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Sustainable Production of Oyster Mushroom (*Pleurotus ostreatus*) in Chiapas, Mexico

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Abstract*—Pleurotus ostreatus* is a common edible mushroom with a number of properties that can help to solve the nutritional and economical problems of people in Chiapas, Mexico. The objective of this project was to produce the mushroom under a sustainable management in which only regional products were allowed as a way to promote the cultivation and consumption of *Pleurotus ostreatus*; 5 different substrates were tested as well as 2 sanitation methods. The obtained results showed that the highest yields were obtained using corn husk and a thermal sanitation method. Pests and diseases were not a problem during the project but they appeared more in the substrates sanitized with calcium hydroxide.

Keywords*—Pleurotus ostreatus*, substrates, sanitation.

I. Introduction

WHILE Chiapas, México has an enormous biodiversity it is also one of the less developed regions in the country, the lack of social development has a great impact in the quality of life of its population resulting in very low education, nutrition and economic indicators. Its natural richness makes it possible to explore alternate production systems. Mushrooms are the fruiting bodies of certain types of fungi, many of which can play highly beneficial roles in forest ecosystems. Many of these fungi have unique abilities to break down wood, leaves, and other organic matter and recycle nutrients back into the system. Pleurotus species are popular and widely cultivated throughout the world mostly in Asia and Europe owing to their simple and low cost production technology and higher biological efficiency [1]. Pleurotus species are efficient lignin degraders which can grow on wide variety of agricultural wastes with broad adaptability to varied agro-climatic conditions [2]. *Pleurotus ostreatus* commonly known as the oyster mushroom is one of the more commonly sought wild mushrooms, though it can also be cultivated on straw and other media. It has a high content of protein, fiber, carbohydrates, mineral such as iron, calcium and phosphorus, vitamins (riboflavin, thiamine, ascorbic acid and niacin), linoleic acid, and low concentrations of fat [3]. Protein content as dry matter oscillates between 10.5 to 30.4% [4], and the biological quality of these proteins in terms of contribution to human health is high.

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Pleurotos ostreatus has a short production cycle, requires little space and few infrastructure for its cultivation, it also has a good selling price and in this part of the country there is a strong culture of mushroom consumption all of which makes it a good option to improve the living conditions of the people in the north part of Chiapas.

II. Objectives

The objectives of this paper are to compare the production of *Pleurotus ostreatus* cultivated in five different lingo-cellulosic materials and to test the efficiency of two methods of substrate sanitation. These objectives are meant to be obtained under a sustainable management and as a way to promote and improve the cultivation of *Pleurotus ostreatus* in Chiapas, Mexico.

III. Methodology

A. Location

The present research was done in the community of Rayon, Chiapas in South East México.

B. Plot Cleaning

Before starting to build the infrastructure for the project the terrain was completely cleaned and all remaining materials were retired in order to avoid contamination of the mycelium.

C. Pre-Emergent Activities

All materials and the surrounding areas of the project were washed with calcium hydroxide, also all the plastic utensils were disinfected before their use.

A double entrance door was built in the main access of the house where the mushrooms were grown; this helped to keep insects, bacterium, spores and pathogens out.

D. House Construction

The region where the project was done has a very wet climate, so to have a place without humidity and a high temperature was extremely important. The walls were made of wood and whitewashed prior to the seeding and finally they were covered with plastic; the roof was made of corrugated zinc sheets, the facility had a dirt floor with a small incline to help water removal. Two small windows were made to give ventilation to the house.

E. Temperature and Light Control

Temperature and lightning control are an essential part of the process of cultivating mushrooms; temperature must always be kept near to 25°C during the incubation period, a relative humidity of 85 to 95% and 12 hours of natural or artificial light (250 lux), it is also very important to have some ventilation in the house to achieve good results.

F. Substrates

Five different kinds of lingo-cellulosic material were used; corn husk, corncob, corn steam, bean´s seed coat and sawdust. All the substrates were dry and completely clean, before the seeding they were cut in small pieces to facilitate hydration and ensure mycelium colonization.

The mycelium of this fungi can grow in temperatures between 0 and 35°C, with an optimal temperature of 30°C and a PH between 5.5 and 6.5, *Pleurotus* spp. grows in a 30 and 300 carbon and nitrogen relationship depending of the life phase of the fungi [5], [6]. High relationships promote mycelium growth whereas low relationships promote the development of fruiting bodies [7].

G. Substrate Sanitation

Appropriate treatment to obviate the risk of substrate contamination can constitute a limiting factor for small producers in tropical countries, given the limited investment in appropriate infrastructures [8].

According to Laborde and Delmas [9] and Valencia and López [10], a number of different methods for substrate pasteurization or sterilization have been proposed: (a) autoclaving (axenic), (b) axenic and inoculation with thermophilic microorganisms, (c) rapid substrate steam treatment between 80 and 100°C for several hours, (d) NADASI system: pasteurization at 72°C for four or five days, and (e) pasteurization by substrate steam treatment for several days (60°C) in a tunnel. Most research on evaluation of substrates for Pleurotus cultivation has been performed using the axenic cultivation system, which is accessible only to research institutions or companies with investment capacity [8]. Nevertheless, reports of contamination problems with sterilized substrates are common, as maintenance of growing conditions free of contaminant microorganisms is arduous. Steam pasteurization and composting are traditional procedures which are more appropriate for small scale mushroom growers, as these substrates are more stable and less susceptible to contamination [11]. Steam sanitation and the use of Calcium hydroxide were tested, everyday all the substrates were observed in order to determine if it had any pest or diseases.

Thermal sanitation was done in metal containers to retain the heat; steam was well distributed all over the substrates for an hour and a temperature of 80°C, it was very important to avoid the contact of the substrate with the hot water. Prior to this treatment substrate was humidified mixing 20kg of substrate with 10 liters of water.

Sanitation with calcium hydroxide was done by adding 1kg of it for every 20kg of substrate in a recipient with 100 liters of water for approximately 15 hours.

H. Yield

Total weight of all the fruiting bodies harvested from all the three pickings were measured as total yield of mushroom. The mushrooms were harvested three times; each collection was made with a separation of seven days between them. The product was collected carefully four days after primordial buttons have appeared.

I. Experimental Design

Mushroom total yield results were analyzed as a complete randomized design using Minitab 15; to analyze the presence of pests and diseases when comparing substrates or sanitation methods a chi-square test was used, the analysis was done using Minitab 15.

IV. RESULTS

A. Total Yield

The highest yield was obtained when using corn husk as the substrate in both sanitation treatments, considering that this region of the country traditionally has dedicated large areas of its territory to grow corn it gives the producers another option to maximize the productivity of their lands in a sustainable way.

There was a significant difference in total yield $F(1, 8) = 3,57$, $p < 0.10$ when comparing thermal sanitation against the use of calcium hydroxide, all substrates registered a higher yield when disinfected with a thermal method, this is an easy and cheap way to do it so it can be a valuable tool to further spread the cultivation of *Pleurotus ostreatus* in the rural communities of Chiapas, Mexico.

Total yield production was different $F(4, 10) = 21,83$, $p < 0.01$. Between the substrates sanitized with a thermal method, they also had the highest total yield. These results are shown in Fig. 1.

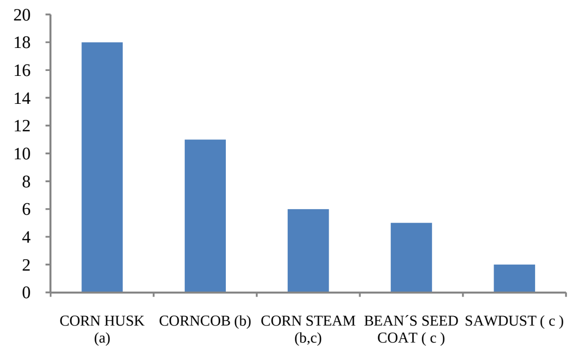

Fig. 1 Total yield in kilograms of *Pleorotus ostreatus* in different substrates sanitized with a thermal method

There were no differences in total yield between the substrates sanitized with calcium hydroxide $F(4, 10) = 2,12$, $p > 0.10$. Results are shown in Fig. 2.

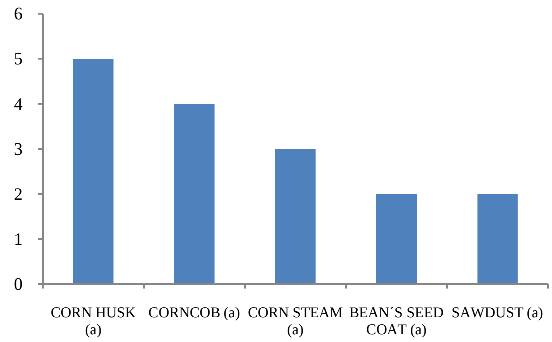

Fig. 2 Total yield in kilograms of *Pleorotus ostreatus* in different substrates sanitized with calcium hydroxide

The highest yield was obtained when using corn husk as the substrate in both sanitation treatments, considering that this region of the country traditionally has dedicated large areas of its territory to grow corn it gives the producers another option to maximize the productivity of their lands in a sustainable way.

B. Pests and Diseases

All the substrates but the bean´s seed coat were completely free of pests and diseases, however this difference was significant χ^2 (1, N = 3) = 12, $p < .05$, results are shown in Table I.

These results demonstrate that both sanitation methods are an appropriate way to disinfect the substrates with the infrastructure and equipment of rural producers, another advantage of this processes is that their cost are low.

TABLE I
NUMBER OF PESTS AND DISEASES FOUND IN THE SUBSTRATES OF *PLEUROTUS OSTREATUS*

Substrate	Pests And Diseases
Corn Husk	0^{A}
Cornhub	0^{A}
Corn Steam	0^{A}
Bean´S Seed Coat	3^{B}
Sawdust	0^{A}

Whiteflies were the only insect plagues found during the realization of the project, no chemicals insecticides were used so pest control was done with traps, insect nettings and removal of any organic waste.

The number of pests was significant low χ^2 (1, N = 3) = 3, $p <.10$, when disinfecting the substrate with a thermal method, even when both treatments were very effective to control sanitation problems, steam sanitation performance was remarkable as any contamination was found in any of the different substrates, results for this variable are shown in Table II.

TABLE II
NUMBER OF PESTS AND DISEASES FOUND IN THE *PLEUROTUS OSTREATUS* CULTIVATION ACCORDING TO THE SANITATION METHOD

Method Of Sanitation	Pests And Diseases
Calcium Hydroxide	3^{B}
Thermal	0^{A}

V. CONCLUSIONS

Rural producers of Chiapas, Mexico have traditionally been one of the groups with a lower degree of development in the country, this situation contrast with the enormous biological richness of the region which has not been used in a sustainable way to generate economic growth. The cultivation of *Pleurotus ostreatus* is an excellent alternative to the production systems that have been carried out for centuries in Chiapas, activities such as traditional cattle breeding and maize cultivation are not very profitable and have a great impact in the natural resources.

In other regions of the country such as the State of Puebla there are companies which are already producing this mushroom in an industrial scale with a good acceptance from the national market, so there is a good opportunity for small producers to embark in an enterprise like this.

It is necessary to keep on promoting the benefits of this product, one of the main problems to start this project was the resistance to change the traditional ways of production so a new culture of sustainable agriculture needs to be developed. Even when the mushroom is well known only a small fraction of the production is cultivated, it is very important to do more research to develop a system that can adapt completely to the idiosyncrasy of rural producers of Chiapas.

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