

# ORGANIC MUSHROOM CULTIVATION MANUAL



**A GUIDE TO GROWING MUSHROOMS  
ORGANICALLY FOR ECO-FRIENDLY LIVELIHOODS**



DEVELOPED AND PUBLISHED WITH SUPPORT FROM



# ORGANIC MUSHROOM CULTIVATION MANUAL

THIS MANUAL IS ALSO AVAILABLE IN THAI LANGUAGE

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## **Mushroom Cultivation: A Growth Area**

Mushroom cultivation offers an alternative and sustainable livelihood for anyone interested in a career change or a new way of supporting themselves and their family. Growing mushrooms has a very low environmental impact compared to other crops, and therefore, can be a good choice for communities planning for the future.

This manual provides comprehensive step-by-step instructions for cultivating mushrooms organically in plastic packs, a scalable method that replicates the natural growth process. This method has proven successful for growing many kinds of mushrooms including: the Phoenix Oyster Mushroom, Oyster Mushroom, Yanagi Matsutake Mushroom, and the Shitake Mushroom. The different materials required for mushroom cultivation, such as sustainably sourced sawdust from rubber trees, are also listed with detailed preparation advice.

Mushrooms are rich sources of protein, popular to eat and can be prepared in a multitude of ways. Mushroom cultivation generates significant revenue for farmers around the world each year. Demand for organic produce is rising steadily in most countries. We hope this manual will help you or your trainees join this thriving sustainable industry.

## **Introduction to Mushrooms**

### **What Mushrooms Are**

The mushroom is a fruiting body of microorganisms called fungi. To propagate, it forms a mycelium in its growth stage, generating spores in the gills for dispersal. As mushrooms lack chlorophyll, they don't photosynthesize (process energy from sunlight) like green plants.

Mushrooms play a significant role in forest ecology, as they help decompose dead plants and animals, including dead trees, branches, leaves, fruits, seeds and animal droppings on the ground. In organic soil, 90% of dead plants are made up of wood with cellulose and lignin, which makes them decay very slowly. Mushrooms produce an enzyme to decompose these substances more rapidly and create nutrients for other plants and microorganisms, thus completing the natural forest growth cycle.

Mushrooms themselves are tasty, popular to eat and a beneficial source of nutrients for people too. Much of Asia's environment is suitable for cultivating many different types of mushrooms. In addition, the low costs associated with growing mushrooms helps farmers get started and make relatively quick and good financial returns, positively contributing to the country's economy.

Before embarking on mushroom cultivation for commercial purposes, it's important to understand the different varieties of mushrooms, their attributes, qualities, environmental needs and characteristics of growth. Different mushrooms have different market demands and profit margins, as well as growing challenges. It's also important to be aware of potential problems, such as pests, disease and inclement weather.

# ORGANIC MUSHROOM CULTIVATION MANUAL

## **Mushrooms Varieties and their Values**

There are more than 30,000 identified types of mushrooms worldwide. 99% of these are safely edible and roughly 1% is poisonous. Yet there are still many undiscovered mushroom species and the effects of some mushrooms on human health remain unknown.

A wide assortment of mushrooms is eaten around the world. Champignon and Field Mushrooms are popular in Europe, Shitake Mushrooms are consumed mostly in China and Japan, while Thai people prefer Yanagi Mushrooms or Straw Mushrooms. Tastes are evolving and chefs are introducing varieties of mushrooms to new markets. Demand for organic produce is also growing globally.

Some mushrooms have medicinal qualities and their popularity is rising too. Nowadays, almost every country devotes more attention to research, experimentation, selection and development of mushrooms.

Cultivation and production techniques are being further developed to increase mushroom production to meet consumer demand. Mushrooms are very popular in many countries and often considered to be as nutritious as meat. Taiwan, Japan, India, Korea and Thailand have the highest global export rates of mushrooms.

**Nutritional Benefits:** Research and analysis by Thailand's Department of Science into the nutritious value of mushrooms reports that mushrooms sold at market, such as Straw Mushrooms, Wood Ear Mushrooms, Oyster Mushrooms, Abalone Mushrooms and Phoenix Oyster Mushrooms, contain varying amounts of the following: carbohydrates, proteins, fat, minerals and vitamins. Scientific research has shown that mushrooms contain many kinds of B-complex vitamins and important minerals. This research adds further weight to the claim that mushrooms are often equal to meat in nutritional value.

## **Growing Conditions**

In addition to demand and marketability, it is crucial to consider climate and available materials before deciding to cultivate any variety or combination of varieties of mushrooms.

Thailand has very suitable conditions for mushroom cultivation as there are a lot of left-over materials and agricultural by-products from plants and animals that can be used for growing mushrooms including some weeds, ground rice stubble, chopped rice straw, sugar cane bagasse, and water hyacinth leaves. Other materials include banana trees, corn trees, cornstalk, green bean shells, molasses, compost, chicken dung, duck dung, horse manure and cow dung.

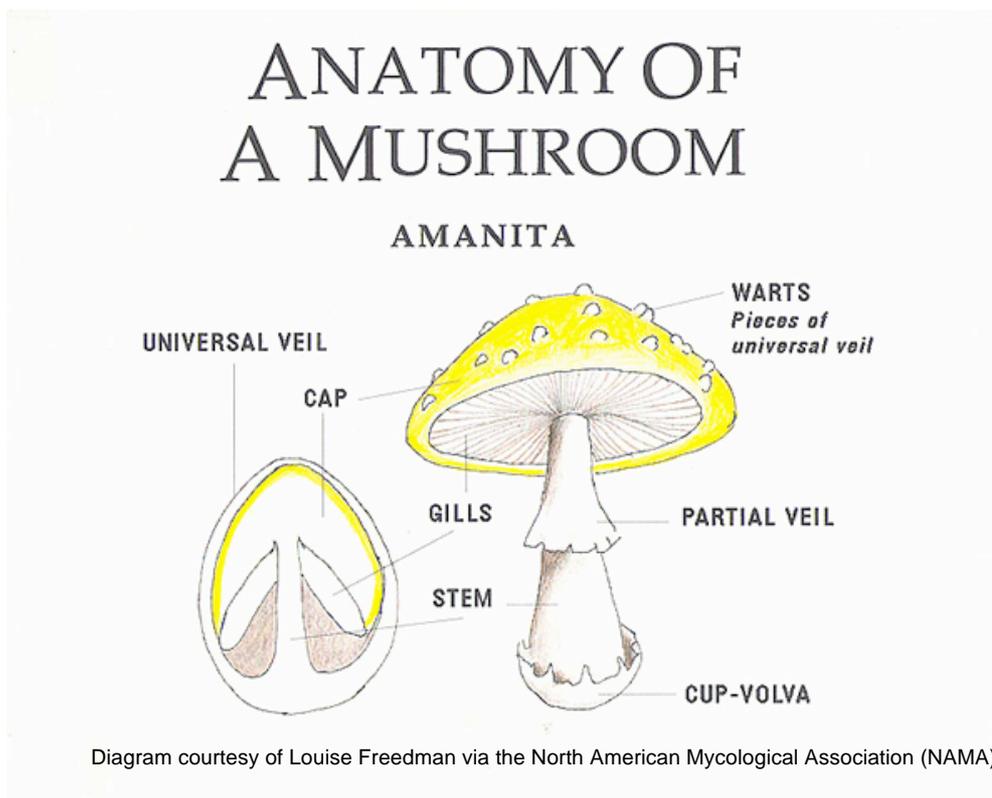
Thailand's weather is also very suitable for growing most mushroom varieties including Straw Mushrooms, Oyster Mushrooms, Abalone Mushrooms, Wood Ear Mushrooms, Champignon Mushrooms and Shitake Mushrooms. With more efficient growing methods, Thailand could expect higher quantities and better quality mushroom yields, which would contribute broadly to nutritional health and food security.

Which kinds of mushrooms have been successfully grown in your country/area? If you don't know, is there a local cooperative, village group or NGO you can ask? Once you have a reliable revenue stream it may be viable to experiment with growing different and higher value varieties.

## What makes up a Mushroom

1. **Cap:** the top part of the mushroom that grows upward. When fully grown, mushroom caps will spread out like an umbrella, e.g. the Straw Mushroom, Champignon Mushrooms, etc. Caps of some mushrooms (like the Phoenix Oyster Mushroom, Oyster Mushroom, Abalone Mushroom) are more flat and may be indented in the middle.
2. **Gills:** the underside of the mushroom cap that has thin sheets connecting in a row around the stalk, and extends upward to the tip of the mushroom cap. The gills of some mushrooms are connected tightly to the stalks, some have pores, and others have teeth.
3. **Stalk or Stipe:** Stalks of each type of mushroom are different in size and length. Normally, stalks are cylindrical. The bottom part of the stalk is big and gets slimmer as it nears the top. The top part of the stalk joins the cap or gills. The skin outside the stalk of some mushrooms is rough while some are scaled like nets (**Reticulum**). Inside the stalk some mushrooms are loosely woven with fiber similar to sponges, while others are bound together tightly. This makes the stalk hard, soft or crispy; the texture varying according to the type of mushroom.
4. **Spore:** Mushroom spores are basidiospores, which are produced in the gill area. Mushroom spores are very small and basically colorless. When these spores gather into cluster, they will be a similar color to that of the gills. Different types of mushrooms have differently shaped spores. If the mushroom cap is put on a piece of paper in a sheltered area, spores will fall on the paper spreading along the gills' lines.
5. **Ring:** Mushroom rings are thin tissues connecting the caps around stalks. When mushroom caps spread out, the tissues fixed between the caps and stalks will break and there will be some tissues left on stalks that will look like thin film wrapping. Types of rings can be used to classify types of mushrooms.
6. **Volva:** located at the base of the mushroom. Depending on the type of mushroom, the thickness of the volva will vary. The Volva is left over from the wrapping tissues of budding mushrooms. When mushrooms grow, they will push these tissues out and stalks will push the caps upward, leaving the tissues below.
7. **Mycelium:** Mycelium is a cluster of fiber woven tightly together. Some mushrooms have tightly gathered mycelium around the base of the stalk. Some mycelium contain rough fibers, while others contain fine ones.

*Each type of mushroom may not have all of these components. Most of them have caps and stalks while other components vary depending on the type of mushroom.*



## **Types of Mushrooms**

There are several useful ways to classify mushrooms.

**Classification of garden plants:** First classify whether it is edible or not

1. Edible mushrooms, such as Wood Ear Mushrooms, Straw Mushrooms, Phoenix Oyster Mushrooms, and Oyster Mushrooms
2. Inedible mushrooms are the small set of poisonous varieties

### **Botanical classification**

1. Subdivision of Basidiomycotina, such as thin types of Wood Ear Mushrooms, thick types of Wood Ear Mushrooms and White Jelly Fungus
2. Subdivision of Ascomycotina, such as the Truffle Mushroom and Conic Morels Mushroom

### **Morphological classification**

1. Classified by gills
2. Classified by mushroom caps
3. Classified by stalk: mushroom with a stalk or mushroom without a stalk

### **Classification by natural state of growing**

1. Mushrooms that can grow well on parts of plants or plant residues, such as Oyster Mushrooms, Phoenix Oyster Mushrooms and Wood Ear Mushrooms
2. Mushrooms that can grow well on partially preserved materials, such as Straw Mushrooms and Common Ink Cap (or Inky Cap) Mushrooms
3. Mushroom that can grow well on completely preserved materials, such as Champignon Mushrooms
4. Mushroom that can grow and live on the roots of trees, such as the Bolete tree and on termite mounds, such as Yanagi Mushrooms

**Common Varieties of Mushrooms**



Oyster Mushroom



Straw Mushroom



Reishi Mushroom



Enokitake Mushroom



Shitake Mushroom



Wood Ear Mushroom



Champignon



Phoenix Oyster



Yanagi Matsutake



Abalone Mushroom



Yanagi Mushroom



Portobello Mushroom

## Key environmental factors to consider for mushroom cultivation

**Temperature** – Temperature is important for the healthy growth of mushrooms. The correct temperature for the growth of fibers in each type of mushroom is a little higher than the correct temperature for the growth of the mushroom cap. For example, Straw Mushrooms grow well at 38-40 degree Celsius, which is the best temperature for producing spores. Fibers grow well at 35-38 degree Celsius while caps grow at 30 degree Celsius. If it is too hot, mushroom caps will be small and open faster than usual. But if it is too cold, fibers will grow slower or even stop growing.

Seasonal temperature variations can dramatically affect mushroom growth cycles. For example, growing Straw Mushrooms in the summer usually takes 7 days for caps to appear, while it takes 8-12 days during the rainy season, and 15-18 days or more, or sometimes no cap at all, during the winter.

**Dampness** – Dampness is essential for the growth of fibers, as well as the production and growth of the caps. But if it is too damp inside the caps, fibers will be soaked and die. The wet small caps will gather at the meeting point between fibers and caps, making it impossible to pass food to the mushroom caps. They will then wither and eventually die. If it is too dry, mushrooms will shrivel up and will not grow.

**Light** – Even though light is necessary for the growth and assembly of fibers and in order to produce mushroom caps, it is not essential for the mushrooms' growth. On the contrary, light darkens the mushrooms' color, unlike growing them in the dark (which whitens them). Although just an aesthetic difference, color considerations can be important for the marketability of produce, for example, white straw mushrooms are much more popular among consumers than darker gray crops.

**pH Levels** – The pH level is important for the growth of mushrooms. Straw mushrooms are neutral or a little acidic. If there is too much acid, bacteria will not grow and they will be less able to digest molecules. Fibers in the straw mushroom will then get less food. This will reduce the number of mushroom caps. A suitable pH level for straw mushrooms and other mushrooms is between 5 and 8.

**Oxygen** – In every stage of mushroom growth oxygen is needed, especially when the caps are coming out and after they have bloomed. If there is too much carbon dioxide in the mushroom bed, fibers will grow slower or stop growing, the mushrooms will grow abnormally and their skin will be affected.

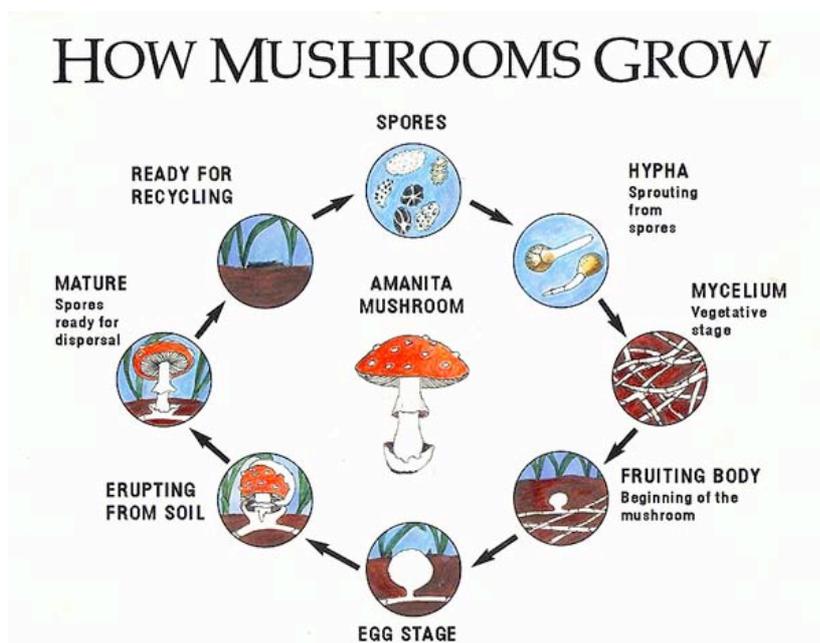


Diagram courtesy of Louise Freedman via the North American Mycological Association (NAMA)

## Biological characteristics of commonly cultivated mushrooms



### Phoenix Oyster Mushroom

**Scientific Name:** *Pleurotus pulmonarius*

**Common Name:** Phoenix Oyster Mushroom

**Cap Appearance:** A group of approximately 6 mushroom caps. Mushroom caps are firm, black-brown and grey or white. Long stalks, white gills, cap diameter: 2-8 cm

**Incubation Period:** Fibers fully grow on food mixed with sawdust (800-900 grams) in 30-40 days time at temperature 30-33 °C

**Blooming Period:** Mushrooms can be collected for 3-4 months at a temperature of 20-30 °C with relative humidity of 75-85 %

**Average Production:** 300-350 grams per pack

**Cultivation Problems:** Fungus spore packs often go bad because they are contaminated by other fungi. To prevent this, avoid adding supplementary food into the spore packs and ensure the sawdust packs are sterilized by steaming at a temperature between 90-100 °C for 3-4 hours before spores are added; furthermore, always clean the mushroom barns once the packs in each lot are opened.



## Oyster Mushroom

**Scientific Name:** *Pleurotus ostreatus*

**Common Name:** Oyster Mushroom

**Cap Appearance:** A group of 8 mushroom caps approximately. Mushroom caps are brown or grey. Gills are thin sheets. Caps are quite big and have 4-7 cm diameter. Stalks are about 5-10 cm long

**Incubation Period:** Fibers grow fully on food mixed with sawdust (800-900 grams) in 30-40 days' time at temperature 30-35 °C

**Blooming Period:** Mushrooms can be collected for 3-4 months at temperature 20-30°C with relative humidity at 75-85%. Mushrooms need light at least 40 % per day.

**Average Production:** Mushrooms weigh 300-450 grams per pack approximately. Production is high. Caps are firm and weigh well when grown in cool weather about 22-26 °C

**Cultivation Problems:** Mushrooms will bloom slower after the packs are opened. To solve this problem, let the fibers bind tightly for 8-10 days and open the packs once fibers have grown all over the inside of the packs.



### **Abalone Mushroom**

**Scientific Name:** *Pleurotus cystidiosus* O.K. miller

**Common Name:** Abalone Mushroom

**Cap Appearance:** Mushroom caps are brown or soft white similar to sea shells. Caps are thick with dark color and have about 9 cm diameter. Stalks are plump with 2 cm diameter and are 8 cm long. There are about 2 mushrooms per pack. Blooming in each lot will always be at the same time

**Incubation Period:** Fibers grow fully on food mixed with sawdust (800-900 grams) in about 40-50 days at temperature 28-32 °C

**Blooming Period:** Mushrooms start blooming after the fibers grow fully in 10-15 days. Each mushroom lot will grow 20 days apart at temperature 28-32 °C with relative humidity at 80-85 %. They need little light

**Average Production:** Mushrooms weigh 350-450 grams per pack

**Cultivation Problems:** There is often brown mucilage bothering the blooming on the packs and creating bad smell. The problem can be solved by scraping the mucilage out.



### **Yanagi Matsutake Mushroom**

**Scientific Name:** *Pholiota cylindracea*

**Common Name:** Yanagi Matsutake Mushroom

**Cap Appearance:** Mushroom caps are quite round with 3-7 cm diameter. The middle of the cap bulges. Caps are brown with white tissues wrapping underneath. Stalks are round and quite long, approximately 5-10 cm. Caps and stalks are firm and crispy similar to Yanagi Mushrooms. They might bloom in a single or group of caps. There are approximately 4-8 caps per pack.

**Incubation Period:** Fibers grow fully on food mixed with sawdust (800-900 grams) in 45-50 days at temperature 25-30 °C

**Blooming Period:** After fibers grow all over the pack, move the packs inside the mushroom barns before opening. Each mushroom lot will grow 15-20 days apart at temperature 24-28 °C with relative humidity at 70-80%. They need little light

**Average Production:** 200-250 grams per pack

**Cultivation Problems:** Mushroom caps can dry, wither and die because of too much watering. To solve this problem, do not pour too much water on the mushroom caps, instead only spray on the caps a little.



### **Straw Mushroom**

**Scientific Name:** *Volvariella volvacea*

**Common Name:** Straw Mushroom

**Cap Appearance:** At first, caps are white with covers. When young, mushrooms are white and become pink-light purple when they're old. When grown up, they look like umbrellas with gills underneath the caps.

**Incubation Period :** Fibers grow fully on growing material in about 5-7 days at temperature 35-37°C, humidity in haystack at 60-70% and relative humidity at approximately 80%. The pH measurement is between 6.5 and 7. A little light can be allowed in the mushroom barns.

**Blooming Period:** The blooming will start 7-12 days after growing. Fibers will assemble into white lumps around the areas sprinkled with fungal spores. In this stage, the suitable temperature is about 28-32 °C

**Average Production:** 10-15 kilograms and 0.75-1 kilograms of dry straw mushrooms in every 50 kilograms of rice straw.

**Cultivation Problems:** They can have small caps and fibers can grow uneven or slowly. This problem can be solved by discontinuing the use of fungal spores and allowing some light into the barns.



### Shitake Mushroom

**Scientific Name:** *Lentinula edodes*

**Common Name:** Shitake Mushroom

**Cap Appearance:** Caps are round with 5-10 cm diameter. Skin has hair and white rough scales scattered all over. On top of cap is red brown. Gills are white thin sheets and become darker when old. Stalks are round and about 4-7 cm long

**Incubation Period:** Fibers grow fully on food mixed with sawdust (800-900 grams) in 2 months and then incubate for 3 more months at temperature 24-32 °C

**Blooming Period:** After fibers grow all over the pack, wait until the fibers bind and turn brown and then move the packs inside the mushroom barns before opening. Each mushroom lot will grow 15-20 days at temperature 24-32 °C with relative humidity at 70-80%

**Average Production:** Approximately 150–250 grams per pack

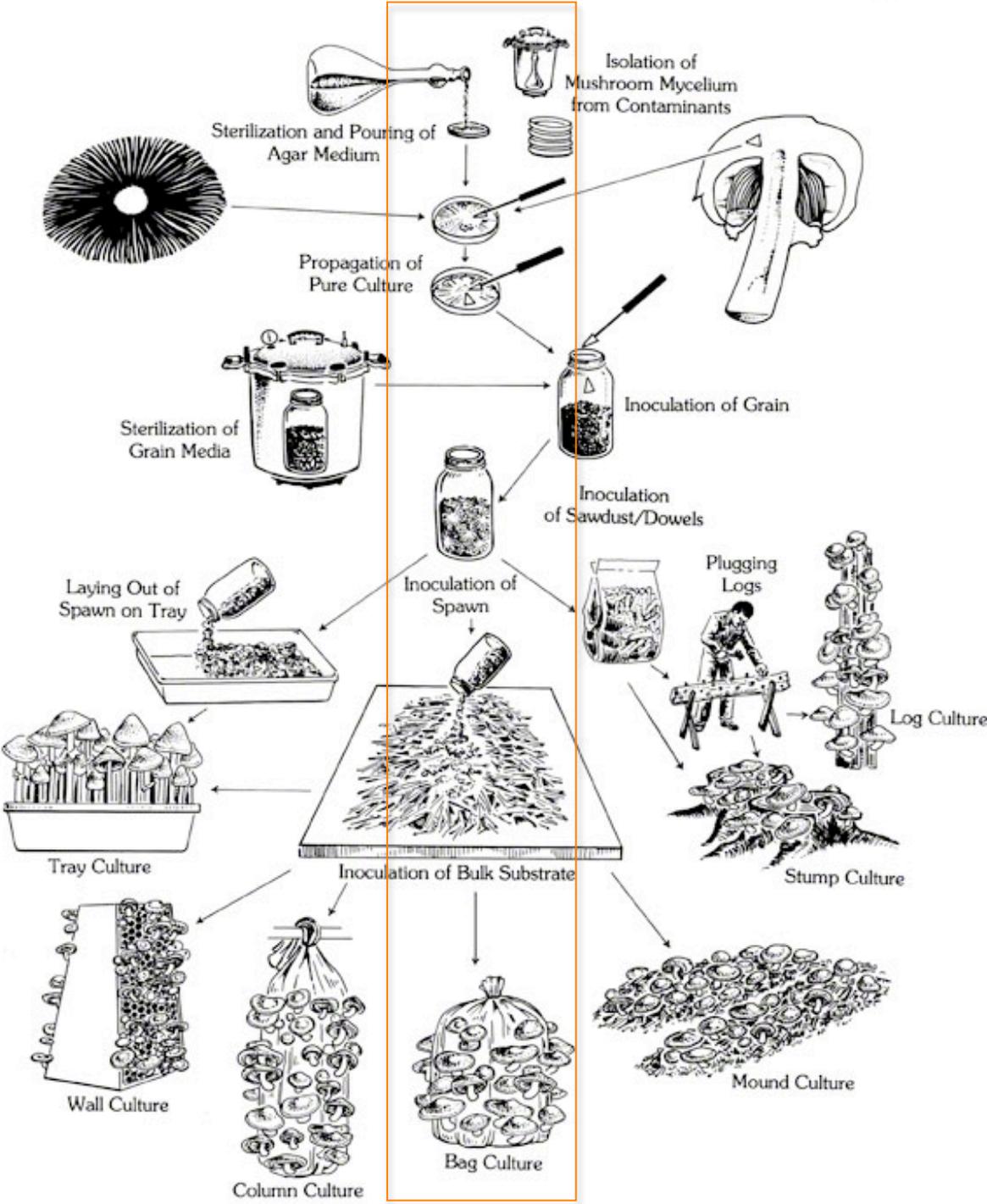
**Cultivation Problems:** Small caps, fibers are uneven and grow slowly. This problem can be solved by discontinuing the use of the fungal spores, adding brown sugar and resting the packs face down, allowing food and humidity to gather in the front of the packs.

## Cultivating Mushrooms (step-by-step approach)

There are multiple methods for cultivating mushrooms, all of which require multiple steps. This manual explains the reliable and easily scalable “bag culture” technique.



# AN OVERVIEW OF MUSHROOM CULTIVATION TECHNIQUES



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Diagram used with permission of Paul Stamets / Fungi.com

## 1. Culturing mushroom mycelium on Agar media

### Materials used for Potato Dextrose Agar (PDA) preparation

- Potato	250	grams
- Glucose	25	grams
- PDA powder	20	grams
- Clean water	1	liter

### Required equipment;

- Aluminum pot
- Flat bottle
- Cotton Ball
- Glass stirrer
- Gas stove
- Pressure cooker
- Biological safety cabinet and other equipment for wiping fungal spore
- 1000 milliliter beaker
- Knife
- Cone
- Heat-protected Gloves
- Filter Clothe

### How to prepare nutritied Agar Media: PDA

- Prepare equipment. Wash potatoes until clean. Peel and cut into 1 cm cube (1 x 1 x 1 cm)
- Boil potatoes in 1 liter of clean water with low gas. Leave them boiling for 15 more minutes after the water has already reached boiling point.
- Filter the potatoes out. Add clean water until it is 1 liter all together and keep boiling. Then, add agar powder. Cold water should be mixed well with the agar powder before it is added to the pot because adding the powder by itself will cause the PDA to form into chunks. After agar powder is cooked or well dissolved, add glucose and stir continuously to avoid burning the PDA at the bottom of the pot. Boil and stir well. Then add clean water until it is back up to 1 Liter.
- Fill  $\frac{1}{4}$  of each flat bottle with PDA. Be cautious when filling. Do no spill any on the opening of the bottles. If split, clean it with clean cloth, then plug the bottles with cotton balls, wrap with paper and bind with rubber bands. The bottles should also be covered with plastic caps so the cotton balls will not get wet during the sterilization.
- Steam the PDA bottles for 30 minutes with a pressure steam cooker (an autoclave steam pressurized oven) under the pressure of 21 pounds per inch. If a pressure steam cooker is not available, you can also steam regularly by steaming it 3 times in a steaming pot, each time for an hour with an 18-24 hour break in-between.
- Let the sterilized PDA bottles sit for 5 minutes. Lean the bottles to allow more space before cooling down or getting hardened. Do not lean so much that the agar touches the cotton balls, or else there might be a contamination while culturing the fungal spores. When PDA hardens and cools down, they can be used to culture the fungal spores in the future.

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## Pictures illustrating steps of making PDA



**Prepare equipment**



**Wash potatoes clean**



**Peel and cut into pieces**



**Boil for 15 minutes**



**Filter for the water**



**Add clean water**



**Pour into a boiling pot**



**Prepare glucose and agar powder**



**Add agar powder**



**Boil until it is cooked**



**Add in glucose**



**Stir well for 10 minutes**

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Add clean water



Pour to 1/4 of a bottle



Plug with cotton balls



Bind with rubber bands



Put caps on top



Add water to pressure cooker (1" high)



Put bottles in steam cooker



Turn valve on, let out air for 10 min



Steam under the pressure at 21 pounds for 30 min



Remove from pressure cooker



Lean the bottles



Keep in a room, waiting to culture fungal spores

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## Starting a mushroom strain by cloning: Tissue culture

Culturing fungal spores on PDA media is the most important process. Mushroom growers have to practice until they become skillful and are able to culture fungal spores on PDA media without any contamination. This method is to multiply the fungal spores to use as concentrated fungal spores in the future. Culturing fungal spores can be done several different ways. In this manual, we will cover how to separate mushroom tissues and how to culture them on PDA media, which is very popular. You will get all the same qualities as the original mushrooms. It is a popular method for growing the Straw Mushroom, Oyster Mushroom, Phoenix Oyster Mushroom, Abalone Mushroom, Wood Ear Mushroom and Champignon Mushroom.

Separating mushroom tissues and culturing on PDA media can be done the following ways;

**Mushroom Selection** should be as follows;

- Mushrooms have to be big and heavy. For Straw Mushroom, select those that are budding.
- The tissues of the mushrooms you use should be perfect, not infected or destroyed by insects.
- Mushrooms should be freshly picked from the barns or from the fungal spore packs because their tissues are in the growing stage and are not contaminated with other fungi.
- Mushrooms that will be separated by their tissues and cultured on PDA media must not be touched by water. If they are, the mushroom will absorb the water, which can contaminate them.

**Equipment required includes:**

- |                                  |  |
|----------------------------------|--|
| - Sterilized cabinet / box       | - Alcohol Lamp                         |
| - PDA Bottles                    | - Lighter or Matches to light the Lamp |
| - Needle for wiping fungal spore | - Sharp Knife                          |
| - Mushrooms                      | - Cotton Balls                         |
| - Alcohol Spray                  |  |

**Equipment preparation:** equipment needs to be especially cleaned in the following ways:

- Use antiseptic cleansing products, such as Dettol or alcohol to clean inside the cabinet / box
- Spray 70 % concentrated alcohol inside the cabinet / box before starting the operation. This step is commonly applied because it is convenient and fast
- Or use ultraviolet rays to sterilize inside the biological safety cabinet before the operation starts.
- You can drop formalin on potassium permanganate to smoke and sterilize inside the cabinet / box. The smoking process will take 2-3 hours and you should start the smoking process 4-5 days before the operation. However, this method takes a long time and may be dangerous to people who are allergic to formalin.

**Caution:** Before you culture mushroom spores, take a shower and clean yourself each time before the operation. You must not be involved in any mushroom harvest or touch any fungus. Always clean fungal spores and wipe down the area before every operation to reduce and prevent any contamination that may occur during fungus spore culturing process.

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## Pictures illustrating the process of separating mushroom tissues and culturing on PDA Media



**Select mushrooms**



**Clean mushrooms**



**Clean hands and body**



**Clean cabinet and equipment**



**Clean the PDA bottles**



**Keep equipment in the cabinet / box**



**Hold over the fire**



**Tear the mushroom**



**Cut mushroom tissues**



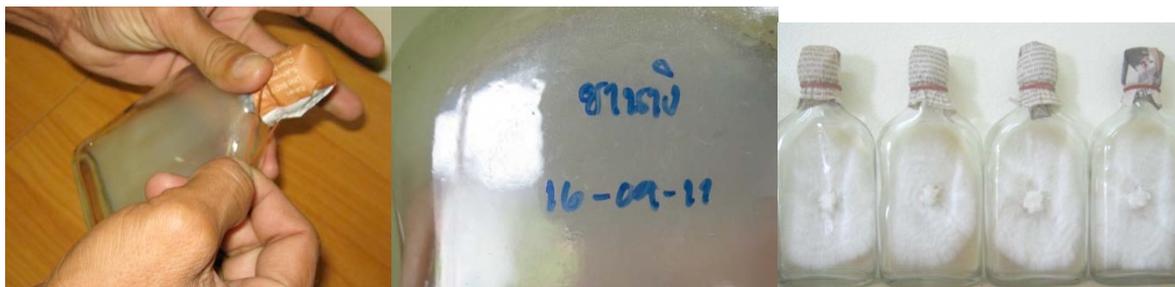
**Hold the bottle's opening over flame**



**Put the tissues in the middle of PDA**



**Plug with cotton balls**



**Bind paper cap with rubber bands**

**Write type of mushroom and date of bottling**

**Fully grown mushroom spore**

**Pure Fungal spores** must not be contaminated with other fungi, e.g. black mold (*Aspergillum*), green mold (*Penicillium*), orange mold (*Neurospora*). No mold should be in the bottles because it will contaminate the production of the fungal spore packs with other fungi. Fibers of fungal spores will be pure white with other colors according to the type of mushroom and will grow all over the inside of the bottles.

## 2. Producing spore seeds from millet

### Materials and Equipment:

- Millet Seeds
- Soda Bottles or Big Flat Bottles
- Large pressure cooker/drum
- Tray or Sieve
- Spatula
- Cotton Balls
- Biological safety cabinet
- Rubber Bands
- Gas stove and other relevant equipment

**Millet Seed Selection** – Choose only big, new seeds that are not broken because they have no insecticide or fungus left over. Red or white millet seeds can be used.

**Millet Seed Washing** – Wash dirt off the seeds and take out those that are floating; those seeds defective or have been destroyed by insects. Only use the sunken seeds for the cooking process.

**Cooking by Steaming** – Soak the clean seeds in water for 12 hours to saturate and make them easier to cook. Wash them with water many times until the sour smell from the rotten broken seeds is gone. Steam them in a pressure steamer until they are well cooked but not wet. This method is not as commonly applied now as people tend to cook millet seeds by over boiling them.

**Cooking by Boiling** – Soak the clean seeds in water for 12 hours to saturate them. Then boil in a pot or suitable-sized container. Increase gas to boil the water and then reduce the gas to bring to a light boil. Stir occasionally with spatula to spread the seeds so they receive equal amounts of heat. Boil for 20 minutes until the seeds swell and split a little. They should not be boiled until they open. Then scoop the seeds out of the pot, steam them for 10 more minutes and lay them out to dry.

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**Spreading the Cooked Millet Seeds** – Spread millet seeds on trays or sieves so the water can easily seep out. Use for example, a sieve with a nylon net. Spread them out thinly. Fanning can be applied while spreading them out until they are half dry.

**Filling in the Bottles** – Big whiskey bottles or soda bottles that are clean and dry are commonly used. Fill them with millet seed by using a cone to prevent the opening of the bottle from getting stained with the cooked millet seeds as this could allow the fungus to grow inside the bottles. **Fill the bottles only with the seeds.**

**Plugging the Bottles** – Use suitable-sized cotton balls to plug the bottles, not too tight and not too loose. Use the same plugging method as with PDA bottles in order to prevent dampness and diseases from entering the bottles after sterilization.

**Preventing the Stoppers from Getting Wet During Sterilization** – You can use plastic caps that are heat resistant or put several bottles in a basket and then cover them with newspaper. This is suitable for repeated use as the process of wiping the fungal spores will be done the next day. If you sterilize many bottles at the same time and would like to keep some for later use, you should wrap the cotton ball stoppers and bind them with rubber bands before sterilizing. After sterilization with the wrapping paper, they can be re-used for a long period of time.

**Sterilization** – Use a pressure steamer and the same method as with sterilizing agar food; the steam pressure should be 21 pounds for 60 minutes. The period of sterilization depends on the amount of bottles. After sterilization, let the bottles cool down before wiping agar pieces into the millet seed bottles inside the biological safety cabinets.

**Putting Pure Fungal Spores in Millet Seeds** – Put the needle you will use for wiping the fungal spores over the fire and then let it cool down. Unplug the stoppers of the bottles that hold pure fungal spores. They should contain well-grown fibers over all or most of the surface of the agar and without any contamination. Cut an agar piece that has approximately 1 x 1 cm of grown fibers, take it out of the bottle, and put the opening of the bottle over the fire and plug the bottle. Then, hold up the millet seed bottle, unplug the stopper, put the opening of the bottle over the fire, lean the bottle to allow the millet seeds to flow close to the opening but not so much that they pour out, and put an agar piece deep inside the bottle, so that when the seeds fall back the agar piece will be in the middle of all the seeds. Put the bottle's opening over the fire after taking out the needle, then put the stopper on, wrap with paper and bind with a rubber band. Continue on to the next step: incubation.

**Millet Leavening Incubation** – Keep the bottles that already have pure fungal spores on a shelf in a clean room away from sunlight and at room temperature. Check regularly if any bottles have become contaminated. Fleas that eat mushroom fibers might be contaminators. If contaminated, take the bottle out and destroy it. During this process, mushroom fibers will grow in all directions all over the inside of the bottle, which normally takes 7-10 days depending on the type of mushroom. The best stage of millet leavening is when the fibers are freshly fully grown all over the inside of the bottle; shake gently to loosen the seeds, which will make it easier to pour the leavening into a sawdust bag. If you leave it too long, fibers will be old and tightly woven and won't loosen after being shook, and as a result they won't pour easily into a sawdust bag. If needed, to prolong the usage of fully grown spawn seeds you can shake the seeds loosely every day but the quality of fungal spore will not be as good as when the fibers are freshly fully grown.

# ORGANIC MUSHROOM CULTIVATION MANUAL

## Pictures illustrating steps of preparing grain media



Soak millet seeds in water for 12 hours



Boil the seeds for 20 mins



Steam for 10 mins



Spread out until half dry



Prepare equipment



Pour into bottles



Plug with cotton balls wrap paper and bind with rubber bands



Add water (1" high)



Place bottles in and close the pressure cooker



Turn valve to let out air for 10 mins



Steam under pressure of 21 pounds for 60 mins

ORGANIC MUSHROOM CULTIVATION MANUAL



**Remove bottles from pressure cooker to cool**



**Shake until contents are loose**



**Clean the cabinet**



**Prepare equipment**



**Put in the cabinet**



**Place needle for wiping fungal spore over flame**



**Unplug the agar food**



**Cut agar piece**



**Place opening of bottle over a flame**



**Plug with cotton balls**



**Unplug millet seed bottle and put opening of bottle**

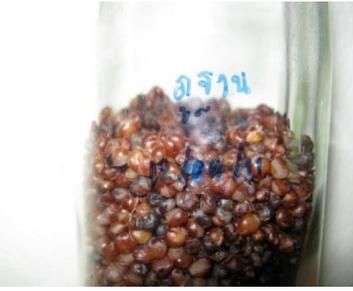


**Put agar piece in the middle and put opening of bottle over**

## ORGANIC MUSHROOM CULTIVATION MANUAL



**Plug with cotton balls, wrap paper**



**Write mushroom type and date**



**Keep in a closet away from light**



**Thriving millet leavening ready for use in mushroom packs**

## 3. Producing mushroom (substrate) packs in plastic bags

If there is enough of a market for mushroom and fungal spore packs you can produce them yourself but check first if it is cheaper to buy fungal spore packs to grow mushrooms rather than produce them. Choose the most economical and convenient method. Research some of the fungal spore pack production farms and find out what tools they use and which methods are the most suitable to your needs. Prepare to send your employees for training at an existing farm or contact an expert for a consultation about how to set up a new farm.

For this process you can buy millet leavening from a trustworthy farm. At an early stage, do not try to produce it by yourself. For minimal investment, you can use a separate boiling pot connected to a pipe to steam the sawdust pack in another pot. You can use a 200L drum for a steaming pot. If there is further demand for orders then consider if it is worthwhile to produce millet leavening and pure fungal spore packs yourself.

Commonly used materials are sawdust from rubber trees or timber wood, as well as rice straw. In general, mushroom farms use (for the convenience of preserving and mixing the materials) sawdust from rubber trees and softwood, which provides valuable nutrients for mushrooms. Buy sawdust from sustainable sources that do not impact on forests.

### Required materials & equipment:

- Sawdust from Rubber Trees
- Fine Rice Bran
- Epsom Salt helps the strengthening and growth of fibers and provides magnesium)
- Phosphate ore or Pumice (helps increase the size and quantity of mushrooms)
- Gypsum (adjusts the pH measurement and provides mushrooms with calcium)
- Lime or Dolomite (adjusts the pH measurement and provides mushrooms with calcium and magnesium)
- Supplementary Food, e.g., broken-milled rice and grinded corn
- Water
- Mushroom Pack Compressing Machine (or compress by hands)
- Sawdust Mixing Machine (or mix by hand)
- Plastic Bags of 6.5 x 12.5 inches to grow mushrooms
- Mushroom Pack Steaming Tank
- Cotton Balls
- Bottle's neck
- Cotton Wool Lid/Newspaper
- Rubber Bands

# ORGANIC MUSHROOM CULTIVATION MANUAL

## Formula for Growing Oyster Mushrooms

- Sawdust from Rubber Trees 100 Kilograms
- Fine Rice Bran 5-6 Kilograms
- Epsom Salt 0.1-0.2 Kilogram
- Phosphate ore. or Pumice 2 Kilograms
- Gypsum 1 Kilogram
- Lime or Dolomite
- Water
- Supplementary Food; broken-milled rice, grinded corn, etc. (1 Kilogram each)

## Formula for growing Shitake Mushrooms

- Sawdust from Rubber Trees 100 Kilograms
- Fine Rice Bran 10-12 Kilograms
- Epsom Salt 0.2 Kilogram
- Phosphate ore or Pumice 1-2 Kilograms
- Gypsum 2 Kilograms
- Lime or Dolomite 1 Kilogram
- Sugar 2 Kilograms
- Water

**Sawdust from Rubber Trees:** should be new sawdust, which can be used immediately. One 10-wheeled truck of sawdust can produce more than 20,000 packs of fungal spore packs. The unused sawdust should be kept dry.

**Dampness of Materials:** should be at 60-70%, not too wet and not too dry. When you become more experienced you can tell the dampness level by holding the materials in your hand. When you open your hand and the materials stick together with a little crack, then they're at the right level of dampness. But if there is water dripping between your fingers then they are too wet. In this case, add more sawdust and supplementary food according to the proportion of the recently added sawdust.

**Supplementary Food** – Use 5-6 kilograms of fine rice bran and any other supplementary food you would like to add, such as 1 kilogram of broken-milled rice and 1 kilogram of grinded corn (If more, there will be more chance of damage, if less, the amount produced will be too little.)

For Epsom Salt 0.01-0.02%, dissolve in water before usage.

**Packing in Bags** – Use plastic bags of 6.5 x 12.5 inches or similar size. Fill 800–1,000 grams of materials in the bags and then compress them with the compressing machine or by beating your hands until they are firm. Then put on plastic bottle's neck, plug with cotton balls, put on a cap (or cotton wool lids). If there is any leakage, close with tape before continuing on to the sterilization process.

**Dealing with Wet Stoppers** – Stoppers can get wet from the condensation of steam during the sterilization process. Wet stoppers will easily let in other fungi or fruit flies that will lay eggs. The use of plastic caps will prevent stoppers from getting wet.

**Disinfection** - There are 2 methods; pasteurization using natural steam from boiling water for 4 hours and sterilization using steam pressure at 15 pounds for 60 minutes. The size of containers for this process depends on your funding, e.g. a 200L tank or a handmade steaming pot of a different size. Fuel can be chaff or firewood. After this process, wait to wipe the fungal spores until the next day or after the mushroom packs are cool.

**Pictures illustrating steps for bloom substrate pack production**



**Spread out sawdust after weighing    Weigh ingredients to proportions    Mix**



**Pour water and mix well    Dampness test by hand    Equipment**



**Fill in sawdust    Weigh    Compress until firm**



**Bind around the neck    Puncture in the middle    Plug with cotton balls**



# ORGANIC MUSHROOM CULTIVATION MANUAL

**Cover with cap**



**Put in metal drawer**



**Arrange in steaming tank**



**Fill water**



**Water-level checking rope**



**Light fire**



**Steam for 4 hrs.**



**Open Steaming Tank**



**Pull drawers out for cooling**



## Steaming using drums



**Arrange packs until full**



**Pour water into the tank  
(10 cm high)**



**Cover with a lid or a hemp sack  
with plastic bound over**

**Light fire and count time**

**Resting Substrate Packs** – Move and keep in a clean room without any breeze. You may use a mosquito net to keep off the dust, insects and other fungi. It is the best method to prevent basic damage.

**Prepare Spawn Seeds Before Putting in Packs** – Choose spawn seeds with fibers fresh and fully-grown all over the seeds and without any contamination. Bump the bottles on thick plastic or use picking metal to loosen the millet seeds. The metal must be sterilized over the fire of an alcohol lamp first. Then, shake the bottle to loosen the seeds again.

**Pour Spawn Seeds in Packs** - Every time you use the fungal spore wiping room, you must sterilize the floor (sweep and wipe the floor with Dettol). Those pouring the spawn seeds should take a shower first and clean their hands with alcohol. This pouring process has to be done in a room without any breeze otherwise it can carry other fungi and then damage the fungal spore packs. The operation can be done any time at your convenience. Be careful that fungal spore packs are completely cooled before you pour spawn seeds packs. Then, prepare the fungal spore packs onto which you will be pouring the millet leavening. One bottle of millet leavening is enough for 40-50 packs. Unplug the seeds bottle that is already loose and place the opening of the bottle over the fire. Then open the seeds pack, pour 15-20 millet seeds in and put the stopper back on. Keep pouring the millet seed bottle into other packs until it is finished. Then wrap the packs' tops with paper and bind with rubber bands.

ORGANIC MUSHROOM CULTIVATION MANUAL

Pictures illustrating adding spawn seeds to substrate packs



Sweep the floor



Wipe with Dettol / disinfectant



Place substrate packs



Prepare equipment



Clean picking tool and hands



Put opening of bottle and pick over a flame



Pick spawn seeds loose



Shake to spread spawn seeds



Take off cotton stopper



Pour 15-20 millet seeds



Put stopper back on



Cover opening with paper

## ORGANIC MUSHROOM CULTIVATION MANUAL



### **Prepare to put in the incubation room**

**Incubation** – Bring fungal spore packs out and place on shelves in the incubation room. Make a list and ensure you document the mushroom type and date each time. Lay vertically or horizontally. Check them daily. Inside the incubation room, the temperature should be approximately 25-30 degree Celsius to allow fibers to grow well in substrate packs. The incubation process takes about 40 days. Packs are best when fibers grow over all or most of the packs. If any packs are damaged or contaminated, separate them at once to inspect the cause of damage. For broken packs, close with a tap, pick out the millet seeds, sterilize and put the fungal spores in again. But if the damage is serious, get rid of the packs. Damage on the side or bottom of the packs will let in fungi. If the packs are broken along the seam or where the bags are connected, then the breakage may be due to the low quality of the bag. This problem can be avoided by buying bags from known and reputable suppliers of good quality bags.

## Managing the incubation room



**Clean**

**Arrange packs on shelves**

**Check on fibers' growth**



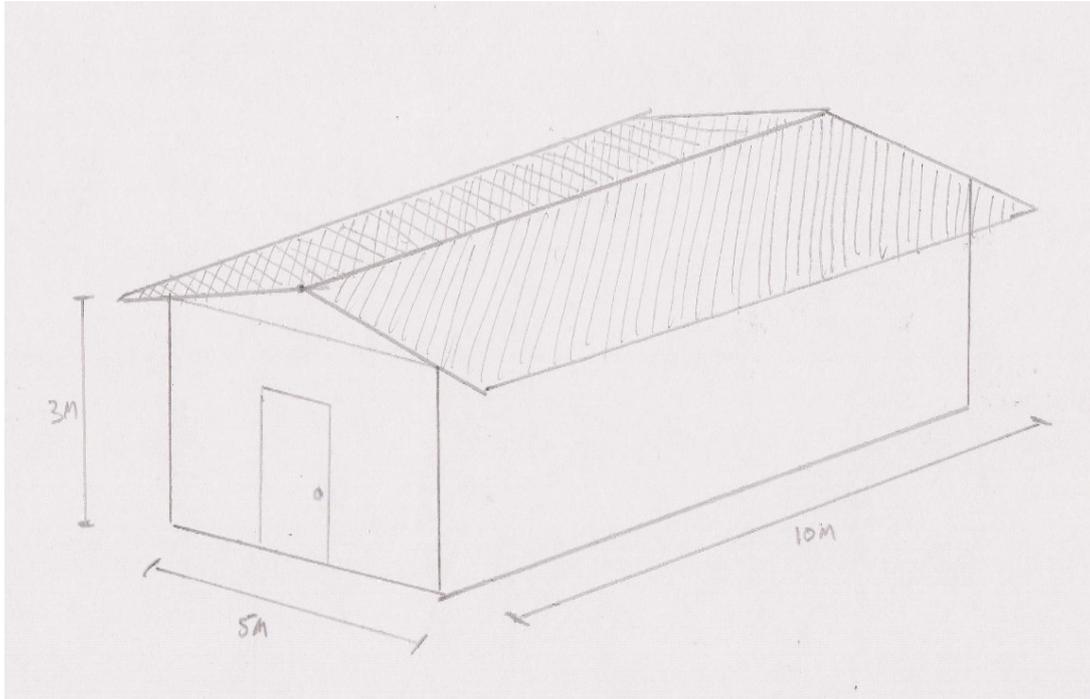
**Mushroom fibers growing in the incubation room**

### Dealing with damage in the incubation room

**Damage to the Opening of the Packs** - If most packs are contaminated with the same kind of fungus, this might be because the millet leavening is dirty and has spread to all the packs. But if the damage only occurred in the same packs and with different kinds of fungi then separate them, pick out the millet seeds and sterilize again. This may be caused by weather or if the fungal spore wiping room was dirty. Make sure it is clean before wiping the packs again.

**Damage from Fleas** – If there are any food scraps that have been dropped in the farm, it could cause undesirable fungi to grow on the mushrooms and attract fleas. Fleas will eat the fungus fibers, and then search for more food and go inside the fungal spore packs, which can contaminate other fungi inside the packs or cause damage to the mushroom fibers. This problem can be solved by keeping the room clean at all times. There should be no food scraps anywhere. It is ideal to have several incubation rooms so you can rotate their use in order to get rid of mushroom pests in each lot.

**Expiration of Fungal Spore Packs** – Once fibers grow all over the inside of the packs, they will get thicker and may produce mushroom buds. If the packs remain closed, mushroom buds will eventually be digested. Packs will slowly flatten, with yellow liquid on the side or bottom. Packs can also expire if exposed to too much sunlight, if they've been bumped hard during relocation, or damaged by fleas or other pests. The best fungal spore packs that are ready to produce mushrooms are the ones with fibers grown all over the inside of the packs, and have started to tie up.



**An incubation room of 5 x 10 meters : you can put 2,500 packs on the floor  
With 4-leveled shelves, you can store 6,000 packs**

### Description

- A tenement of 5 x 10 meters with triangle roof sticking out 1 meter on each side. One door of 1 x 1.5 meters. Using lalang leaves or another rain resistant material over the roof.
- Wall: stretch clear plastic covered with black sunshade netting up to 30 cm from the roof. Cover both triangle spaces at each end of the roof with lalang leaves.

### Structure

- **Side Posts:** 10 cement posts of 3 x 4 inches and 2 meters high, buried 50 cm deep. Bury 5 posts along each side.
- **Central Posts:** 5 cement posts of 3 x 4 inches and 3 meters high, buried 50 cm deep in the middle row. Extend with Light Lip Channel Steel of 3 x 1.6 mm and 0.5 meter long. (This extension with Light Lip Channel Steel is to make the roof triangle higher to reduce the heat. In cool areas, you may not need to do an extension).
- **Roof Structure:** Roof structure is Light Lip Channel Steel part. For the rest of the roof, use round steel bars of 3/4 x 1.2 cm.

#### 4. Managing mushroom development from seeded packs

The vast majority of mushroom farms start with small barns that produce small amounts of mushrooms. They start their business by buying fungal spore packs from other farms in order to practice and gain knowledge until they have become skillful enough to grow their own. Until then, it is better not to invest and produce fungal spore packs by yourself. Buying them from other farms is a good start. Begin with something small, sell the mushrooms you produce to the sellers at the market or sell them by yourself. Extend your mushroom market until you have established demand and regular orders. Then you can also consider producing fungal spore packs. But until there is a market, you should keep from producing your own to save some money.

**Unplug the Stoppers to Allow Mushrooms to Grow Out** – Lay the packs vertically or horizontally, depending on the type of mushroom. Unplug the stopper or remove the bound wrapping paper and then use the end of a spoon (that's been cleaned with alcohol) to pick out the millet seeds. After leaving the packs open overnight, spray water on the packs and the mushrooms will start to grow out of the opening. You can use this method several times or until the food in the packs is finished.



**Unwrap the paper**

**Unplug the cotton balls**

**Pick out seeds with end of spoon**

**Puncture the Sides of the Packs** – Lay the packs vertically. Puncture a small round hole on the side of the packs with a sharp knife or a razor to allow the mushrooms to grow out. Use this method especially when growing Wood Ear Mushrooms.

**Opening the Stoppers in the Mushroom Growing Barns** – You can build a mushroom growing barn in any size according to your ability to maintain a suitable environment. It may be more convenient and easier to build a number of small mushroom barns instead of one big barn. They should be designed to retain dampness, keep a steady airflow and have an easily accessible entrance and exit. A 4 x 8 meter barn can hold 4,000 packs (for beginners, 500 packs at a time is enough until you're used to the mushroom's cycle, then you can increase the number of packs the next round). Inside the mushroom barn position mushroom shelves in the middle and on the sides. The middle shelves should not be more than 2 meters wide. Packs can be layered or hung 12 packs per row. The roof should be 1 meter high to help the air flow.



**A Mushroom Growing Barn made of Wood** – A mushroom growing barn of 4 x 6 meters, 2.50 meters high with 1-meter wide aisle can contain 2,800-3,000 mushroom packs depending on how many packs you would like to put on each stack. It is recommended to stack up to 10-12 packs with 4 on each shelf. If you add more than this amount, the packs below will be too heavily pressed. Use lalang leaves for the roof and 80% black sunshade mesh to cover the front and sides. Build them both with angled roofs to facilitate closing and opening to allow heat release and let air flow. Level out the ground to make it easy to clean. The general cost for this wooden mushroom barn is 5,000 Baht.

## ORGANIC MUSHROOM CULTIVATION MANUAL

**A Mushroom Growing Barn made of Brick** - A mushroom barn of 4 x 6 meters, 3 meters high is effective in maintaining dampness, easy to clean and does not often need repairs. Use tiles for the roof and metal for the shelves. The cost for this brick mushroom barn is approximately 25,000 Baht.

**A Hanging-Pack Setup Mushroom Growing Barn** - A mushroom barn of 5 x 9 meters, 3.50 meters high with lalang leaves for the roof and the sides covered with mesh to filter the light. Spread sand on the ground to keep in dampness and make shelves to hang the packs. This barn can contain 4,500-5,000 packs whilst looking clean and tidy. The cost of this type of mushroom barn is around 15,000-20,000 Baht.



**Air Flow** – It is important to keep dampness in a mushroom barn but stifling conditions often occur, making it difficult for the air to flow. When growing small amounts of mushroom packs this does not usually happen as there is enough oxygen. However, since all mushrooms release carbon dioxide, when there are a lot of packs in a barn the carbon dioxide levels can get too high, which can cause the mushrooms to wilt, remain small or not even bloom. Therefore, it is necessary to arrange the barn with an airy bottom-section, since carbon dioxide is heavier than oxygen and will be able to spread out. For very big mushroom barns, ventilation fans may be needed. The wind flow will take away some dampness, so in order to compensate, simply water more frequently to keep the mushrooms fresh.

**Watering** – Sprinkler systems are the most commonly used method for watering. You may create one by using pipes connected to a water pump that pressures the water out in a fine spray. If you don't have a water pump, you can use a hose or a watering can. Water the packs until they're damp but not so much that it leaves puddles. Water them 3 times a day: morning, noon and evening. If you see that the rim of mushrooms is dry and mushrooms are light, the mushrooms or the packs might lose water due to low relative humidity. If the weather is hot and windy, mushrooms will dry quickly. In windy conditions, you should build closed mushroom barns and water the packs with fresh water, e.g., rainwater, tap water (after exposing it to the sun to evaporate chlorine), pond water or ground water that is not salty. Tap water used in households can be used for watering the mushroom packs. Water for mushrooms should have a neutral pH balance.



**Water by fogging system**



**Water by water hose**

**Suitable Temperature for Mushroom Production** – Mushrooms grow well at 25-32 degrees Celsius.

## ORGANIC MUSHROOM CULTIVATION MANUAL

**Collecting Mushrooms** – After watering the packs in the barn for 1 week, mushrooms will start to bud. At this stage, water them regularly. In the 2-3 days after that, mushrooms will grow fully, ready to be collected. At this point, water them less and not so much that they get wet. If mushrooms are too wet, the quality will drop; they can go bad easily and can't be preserved for a long period of time. To identify that the mushrooms are fully-grown, check the edge of the mushrooms. When mushrooms are young, the edge rolls inward and will spread out when they are fully-grown. You should collect them at this time or depending on the market's need. Collect mushrooms manually and then cut the growing materials off the bottom of the mushrooms with a sharp knife or scissors. After each collection, you have to pick all the mushroom scraps off the surface of the fungal spore. To preserve the mushrooms, put them in plastic bags with wrapping paper inside to prevent them from getting soaked and keep them refrigerated. For selling, mushrooms should be contained in plastic bags with holes to let out air and vapors.



**Collect Yanagi Matsutake Mushroom**



**Cut the bottom**



**Put in a bag**



**Weigh the mushroom**



**Staple the bag**



**Place in fridge before sale**



**Collect Oyster Mushroom**

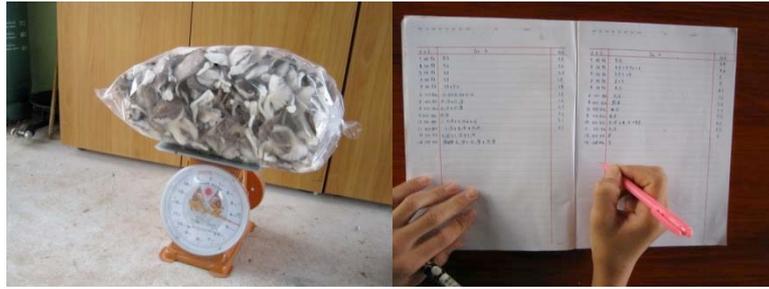


**Cut the bottom**



**Put in plastic bag**

## ORGANIC MUSHROOM CULTIVATION MANUAL



**Weigh and sell or refrigerate      Record mushrooms' total weight**

**Management During and After Mushroom Collection Period** – When growing mushrooms, cleanliness is very important. Every step has to be kept clean. Never allow in any dirt otherwise it might bring in disease and insects. There are some things to consider when dealing with expired growing materials and a single big mushroom barn. Although a single barn is convenient for operation, if there is an epidemic, the damage will spread more quickly than with separate small barns. Expired packs usually collect disease and mushroom pests. Keeping many expired mushroom packs close to the mushroom barns will cause damage in the long term. Therefore, they should be dumped far away from the mushroom barns or be made into fertilizer for the plants. Abnormal stages of growth, e.g., growing long like straws or have flat/uneven sizes, can be found occasionally in the mushroom barns that have a high carbon dioxide level. You need to make a passage to create better airflow so that the next set of mushrooms will grow normally.



**After each harvest, pick out all mushroom stalks/scraps that are stuck in the pack openings.**

## ORGANIC MUSHROOM CULTIVATION MANUAL

### Opening, Placing and Managing Packs for Each Mushroom Type

Mushroom Type	Opening /placement instructions	Maintenance
1. Oyster Family, e.g., Oyster Mushroom, Abalone Mushroom, Golden Oyster Mushroom, Yanagi Matsutake Mushroom, Phoenix Oyster Mushroom, etc.	Unplug the stoppers, pick out the millet seeds and then either lay packs horizontally, arrange them on the hanging shelves, or lean on bamboo lath.	Clean the mushroom barns, water 3 times a day: morning, noon and evening. If it rains or in the rainy season, water only twice: morning and evening. Control relative humidity at approximately 85 - 90%.
2. Lentinus Mushrooms	Lay packs horizontally same as for the oyster family. Unplug the stoppers, pick out the millet seeds and cut around the opening of the packs with a sharp knife or a razor because the mushrooms are small. Budding mushrooms are easy to collect.	Clean the mushroom barns, water 3 times a day: morning, noon and evening. If it rains or in the rainy season, water only twice: morning and evening. Control relative humidity at approximately 85 - 90%.
3. Wood Ears Mushroom	Unplug the stoppers, pick out the millet seeds and then take out the bottle's neck. Bind with rubber band in the same distance, cut the side of the pack with a razor or a sharp knife. Hang the pack or put on sanded floor as mushrooms like cooler temperatures or put on a wooden shelf. Wood Ear mushrooms like dampness more than other mushrooms and don't need much light.	Clean the mushroom barns, water 3 times a day: morning, noon and evening. If it rains or in the rainy season, water only twice: morning and evening. Control relative humidity at approximately 85 - 90%.  <b>Table continues next page</b>

## ORGANIC MUSHROOM CULTIVATION MANUAL

<p>4. Shitake Mushroom</p>	<p>Once fibers are fully-grown, unplug the stoppers and pick out the millet seeds. Cut out the plastic bags, leaving the bags with plastic 1 inch high from the bottom. Lay the packs down on the ground but not too close together. Cover them with a clear plastic sheet for about 1 month. The packs will change from white to dark brown. After removing the sheet, soak the Shitake packs in cold water for 1 night to stimulate fibers to bloom. After soaking for 1 night, lay them out on sanded ground and water regularly. Mushrooms will bloom out at the same time.</p>	<p>Clean the mushroom barns, water 3 times a day: morning, noon and evening. If it rains or in the rainy season, water only twice: morning and evening. Control relative humidity at approximately 85 - 90%.</p>
<p>5. Parasol Mushroom</p>	<p>To make these mushrooms bloom, the process is completely different from other mushrooms. Once the fibers are fully-grown, prepare land for gardening by digging 1 foot deep into the ground in a rectangle shape (size depending on the number of the packs). Take out the plastic bags and arrange the mushroom packs tightly in the dug up ground. Cover with 2-inch layer of soil over the top of the packs.</p>	<p>Water well and sow vegetable seeds; e.g., Chinese cabbage, Morning Glory, Kale, etc. Cover with rice straw and water again to let the straw absorb the dampness. Water in the morning and evening for 30 days. Vegetables will be ready to harvest, as well as the mushrooms. Both types of mushrooms can be planted together with other homegrown vegetables.</p>

## **Making use of spent substrate packs (recycling)**

1. Using the left-over mushroom growing materials to make new material for growing mushrooms
2. Using the left-over/exhausted materials to make animal feed
3. Using the left-over materials to grow straw mushrooms
4. Using the left-over/exhausted materials to produce fertilizer

### **1. Using the left-over mushroom growing materials to make new material for growing mushrooms**

#### **Formula**

- New Sawdust from Rubber Trees 70 Kilograms
- Leftover Material from Growing Mushrooms 30 Kilograms
- Fine Rice Bran 6 Kilograms
- Phosphate ore or Pumice 2 Kilograms
- Lime or Dolomite 1 Kilogram
- Supplementary Food; broken-milled rice, grinded corn, etc. (1 Kilogram each)
- Epsom Salt 0.1-0.2 Kilogram
- Gypsum 1 Kilogram
- Water

#### **Mixing Method**

Mix all the materials together well and follow the same instructions as when producing the mushroom fungal spore packs from new sawdust.

**2. Using the leftover mushroom growing materials to make animal feed** – Mushrooms are a kind of fungus, an organism similar to plants. They will digest sawdust and produce plenty of fibers. When fibers are fully grown under suitable conditions, they will gather into mushrooms that can be collected for sale and consumption. After collecting all the mushrooms, the packs will normally be destroyed. In fact, the growing material packs still have mushroom fibers left but not enough to assemble into mushrooms. These fibers still contain a lot of protein, calcium and phosphorus. After comparing them to cassavas, which are produced normally as animal feed, studies have found that mushrooms have more nutrients, as demonstrated by the following table:

## ORGANIC MUSHROOM CULTIVATION MANUAL

**Table displaying nutrients in old mushroom packs compared with cassavas**

<b>Mushroom Type</b>	<b>Protein</b>	<b>Calcium</b>	<b>Phosphorus</b>
Shitake Mushroom	6.970	2.763	0.503
Abalone Mushroom	4.646	1.573	1.120
Wood Ear Mushroom	4.544	2.657	0.085
Phoenix Oyster Mushroom	3.104	2.995	0.217
Reishi Mushroom	3.001	2.389	0.251
Yanagi Matsutake Mushroom	2.710	2.365	0.300
Lentinus squarrosulas Mushroom	2.975	4.640	0.230
Lentinus polycrova Mushroom	2.340	2.585	0.184
Oyster Mushroom	1.912	1.791	0.164
Cassava	2.660	0.300	0.190

Source: Department of Agriculture, Chandrakasem Rajabhat University

From the comparison analysis, it is clear that the leftover growing materials for 9 types of mushrooms have higher protein, calcium and phosphorus than cassavas. They can, therefore, be replaced or added to animal feed for poultry and ruminants. From the student experiments and those done by the Department of Agriculture and Chandrakasem Rajabhat University, it was found that after mixing the leftover materials with animal feed (chicken meat), putting through pelletizing process and feeding 3-to-6 week old quails, the result shows that 15% of mushrooms from the Oyster family can be used because they are not so different than normal animal feed formula.

### **Production Materials**

- Animal Feed (Chicken Meat)
- Pelleting Machine (Meat Mincing Machine)
- Tray for Drying Pelletizing Materials

### **Formula**

- Animal Feed 85 Kilograms
- Leftover Mushroom Growing Materials 15 Kilograms

# ORGANIC MUSHROOM CULTIVATION MANUAL

## Instructions

Weigh both materials and grind them well together. Adjust the dampness and put in Pelleting Machine (Meat Mincing Machine). Dry the food pellets on a tray. To make them completely dry, expose them to the sun for 2 afternoons so they can be kept to feed animals for a long time. This method helps reduce the production cost.

### 3. Using left-over mushroom growing materials to grow Straw Mushrooms

#### Equipment

- Growing Materials (rice stubble, vetiver grass, old sawdust pack)
- Supplementary food, e.g., cottonseed husks, dried chopped-up water hyacinth, banana trees
- Glutinous Rice Flour
- Straw Mushroom Spore
- Block for growing mushroom
- Cow Dung and Ground Surface
- Clear Plastic Sheet
- Lime
- Watering Can

**Soil Preparation** – Flip soil and expose to the sun for 2-3 days to bring it to a neutral condition. Water the soil well so that it absorbs water and won't soak up the dampness from nearby growing piles. Prepare some straw and supplementary food, e.g., cotton seed husks, water hyacinth, banana trees (chop up, dry in the sun and soak in water for 1 night)

#### Planting

1. Water the soil and spread lime on top. Prepare the block.
2. Put approximately 7-8 kilograms of straw in the block, press hard until it's 3-4 inches high and then press hard again. Then put  $\frac{1}{2}$  – 1 kilogram of supplementary food around the block for a width of 2 inches. Mix Straw mushroom spores with a bag of glutinous rice flour and separate into 3 parts (this can grow in 1 pile). Sprinkle the spores all over the supplementary food. Repeat this 3 times so there are 3 layers. Cover the third layer with 2-5 kilograms of straw.
3. Take out the block. Leave space, about 1 foot, between the first pile and continue the same procedure.
4. After finishing each pile, water well. Once you finish with all the piles, water them again.
5. Loosen the soil between the piles and around the piles again. Loosen 20 cm of soil around the piles.
6. Mix the spore with supplementary food with the proportion 1:10. Sprinkle on the soil surface and loosen the soil all over the planting area, including the surrounding areas.
7. Cover a plastic sheet over the growing piles, including 50 cm of the ground around the piles (don't only cover the piles, as the mushrooms will not grow so much on the ground). Put 2 plastic sheets on top of the middle of the piles.
8. Cover the plastic sheets with straw. For summer, cover thickly while making the piles smaller, laying 1-foot apart and let air flow often. For winter, cover thinly and the piles should be made bigger,

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laying close together and applying a lot of supplementary food. Ensure they are covered closely with plastic sheets to keep the temperature high. During the rainy season, use the same procedure as summer but make sure to drain well.



Learning how to make growing piles from recycled materials

### **Mushroom Plots Maintenance**

- Covering the mushroom plots with plastic sheets will maintain a suitable temperature and dampness level for the mushrooms' growth. Keep the sheets covered for the first 3 days without uncovering at all.
- On the third day, lift the sheets up 1 cm to circulate air (at this stage, the fibers growing on the supplementary food and straws will be visible.)
- Cover the mushroom plots with some straw (3-5 cm high), put the same plastic sheets over the straw, and then put other materials, e.g., coconut leaves, lalang, dry straw etc., to protect from sunlight on top of the sheets. After the 4<sup>th</sup> day of planting, uncover the plots on a daily basis to circulate air and examine the mushrooms' growth. On the 5<sup>th</sup> day, small white mushroom buds should be visible on the plots.
- At this stage, lightly spray water on and around the straw. Do not water the mushroom plots as it will cause the mushrooms to wither and rot. In the rainy season, use plastic sheets to cover tightly and manage the drainage channel around the plots.

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- Mushrooms will grow and be ready for collection around the 7<sup>th</sup>-9<sup>th</sup> day. After this, mushroom production will decrease (if you use 10 kilograms of straw, you will get 1-2 grams of mushrooms).

- Mushrooms should be collected early in the morning because they bud fully around 3-4am. If you wait to collect, they will bloom and the price will go down. When collecting, hold on to the mushroom root with your hand, move it back and forth and pull. If there are many mushrooms next to each other, collect them all. Do not leave any torn parts as it will rot and cause the others to rot as well.

#### **4. Using the left-over growing mushroom materials to produce fertilizer**

a. This can be done 2 ways:

- The natural organic way: tear the plastic bags off the mushroom growing materials, break them and put in U-shape. Water the materials well and cover them with a plastic sheet for 7 days. Then, flip the materials inside-out. Put them in a U-shape and cover them with the plastic sheet for another 7 days. After the due date, uncover the sheet, flip the materials again and put in a triangular pile. Cover the pile with a plastic sheet for 15 more days, flip and put them in a triangular pile, ready to be used. This method takes a long time to ferment.

- Using an accelerating agent: tear the plastic bags off the growing mushroom materials, break them and put in U-shape. Then, mix an accelerating agent with water and spray the solution on each layer of the materials and cover with plastic sheet for 10 days. Flip the materials, put them in a triangular pile to allow air-flow and cover with plastic sheet for 3 more days. Then, it is ready to be used or put in bags for sale.

Note: Any plastic that cannot be reused should be disposed of thoughtfully.

## Identifying and Dealing with Bagged Mushroom Disease

Diseases and abnormalities can be categorized by the following primary causes:

- Fungus, bacteria or viruses
- Adverse environmental conditions

### Diseases caused by fungus

1. **Black mold (*Aspergillus*)** Some parts of the packs are dark green, almost black. This might start close to the opening and spread down to the bottom, or spread up from the bottom. Some parts of the packs are brown next to the dark green area.



2. **Black mold (*Botryodiplodia*)** The sawdust inside the packs is dark brown, almost black. At first, the fungus is white and keeps expanding. If left for a long time, small black lumps of breeding organs will grow pushing against the plastic bags.



3. **Green mold (*Trichoderma, Gliocladium*)** This type of contamination is easily noticed as the green mold's spores are a clear, light green. When they are gathered densely, they are seen as dark green clusters in the packs.



4. **Green mold (*Penicillium, Paecilomyces*)** Both of them are very similar due to their rapid growth and high number of spores produced. *Penicillium* likes moderate temperatures. It is seen through the packs as light green, light yellow with green or gray clusters, which resemble dust on the packs. They usually start from the bottom of the pack. *Paecilomyces* likes quite hot temperatures and

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can withstand them. It usually occurs with Shitake mushrooms and is seen as pale dust in brown and light or pale yellow. The growth of mushroom fibers and fungus fibers are distinctively visible.



5. **Orange mold (*Neurospora*)** usually gathers around the opening of the packs in pink/orange cluster.



6. **Slime mold** occurs with mushroom packs that have been harvested from many times and placed at the bottom of barns shelving or hanging arrangements. Yellow fibers are clearly visible on the side and around the opening of the packs. This usually occurs with Wood Ear Mushrooms whose packs were cut on the side and watered for too long, so that the packs got soaked. It also occurs when using mushroom packs that haven't been relocated during cleaning of the mushroom barn.



Fungi that are either contaminated or competition can cause bagged mushroom disease. Fibers of most contaminating fungi grow very fast, causing the growth of the mushroom fibers to halt. The borderline where mushroom fibers grow and fungus fibers grow is easily visible. Fungus contamination usually reduces mushroom production. If there is fungus around the opening of the packs, it will spread out all over the mushroom barn, causing damage and severely reduce production. There are many causes of fungi contamination. For example, leaving used packs in the barn area when it rains, as the wind blows the fungus, or the fungus falls into the water used for watering the mushrooms. Other causes can be that the concentrated fungal spores are not pure, the sterilization didn't get rid of all the fungus, the packs are broken or damaged by insects, etc.

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## Prevention Procedures:

- Examine cleanliness and pureness of concentrated fungal spores before purchasing.
- Transplanting thriving tissue from the mushroom should be done in a clean room without dust or other diseases, or a closed room without airflow.
- Sort out bad mushroom packs, broken mushroom packs, packs with damp cotton stoppers for sterilization or destroy them to decrease the spreading of fungus.
- Keep the mushroom barns and areas around them clean.
- After collecting all the products, the mushroom barns should be given a break for 2-3 weeks in order to clean and spray insecticide to get rid of any insects or fungus that could be on the ground, posts and walls before bringing in the new packs. If possible, the incubation room and growing barns should be separated by some distance.

## Diseases Caused by Bacteria

1. **Brown Rot in Phoenix Oyster and Oyster Mushrooms** is caused by *Pseudomonas tolaasii* bacteria. The symptom shows up as light yellow dots on mushroom caps, which change to brown and spread all over. There will be a yellow or red-brown eruption on the stalk skin, which will go down when water is poured on the spot. This disease makes the mushroom smaller than the usual size, the caps light brown and easily bruised and therefore not desirable in the market.

2. **Brown Spots in Abalone Mushroom and bacterial spots in Oyster Family mushrooms** are caused by *Pseudomonas fluorescens* bacteria. The primary symptom shows up in Abalone Mushrooms as light yellow mushrooms emerging from the bottle's opening in a curling condition. Mushrooms will be flawed, undeveloped and not fully bloomed. Groups of 2-4 mushrooms start to grow with clusters of undeveloped stalks. There are light brown spots scattered on top and under the caps and stalks. These spots will get darker in 1-2 days and the spotted areas will be flattened. The symptoms in Oyster and Phoenix Oyster mushrooms show up as yellow mushrooms emerging from the opening of the bottle. The mushrooms are smaller than the usual size and some are curling. The mushroom clusters are undeveloped, withered and yellow. This yellow and withered condition is different from an insufficient dampness condition. If the next newborn mushrooms are still yellow and withered, then it was caused by bacteria. If there are a lot of bacteria, all the production will be damaged.

## Prevention Procedures:

- Reduce the dampness in the mushroom barns to not over 80-85 %
- For young mushrooms, their surface should be dry within 3 hours after watering. Each time after watering, there should not be any water left on the mushroom. – Pour a chlorinated water formula (proportion: chlorine product 250-300 cc / water 40 gallon or chlorine product 10 cc / water 1 bucket). Dissolve Clorox or Haiter in water in order to produce chlorine water for disinfection and general cleaning.

## Disease caused by virus

This disease is found in Oyster mushrooms. The symptom shows up as mushroom caps rolling up or rolling down, small mushrooms, uneven edges, soaked more than usual when being watered, or

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mushrooms being frutescent. The stalks are short and clustered. This virus can be passed on by touch and can be prevented by not using any mushrooms suspected of carrying it for breeding spores.

### **Growth abnormalities cause by adverse environmental conditions**

Abnormalities in mushroom growth can be caused by adverse environmental conditions (such as the changing of weather, temperature, dampness, etc). For example, Oyster Family and Abalone Mushrooms can develop abnormally due to too much carbon dioxide, unusually hot weather etc. (note: weak breeding spores can also cause abnormal or poor growth).

The symptoms of deformities in Oyster and Phoenix Oyster Mushrooms are similar. Mushrooms will bloom in clusters with 5-15 mushrooms per each cluster. Mushrooms are small, 1-2 cm. Some are bigger but not more than 4 cm. Mushroom caps don't bloom or spread out. Stalks might form in a single piece or 3-4 of them connected in one piece. Mushroom caps are crooked or rolled out. The other abnormal symptom is found in stalks that are quite long, withered and without mushroom caps, or the stalks are unusually big with mushroom caps in funnel shape, or in small mushrooms that don't spread out. The color of mushrooms is either white, soft white or light gray.

The symptoms in Abalone Mushroom are different from Oyster Family mushrooms as stalks are shorter than usual, withered and undeveloped. Mushroom caps are small, withered and don't fully spread out. For bigger mushrooms, they will not be fully spread out. Their edges will be curvy. Some roll down and twist. Mushroom caps split into small outgrowths on the same stalk. Mushrooms are gray/black in the front and the back. If you see these symptoms, here are some solution guidelines you can follow:

**Ventilation** – In mushroom barns, there must be gaps to ventilate air sufficiently. You should open the door and windows at dawn to ventilate and prevent the collection of carbon dioxide.

**Light** – In mushroom barns, there should be sufficient light for mushrooms' growth. Open the windows, skylight windows or use light run by electricity, especially during collection at dawn.

**Dampness** – Relative humidity inside and outside the barns should be checked and kept at a suitable level. In general, relative humidity during the harvest period should be between 80-90%. Dampness inside the barns relates to the temperature outside. Therefore, in winter when the weather is dry, you should cover inside the barns with plastic sheets, close doors and windows to prevent the dampness evaporating. Watering 3 times per day will help keep the growing barn appropriately damp. In summer, the temperature outside is high so you should water many times in order to keep the barns damp. Watering the ground, wall and roofs and ventilating the air will help with controlling the dampness inside the barns.

**Food formula** – Food formula has to be standard and contains appropriate ingredients for the mushrooms needs. Using the wrong growing materials could cause an imbalance of material digestion along with chemical and physical change, affecting the mushrooms quality and change in their nutrients.

## Identifying and dealing with common insect pests

**Fly Maggots** – Fly maggot outbreaks are found in most types of mushrooms, especially in the second year of mushroom cultivation. They live in smelly decaying objects, including the ammonia smell from the mushroom packs. The damage is usually to parts of the mushroom packs that change to brown or black and often found with bacterial spot disease. Fly maggots that severely damage mushrooms include offspring of:

1. **Sciaridae (Sciarid) Fly** – When a larvae, they eat mushrooms. They are found in Wood Ear Mushrooms and champignon mushrooms, causing damage to the quality of the mushroom and thus to the price. The larvae have clear white or orange yellow bodies, 5-7 cm long with black heads. They move very quickly and eat a lot. Adult sciarids are black and 2-3 cm long. Their life cycle from eggs to adults takes approximately 25-30 days.

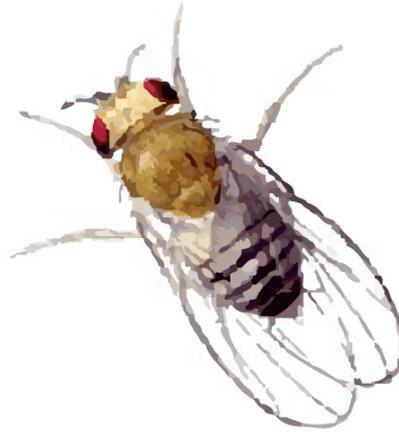


2. **Phoridae (Phorid) Fly** – Adult phorids are found with and without wings. In larva period, they will damage mushroom fibers growing on the surface of the packs and often pierce or perforate the roots and mushroom caps. However, the risk of damage is less than with the sciarids.



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**3. Fruit (Pomace) Fly** – They are black and very small, similar to fruit flies. They can be found in damp leeward places, especially in leeward toilets. Adult ones often cling to mushrooms, packs, walls and barn posts. Larvae will pierce the base of mushrooms, especially in the budding period, making mushrooms undeveloped, brown and rotten throughout the whole pack. The outbreak is usually found after 5-6 months of mushroom cultivation. The damage is not so severe but occurs late in Champignon mushrooms, causing them to wither and rot.

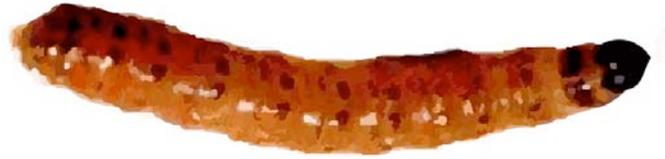


**Butterfly larvae (caterpillars)** – Adult butterflies (8-9 mm) are found clinging on the barn walls and openings of mushroom packs. Their wings are brown and black. While clinging still, they look like triangle roofs. They lay eggs on cotton stoppers. Eggs are covered with clusters of cream fibers. In the larva period, they are cream colored and change to brown red, with black or dark brown red heads and mouths. There have brown stripes crosswise on the back of areas connected with their heads. Fully-grown larvae are 15 mm long. Their larva period takes approximately 14-21 days. After they turn into butterflies, they will feed around the opening of the packs or burrow along the packs looking for white mushroom fibers, breaking them and halting the mushrooms' growth and bloom. Sometimes they pierce into the packs and spin webs together with sawdust to make their nests. These can be seen as long curvy brown flakes. If the outbreak is very severe, there will be brown larvae excrement all over the place. The damage takes place very quickly and severely if not eliminated in time. They can damage 40% of an oyster mushroom crop within 2 weeks.



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**Moth Larvae (Lepidoptera)** – Adult moths are medium sized, brown and hairy at the end of stomachs. They lay eggs on leaves that used for making the barns. Larvae are brown (10-20 mm) with big black heads. They eat nipa leaves and mushrooms in blooming period. They can damage around 20% of a mushroom crop.



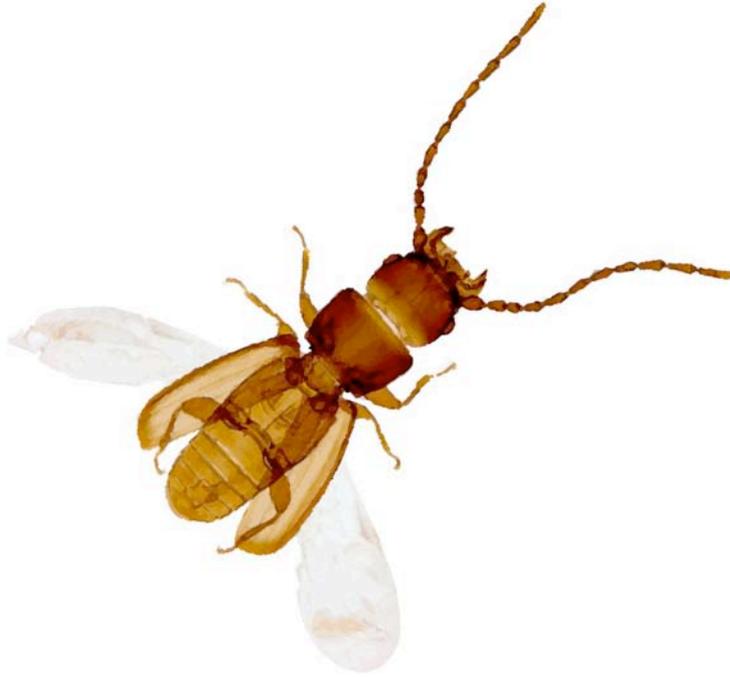
**Histioglyphus bakeri mite** – Small, white colored and hard to see, this is another type of insect pest that causes severe damage to mushrooms. The life cycle from eggs to last day of being young larvae takes on average 5.87 days. Fully-grown ones can only live at high relative humidity while young larvae during the Hypopi period, can live at lower relative humidity for a period of time. This period is very dangerous for causing an outbreak. *Histioglyphus bakeri* Hughes will damage mushroom fibers during the mushroom spore incubation period. Fibers will be eaten and only agar is left. At first, fibers in the packs grow and then stop growing. You can see curvy or straight lines. Damaged fibers are clearly visible, looking like stripes cutting through the packs. The ends of fibers are not fluffy and get thinner and thinner until light brown sawdust can be seen. They would not be able to form mushrooms, which would severely reduce your production.

**Cigarette Beetles** (*Lasioderma serricorne* Fabricius) are small oval-shaped insects. They are light brown and 2-2.5 mm long. Females lay single eggs all over food. Eggs are oval and soft white. They take 47 days to hatch into larvae and start damaging dried Shitake mushrooms. Holes are visible and dust falls out. Their larva period takes about 21-28 days. Then, the chrysalis period takes another 6-7 days and they are fully grown with an average life span of 16-25 days. Suitable conditions for growing is at 30 degree Celsius with relative humidity at 70%.



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**Flat Grain Beetles** (*Cryptolestes Pusillus* Schonherr) are very small insects. When fully grown, they will be reddish brown, flat bodies (1.5-2 mm) with long beaded antennae. The head and thorax are big. Their life cycle takes about 27-30 days. They cause damage to dried shitake mushrooms, other grains, dried nuts and fruits and cocoa. They will continue damaging the wounded spots caused by other insect pests. Flat grain beetles mostly damage agricultural products in high moisture environments.



Other insect pests, such as beetles and fruit flies, don't cause such severe breakouts. However, agriculturalists should always pay extra care and inspect for an insect pest outbreak.

### Using non-chemical pesticide to protect mushrooms from diseases and insects

Nowadays, the usage of chemical and insecticide to eliminate pests is applied extensively as well as in mushroom cultivation. Using these chemicals can affect growers themselves, consumers as well as the environment in the long term. This manual focuses on safer organic and natural approaches. We recommend using biological pesticide as an alternative to get rid of insect pests. The following are some examples that can be successfully applied:

#### Fighting Larvae with the Microbial Insecticide: *Bacillus thuringiensis* (or Bt)

*Bacillus thuringiensis* (Bt) is a naturally occurring bacterium that can be commonly found. It is considered a highly beneficial bacterium as it is useful for controlling pests, for instance, Common Cutworm *Plutella xylostella*, Beet armyworm, *Trichoplusia ni*, Cotton bollworm, Lepidoptera-Moths *Limacodidae*. As Bt causes an adverse effect, specifically on larvae, it is nontoxic to people and warm-blooded animals, e.g., fish, birds and other beneficial pollinators like honeybees and wasps.

#### Application

- Incubate with fresh chicken eggs (proportion; 15-20 liters of water: 5 chicken eggs: 500g of smectite; 2 spoons of vegetable oil). Mix the ingredients well and add 5g of Bt. Put an aquarium water pump in the mixture and leave it on for 24-48 hours (do not exceed the hours). After that, mix with 100 liters of water and then it is ready to be sprayed.
- Incubate with coconut. Chop a coconut open and put in 5 grams of Bt. Close the lid and leave it for 24-48 hour. After that, mix with 20 liters of water and then it is ready to be sprayed.
- Incubate with UHT milk, Lactasoy or Vitamilk. Put milk or soymilk in a bag, tie one side and hang it for 24-48 hour. After that, mix with 20 liters of water and then it is ready to be sprayed.

#### Principle Techniques and Usage

- Bt is a bacterium that can be killed by ultraviolet rays from the sun, therefore it should be sprayed at dusk when the sunlight is weak. This will prolong the efficiency of Bt on plants.
- Some insect pests, such as *Plutella xylostella* and *Trichoplusia ni*, usually cling underneath the leaves and feed there. Therefore, to effectively control the pests, the top and underneath parts of the leaves should be covered when spraying the Bt.
- Adjusting the spray head to the finest spray will help the leaves better absorb the Bt mist.
- Sticking agent should be added every time you spray. Follow the recommended proportion on the instructions.
- Bt should be applied if you find small larvae during the inspection. Taking care of the situation early is better than spraying after you big larvae are found.
- Bt shouldn't be mixed with insecticide as other chemicals might render it ineffective.
- It takes 2-3 days for Bt to take effect on killing larvae. Using a high dose mixture will not kill them faster. Using a lower dose will not kill the pests and will cause damage to the crops. Therefore, the instructions on the Bt proportion should be strictly followed.

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- Once an outbreak is discovered, spray Bt according to the recommended proportion. Spraying twice with a gap of 3-4 days will help reduce the damage better than spraying only once.

### **Fighting fungus diseases with Bacillus subtilis (Bs)**

This type of bacteria is used to prevent and eliminate Trichoderma spp., black mold and other parasitic fungus, but cannot restrain stronger green mold (Penicillium sp). It has a stimulating effect on mushroom fibers assembling them into bigger amounts of mushrooms if enough food is available. This bacterium should be incubated and then used all at once.

#### **Application:**

Chop a coconut, pour its juice into a plastic bag and add a teaspoon of Bs in the juice. Hang the bag in the shade for 24-48 hours. For best results hang for 36 hours. After that, mix with 20 liters of water and then it is ready to be sprayed.

#### **Principles and Application Techniques:**

- After the incubation process, mix it with water, then spray all within 1 day. To prevent spoiling it must all be done in one day and cannot be kept for later use
- Incubated Bs can be mixed with sawdust while adding water to help make growing materials damp enough to form packs. This will prevent the infection and reduce spoiled packs. (Proportion: incubated juice of a coconut: 100 kilograms of sawdust with dampness level at 60-70%. Mix them well).
- If there is infection in front of the packs, spray there. If the infection is inside the pack, use hypodermic syringe to inject 5-10 cc of incubated Bs into the infected area. If the infection is severe, pour incubated Bs into the packs, let it soak for a while and then pour it all out. Do not leave any Bs in the pack, otherwise the fibers will suffocate.
- If using the soaking technique, give the packs a break to dry and then inject Bt to stimulate blooms.
- If responding to a large outbreak, you can mix 3-4 Chinese soup spoons of Bs powder with 10 liters of water and stir well. It is then ready to be sprayed, but this isn't as effective as the incubation process.
- Bs powder can be kept for 1.5 to 2 years in a dry place, stored at room temperature (not in the fridge), away from the sun and humidity.

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## Fighting mites

This Bacillus produces an enzyme that irritates the mite's skin, causing wounds, seeping liquid and eventually the death of mite. This is used to eliminate small mites, e.g., Luciaphorus sp. and also mites in orchids. This microorganism should be incubated and used all at once.

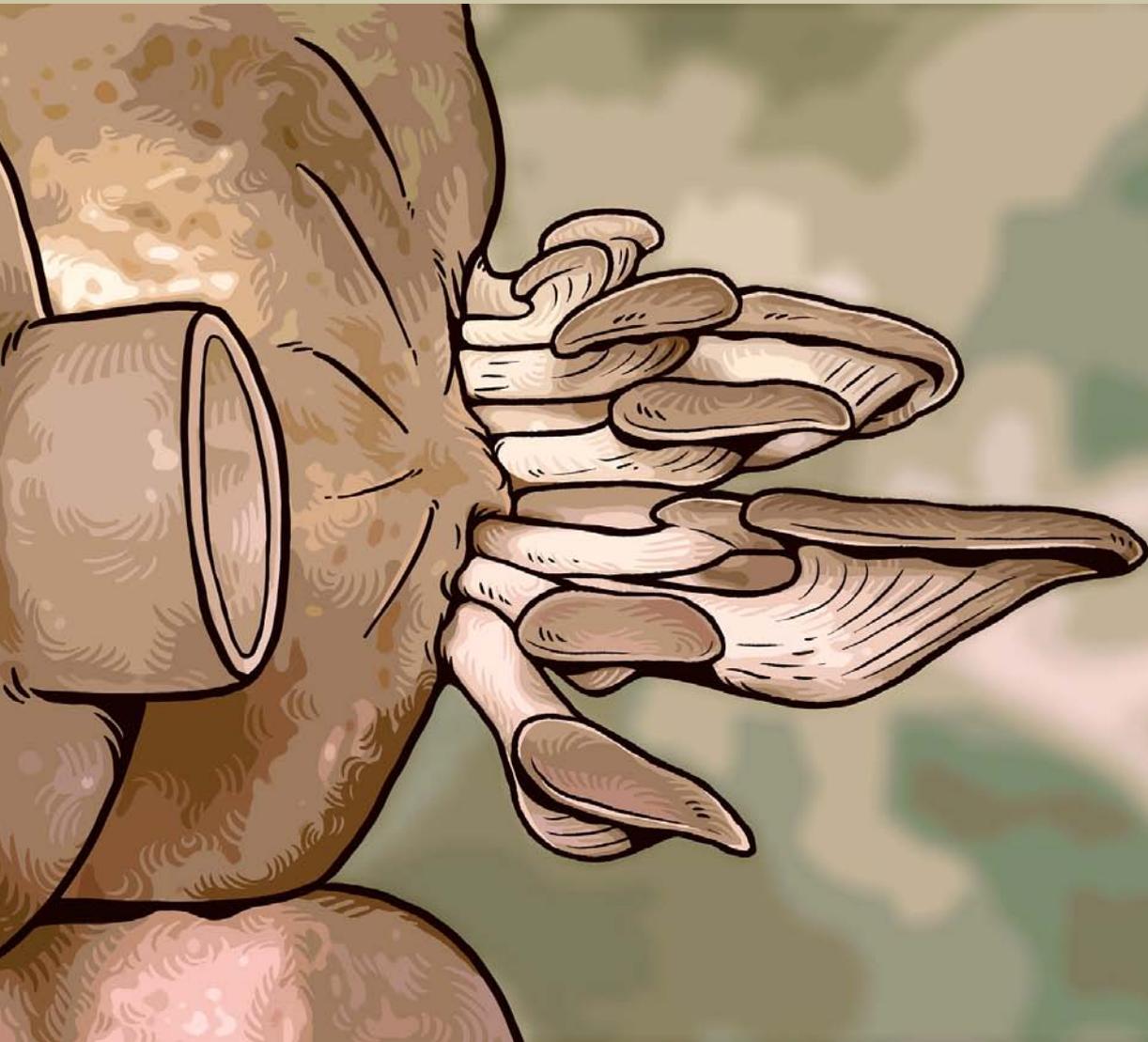
### Application:

- Chop a coconut and pour its juice into a clean plastic bag.
- Add a teaspoon of Bs powder to the juice and stir well. Hang the bag in the shade for 24-48 hours. For best results hang for 36 hours.
- After that, mix with 20 liters of water (1 bucket) and then it is ready to be sprayed.

### Principles and Techniques:

- After incubating and mixing with water, Bs will produce substance that strongly affects mites.
- Incubated Bs can be mixed with sawdust while adding the water to make growing materials damp enough to form packs.
- This will prevent mites and reduce spoiled packs. (Proportion: incubated juice of a coconut: Mix 100 kilograms of sawdust with dampness level at 60-70%. Mix them well)
- If there are mites in front of the packs, spray there. If the infection is inside the pack, use a hypodermic syringe for injecting 5-10 cc of incubated Bs at the infected area. If the infection is severe, pour the incubated Bs into the packs, let it soak for a while and then pour it all out. Do not leave any Bs formula in the pack, otherwise the mushroom fibers will suffocate.
- Spray all over the barns, ground, walls, shelves, next to the packs, hidden corners, all over the incubation room and growing barns Spray once every 5-7 days.
- During an outbreak, spray ever day or every other day. If responding to a severe outbreak, you can mix 3-4 Chinese soup spoons of Bs powder with 10 liters of water and stir well. It is then ready to be sprayed, but it is not as effective as incubated Bs. Bs powder should be kept in a dry place, away from the sunlight and dampness, and stored at room temperature.

We hope you enjoy growing and eating delicious healthy organic mushrooms.



FREELAND acknowledges the U.S. Fish & Wildlife Service, U.S. Agency for International Development (USAID), Blue Moon Fund, and all donors supporting our efforts to provide alternative livelihoods to ex-poachers, as well as our mission to package and propagate this knowledge for the benefit of vulnerable communities and natural ecosystems everywhere.

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