LENTINULA EDODES CULTIVATION TECHNIQUES AND MODELS IN CHINA

QI TAN*, XIAODONG SHANG, LUJUN ZHANG, YU LI, HAILONG YU, FENG ZHOU, MEIYAN ZHANG AND CHUNYAN SONG

(National Engineering Research Center of Edible Fungi, Ministry of Science and Technology (MOST), P. R. China; Key Laboratory of Edible Fungi Resources and Utilization (South), Ministry of Agriculture, P. R. China; Institute of Edible Fungi, Shanghai Academy of Agricultural Sciences, Shanghai, P. R. China
syj0@saas.sh.cn

ABSTRACT

Lentinula edodes (Xianggu) is a major cultivated mushroom in China, with the widest production area, highest total output and best economic returns. The mushroom was originally cultivated in China around 1100 AD using the 'hatchet-notching' method. Later, in the 1960s, the cultivation technique involved inoculating pure culture spawn into natural wood logs. During the following decade, the Institute of Edible Fungi, Shanghai Academy of Agricultural Science, developed the sawdust-based cultivation method whereby it became possible to cultivate the mushroom under natural environmental conditions using as mall-scale, family-oriented production model. After popularization of this technique, *L. edodes* cultivation areas expanded rapidly to all provinces in China southwards from the Yangtze River Basin. Since 1989, China has been the world's largest producer and exporter of *L. edodes*, and total output in 2012 reached 6.35 million tons. However, with China's fast economic growth in recent years, problems have arisen with the family-oriented *L.edodes* cultivation model. It is a heavily labour-intensive production process with a low level of mechanization, year-round production cannot be sustained due to the seasonal production cycle, product quality is often unstable, and there is a limited ability on the part of growers to resist fluctuations in market prices. Currently, an intensive cultivation model has been adopted in China's main *L. edodes* production areas which, compared with the traditional model, ensures the safety and security of the raw materials used for cultivation, and lends itself to increased mechanization. Standardized spawn production, inoculation procedures and management practices have helped to ensure higher yields, and integrated *L. edodes* product collection and distribution has served to reduce the risks associated with market price fluctuations. However, the intensive *L.edodes* cultivation model requires more careful supervision and stronger technical support, especiallyin the control of spawn quality. Furthermore, the intensive *L. edodes* cultivation model is still limited to seasonal production. Therefore, in order to ensure an all-year-round supply of fresh *L.edodes*, an industrialized cultivation model has emerged, and the development of a technological process with Chinese characteristics is in progress.

Key words: *Lentinula edodes* (Xianggu), cultivation techniques, cultivation models

Lentinula edodes has been a major contributor to the vigorous development of China's edible fungi industry, with the widest production area, highest total output and the most profitable economic returns. In 2012, the total output of *L. edodes* in China reached 6.35 million tons, accounting for approximately 80% of production worldwide. *L. edodes* is a traditional food in oriental countries, beloved especially by consumers in China, Japan and Korea.

Cultivation of *L. edodes* originated in China, dating back over 800 years, and its development can be divided into three important phases: 'hatchet-notching' cultivation, cut-log cultivation and artificial cultivation (Fig. 1). 'Hatchet-notching' cultivation is a semi-artificial method in which a hatchet was used to make cuts in felled broadleaf tree trunks and relied on wild *L. edodes* spores ('spawn') floating down with the wind to inoculate the cuts and ultimately lead to fruit body formation. A relatively primitive technique, *L. edodes* yields depended very much on the density and quality of the *L. edodes* spores in the natural environment and on the local climatic conditions.

Figure 1. 'Hatchet-notching' cultivation

When, during the last century, the Japanese scholar Hikosaburô Morimoto isolated a pure strain of *L. edodes*, production of this mushroom in China moved from the 'hatchet-notching' method to the artificially inoculated cut broadleaf-wood log cultivation technique. Introduction of this method into China necessitated adoption of a centralized manual management system in areas suited to *L. edodes* growth after pure *L. edodes* strains had been artificially inoculated into logs cut from fallen broadleaf trees. The cut-log procedure represented a technological revolution in *L. edodes* cultivation and unified both natural and artificial methodology. Not only did this technique shorten the length of the *L. edodes* cultivation cycle, it also led to substantially increased mushroom yields. A major drawback, however, was that it consumed huge amounts of forest resources and threatened ecological stabiliy. In 1978, a research team composed largely of scientific and technical personnel from the Shanghai Academy of Agricultural Sciences (SAAS) developed the sawdust brick system for cultivating *L. edodes* (Fig. 2). This system was focused on the use of an artificial substrate formulation based on sawdust waste, inoculated aseptically with a pure mushroom strain, and careful management of the growth facility. It reduced the demand for wood resources typified by the cut-log procedure, eliminated geographical restraints previously applicable to *L. edodes* cultivation, facilitated the expansion of *L. edodes* production from remote forest regions to more easily accessible lowland areas, greatly improved biological efficiency, and represented another significant technological revolution.

In 1983, inspired by the 'bag' cultivation of *Tremella fuciformis*, Zhaowang Peng and others from Gutian County, Fujian Province, modified the sawdust brick technique and developed the sawdust bag for cultivating *L. edodes* (Fig. 3). After popularization, this technique rapidly superceded the cut broad leaf-wood log cultivation technique and resulted in *L. edodes* cultivation expanding rapidly to all provinces in China southward from the Yangtze River Basin.

Figure 2. The sawdust brick system for cultivating *L. edodes*

As a consequence of this unceasing expansion, diverse cultivation models, and varieties suited to climatic conditions in different regions and to different cultivation traditions have

Figure 3. The artificial sawdust log for cultivating *L. edodes*

emerged. Principal *L. edodes* artificial cultivation systems operating in the major producing areas include the 'shelf', 'bag-on-the ground' and 'soil-covering' models.

However, due to China's fast economic growth in recent years, problems have arisen with the small-scale, family-oriented *L. edodes* cultivation model. It is a heavily labour-intensive production process with only a low level of mechanization, year-round production cannot be sustained due to the seasonal production cycle, product quality is often unstable, and there is a limited capacity on the part of growers to resist fluctuations in market prices. Currently, an intensive cultivation model based on specialization and division of labour has been adopted in China's main *L. edodes* production areas which, compared with the traditional model, ensures the safety and security of the raw materials used for

cultivation, and lends itself to increased mechanization. Standardized spawn production, inoculation procedures, spawn-running and other management practices have helped to ensure higher yields, and integrated *L. edodes* product collection and distribution has served to reduce the risks associated with market price fluctuations. However, the intensive *L. edodes* cultivation model requires more careful supervision and stronger technical support, especially in the control of spawn quality.

Nevertheless, the intensive *L. edodes* cultivation model is still limited to seasonal production. Therefore, in order to ensure an all-year-round supply of fresh *L. edodes*, an industrialized cultivation model has emerged, and the development of a technological process with Chinese characteristics is in progress. After three years of exploratory work, researchers at the SAAS have proposed an 'industrial-scale production technology for *L. edodes* based on secondary culture'. Using special *L. edodes* strains, this model has adopted the concept of 'spawn running in the bottle, fruiting by means of briquetting'. The two-stage procedure combines the automated conversion of the colonized cultivation substrate from the culture bottles into briquettes for subsequent brown film formation and fruiting. While existing *L. edodes* industrial-scale production models operating in Japan and Korea require special equipment and materials, this new Chinese model allows for more automation to be introduced in the production line at lower cost, thereby greatly reducing the probability of contamination inherent in ventilated bag cultivation, and will make it easier to achieve a fully mechanized system for large-scale *L. edodes* production.

In the light of current developments, family-oriented production models for *L. edodes* will eventually be eliminated, and fully automated industrial systems involving intensification and division of labour based on specialization will become the main *L. edodes* cultivation model in China in the future.

Figure 4. The two-stage procedure for cultivation of *L.edodes*

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