CHAPTER 14

PROGRESS IN CULTIVATION TECHNIQUES FOR *AGARICUS BISPORUS* IN CHINA

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1. INTRODUCTION

The growing of *Agaricus bisporus* in China dates back about sixty years. Mushrooms produced at that time were marketed fresh as one kind of luxurious vegetable in only a few large cities (Huan,1987). From the beginning of the 1970's, in order to meet the requirements of the canning industry, the growing of mushrooms increased rapidly. However, most of the growers still operated on a small scale as a part-time job or a subsidiary family occupation. For years, mushroom growers attempted to increase the productivity of the crops, but in fact they gained little. In 1978, the reasons for the low yields were extensively studied and analysed as follows:

1. The composting process was primitive, no Phase II procedure was used.
2. The spawn used had not been well selected or bred, and the origins of spawn were confused.
3. The growing houses were not well constructed. There were neither cooling systems nor heating systems installed. The temperature and moisture could not be well controlled.

Research into these areas has been carried out in the main mushroom-growing provinces. In particular, the Fujian Mushroom Research and Development Station was established in the Fujian Research Institute of Light Industry, and is engaged in the problems mentioned above.

2. RESEARCH ON A NEW TECHNIQUE OF COMPOSTING (1978-1985)

Before 1978, the composting of straw and manure was only done outdoors for a duration of about one month with 5-6 turnings at an interval of 5-8 days each. After outdoor composting, the compost was filled on shelves and spawned. The average unit yield was only 3.6Kg/m^2. Under the instruction of Prof. S.T.Chang, The Chinese University of Hong Kong, the technique of Phase II composting was first introduced. Prof. Chang pointed out that the unit yield of mushroom was decided by whether or not growers adopt the technique of Phase II composting. In March 1979, on-the-spot Academic Exchange Meeting of Phase II composting was convened at the Fujian Putian experimental ground. Some simple type peak-heating systems which attemped to suit the circumstances

in the countryside were developed (Wang & Shou,1981). But, since a great deal of fuel would be consumed during the peak-heating stage due to the poor heat insulation of the growing house and the low efficiency of the heating systems, the popularizing of the technique of Phase II composting was restricted. In 1985, a modified mode of Phase II composting with low energy consumption was suggested after testing by the Fujian Research Institute of Light Industry. The main points were as follows.

1. Phase I composting was shortened to about 10 days.
2. The compost after Phase I composting was stacked in half bulk on the shelves (Figure 1) to increase the thickness of the compost and to impel the accumulation of heat.
3. The process of peak-heating or pasteurizing was arranged between two stages of conditioning (Figure 2).

The technique was characterized by the following: 1) The energy given out from the microbial fermentation could be fully utilized and much fuel would be saved. The first stage of conditioning spontaneously raised the temperature of the compost. Generally, no extra heat was required and the temperature of peak-heating would easily be reached by introducing just a small amount of steam. 2) Two conditioning stages would promote the growth of beneficial microbial populations and improve the quality of compost. 3) The total technique would be easy to learn and control, and convenient to popularize (Ke,1991). The technique led to a general increase in the unit yield of up to 15-30% and the unit yield was 4-5Kg/m^2. Fuel consumption was reduced by about 50%.

3. BREEDING OF STRAINS WITH HIGH PRODUCTIVITY AND OF GOOD QUALITY FOR SPECIAL PURPOSE CANNING (1983-1992)

Strains of *A. bisporus* were first introduced into China during the 1930's. Although the quality

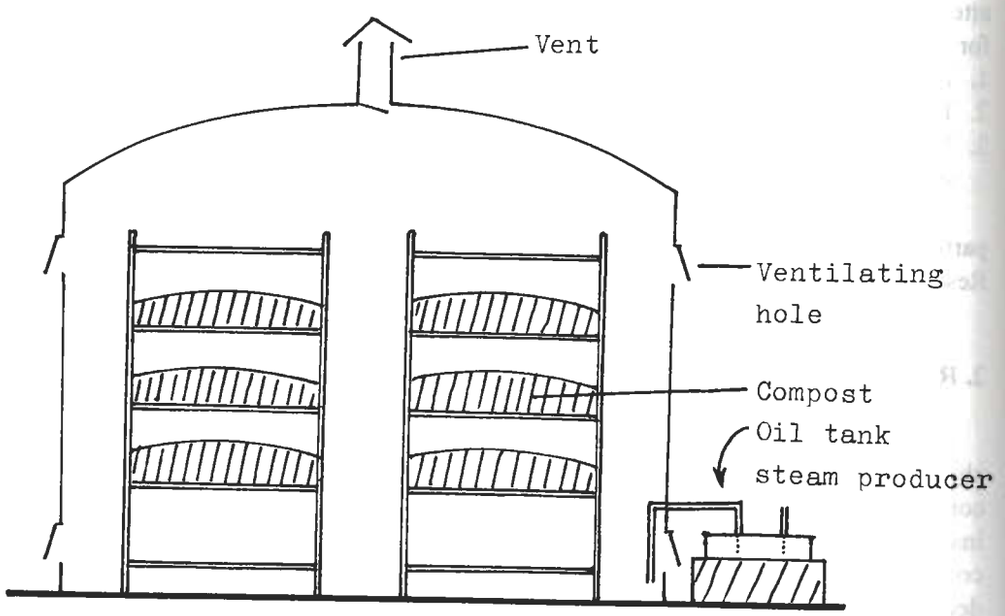

FIGURE 1. Sketch map of Phase II composting stacked in half bulk on the shelves.

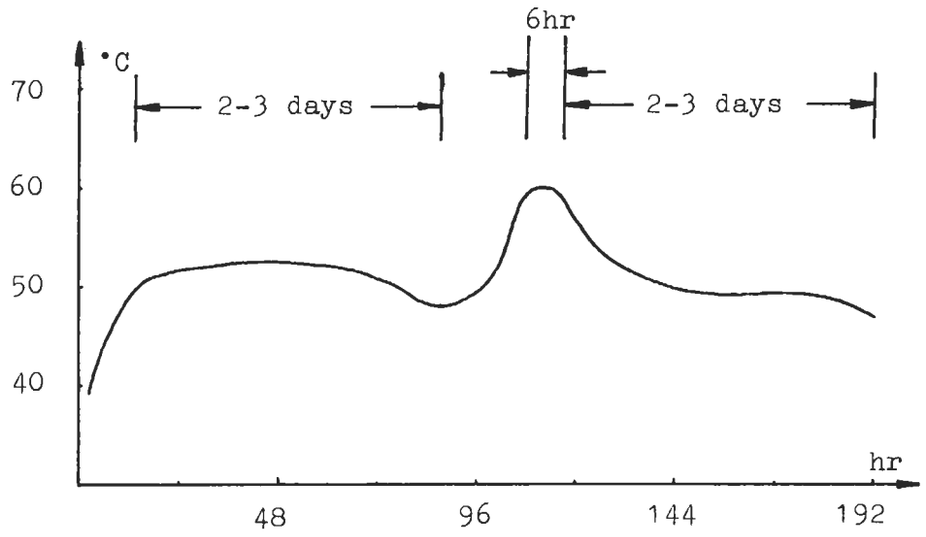

FIGURE 2. Diagrammatic variational curve of temperature in the compost and growing house during conditioning to culture first and pasteurizing afterwards. It shows the Modified Mode of Phase II composting.

of such strains was good, the unit yield was on the low side. From the end of the 1970's to the beginning of 1980's, some strains with better productivity were introduced, but the quality was unsatisfactory. In order to meet the need of the canning factories, new strains with high productivity and good quality suited for special purpose canning and also for Chinese cultivation conditions needed to be bred (Wang *et al.*, 1983, 1989a, 1992). The Fujian Research Institute of Light Industry, Research Institute of Edible Fungi of Shanghai Academy of Agricultural Sciences, Zhejiang Agricultural University and the Institute of Food and Fermentation Industry of the Ministry of Light Industry, embarked on the necessary research. The Fujian Research Institute of Light Industry started the research on crossbreeding in 1983, and a series of cross-breeding techniques with practical value had been established after 6 years, including selecting hybrid parents, separating and purifying the tips of mycelia, identifying hybrids and predicting new strain characteristics (Wang, 1991; Wang, *et al.*, 1989a,b, 1991a, 1992) (Figure 3). The main experimental work was concentrated on breeding new strains which combined certain good characteristics possessed by different types of parents, such as the combination of high productivity with good quality. Many types of hybrid strains, according to their isozyme patterns, were selected (Figures 4 and 5). For example, the esterase isozyme pattern of hybrid strain As1671 inclined to G type (Figure 6), and that of hybrid strain As2796 represented HG4 type (Figure 7). However, these hybrid strains have occupied 70-90% of the total spawn used in Fujian province and will soon completely replace old strains (Wang, 1992a). The characteristics of these strains may be generalized as follows: 1) Stronger resistance to natural climatic conditions; 2) High productivity combined with the good quality of the parent strains. As these hybrid strains have been adopted, the unit yield of mushrooms has increased by 20-50%, and the average unit yield in middle-sized testing grounds from 6-9Kg/m^2 to about 15Kg/m^2. They were well received by both growers and canning factories (Ke, 1991).

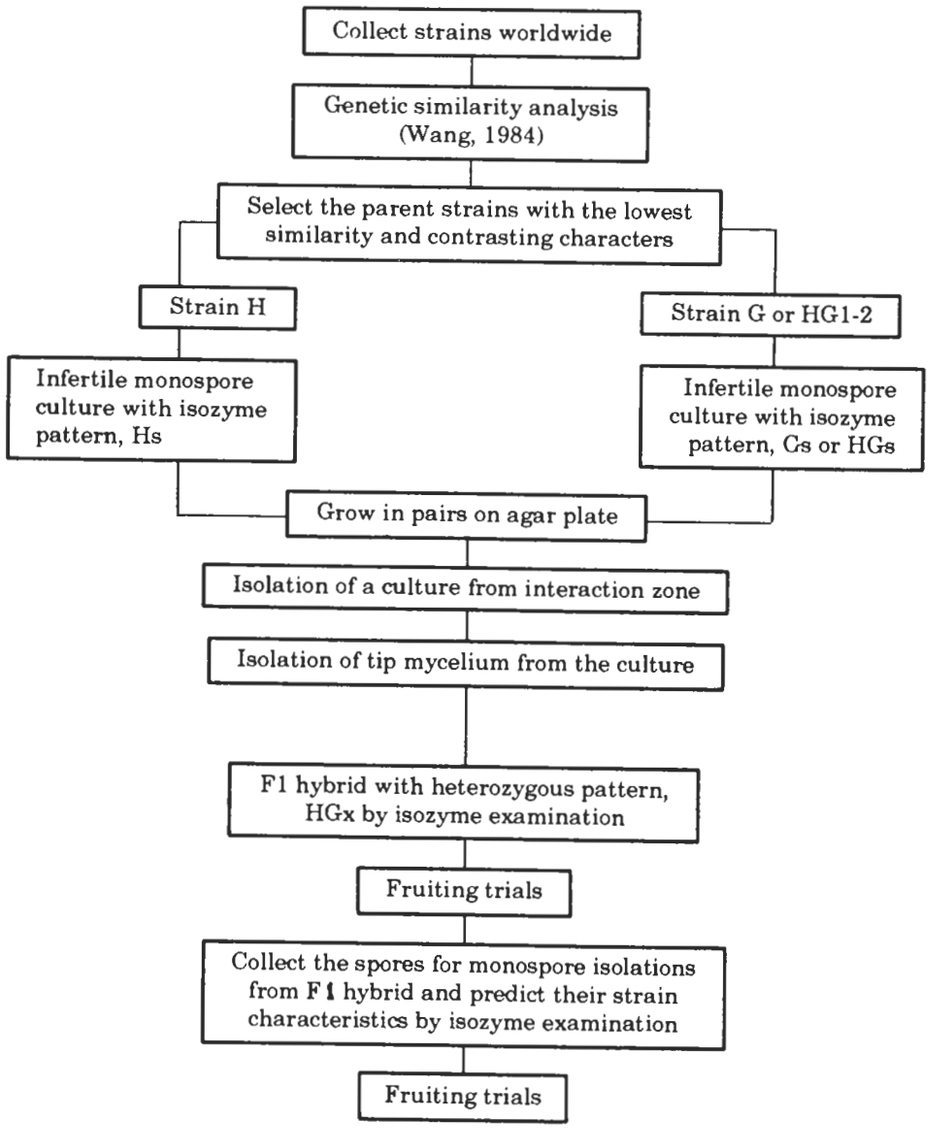

FIGURE 3. The crossbreeding program for hybrid formation in *Agaricus bisporus*.

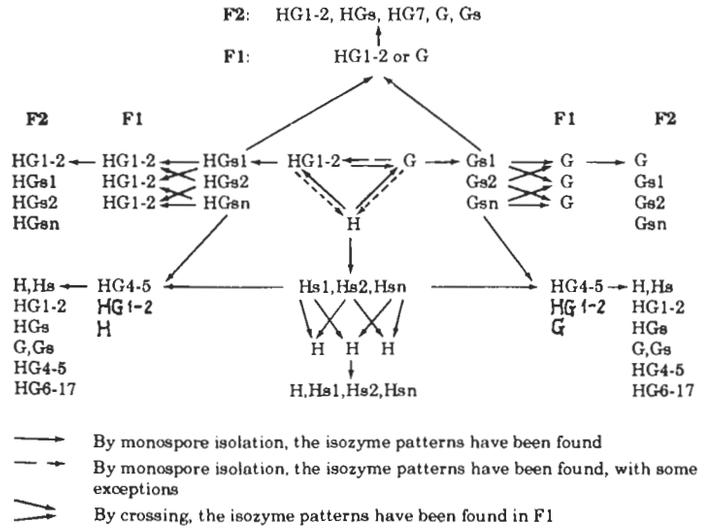

FIGURE 4. Analysis of genetic variations in traditional strains of *Agaricus bisporus* and their F1 and F2 hybrids by using esterase isozymes as biochemical markers.

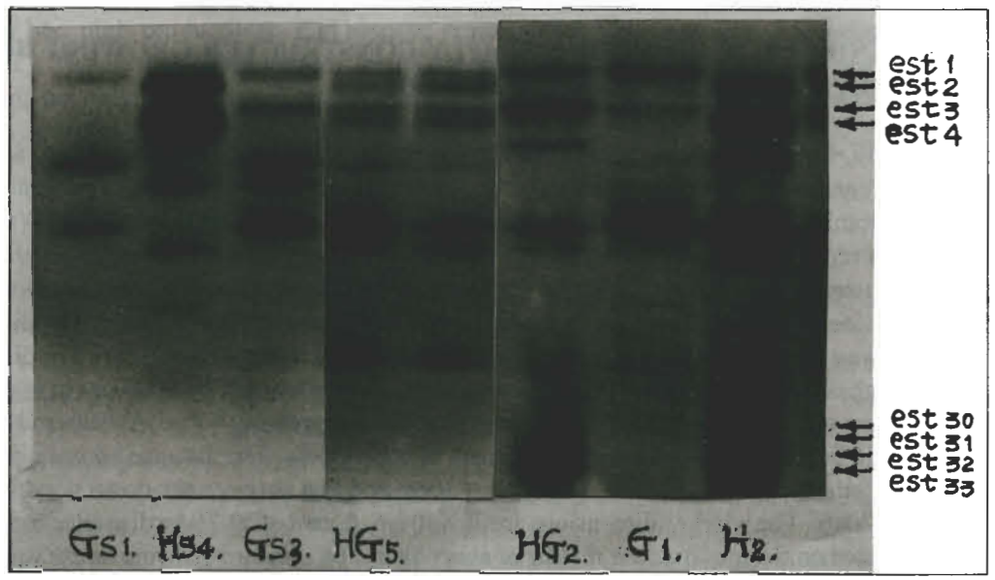

FIGURE 5. Esterase isozyme (EST) patterns of genetic variations in traditional strains, and their hybrid F1 and F2, of *A. bisporus*.

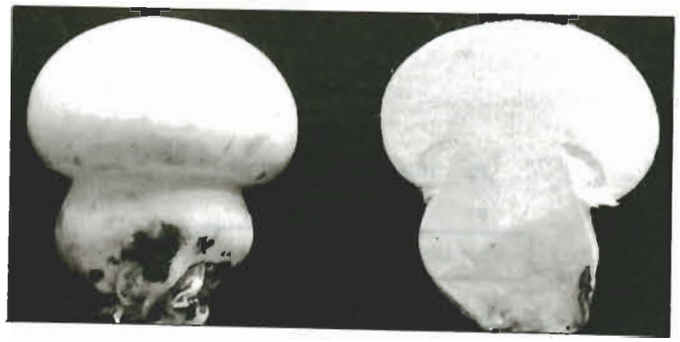

FIGURE 6. Hybrid strain As1671.

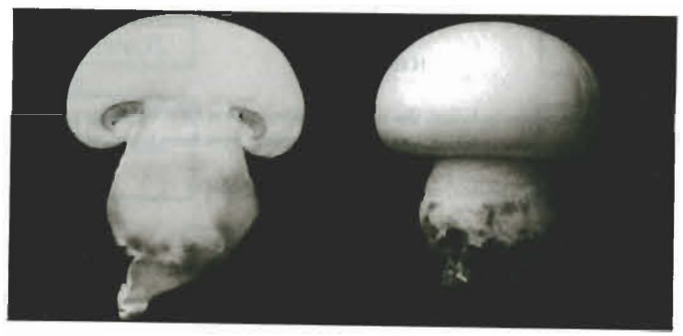

FIGURE 7. Hybrid strain As2796.

4. DESIGN AND APPLICATION OF A SIMPLY-CONSTRUCTED GROWING HOUSE USING POLYETHYLENE (P.E.) FILM (1988-1993)

Previously, Chinese growing houses were constructed mainly with clay and wood, and the environmental conditions could not be effectively controlled. In 1988, "The rules of cultivation of *A. bisporus*" submitted by the Fujian Research Institute of Light Industry were approved (Wang, *et al.*, 1990). This report advanced a kind of simple, economical, easy to build and manage, growing house to be constructed as follows: 1) Racks: the width of beds operated upon two sides would be 1.2-1.5M, one side, 0.8-1.0M. There are five beds in one rack arranged appropriately. The distance between the lowest bed and the floor should be 20cm, and each bed is about 60cm apart. The distance between the highest bed and ceiling should be at least 1m. The path would be 60-80cm in width. 2) Ventilation: there would be a buffer room at the entrance into the growing house. At each end of one path there would be a screen up window and a screen down window. The distance between the up-edge of the up window and eaves should be at least 30cm and that between the down window and the floor about 20cm. The window dimensions are 30X40 cm. A vent of 20-30cm diameter and 50cm in length is located on the roof over the middle of every path. The standard growing house was built using a bamboo framework in unused rice farming fields, tightly covered with polyethylene (P.E.) film and then with a rice straw curtain above. The area occupied by the growing house is about $50m^2$,

FIGURE 8. A specialized farm for standardized mushroom cultivation.

with a growing area of $130m^2$.

During the growing season, from the winter 1992 to the spring 1993, there were about 8000 growing houses of this kind popularized in Fujian (Wang, 1992b). Many growers managed to use about 100 growing houses. For example, Mr.Y.H. Fang owned 135 growing houses of this kind in Putian (Figure 8) and has produced a total of 160 tonnes fresh mushrooms, average unit yield about $9Kg/m^2$ and about 50% higher than that of a general growing house.

The energy saving modified Phase II composting technique, new hybrid strains with good quality and high productivity, and simple, practical P.E.film constructed growing houses have created a standard growing system for mushroom cultivation possessing Chinese features, and resulting not only in increases in yield of up to 50% (in some good cases, 150%), but also an obvious improvement in the quality of mushroom.

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