17728-Utilization of cassava peels by-products as substrate for edible mushrooms (2020)

Description

Accumulation of cassava peels in cassava processing facilities is a source of environmental problems. This study promotes commercial use of cassava peels in Colombia to produce mushrooms. The main substrates for mushroom production are currently sugar cane bagasse and coffee husks. The lower price of cassava peels and proof-of-concept production of mushrooms (Pleurotus ost*orellanas*) on cassava peels substrate in 2018 & 2019, open the door to utilization of cassava peels by commercial mushroom farms.

Activities 2020: (1) Prepare and deliver 200 kg of dry cassava peels to commercial producer of mushrooms to test cassava peels as substrate, compared to sugar cane bagasse control. Monitor growth and yields of mushrooms. (2) Prepare working paper including business plan for use of cassava peels.

Project Summary

The production of sour cassava starch in Colombia, specifically in the department of Cauca, is one of the main economic activities for small and medium-sized rural producers in Cauca, as well as for families located in this department, which has been historically very affected by the armed conflict and the illegal activities of illegal dissident groups. In addition, these producers are frequently visited by regional environmental control agencies because of the environmental impact generated by high water consumption, the generation of effluents and waste with a high organic load, such as fiber (known as afrecho), protein (known as mancha), and cassava peels. So far, no adequate use has been found for the peels, other than the use of certain quantities for composting and fertilizers. The rest of the peels accumulates, generating contamination and in some cases is discharged into water sources such as nearby streams or rivers, which increases the organic load of the effluents generated by this transformation. The accumulation of these peels in cassava processing facilities is and has been a major source of environmental problems.

Currently, the substrates most used in the production of Pleurotus mushrooms are agricultural residues rich in organic compounds. In Colombia it is common to use legume pods, sugarcane bagasse, coffee pulp, dry grass, wood shavings, sawdust, and palm residues, among others (Guarín and Ramírez, 2004). The genus Pleurotus, includes a complex of species known for their exceptional flavor and low production costs (Estrada et al., 2010), as well as for their high protein content, which can be in the range of 30-40% crude protein, depending on the species and growth substrate (Mintesnot et al., 2014). In addition, they are a good source of non-starch carbohydrates, high fiber, amino acids, minerals, and vitamins (Ahmed et al., 2013). It is worth noting that mushroom crop residues can be used as soil improvers, as well as a supplement in livestock feed.

The low cost, high availability and the solution to environmental problems generated by cassava peels open the door to this study for the use and utilization of this in the production of mushrooms (Oyster mushrooms).

This study was carried out with the main objective of using and valorizing cassava peels (agroindustrial waste) as a substrate to produce edible mushrooms, specifically Pleurotus ostreatus commonly known as Oyster mushrooms.

The production of Oyster mushrooms as an economic activity could represent an interesting opportunity to be scaled up in the starch extraction plants (rallanderias) of the department of Cauca, where the environmental contamination generated in part by this agro-industrial waste such as cassava peels is evident. On the other hand, it would generate many more sources of employment, higher income for the producers and consequently a greater offer to the consumer, who would benefit from a lower price for a product that besides nourishing him/her, would bring great benefits to his/her health.

Thanks to recent research advances by the team of CIAT's post-harvest quality laboratory RTB (Roots, Tubers and Bananas), coordinated by Dr. Thierry Tran, where mushroom production trials were conducted using cassava peels as a substrate, it became evident that this has a potential use as a productive model of utilization. However, further research is needed to refine the most appropriate production techniques that can provide high yields during production.

Steps for the production of oyster mushrooms (*Pleurotus ostreatus*) using cassava peels and sugarcane bagasse as substrates

Illustrative guide

Introduction

The cultivation of edible mushrooms has become a common practice around the world because of their ability to grow in a wide range of temperatures using different substrates. Latin America has great potential for the cultivation of edible species due to its wide variety of climates and the great diversity of organic waste generated by different agricultural crops and agro-industries.

Currently, consumer interest in acquiring products free of fertilizers, preservatives and other chemical products is on the rise, and this is where the mushroom production process comes in.

Mushrooms are characterized by their high nutritional level, since they have twice the protein content of most vegetables and have the nine essential amino acids, including leucine and lysine (absent in most cereals), which makes them an attractive food with a growing demand worldwide.

They also have a high amount of minerals (surpassing the meat of many fish) such as calcium, potassium, sodium, and phosphorus, in addition to folic acid, an ingredient that enriches the bloodstream and prevents deficiencies such as anemia. Iron is also present in mushrooms in an appreciable amount and together with phosphorus, can provide a good amount of the recommended needs for a daily diet. Mushrooms are low in calories, carbohydrates, and sodium, making them ideal for people with certain types of heart and kidney problems (MushWorld. 2004). They are also characterized for having other medicinal properties as they slow the growth of tumors, lower blood cholesterol levels, have antioxidant and immunomodulated substances that help stimulate the immune system, contributing to the body's fight against cancer, infections, and other diseases (Romero et al., 2000).

The consumption of mushrooms is not a common and extensive practice in Colombia, it occurs specifically in high socioeconomic level, because the supply in the country is exceptionally low and their prices are remarkably high. In addition, the general population has truly little knowledge about the benefits of consuming mushrooms; it is believed that they are simply used as a garnish for food in general, thanks to their delicious characteristic flavor. Culinarily, mushrooms are widely appreciated for the excellent flavor they bring to gourmet dishes. Mushrooms can be eaten fresh or cooked, unlike other protein sources such as soybeans and yeast that must be processed or masked in some way to be palatable.

The most common and easy to grow mushrooms in many parts of the world are:

- Oyster mushrooms or Orellana in Colombia (Pleurotus ostreatus)

- Straw mushrooms (Volvariella volvacea)

- Wood ear mushrooms (Auricularia spp.)

Most mushrooms, especially the macromycetes, grow naturally on dead wood or decaying plant materials and can therefore be cultivated.

It is recommended that a person new to mushroom cultivation start with mushrooms that are easy to grow and easy to sell, such as oyster mushrooms or orellanas.

This illustrated guide has been prepared with the purpose of providing the basic knowledge and techniques necessary for the cultivation of Oyster mushrooms using cassava peels and sugar cane bagasse as substrate and is largely based on experiences working with two producers: Jose Maya "Orellanas del bosque" located in Timbio, department of Cauca and Luis Angel Arteaga "Setas Life" located in Palmira, Valle del Cauca.

Description

Pleurotus ostreatus, oyster mushrooms or orellanas (name in Colombia), are part of the most popular group of edible mushrooms, belong to the phylum Basidiomycetes, family Pleurotaceae, order Agaricales and genus Pleurotus. It has a whitish-gray color in all its parts. The cap is waxy, 5-25 cm wide with a rolled and often split margin. Over time, the cap becomes increasingly funnel-shaped. The fleshy part is white and firm. The gills descend about halfway down the stem. The stem is short and firm.

STEP 1. General information on growing oyster mushrooms (*Pleurotus ostreatus*)

An oyster mushroom production cycle takes between 3 - 4 months, it is important to have an overview of all the details of production, considering time, materials, and costs. Oyster mushrooms can be grown all year round, depending on the climate.

To start in the Oyster mushrooms business one should have at least an overview of the costs involved, the market, considering how much Oyster mushrooms can be sold in local markets, restaurants, health food stores and at what price, after which the profit should be calculated.

Regarding the materials needed for the cultivation, it is important to check the availability of the substrate, as well as the various minerals needed to mix with the substrate, as well as the bags that will be used to pack the mixture and generate the blocks. It is important to identify the suppliers of all the materials that will be used to assemble the crop.

The equipment needed for production is basic, inexpensive, and easy to find. The following is a list of the equipment and materials used:

- Scales
- Shovels
- Watering cans
- Plastic bags (high density polyethylene 2 caliber of 7''x12.5'' (17.8 cm wide x 31.7 cm long), preferably).
- Ring collars (4 cm diameter pvc tube)
- Filter paper (kraft paper) or cotton
- 55-gallon metal barrels for artisanal sterilization (or autoclave)
- Alcohol burners
- Laminar flow chamber or laminar flow hood for inoculation
- Gloves, gowns, mouth covers, gowns, etc.

STEP 2. Choose the substrate: cassava peels and sugarcane bagasse and mix it with lime

Obtain the sugarcane bagasse (agro-industrial waste from sugar mills or large local sugar mills) and cassava peels (agro-industrial waste from the rallanderias of the department of Cauca). Start with small quantities of 500-600 kg (250-300 kg of each substrate) for 1000 bags of approximately 1 kg total of the mixture of substrate + lime + corn bran + water.

Bags of Mushrooms	For 1000 bags	For 5000 bags	For 10000 bags
Substrate*	500 - 600 kg	2500 – 3000 kg	5000 – 6000 kg
Agricultural lime	10 - 12 kg	50 - 60 kg	100 - 120 kg

* Sugarcane bagasse and cassava peels (50%-50% proportion of each substrate).

Cassava peels

Sugarcane bagasse

Mixing of substrate (cassava peels, sugarcane bagasse) and lime

A) Make sure that the lime (calcium carbonate) is homogeneous by sieving it to a fine powder through a sieve.
B) Mixing substrate and powdered lime should be done on a cement floor or thick plastic sheeting (avoid direct contact with the soil if it is not cement).
C) After mixing with the lime, add water until the water can drip when pressed hard in your hand (approx. 60 - 65 %).
D) Allow the substrate-lime mixture to rest for at least one month on cement or heavy plastic and cover it with plastic wrap to maintain moisture. It should be stirred periodically with the help of a shovel.

STEP 3. Seed procurement

Check the price and quality of seed from more than one producer. Calculate the number of bags or kilograms needed.

Bags of Mushrooms	**For 1000 bags**	**For 5000 bags**	**For 10000 bags**
Bags of Seeds (1Kg)	40	200	400

STEP 4. Final mixing, filling, and sealing of plastic bags

A) Make sure you have all the material and equipment.

Material	**Quantity per bag**	**Number of mushrooms bags**		
		For 1000 bags	**For 5000 bags**	**For 10000 bags**
Corn bran	100-110 g	100 - 110 kg	500 - 550 kg	1000 - 1100 kg
Magnesium Sulphate	3-5 g	3 - 5 kg	15 - 25 kg	30 - 50 kg
Plastic bags (7''x12.5'')/1000 pcs	1	1 pack	5 packs	10 packs
Plastic collars (pvc) /1000 pcs.	1	1 bag	5 bags	10 bags
Kraft (roll) or cotton (kg)	One square 10x10 cm	1 kg	5 kg	10 kg
Elastic bands/1000 pcs.	1	1 bag	5 bags	10 bags
Plastic sheeting	1 roll	1 roll	5 rolls	10 rolls
Metal drums (55 gallons)	2	2	5	10

Materials

- Corn bran
- Plastic bags
- Magnesium sulfate
- Elastic bands
- Paddles
- Plastic collar (PVC)

- Kraft paper or cotton

B) Final mixing of the culture material

Mix corn bran and magnesium sulfate with cassava peels- sugarcane bagasse (50%-50%) and lime mixture. Make sure the mixing is done on the cement floor or on thick plastic.

C) Add water

Add water to maintain moisture until you can make a cake by pressing with your hand without dripping water (equals 60 - 65% water).

D) Filling and packing the bags

Fill the plastic bags with the final mix (substrate, weight approx. 980g per bag) using small shovels. Then press by hand until the mixture is slightly compacted.

Another option is to compress the bags with specialized machines for this, commonly used in Asia and varying according to the magnitude of production.

E) Closing the bag

- ✓ Putt he plastic ring as the neck of the bag.

- ✓ Fold the plastic back.

- ✓ Place the Kraft paper (or cotton) on top as a cover or oxygen inlet filter.

- ✓ Fasten the Kraft paper with an elastic band.

STEP 5. Sterilizing the substrate bags

It is particularly important to thoroughly sterilize the substrate bags - (if not done as described below, you will have a poor crop or possibly no crop at all).

A) Metal barrels (55 gallons) or in an autoclave
Make sure they are on a stable surface and make sure you have enough gas or wood to boil non-stop.

B) Insert the frame or base, the sacks of fique and the water
Introduce the 40 cm high frame or base on which the bags will be placed.
Soak the fique sacks in water and line the barrel internally with two layers of these to avoid direct contact of the hot walls of the barrel with the bags with substrate. Add water until the first part of the base of the frame is almost covered.

C) Fill the metal barrel of bags with substrate
Make sure the barrel is tightly packed with bags, each barrel can hold between 80-90 bags of approximately 1 kg.

Artisanal process in metal barrels

Autoclave

D) Closing the metal barrel
Fold the fique sacks at the top, cover them with two layers of plastic sheeting and close them tightly with tires, trying to make it as airtight as possible.

E) Sterilization of the bags
Boil the water for at least 5-6 hours and the steaming water will ensure sufficient heat to sterilize the substrate bags.

STEP 6. Inoculation of the bags

After 5-6 hours of sterilization, allow the pouches to cool for 30 minutes before removing the plastic from the lid and allow cooling for 4 hours.

A) Transport to the inoculation site
Any method of transport can be used, but make sure that the bags are kept clean and avoid contact with soil to avoid possible contamination.

B) Ensure that the inoculation room is clean
The inoculation room should be kept disinfected, clean and inoculation should be done indoors, without much air circulation. Place the bags neatly in rows.

C) Prepare the inoculation materials
Get the seeds of good quality, normally these are inoculated on sorghum seeds.

Steps to follow:

- ✓ Wash hands. Use gloves, mask, cap, gown, etc. All equipment should be clean and disinfected with 70% ethanol
- ✓ Shake the inoculated sorghum seed bag or bottle against the semi-soft materials to loosen and separate the seeds
- ✓ Clean the seed bottles or bags with ethanol 70%
- ✓ Then, take the bottles or bags to the inoculation room
- ✓ Do not open the bottles or bags

D) Clean the hands and put the alcohol burner on
Light the burner containing alcohol 90% and clean your hands again with soap and ethanol 70% before inoculation.

E) Start the inoculation (maximum two people)
Inoculation should be done with extreme caution to ensure high yields and disease-free substrate bags.
Open the bag or bottle containing the seeds close to the flame and heat it around the opening (2-3 seconds).

At the same time another person opens the sterilized substrate bag and adds 40 g of inoculated sorghum seeds. Then shake or massage the substrate bag with the seeds. Perform this procedure quickly and close the bag as follows:

- ✓ Put plastic rings as the neck of the bag
- ✓ Fold the plastic backwards
- ✓ Place the kraft paper (or cotton) on the top as a lid or oxygen inlet filter
- ✓ Secure the kraft paper to the ring with an elastic band

STEP 7. Resting of the bags (incubation)

Keep the inoculated bags upright in the incubation area to allow the fungal mycelium to grow for 25-30 days, until the bag is completely white.

Incubation area

Inoculated bag

The incubation area should be closed, but with some ventilation and low light. (Optimal mycelial growth temperature can range from 25°C to 28°C and pH range is around 5.5 to 6.5, relative humidity between 60-80 %. CO_2 tolerance is low, concentrations higher than 30% cause growth to decline).

Check if any of the bags develop abnormal mycelium (such as black, green, brown, orange, or red spots), if so, remove them to a remote, safe place and burn them.

STEP 8. Fruiting area

The fruiting area can be constructed with locally available material (e.g., guadua, etc.) and sized for planned harvests of 4-5 cycles. The approximate area to produce a certain number of bags is presented below:

1000 bags: 2m x 3m (6 m^2)
2000 bags: 3m x 4m (12 m^2)
3000 bags: 4m x 5m (20 m^2)
4000 bags: 5m x 6m (30 m^2)

5000 bags: 6m x 7m (42 m^2)
The area should be kept semi-dark with some ventilation at the top of the roof.

The floor should preferably be in cement or have a layer of sand to keep the area clean and without any possible contact with soil to avoid contamination.

STEP 9. Move the bags to the fruiting area

A) moving bags to the fruiting or growth area
Once the incubation period is over, move the inoculated bags to the fruiting area.

Fruiting area

B) Opening the bags
The mycelium has spread well inside the inoculated bag and it is time to open the bags.
Remove the elastic bands and kraft paper, leave the bags open with the PVC collar, in addition to this, with a new or disinfected scalpel open 3 new holes on the side and side of the bag, these holes should be approximately 1.5 - 2 cm.
After 2 or 3 days add water to increase humidity and improve fungal growth.

C) Spraying with clean water
Irrigation could be done using a misting system, a back pump or simply with an atomizer or hand sprayer or a hose, spraying the water finely, this operation has the purpose of maintaining a high humidity in the growing area not lower than 80%.
Water the bags 2 times a day if necessary, depending on weather conditions. Pour the water from the top, so that the water can run down but not into the bags.

STEP 10. Harvest and daily care

A) Harvesting
The fruiting bodies of the mushrooms will appear a few days after the bags have been opened.
Care should be taken in the handling of the mushrooms at the time of harvesting. It is important to keep in mind that if the fruiting bodies are too small the income will be lower (lower weight)

and if they are too old, they are less palatable and will sell at a lower price. Harvesting continues for 3-4 months (Important: always harvest all fruiting bodies from one bag, do not harvest one and leave another to harvest later).


Fruiting bodies

B) Daily care
In addition to watering, also check the mushrooms and bags for contamination.

If they contract diseases, immediately remove the bags to a safe place, at least 200 m away from the growing area, measure at least twice a day the temperature and if it exceeds 35°C, spray with water at least 3 times a day.

C) Contamination problems of other small fungi
Daily, check the bags for any stains or if any part of the bag becomes abnormal. Green fungi will appear if the bags have not been well sterilized or have been contaminated during inoculation (e.g., with dirty hands and tools). Bags with the presence of these abnormalities should be immediately taken outside and burned.

Contaminated bag - green fungi

Important note: The best way to prevent pests and diseases is to follow instructions carefully; keep tools and growing area clean and do not allow too many people in the growing area.

D) Rodent and other animal problems

During incubation, rodents and other animals would like to eat the seeds, in this case sorghum, and will spread diseases. Also, during harvest rodents will eat the fruiting bodies, for this reason the area should be protected by keeping the soil clean, use traps.

Recommendations

- ✓ More trials should be carried out to refine and standardize the production techniques for edible mushrooms using cassava peels as a substrate, which is agro-industrial waste.
- ✓ Diagnose the main barriers for the scaling up of edible mushroom production technology and develop respective strategic plans for the adoption of the technology.
- ✓ Development of technical and administrative capacity in production models of combustible mushrooms using cassava peels.
- ✓ Workshops, ongoing technical support, and knowledge transfer should be carried out for the implementation of a possible community production project for the production of edible mushrooms for the utilization of cassava peels (agro-industrial waste).

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