Oyster Mushroom Cultivation

Part II. Mushrooms

Chapter 5

Substrate

CEREAL STRAW AND CORNCOBS

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Oyster mushrooms have the ability to utilize cellulose, hemicelluloses and a large or small quantity of lignin thanks to their enzymes. Oyster mushrooms need substrates abundant in polysaccharides (cellulose and hemicelluloses) and lignin for their growth. The mycelial growth of oyster mushrooms makes use of soluble carbohydrates, glucose, molasses, organic nitrogen sources like wheat bran, barley, oat, maize, soybean crust and sunflowers, as well as mineral sources such as ammonium sulphate.

Nutritious substances for oyster mushroom can be categorized into two categories: staples, which are the base nutritional materials, and additives, which are protein and nitrogen sources.

A. Staples that are rich in cellulose and hemicelluloses: wheat straw (Fig. 1), barley, hardwood chips (Fig. 2) or corncobs (Fig. 3).

Figure 1. Wheat straw

Figure 2. Hardwood chips

These can be utilized alone, as is done in 90-98% of the cases, or mixed with other materials, as in the example of 55% wheat straw and 38% corn cobs. Table 1 shows the nutritional values of each staple substrate material.

B. Additives as protein and nitrogen sources: wheat bran, barley, oats, maize; soybean crust, and sunflowers.

These materials are only used in 2-10% of the cases. However, it is recommended to add only a small quantity of them (max. 5%) because they can cause an increase of temperature in substrates during incubation that may

cause the death of mycelium as a result. According to my personal experience, supplementation with additives didn't increase productivity significantly, but did accelerate mycelial growth by increasing substrate temperature. Table 2 shows the chemical analysis of the substrate in different phases of growth.

Figure 3. Corncobs and rice bran

Table 1. Nutritious substance contents of staples

Material	Nitrogen(%)		Hemicellulose	Cellulose	Lignin
	Total	Assimilable	(%)	(%)	(%)
Wheat straw	0.36	0.07	30.0	41.0	15.0
Barley straw	0.52	0.10	31.3	44.4	5.8
Hardwood chips (of poplar, beech, ashen)	0.57	0.04	15.4	16.7	26.0
Corncobs	0.49	0.06	38.0	28.0	11.0

Table 2. Physio-chemical trend of substrate in each stage

Substance	After soakage with water	After thermal disinfection	After second flush
Nitrogen	0.80	0.72	0.79
Hemicelluloses	24.3	20.1	14.6
Cellulose	33.1	33.5	22.8
Lignin	5.8	7.0	6.5
Phosphor (total)	0.06	0.05	0.04
Calcium (total)	6.64	7.40	8.95
Potassium (total)	0.46	0.49	0.27
pH	6.6	7.5	4.8
Water (fresh material)	73.8	72.4	71.3

According to Table 2, oyster mushrooms consume significant amounts of cellulose and hemicelluloses as their main nourishment source. On the other hand, lignin is rarely used, so any fermentation process, which causes an accumulation of lignin, should be avoided. Calcium serves the function of a catalytic buffer and nitrogen is consumed only during the incubation process. If the pH of the substrate falls to an acidic value, this indicates that it is time to end the harvest.

pH of Substrate (Supplementation with Gypsum)

The optimal substrate pH value for mycelial growth is 5-6.5, though mycelium can survive between pH 4.2 and 7.5. The mycelium grows slowly as the pH lowers and stops growing at pH 4. If the pH is higher than the optimal value, mycelial growth accelerates but produces an abnormal structure. Optimal pH for primordial induction and fruiting is 5-5.5 though it is possible at 5.5-7.8. The pH of the substrate can be adjusted by the addition of gypsum or lime.

Preparation of the Substrate Material

Staples such as straw of wheat, barley, or hardwood chips must be crushed or chopped into fragments of 1-2.5cm. Corncobs must be ground into fragments of 0.5-1cm. These staples should be stored in a dry condition. If green, black, or white mildew is found, growers should never use the material. Using substrate materials infected by mould, bacteria or insects will considerably reduce crop yield, and will sometimes spoil the whole mushroom crop. To prevent contamination, make sure not to allow contact between substrate materials and remnants from previous crops. Considering that oyster mushrooms can utilize cellulose, hemicelluloses, lignin and soluble carbohydrates such as glucose and saccharine, it is recommended to add about 2-3% of soybeans, barley or oat meal to accelerate mycelial growth and obtain higher yields.

Watering Substrate Material

Water is one of the very important factors in mushroom growing. Suitable amounts of water should be maintained in the substrate during the whole process of cultivation. During preparation the substrate materials are soaked in a pool or a large container for 12-24 hours in order to achieve a water content of 65-70 percent. The soaking time varies according to the season. In summer 12 hours is required. Generally, 100kg of dry straw turns to 300kg of wet straw after soaking. After removing the excess water, the water content must be verified by squeezing strongly with the hand. The palm has to be wet with water drops at the base of the fingers. Appropriate water content for substrates is between 65 and 75 percent. If the water content is too low, mycelia won't grow in the substrate. If the water content is over 78 percent, the substrate becomes anaerobic and mycelia within the substrate die.

Thermal Disinfections - Pasteurization

The harmful bacteria or microorganisms in the substrate can be destroyed through thermal disinfection. After pasteurization, the substrate should have a nice scent and be of a similar color to the initial material. The substrate is usually pasteurized at 60℃ with hot water or steam.

Pasteurization with hot water: Submerge the substrate in a metallic basin and heat it up to 60-65℃. Keep the water temperature at 60-65℃ for 2 hours. Then leave the substrate overnight to cool down to 25℃.

Disinfections with steam: After soaking into the water for 12 hours, move the substrate to the pasteurization room. Heat up the room temperature to 60℃ and maintain the temperature for 2-3 hours by steam injection. Cool down the substrate temperature with the same method above. Cooling can be accomplished by injecting cool air if faster cooling is required.

Mixing of Substrate Materials

After cooling the temperature of substrate to 25℃ and removing the excess water, the pasteurized substrate is put in a pool or on a concrete floor that has been disinfected with a 10% lime solution and 3-5% blue vitriol. Generally, several materials are added, including 5-10% pulverized fungicide, 2% lime powder, 4-6% fodder chalk, or 3-4% gypsum. The additives should be thoroughly mixed with the whole substrate.

Before entering the mixing area, all workers have to step in a powder lime solution outside the area. It is recommended that all workers wear clean clothes and rubber boots and they should not leave the area until they finish bagging. All the necessary materials should be accessible within the mixing area.

Bagging and Spawning

Figure 4. The holes punched in bag

The bags are made of polyethylene with a thickness of 0.05-0.1cm and have a 25cm diameter and are 80-100cm in length.

At first, the bags are perforated with an arch punch that makes holes 1.0-1.2cm in diameter at intervals of 10cm both horizontally and vertically (Fig. 4). The bottom of the bag should also have 2-3 smaller perforations in order to easily drain excess water.

Figure 5. A bag after filling with substrate

The quality of spawn is a key element in the production of high yields of mushroom. The grain spawn should have a nice scent and the grain should be thoroughly colonized. In Europe, the most popular strains of oyster mushrooms are from Italy, France, Holland and Hungary.

After mixing substrate materials, bagging and spawning is done simultaneously. Growers put a layer of substrate into a bag and sprinkle the grain spawn over the layer. They then put in another layer of substrate and again sprinkle spawn. They repeat this until the bag is full. The last layer spawn is covered with very shallow layer of substrate. They pack the bag well without empty space and tie the bag's opening tightly (Fig. 5). The weight of a bag is about 18-20kg, so the amount of spawn inoculated is about 550-600g per bag.

Spawn Run (Incubation)

After inoculation, the bags are incubated in specially arranged rooms where the microclimate factors such as light, temperature, humidity, and ventilation are strictly controlled. Light should be absent, the temperature should be maintained between 20 and 22℃, humidity should be between 75 and 85%, and ventilation should be done through air filters in such a way as to exchange all of the air in the incubation room 1-2 times a day. The bags should be placed with a distance of 5-8cm between them (Fig. 7).

Figure 6. Bags in incubation

Figure 7. The arranged bags in incubation room

Figure 8. Pinning of oyster mushrooms

Figure 9. Oyster mushrooms from cereal straw

If procedures are followed carefully, the mycelia will colonize the whole substrate within 20-21 days, but this time can be shorter or longer according to the species and strains cultivated. If the temperature inside the incubation room is lower than optimal temperature, the incubation process can be extended up to 40-50 days. If the temperature is over 25-26℃, the bags can become overheated and the mycelia will die as a result. When the room temperature is over 26℃, the temperature measured inside the bags in the first 10-12 days can be higher than the room temperature by 4-5℃ and sometimes by 7-8℃ The bags should be arranged on the floor or on shelves, with some space between them to prevent overheating. These parameters should be checked daily along with rigorous pest control.

Figure 10. An oyster mushroom bag

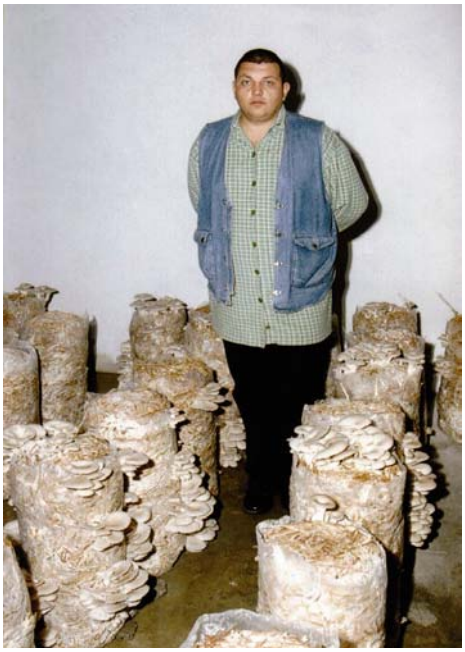

Figure 11. The author and oyster mushrooms

When the mycelia colonize the whole substrate thoroughly, the bags are carried to the fruiting room for fruiting induction, or they can be left in the same place, depending on the farm's arrangement.