Part Ⅱ Mushroom for Better Life

Chapter 9

Mushroom Growing Project

MUSHROOM GROWING PROJECT IN COLOMBIA

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Project Outline	
Duration	6 years (1999-2004)
Location	Urban area of Manizales in Chinchiná and rural coffee farms in 3 states
Goal	Income generation of coffee growers by mushroom growing with coffee residues
Beneficiary Groups	Female family heads in the urban area of Manizales and coffee growers in rural farms
Participating Organizations	Zero Emission Research Initiative (ZERI), the National Center for Coffee Research (Cenicafé), National Federation of Coffee Growers of Colombia, Proexport Colombia, Agrópolis IDRC, Office of the Mayor of Manizales, Chamber of Commerce of Manizales

Introduction

Figure 1. Coffee growing regions in Colombia

Colombia is a tropical country located at the latitude of 4-14 °N that features a high level of topographic and climatic diversity. The provinces (departamentos) that have been collectively known as the "Coffee-Growing Region" are in the center of the country, on the Andes Mountains (Fig. 1). For many years coffee production was the main growth engine for the region and the whole country. During the last 15 years, however, international coffee prices have plunged (Table 1), and so has the income of more than half a million Colombian coffee-growing families.

Regardless of the decreasing coffee price, Colombian coffee growers have themselves never really been the main beneficiaries of the coffee processing industry. It is estimated that the Colombian coffee farmers receive only 10 cents for each dollar of their coffee that is sold in the United States (Jaramillo, 1999).

For these reasons, and the additional reality that the coffee production process throws away 99% of the biomass generated by the coffee plants (Pauli, 1999), it is now imperative that the Colombian coffee growing industry develop alternative production models. These alternative models should, ideally, be able to address the under-utilization of the biomass available, and also give coffee growers a much needed, extra source of income.

Among the many contributions that the coffee industry has given the country, one of the most important has been a research center dedicated to the coffee-growing activity related fields of study and alternative production models applicable

to coffee-producing farms. One of its specific aims has been to simultaneously improve the quality of life of coffee growers and optimize the use of non-renewable resources. Coffee production generates a large quantity of waste during its industrial processes. Some of these waste types are coffee pulp, stem and sawdust (Figs. 2). The management given to these solid materials is often inadequate and therefore harmful for the environment.

Table 1. Change in price indices of selected primary commodities of the LDCs, 1997–2001

Year	All foods	Cocoa	Coffee	Rice	Sugar	Tea	Wheat	Cotton	Crude petroleum
1997	100	100	100	100	100	100	100	100	100
1998	87	104	82	101	79	104	79	82	68
1999	71	71	64	82	55	97	74	66	95
2000	69	56	48	67	72	104	76	74	147
2001	69	70	34	57	76	83	80	61	127

Source: UNCTAD secretariat estimates based on UNCTAD Commodity Price Bulletin

Figure 2. Coffee residues available as substrate for mushroom growing **A**: Coffee pulp **B**: Silver film **C**: Coffee stem **D**: Coffee sawdust

Centro Nacional de Investigaciones de Café (Cenicafé)

Cenicafé, the National Center for Coffee Research, has received the support of the Colombian coffee growers, and has thereby developed more than a thousand research projects related to coffee, since established in 1938. The areas of research have included genetic research for new varieties, and research on harvesting, processing, and quality. Cenicafe's research initiatives have allowed coffee growers access to the information required for them to produce high quality coffee and be competitive in the world coffee market. Among the many programs undertaken by Cenicafé, the initiative to inquire into the feasibility of using coffee residues in the cultivation of tropical mushrooms has been successful, the many obstacles and challenges for the future notwithstanding.

Cenicafé
Centro Nacional de Investigaciones de Cafe

Figure 3. The logo of Cenicafé

Figure 4. Cenicafé, the National Center for Coffee Research

Figure 5. Researchers of Cenicafé

Mushroom Projects

Taskforce

The composition of the taskforce in charge of undertaking the project is as follows:

Carmenza L. Jaramillo	: Team leader
Nelson Rodriguez Valencia	: Scientific support and laboratory analysis
Ana Luz Arango Pastor	: Methodological and critical points
Pamela Jaramillo Lombana	: Support and economic models
Maryeimy Varón López, Luz Echeverri Mejía	: Mycelium production
Asohongos (communities of women cultivators)	: Institutional, marketing, and commercial support

Objectives

With the guidance of Cenicafé, a pilot mushroom project was launched in 1998 to encourage cultivation of edible mushrooms such as shiitake and oyster mushroom. This project was aimed at generating a constant, decent and independent source of income for low-income participants in the coffee-growing farms among the poorest communities of the city of Manizales and its metropolitan area.

Specific objectives are as follows:

- To implement the commercial cultivation of the edible mushrooms *Lentinula edodes* and *Pleurotus* spp. with methods developed by Cenicafé in rural farms and in the urban areas of the city of Manizales.
- To train coffee growers so that they become proficient in the cultivation of the mushroom *Lentinula edodes* with coffee residues and communities in the urban area of Manizales in the cultivation of the mushroom *Pleurotus* spp.
- To find export markets that could insure a more constant demand for the products.

Feasibility studies and results

Cenicafé undertook research for 10 years (1990-1999) with the objective of assessing the feasibility of using coffee residues in the cultivation of tropical mushrooms. Of those 10 years the latter 5 were dedicated to research in the cultivation of the mushrooms *Pleurotus, Ganoderma lucidum* and shiitake. In 1998 as a result of these efforts Jaramillo *et al.* determined that the agro-industrial residues at hand in the coffee growing region of Colombia could be used as substrates for the cultivation of tropical mushrooms such as *Lentinula edodes, Pleurotus sajor-caju, Pleutorus florida, Hypsizygus marmoreus* and *Ganoderma lucidum* (Jaramillo *et al*., 1999) (Figs. 6). During the investigation "Cultivation of edible and medicinal mushrooms on agro-industrial residues in the coffee-growing region of Colombia," it was determined that the shiitake mushroom species was a promising mushroom type for the area.

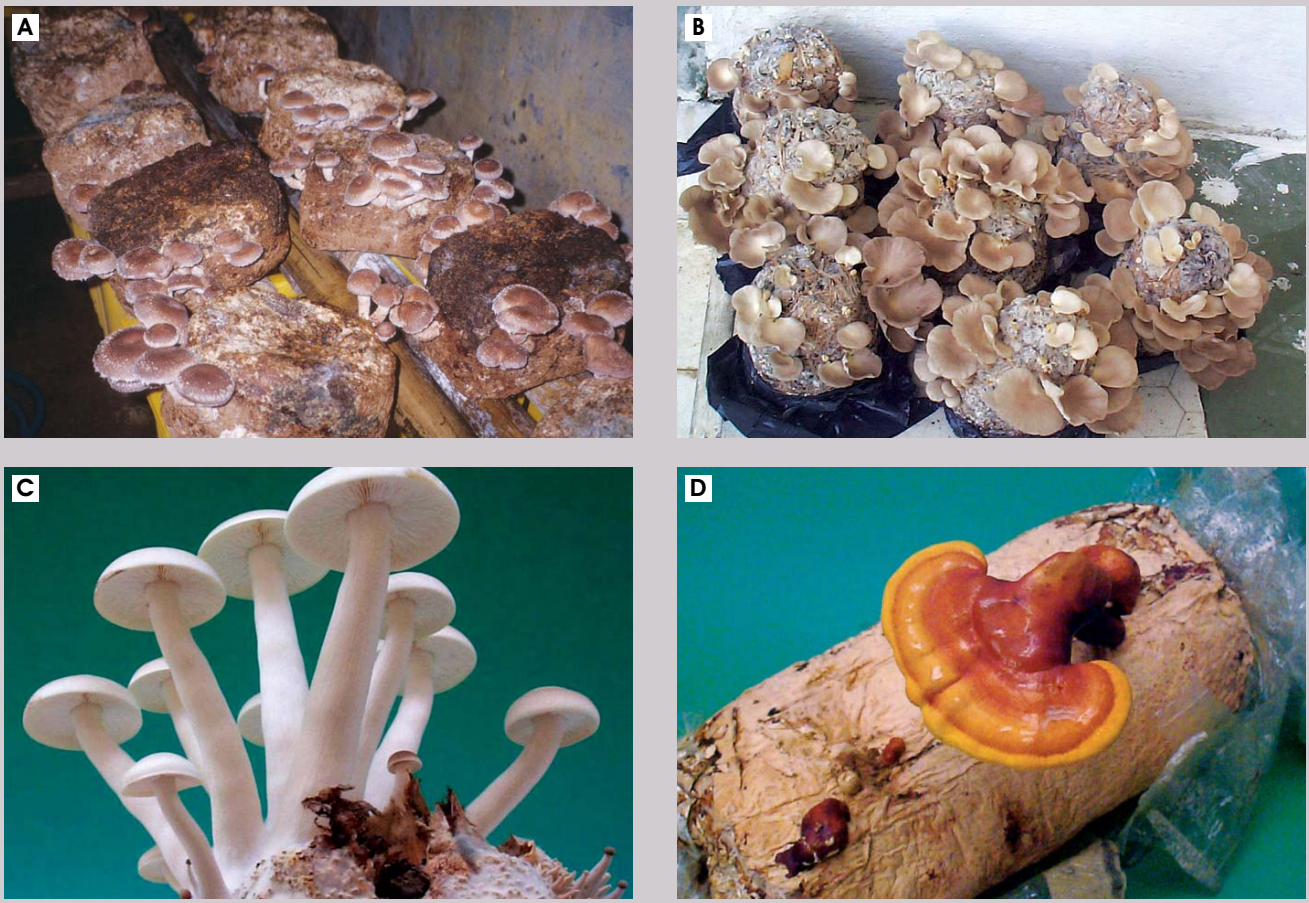

Figure 6. Various mushrooms grown on coffee waste **A**: Shiitake **B**: Oyster mushroom **C**: Hypsizygus marmoreus **D**: Ganoderma lucidum

The research initiative determined the best formulations available from the by-products of coffee cultivation, and the best procedure to use them as raw substrate material. In the case of shiitake, biological efficiencies reached levels of up to 60-75% in laboratory tests and in the case of *Pleurotus* this efficiency reached 60-80% in controlled tests. This phase of the research program enjoyed the guidance of Prof. S. T. Chang. For the cultivation of *Pleurotus* spp., simple technologies were used among low-income communities in the urban areas of the city of Manizales (Jaramillo, 1999). These initial trials reached biological efficiencies of up to 80%, without supplementing or altering the formulations.

Market research

Shiitake has a very sizable market in the United States. This is an interesting market because prices in that country reach USD3 per fresh pound and between USD70 and USD90 per dehydrated pound. Further, the increase in world wide shiitake consumption during the last five years predicts a positive outlook for initiatives of production of this mushroom, and it seems reasonable to expect that Colombia could take advantage of this situation.

Another advantage that Colombia has is its proximity to the U.S. markets. Colombia is much closer to the U.S. than its Far East Asian competitors. In addition, the coffee-growing region of Colombia is particularly suited for shiitake growing because it has a considerable amount of biomass available, abundant workforce and favorable climate conditions. The combination of all of the reasons creates the appropriate conditions needed for Colombia to be able to produce and sell shiitake internationally.

Activities

Training for the coffee growers in the initiative "Cultivation of Shiitake in Pilot Farms" took place from 2001 to 2003 in the coffee-growing region of Colombia known as the "Coffee Axis". The task force found a group of 15 coffee growers who were female family heads interested in mushroom growing and willing to contribute the necessary space and labor (Figs. 7).

Figure 7. Female family heads in Manizales participating in the Agrópolis-supported training

Theoretical training

Theoretical training in mushroom growing was given to 15 coffee growers in Manizales, 10 of whom finished all the training courses and participated in the final field tests. Coffee growers were tutored at the central headquarters of Cenicafé, and the women that were not coffee growers were trained through Colombia's National Training Service (SENA) under the supervision of Cenicafé itself. Courses normally had a duration of one week. Lectures were given on biology and substrate formulation and individual workshops were organized to provide opportunities for the students to learn how to pasteurize, inoculate, incubate substrate bags and manage growing conditions.

Spawn production

For the laboratory and field tests, mushroom cultures had to be preserved and transferred into mushroom spawn. Training staff also produced the inocula and maintained mushroom cultures. An inoculated substrate production team was also assembled at Asohongos.

Field tests and results

Field tests for shiitake growing involved both a traditional methodology and an industrial management model. A total of 15 farms participated in the field tests carried out in 2001-2002, using a Chinese method. Ten of them then joined in the 2002-3003 field tests exploiting an industrial production model. The dire situation of the coffee growers limited the amount of initial investment available. To maximize the utilization of given resources while minimizing expenses, the Chinese methodology based on manual work was adopted. Farm activities according to the method consist of raw material preparation, mixing, bag filling, thermal treatment, inoculation, spawn run, thermal shock and production (Luo, 1995) (Figs. 8).

The taskforce first selected growing sites by considering elevation, average temperature, sunlight exposure, wind direction, oxygen content and proximity to neighboring crop animal farms. A clean, well-ventilated place with no neighboring farms was favored to avoid possible contamination sources. Growing houses were faced south to ensure maximum solar exposure particularly in low temperature places at high altitudes. In warmer temperatures, sites in shade or partial sun were chosen. Oxygen content inside the chosen growing rooms was considered, given that the coffee growing region of Colombia is located higher than 1,100m above sea level.

Figure 8. Processes of shiitake production in Chinese methodology **A**: Heat treatment for pasteurization **B**: Spawn run **C**: Cold shock for fruiting induction in a refrigerator

Each farm used underused construction such as silos, old rooms, garages, former pigpens and stables (Figs. 9). The microclimate and management required to optimize the location for mushroom growing were different for each farm.

The results obtained via the small scale, hand-crafted methodology were acceptable, considering that it was the first trial. The results also showed that the Chinese method is an excellent vehicle for teaching farmers about the cultivation of edible mushrooms such as shiitake and oyster mushrooms.

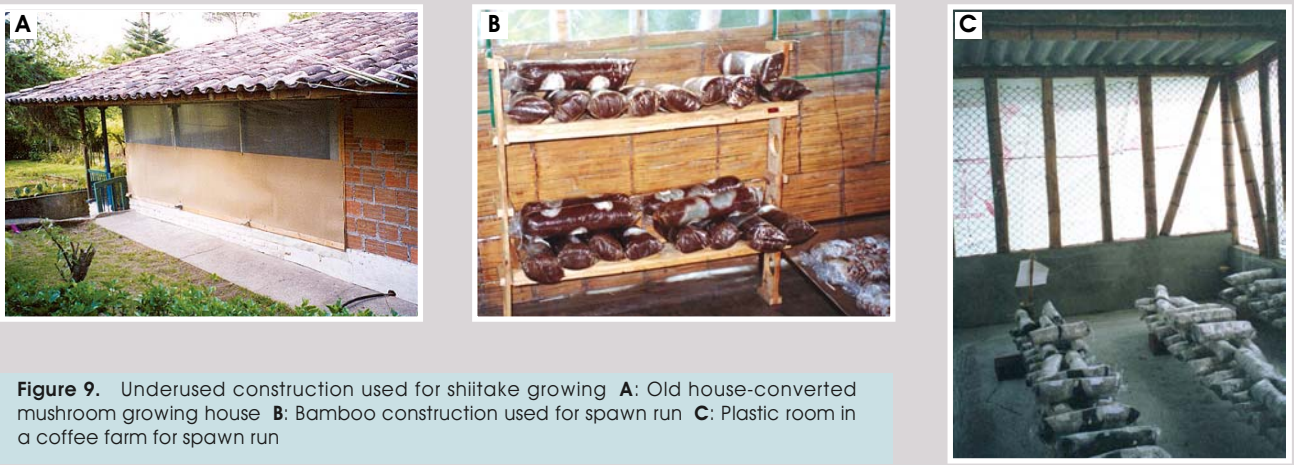

Figure 9. Underused construction used for shiitake growing **A**: Old house-converted mushroom growing house **B**: Bamboo construction used for spawn run **C**: Plastic room in a coffee farm for spawn run

Figure 10. Central production of inoculated substrate bags **A**: Spawning (grain spawn) **B**: Heat sealing of the bag **C**: Inoculated bags in the truck ready to be delivered to growers

Because of high labor costs in Colombia, however, specialization and concentration of production were required. By establishing a substrate bag production center, where substrate preparation, pasteurization and inoculation were professionally performed (Figs. 10), growers would be able to concentrate on only the final stages of mushroom growing, including spawn run, thermal shock and fruiting (Fig. 11).

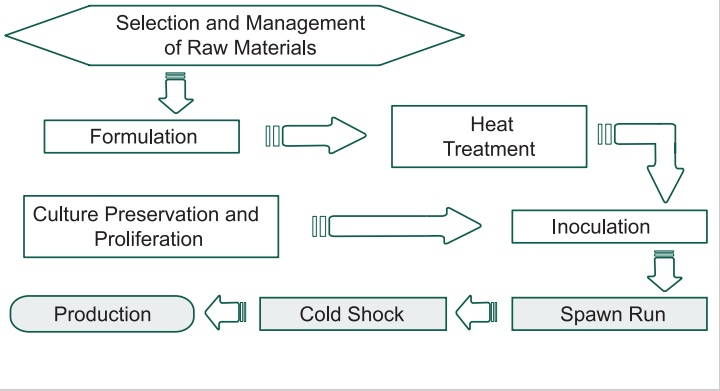

Figure 11. Shiitake production flow in the industrial management model

Field tests for oyster mushroom growing involved three communities and started in 2001. Industrial field tests for oyster mushroom growing could be carried out in 2005 with financial support from Agrópolis. Communities involved in field tests for oyster mushroom growing faced inconsistent production and operational challenges due to insufficient knowledge and little experience in mushroom growing and business and management principles and practices.

Most of the common errors in mushroom growing were observed in the substrate preparation and the management of growing parameters. In some cases, inappropriate raw materials were selected and the raw materials were poorly formulated and mixed, moistened or pasteurized. Substrate mixtures with improper moisture content or pH were prone to contamination. Farmers must be taught that mushrooms, unlike other crops, require a high level of hygiene and sanitation, especially during spawning. The need to control temperature, humidity and pests must be emphasized. The potential mushroom growing communities also need to be familiarized with basics of business and entrepreneurial management. In addition to mushroom growing basics, the issues of production planning, financial planning, marketing, and the management of resources including human resources, bookkeeping and accounting must be emphasized. Most participants have little formal education, low incomes and low self-esteem. An understanding of their mentality and attitudes can lead to the development of better education and management programs. Special attention needs to be paid to checking acquired knowledge and stressing the importance of hygiene.

After trying two different cultivation methodologies on 15 different coffee farms for shiitake growing and in the urban and suburban areas of Manizales for *Pleurotus*, the taskforce developed a better model that combined the strengths and addressed the weaknesses of both methods. The results indicated the need to build a bag production center with an adequate pasteurization system in order that higher volumes of substrate might be managed. The bag production center is an economic consideration which minimizes the initial investment of growers. Growers were able to obtain higher earnings from substrate professionally produced on a large scale (Figs. 12). Higher productivity were possible using this system because it eliminated formulation errors and contamination risks from poor pasteurization and inoculation. Production of large volumes of mushroom created a constant supply, which would greatly enhance the chances of export success.

Two different kinds of low cost buildings were designed for shiitake growing. These two methods varied according to their altitude, with one type being used for altitudes higher than 1,600m above sea level, and another type being used for lower elevations. For *Pleurotus*, two types of constructions were devised, and the costs were lower than those for shiitake. Also systems for temperature, humidity and CO_2 measurement were devised to optimize conditions for inoculated substrate bag production, and thus to facilitate the standardization of the finished products.

Figure 12. Shiitake growing in a coffee farm using central-supplied substrate bags **A**: Inoculated substrate bags to be delivered to coffee farms **B**: Spawn run of the central-supplied bags in a coffee farm **C**: Spawn run under the controlled microclimate conditions **D**: Shiitake ready to harvest in a coffee farm **E**: Harvested shiitake **F**: Shiitake packed for sales

The integrating entity

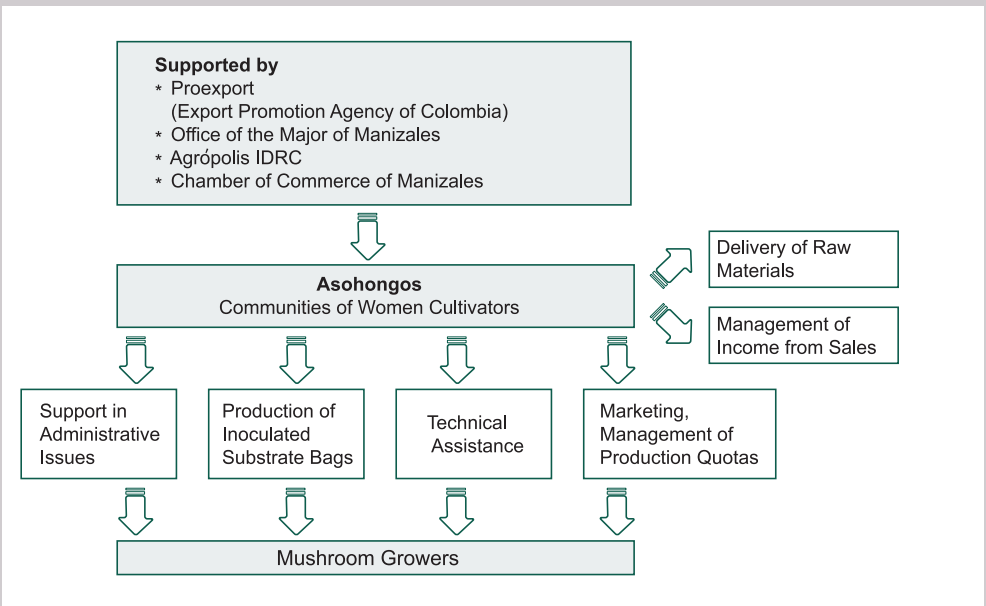

Figure 13. Roles of Asohongos as an integrating entity

To centralize follow up tasks involving the administrative, technical and commercial aspects of mushroom cultivation, the taskforce suggested the creation of an integrating entity. This entity was expected to take responsibility for determining pro-

duction volume, looking for marketing possibilities, production and distribution of inoculated bags, delivering technology and technological and managerial consulting to growers. Other required activities included performing quality control of products, managing incomes from mushroom sales and coordinating a management consulting program in assistance with professionals in the areas of chemical and industrial engineering and enterprise economics. This supportive role also involved the centralization of sales, which regulated production volume and thus maintained mushroom prices.

Asohongos, established in 2001 to promote the cooperation between trained shiitake growers, became an integrating force for commercial shiitake production (Fig. 13). Currently the association unites shiitake growers and growers of other mushrooms. As an integrating entity, Asohongos significantly improved the competitiveness, productivity and return on investment of the production of oyster mushrooms and shiitake. The successful cultivation and marketing of shiitake in coffee-growing regions could significantly improve the life standards of peasants. The advantages of a united growers entity include uniting cultivators, protecting their interests and facilitating the processes of training, technical assistance, collection of harvested products and marketing.

How to organize the final productive project?

Financial support for the laboratory tests was contributed in its entirety by the National Federation of Coffee Growers of Colombia, of which Cenicafé is a subdivision. The Federation also backed the other field tests with the help of Proexport Colombia, a government agency that strives to increase Colombia's exports. Other financial supporters included Fomipyme, a governmental agency that promotes small businesses, the Mayor's office of the city of Manizales, the Chamber of Commerce of Manizales, which has also been very active in its support of the whole initiative, and international organizations such as Agrópolis (Canada), that awarded the project with the Agrópolis Award in Urban Agriculture.

With the generous support of the aforementioned organizations, the final project was organized into a private commercial venture in 2004. The commercial project was organized by incorporating all the lessons learned during the initiative feasibility, pilot and field tests.

Recommendations

Relevant to the methodology

- Low-scale, hand-craft technology is viable for farms and communities with certain elements, such as necessary initial equipment and adequate existing infrastructure.
- An inoculated substrate bag production center is a good starting point for a mushroom project. Growers can start mushroom growing with ready-to-grow bags much easier than with raw materials. Production performance was higher with the central-supplied inoculated substrate bags due to a lower contamination rate and improved biological efficiency.

Relevant to the management of cultures

- It is recommended that the culture management be done by people who have time to invest in the program, good training and a high level of dedication.

Relevant to growing houses

- All converted, custom-made growing houses require a higher level of asepsis and control.
- Construction of growing houses in rural areas requires a higher level of protection than in urban areas because of the larger quantity of potentially pestiferous flora and fauna in the rural areas.

Relevant to shiitake growing

The cultivation of shiitake can be implemented in any coffee farm that has the following conditions:

- At least one person should be dedicated exclusively to cultivation and have solid training in the area.
- Basic growing conditions include lofty, well-ventilated ceilings and barriers that block the entrance of insects and rodents.
- At an altitude higher than 1,500 meters above sea level, the growing shed requires hermetic sealing with plastic (Fig. 14) and at the same time CO_2 control. At lower altitudes, brick or bamboo walls are appropriate (Fig. 15).

Figure 14. Plastic-sealed growing house in Manizales (2,000m above sea level)

Figure 15. Shiitake growing house built of bamboo

Relevant to oyster mushroom growing

The cultivation of *Pleurotus* spp. (oyster mushroom) can be successfully achieved in urban areas under the following conditions:

- Growers should be trained in the processes of spawn run and production. These activities are labor intensive and as such, generate a good source of income.
- Communities require the continuous support from an integrating entity that is in charge of the training, small business management, the supply of raw materials, marketing of produced mushrooms, and technical assistance.
- Buildings for the cultivation of oyster mushroom require less insulation and thus are less expensive than those used for shiitake growing.

Figure 16. Oyster mushroom produced from the central-supplied bags

Possibilities for replication

Success in the formulation of a substrate that is both effective and inexpensive allows for easy substrate replication of Colombia's optimal formulation. Each country must adapt the technology to its own particular weaknesses and strengths. Extensive training is the key to a successful mushroom cultivation. Because of the care needed in the production of mushrooms, training for the communities in oyster mushroom and in farms for shiitake has taken a minimum of 2 years.

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