when pinheads are initiated. Pinheads are knots of mycelium that eventually develop into mushrooms. All species of mushrooms require a set of environmental conditions for pinning that are different from the conditions for optimum mycelial growth. Most, if not all, cultivated mushrooms fruit at lower temperatures than the optimum for substrate colonization. To initiate mushroom formation several techniques have to be adopted and these include, dropping temperatures to 15-18^{o}C for 2 days to 2 weeks, introducing fresh air or lowering CO_2 levels and light is provided (if you can read by it, there is enough light). Humidity should be maintained at between 85-90% to avoid drying of pinheads during this stage. Often at small scale where there are no temperature, humidity and carbon dioxide control devices, bags are simply opened and moved to the growing room.

4.2.6 Fruiting

The colonized bag of substrate is placed in a growing room maintained at cool temperatures (19^{o}C) is a good average for oyster mushrooms and high relative humidity (85-95%). Oyster mushroom requires light for proper development. Holes are cut in the plastic bag and the mushrooms are allowed to grow through the holes. During this stage it is important to maintain optimal growing conditions, follow strict hygiene regimes and optimal pest and disease management.

4.3 MAINTENANCE OF OPTIMAL GROWING CONDITIONS

Although spawning and spawn run can be accomplished in any clean room at normal room temperature with fresh air, sterile techniques are absolutely necessary for successful cultivation of most mushrooms. Such methods include: a clean lab bench (swab with 50% Lysol, 10% bleach, or 70% ethyl alcohol); washed hands (with soap and sprayed with alcohol); clean clothes; and clean air.

The growing room requires maintenance of optimal special conditions such as temperature, moisture, and other conditions for optimum mycelium growth and the conditions that favour fruiting (this is the most challenging step). In addition to cooling requirements, the humidity must be maintained at optimal levels as stated above (or even higher in some situations) with just enough air movement to avoid pockets of stagnant air. Excessive air movement, even with high relative humidity, will dry the surface of a substrate and can damage delicate pinheads.

Some of these materials do not require sterilization, only pasteurisation, which is less expensive. To avoid loss of essential nutrients from growing material, substrates should be stored in parched rooms free from moisture or dripping rain.

Creating a very humid environment for mushroom production is perhaps the limiting factor in small-scale cultivation. Creative steps may be necessary to provide high humidity. Aquariums, plastic tents, ice chests with cellophane windows, etc., are potential humid chambers used for growing.

Humidifying the growing room with knap sack sprayers, irrigation of floors and ceilings using horse pipes can be other methods used to provide a humid environment.

On large scale, one way to humidify a growing chamber is to bubble a stream of air (perhaps using an aquarium air pump and porous stone) through water slightly warmer (perhaps using an aquarium heater) than the air you want to humidify. The home cultivator also uses various humidifiers.

4.4 HYGIENE REGIMES

Hygiene practices should be maintained in a house designed for mushroom growing. Strict adherence to hygiene programs at all stages of production will greatly reduce potential problems. Although the following procedures may appear excessive and shortcuts maybe tempting, therefore strict quarantine should be enforced at all entries to mushroom growing areas. Footbaths containing a sterilising solution should be supplied at all entrances and sterilising solution should be changed regularly. Movement between 'dirty' (for example where the compost is produced) and the 'clean' areas (the mushroom growing rooms) should be restricted. Any personnel entering the mushroom growing house should wear clean or protective clothing (dust coats, jumbos, hats; etc.). Opening of doors should be kept at minimum and keep the entrance room clean. Do not allow used equipment to be placed in areas for storing, growing or harvesting mushrooms unless it has been sterilised.

Not maintaining high levels of hygiene will often result in production problems with a corresponding loss in yield. Pest management programs, particularly for diseases are made more difficult by the fact that the mushroom is itself a fungus.

4.5 PROBLEMS, PEST AND DISEASE MANAGEMENT

Pest management programs, particularly for diseases, are made more difficult by the fact that mushroom in itself a fungus. Strict adherence to hygiene regimes at all stage of production will greatly reduce potential problems. The following are often experienced in mushroom production, particularly when using fruit bags.

4.5.1 Problems in Fruiting Bags

Table: Problems commonly encountered in mushroom production.

Problem	Cause	Solution
Mycelial growth very thin	Not enough nutrients	Change substrates or add suplements
Mycelia going down or very slowly	Substrate texture too fine or compact resulting in poor substrate aeration	Add/change to a coaser supplement. Loosen or punch hole on the centre before plugging
Mycelial growth stopped a certain level before reaching the bottom	Excess water has accumulated at the bottom	Add just enough water. Pierce the bottom of the container and let water pass out of the container and allow the mushrooms free aeration.
Mushrooms taking too long to appear after the bag has been opened	Mycelium not mature enough. The temperature may be too high or too low. They may also not be enough light or air. Culture degenerated.	Allow maturing for 1-2 weeks more. Learn and follow proper temperature regimes. Relative humidity (80-90%); light 120W; provide air vents for free circulation, or regenerate strain.
Mycelial growth very thin	Not enough nutrients	Change substrates or add suplements
Mycelia going down or very slowly	Substrate texture too fine or compact resulting in poor substrate aeration	Add/change to a coaser supplement. Loosen or punch hole on the centre before plugging
Mycelial growth stopped a certain level before reaching the bottom	Excess water has accumulated at the bottom	Add just enough water. Pierce the bottom of the container and let water pass out of the container and allow the mushrooms free aeration.
Mushrooms taking too long to appear after the bag has been opened	Mycelium not mature enough. The temperature may be too high or too low. They may also not be enough light or air. Culture degenerated.	Allow maturing for 1-2 weeks more. Learn and follow proper temperature regimes. Relative humidity (80-90%); light 120W; provide air vents for free circulation, or regenerate strain.

4.5.2 Pests

Most pests you are likely to encounter, however, have probably already been studied. These include;

- A variety of small fly and midge species are pests of mushrooms. The larvae feed on the fungal mycelium in the compost, but may also tunnel into fruiting bodies. Mushroom flies, a common pest in mushroom production, are attracted to the smell of decaying vegetation such as mushroom substrates.
- A range of mite species may affect the mushroom crop; some directly damage the fruiting bodies whilst some may attack the mycelium. Mite damage on the fruiting bodies often shows up as cavities in the stem and cap similar in appearance to bacterial pit disease. Mycelium eating mites can cause high yield losses. Mites are very small and easily transported on clothing and tools.

Nematodes

Nematodes will cause a loss in yield and brown, water mushrooms, and in extreme cases soggy, smelly compost. Peat is a common source for nematodes and should be treated before use.

Controls

Here are some examples of non-chemical methods used to control typical pests in the production of oyster mushrooms. Screening the mushroom house ventilation system will keep adult flies out. Double doors and positive atmospheric pressure within the structure also prevent flies from entering. Since adult fungus flies are drawn to standing pools of water on benches, walks, or floors, places where water can collect should be eliminated.

In any case, a grower will probably have to design their own pest management system; biological, cultural and mechanical controls methods or identify the best Integrated Pest and Disease Management (IPDM). Stay alert for any evidence of damage to the fruiting mushrooms and act quickly to identify its cause. Use whatever information you can find, along with your own creativity, to devise ways to protect your crop. A mushroom grower should use all the resources that can be found in libraries, at bookstores, or on the Web.

4.5.3 Diseases

Fungal Diseases

Even though mushroom in itself is a fungus, a range of fungal pathogens listed in the following table can in turn affect it;.

Diseases	Other Names	Symptoms
Dactylium	Cobweb, mildew	White pink cobweb-like fluffy mould
Diehlomyces	Calves brain, false truffle	A competing fungus that produces brain shaped fruiting bodies.
Fusarium	Damping off	Mushroom wither
Mycogone	Wet bubble, white mould	Dense white growth on gills.
Papulaspora	Brown plaster mould	Brown plaster like patches on casing
Scopulariopsis	White plaster mould	White plaster like patches on casing
Trichoderma	Green mould	Dark green mould patches on casing spreading to lesions on stems
Verticillium	Dry bubble/ brown spot	• Brown irregular pitted areas on stem and cap • Distortions and splitting.

Bacterial Diseases
Pseudomonus (bacterial spot, bacterial or pit or brown blotch), causes yellow to brown blotches on the cap which may exude sticky residues. Early symptoms are similar to *Verticilium*.

Control
Maintaining high levels of hygiene will assist any disease management program by reducing the number of problems that are likely to occur. If an outbreak does occur, ensure that the pest or disease is correctly identified before taking action.

4.6 HARVESTING, STORAGE AND GRADING

4.6.1 Harvesting
Mushrooms for fresh market must be carefully picked and it is important to have a pool of reliable experienced pickers. They are easily damage and require careful hand picking and good presentation. The mushrooms are graded during picking into a variety of packages. The market outlet determines the type and size of the package that growers may use.

Oyster mushrooms growing on one bag will not usually develop at the same time. Therefore the need to check bags frequently and mushrooms harvested at just the right time to maximise quality. Oyster mushrooms should be picked when the cap in opened approximately 50-75 percent. At this stage the gills are exposed but the cap edges are still rolled under the cap. Harvesting mature mushrooms (cap 100 percent opened) can lead to reduce shelf life, a longer delay before the next flush and increased pest problems.

Mushrooms are picked by grasping the lower portion of the stem and with a slight twisting motion, pulling the mushroom from the bag. Since bruises on the caps and gills discolour rapidly, only the stems should be touched during picking. Picking mushrooms starting from one row to next can minimise accumulation of debris on unpicked mushrooms. After mushrooms are picked, the stems can be trimmed to remove debris.

Picked mushrooms can be put into a basket, box, paper bag and other suitable container. Air vents are recommended so that the mushroom can be cooled rapidly. To prevent bruising and promote rapid cooling, picking containers should not be filled more than four to six inches deep with mushrooms.

NB: Harvesting should be progressively done from the younger to older areas. Pickers and equipment should be allocated areas or rooms and can be restricted to these areas. When harvesting pickers should be provided with overalls or dustcoats that are washed daily. Equipment (knives, trays etc) used for harvesting should be disinfected after use.

4.6.2 Storage
The immediate objective after harvesting is to cool the product to 2-10^{o}C as rapidly as possible. The uses of plastic 'crates' that are slatted on all sides are recommended for refrigeration. Mushrooms' shelf life is reduced dramatically by using containers that do not allow rapid cooling. Also frost-free refrigerators tend to dry mushrooms excessively.

4.6.3 Grading
Mushrooms are graded within size ranges to suit a variety on containers. Any deviation from the quality standards results in a lower price. Another benchmark for quality is that mushrooms must be clean, white and closed.

4.7 Cleaning the Facility and Beginning Again
The growing house should be thoroughly cleaned and routinely disinfected. Before planting the growing area should be thoroughly treated with both an insecticide and a fungicide to minimise/control remaining pests and diseases. A fumigant or sterilant could be considered. Disinfections of the floor and walls of the growing house should also be done before using it for the next crop. All growing containers should be suitably disposed of after the production cycle or sterilised if being reused. Remove the spent media and transfer it off the growing house to minimise disease risk..

CHAPTER 4

5. MARKETING MUSHROOMS

Marketing is the most important consideration of all. This section provides an overview of market trends, some ideas about how to research, potential markets, suggestions about marketing channels, and advice on financial analysis. If a farmer can't sell mushrooms at a price that ensures a reasonable profit margin, there won't be any need to invest in this enterprise. Farmers need to spend some time and even some money—educating themselves about marketing a potential product.

The key to the mushroom business is to have established buyers and be capable of consistent production. Make the market drive your production. Talk to potential buyers about volume and prices. *Explore various marketing options: brokers, distributors, farmers' markets, restaurants, grocery stores, food service operations, and co-ops.* New growers might encounter an uphill educational experience for two or three years. Launching a commercial mushroom operation is costly, approximately between US $50,000 and US $250,000, depending on whether a grower starts with an appropriate building. For that reason, it is prudent to start small, Naegely (2000).

5.1 Market Research

The goals of market assessment are to project the sales volume and gross income of a new enterprise, to analyze its potential profitability and cash flow, and to gather information about potential buyers and competitors (to help develop a market strategy). It is very difficult for a beginning mushroom grower to compete with well-established mushroom producers.

If you are thinking about starting a commercial mushroom enterprise, begin at the end: to whom will you sell them? You cannot make money in any business if you don't have buyers for your product. Learn who buys mushrooms, what kinds they want, and where they shop. You must thoroughly investigate the demand for each mushroom species or product— as well as the available marketing outlets— before committing large amounts of capital to the enterprise. Check the local situation on your own.

Some common methods for conducting initial research include observation of buyers, surveys of stores, personal interviews with growers, and test marketing (once you have an experimental product). Another function of market research is to evaluate the competition. This will help you determine what market already exists and identify any niches you could fill. To find out more about your competitors, use their products. Talk to them. You may be surprised how much information they will share.

5.2 Market Channels

Explore as many marketing strategies as appeal to you. Below are some possibilities. Market the fresh or dried product directly to your customers (at farmers' markets, over the Internet, through mail-order offerings). Add value to the mushroom by creating processed products (mushroom sauces, dried entrée mixes, extracts). Wholesale as fresh produce (on contract or by the batch).

5.3 Direct marketing

If you can sell your mushrooms or mushroom products directly to an end user, you will naturally receive a better price than if you sell to a wholesaler. Direct marketing of mushrooms at local farmers' markets, to restaurants, or in supermarkets is possible in many locations. Oyster mushrooms have an advantage if locally grown because they have a very limited shelf life and are too fragile to ship easily. The grower with direct, local sales can supply a fresher product that arrives in better condition.

When competing in local markets, excellent service, top quality, and consistent supply, rather than the lowest price, might win the sale. Others are willing to pay for fresh, premium produce. In any case, establishing a relationship with the buyer and reliably delivering a quality product are essential for this type of marketing. Find the buyer to whom quality matters, and you will have found a market for your product..

5.4 WHOLESALE MARKETS

Selling fresh mushrooms to a wholesaler will mean a lower price than if you market directly. However, for growers who choose not to involve themselves in direct sales, there are established wholesale markets for mushrooms.

In Zimbabwe, the industry is made up mainly of a few wholesalers; individual farmers market their own produce to maximize returns. Companies such as Interfresh and Katope collect, grade and market the finished product. Other commecial buyers are listed in Annex 3.

5.5 ADDING VALUE TO FRESH MUSHROOMS

Adding value to fresh mushrooms usually means either developing a processed product, such as a sauce, or drying surplus mushrooms for sale in the off-season, when prices are higher. A value-added product can be sold either directly to the consumer or to wholesalers. Hence drying mushrooms is another way to add value and avoid the low prices of the peak season.

5.6 FINANCIAL ANALYSIS

As a part of your market research, you need to do a financial analysis of the potential enterprise. Develop an enterprise budget with as much detail as you can provide. As with many farm enterprises, mushroom production is often only marginally profitable when labor and management costs are taken into consideration.

Try to anticipate every cost so that you can construct an accurate financial picture. Include an educational and/or marketing component in your budget, allowing for free samples especially if you are developing a new product or will be doing direct marketing.

If you are adding mushroom production to an integrated farming system, financial analysis is more difficult. Making a clear profit might not be as important as making use of off-season labor or substrate from farm waste to create a saleable product from what otherwise would have been waste.

CONCLUSION

Commercial cultivation of mushrooms is not for everyone. It requires someone who is familiar with fungi life cycles and willing to commit time and money to research, designing a system, and developing a business. The mushroom cultivator must be able to carry out operations on time, be attentive to details, and be vigilant about pest invasions. In most cases, marketing requires excellent public relations skills.

Nevertheless, there is potential for an innovator who can use an existing facility, obtain a low-cost substrate, and produce a reliable supply of a high quality product. As part of a whole-farm system, mushrooms can augment productivity at any scale. Producing a nutritious food at a profit, while using materials that would otherwise be considered "waste," constitutes a valuable service in the self-sustaining community we might envision for the future. Even though it is a challenge some will find worth taking.

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ANNEXES

ANNEX 1: Consumables List

Equipment Required	Use
Cotton Twine	Used in tying bags
Jik	Used for hygiene purposes
Thatched Mushroom Production House Requirements	
Thatch	Used in construction of simple production houses. Quantity depends on size of structure to be produced.
Sand	Used on floors for cooling purposes in areas that have high temperatures
Plastic Sheeting	Used for ceiling construction and helps to avoid rain water from dripping into the production house
Cement	Used for construction of floors
Timber and Poles	To provide support to the structure
Wire Gauze	To allow for ventilation on small openings at same time preventing pests from entering the production house

ANNEX 2 – LIST OF COMMERCIAL SPAWN PRODUCERS IN ZIMBABWE

Scientific & Industrial Research and Development Centre (SIRDC)
1674 Alpes Road, Hatcliffe extension, Harare, Zimbabwe.
Telephone: (04) 866320/33, Cellphone: 011631893 (Mr. E. Masita)

Mushroom Technology Centre (MTC)
PO Box 2142, Harare, Zimbabwe.
Cellphone: 0912909803 (Mr Sibari)

Africa University (AU)
Faculty of Agriculture and Natural Resources
P. O. Box 1320, Mutare, Zimbabwe
Telephone: (020) 60026/ 60075/ 61611

ANNEX 3 – LIST OF COMMERCIAL BUYERS IN ZIMBABWE

INTERFRESH Wholesale Fruiters buys mushroom directly from different mushroom growers in the country. Tel. (020) 66164/ 61948/ 63620 Cell: 011412771	***INNSCOR*** No. Greenock Workington Harare Tel: (04) 662393/ 666988 Cell: 091203527	***Fruit and Vegetable Growers Co-operative (FAVCO)*** 306 Hillside Road Harare Tel.: (04) 486961/2/7/8 Cell.: 091203527