MUSHROOM GROWING PROJECT AT THE LOS HUMEROS, MEXICO GEOTHERMAL FIELD

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INTRODUCTION

There are several projects of direct (non-electrical) use of geothermal energy in Mexico. Personnel of the Comisión Federal de Electrícidad (CFE) has experience in various of these projects, like drying of timber and fruits, space heating, food processing, etc.

At present, at the Los Humeros geothermal field in the state of Puebla, some 200 km east of Mexico City, a mushroom growing project has been in operation for a number of years.

There are two basic requirements for a commercial mushroom growing operation: 1) the capacity to control temperature and moisture conditions, and 2) the ability to inhibit the growth of competing, undesirable mushrooms which contaminate the commercial product. In other words, a plant growing edible mushrooms not only requires a source of heat, but its installations should be as hermetic as possible, and the operations have to be conducted under rigorous aseptic conditions.

Taking this in consideration, CFE built the Los Humeros mushroom plant using for heat source the geothermal steam from Well H-1. The main purpose of the project was to take advantage of residual geothermal energy in a food production operation and to develop the appropriate technology.

In 1992, existing installations were renovated, preparing appropriate areas for pasteurization, inoculation and production. The mushroom Pleurotus ostreatus var. florida and columbinus was used.

A year later, CFE proposed the construction of improved facilities for growing edible mushrooms. New materials and equipment, as well as different operation conditions, were proposed on the basis of the experience gained in the initial project. The construction and renovation activities were completed in 1994.

CHARACTERISTICS OF THE PLANT

The plant is divided into three working areas plus a warehouse.

Section A. It has three areas originally planned for inoculation, incubation and production. Currently, this section is only involved in production and harvesting activities.

Central Section. It is the pasteurization area.

Section B. Originally, it was supposed to be similar to Section A; but, now it contains areas where inoculation, incubation and dehydration is done.

The characteristics of the different working areas are given in Table 1.

Table 1. Characteristics of the Working Areas in the Plant

AREA	CHARACTERISTICS	EQUIPMENT
Pasteurization	Area: 60 m^3; three 2 m x 2 m x 1 m tanks for hydration, drainage and pasteurization. The pasteurization vat is heated by circulating geothermal steam.	0.80 m x 0.75 m x 1.75 m hydration and pasteurization trays; heating system based on a coil through which geothermal steam circulates; cart to move the trays.
Inoculation	Area: 44 m^2; 9 m^2 working table.	Air filtering system with a capacity of 2,500 m^3/hour; 0.04 micron filter.
Incubation	Area: 48 m^2; heating system based on the circulation of geothermal steam; capacity of up to 320 15-kg substrates.	Thermometers and hygrothermometers.
Production	Area: 92 m^2 heating systems; capacity of up to 411 15-kg substrates.	Ventilation system with a capacity of moving 1,500 m^2/hour air equivalent; thermometers and hygrothermometers.

PRODUCTION PROCESS

Substrates

Substrates is the material whose degradation sustain the growth of the mushrooms growing on it. The type of substrate depends on the mushroom. Pleurotus ostreatus feeds on the products from the degration of lignite and cellulose; one could use as substrate industrial clippings and agricultural waste products (straw, stubble, pulp, bagasse, etc.) (Figure 1).

Figure 1. Mushrooms growing on substrates.

Substrate Treatment

The wheat straw used at Los Humeros as substrate is simultaneously hydrated and pasteurized by immersing it in 90°C water for two hours. This eliminates sugars, removes the ceraceous (waxy) layer, starts the decomposition of the cellulose and assures a growth medium free of competing organisms (other fungi, bacteria, etc.). The water in the pasteurizing vat is heated by circulating geothermal steam (Figure 2).

Figure 2. Wheat straw used for substrates.

Seeding

Seeding is done by mixing the mycelium or inoculum with the substrate. To guarantee a good seeding, the temperature sbould be in the 20 - 21°C range. The seeded area should be completely clean to avoid contamination. The substrate moisture should be around 75% (Figure 3).

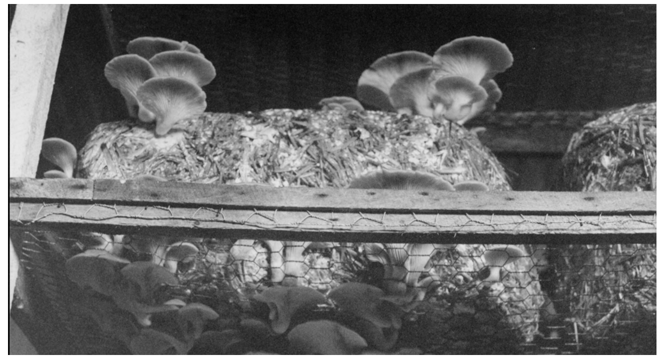

Figure 3. Mushrooms growing on substrates.

Incubation

During the first 24 hours, the mushrooms grow little while adapting to the medium. Increased growth starts about 48 hours after seeding, depending on ambient conditions. During this vegetative state of the mushroom, the temperature has to be between 22 and 26°C. Optimally, the incubation period should not exceed 17 to 22 days. It is vital to carefully control ambient conditions during this time; future production strongly depends on it (Figure 4).

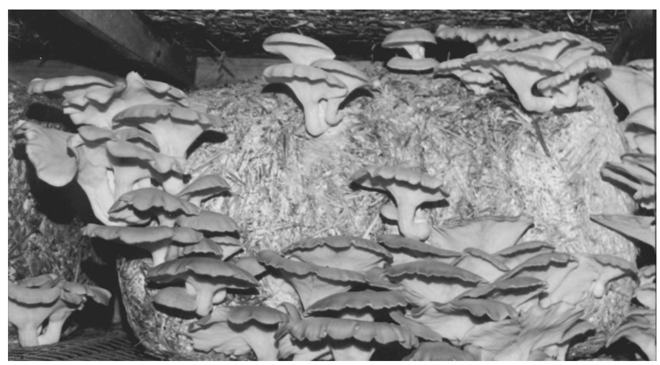

Figure 4. Mushrooms during incubation period.

Production

In substrates with fully developed mycelia, primordia of fruiting structures appear in a few days. When this happens, the humidity and temperature conditions will have to be changed to 90 - 95°C and 24 - 26°C, respectively. That is why the substrate trays are moved to the production area. The primordia will start growing immediately and fruting bodies will appear in about five days (Figure 5).

GEO-HEAT CENTER QUARTERLY BULLETIN
ISSN 0276-1084
A Quarterly Progress and Devlopment Report
on the Direct Utilization of Geothermal Resources

This article is in the Vol 19, No. 2 bulletin

This material was prepared with the support of the U.S. Department of Energy (DOE Grant No. DE-FG07-90ID 13040). However, any opinions, findings, conclusions, or recommendations expressed herein are those of the author(s) and do not necessarily reflect the view of DOE.

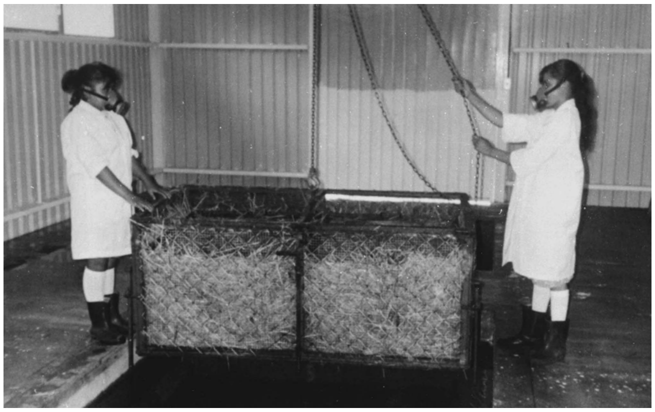

Figure 5. Substrates trays.

Harvest

The fruiting bodies are harvested when they are fully developed, the larger ones first, leaving the smaller ones for later. The bodies are removed by cutting the base of the stalk with a clean, sharp blade. Four to six days after harvesting, the next sprouts begin to appear.

Each of the 15-kg substrate may produce three to four harvests; however, 80% of the production is obtained during the first two harvest (Figure 6).

Figure 6. Bagging substrates straw.

Plagues and Diseases

Beginning with the incubation stage, a very common problem is the attack by insects and rodents which will affect the crop. Production may be totally lost since insect larvae feed on mycelia and fruiting bodies, damaging the product making it non-marketable. On the other hand, the rodents feed on the grain hosting the mycelia and contaminate the substrate with fungi that will compete with the crop.

RESULTS

The operation of the mushroom growing plant has been improved since its beginning, for example.

The use of water has been reduced by 75% by simultaneously carrying out the hydration and the pasteurization of the substrate.

The amount of inoculum needed has decreased by 37.5%.

The yield of the substrate has increased. Up to four crops may be obtained from 15 kg of substrate.

In addition, a better control of temperature and moisture conditions has resulted in increased production as shown in Table 2.

Table 2. Production Data

MONTH	1997 HARVEST (in kg)	1998 HARVEST (in kg)
January	20	109
February	106	187
March	86.5	125
April	128	296
May	254.5	302.5
June	228	54*
July	74	168
August	68	?
September	247	?
October	184	?
November	90.8	?
December	57	?

* Note: In June 1998, the plant underwent maintenance requiring the clearance ofthe production area.

The problem of contamination by molds and other fungi was solved by using longer pasteurization times. This has substantially reduced losses that occurred initially.

However, there still exist problems--some related to local environmental conditions and others to the design of the plant and equipment used. This results in unstable rate of production.

GEOTHERMAL UTILIZATION

The flow rate is 2.0 tonnes per day of a steam-brine mixture, taken directly from the wellhead at a temperature of 130°C. The water used for pasteurization has a temperature of 90°C. The room temperatures are kept within the following ranges: 1) 20 -22°C for inoculation, 2) 18 - 22°C for incubation, and 3) 15 - 20°C during growth.

CONCLUSIONS

The replacement of fossil fuels and/or electricity by geothermal steam has lowered pasteurization, incubation and production costs.

The operation of the mushroom plant has resulted in new technology that uses geothermal steam in foodstuff production. It is a showcase for direct application of geothermal energy and as such, is being presented to schools, universities and government groups visiting the installations.

By working on the project, local people have been trained in a new and non-traditional activity.

The production of edible mushrooms has given the local population a new and healthy source of food which is available yearlong at an affordable price.

ACKNOWLEDGMENT

Thanks to Luis Quijano Leon of CFE, Morelia, Mexico for his assistance in preparing this article.