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Original Research

Using Discarded Mulberry Branches to Cultivate Edible Fungi Brings Green Economic Benefits

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Abstract

With the development of modern agriculture and green environmental protection concepts, recycling agricultural waste has become an important direction for sustainable development. However, effective means to achieve clean agricultural production, sustainable utilization of agricultural resources, and solve the difficulties in the development of modern agriculture are still insufficient. This paper explores the feasibility of using abandoned mulberry branches to cultivate edible fungi. The recycling project of mulberry branches is analyzed through the data provided by Yuexi County Siyuan Ecological Agriculture Co., Ltd. The economic benefit model of return on investment is simulated and analyzed, and the impact of carbon emission reduction and energy saving benefits on the environment is further calculated through formulas. Studies have shown that abandoned mulberry branches are rich in lignocellulose and are suitable as raw materials for edible fungi culture medium. The use of reasonable treatment methods can significantly improve the degradation rate of mulberry branch matrix, cultivate high-quality edible fungi, and bring green economic benefits. At the same time, this model can not only effectively reduce the environmental pollution caused by mulberry branch burning, but also reduce the production cost of edible fungi and increase added value. It has good waste management and resource recycling, and provides good economic, social, and environmental benefits.

Keywords: discarded mulberry branches, edible fungi, recycling, green economy, sustainable development

Introduction

Environmental resources refer to various resources that people can use in their reproduction and survival activities, including natural resources and social resources. Natural resources mainly refer to the general term for materials, energy, and environmental conditions that exist in nature and can serve human production, mainly including water resources, land resources, climate resources, and species resources [1].

In the process of modern agricultural production, seasonal pruning of mulberry branches is an important part of sericulture, which also causes environmental and resource problems. The mulberry leaf sericulture industry has developed in Asia, Europe, America, and Africa. Asia is the main production area, with representative countries such as China and India. China is the world's largest silk cocoon and silk industry, with an annual seed production of more than 17 million sheets [2]. Brazil is the largest commercial-scale silk

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cocoon producer in the West and the world's fifth-largest silk thread producer [3]. However, as these countries develop their industries, they are faced with the problem of dealing with a large number of discarded mulberry branches, which plagues the development of sericulture. At present, incineration and stacking are still the main treatment methods, but the former is prone to air pollution, and the latter may cause pests and diseases. Based on the concept of waste resource utilization, the use of discarded mulberry branches to cultivate edible fungi can not only effectively reduce environmental pollution, but also be converted into high-value-added agricultural resources, improve the yield and quality of edible fungi, and bring green comprehensive benefits. This paper systematically analyzes the feasibility and green economic benefits of discarded mulberry branches in edible fungus cultivation, and explores its application potential in waste management, resource recycling, and sustainable agriculture.

Materials and Methods

Mulberry Branch Substrate and Edible Fungus Growth

All materials in this experiment come from Laibang Town, Yuexi County, the largest town in Anhui Province in terms of the sericulture industry, including discarded mulberry branches from farmers' sericulture, and introduced edible fungi such as black fungus and shiitake mushrooms. We analyzed the mulberry branch matrix, and research using efficient, systematic, and practical sample preparation and separation protocols combined with various analytical systems has been applied to discover, separate, and identify analytes in natural plants, especially in traditional Chinese medicine, and to explore scientific principles that are conducive to the standardization and modernization of natural product research [4], as shown in Fig. 1. In the matrix analysis, the method of cultivating edible fungi with mulberry branches refers to the high-yield formula experiment of cultivating *Pleurotus geesteranus* with mulberry branch chips [5]. Mulberry branch edible fungi are cultivated in greenhouses with an annual average temperature of 17.1°C, an annual average air humidity of about 77%, and fertile and slightly acidic soil.

Cultivation Background and Site Selection

Laibang Town is the largest town in Anhui Province in terms of the sericulture industry. It currently has a mulberry garden area of 12,980 acres. Every year, a large number of discarded mulberry branches are not only wasteful but also pollute the environment. Improper treatment of agricultural waste can lead to soil pollution. Many farmers choose to burn or discard the straw at will after harvest, resulting in the loss of a large amount of organic matter and nutrients. At the same time, the smoke and harmful substances produced by burning

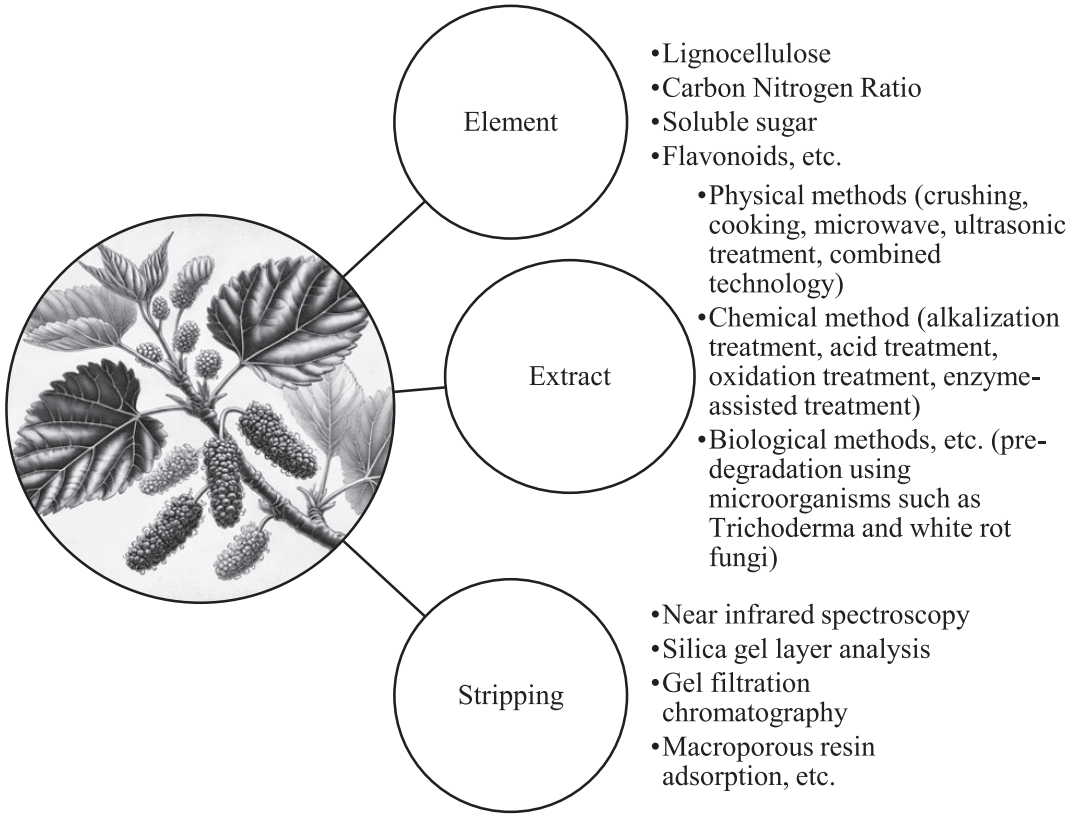

Fig. 1. Analysis of mulberry branch matrix.

Table 1. Data on natural climate conditions in Laibang Town, Yuexi.

Average altitude	Average annual temperature	Extreme temperatures	Effective accumulated temperature	Sunshine hours	Frost-free period	Average rainfall over the years	Average annual air humidity
600 m	14ºC	-13.2ºC-38.4ºC	460-5300ºC	1800-2500 hours	200-250 days	1445.5 mm	≈77%

Source: developed by the author based on (Technical information from Yuexi County Science and Technology Bureau, Agricultural Committee, and Laibang Agricultural Station).

also pollute the air [6]. Using mulberry branches as raw materials to turn waste into treasure can not only effectively utilize mulberry branches, but also effectively reduce the felling of trees for the cultivation of edible fungi such as black fungus and shiitake mushrooms, which is both economical and environmentally friendly. Laibang Town, Yuexi, is located in the hinterland of the mountains. There are few industrial and chemical enterprises, excellent ecology, and a beautiful environment. It belongs to the subtropical continental humid monsoon climate zone. The soil is fertile, slightly acidic, and the vegetation coverage rate is high. The natural conditions are excellent and suitable for the growth of a variety of fungi [7]. We have statistically analyzed the specific local natural climate conditions as shown in Table 1.

Results and Discussion

Benefit Analysis

The planned land area of the mulberry branch edible fungus bag processing plant is 10 acres; a new cultivation workshop of 2,700 m^2, special power transformation equipment of 300 kW, a 30-acre fungus cultivation greenhouse, a set of intelligent irrigation systems, 400 m of agricultural roads, and the introduction of 5 new varieties of edible fungi will be built. Yuexi County Siyuan Ecological Agriculture Co., Ltd. is responsible for conducting trials and demonstrations and providing comprehensive services to farmers implementing the project before, during, and after production. Make a preliminary design of the project, prepare an implementation plan, hire technical experts, and secure construction land and supporting funds. Two main unfavorable factors may be encountered during the implementation of the project: one is irresistible natural disasters; the other is the phenomenon of "high yield but low harvest" caused by market prices. We made an investment estimate, and the specific project data are shown in Table 2.

In the process of cultivating edible fungi with discarded mulberry branches, the quality of the mulberry branch substrate must be strictly controlled. It needs to be crushed and pre-treated (such as alkalization or steaming) to increase the degradation rate of lignin, eliminate potential pests and diseases [8], enhance its palatability and water absorption, and thus improve the growth efficiency of the fungus. There are also requirements for edible fungi species. Different types of edible fungi have different adaptability to the substrate. At present, fungus, ganoderma, shiitake mushrooms, straw mushrooms, etc., have been proven to be able to grow well using mulberry branch substrates. During daily cultivation and management, attention should be paid to temperature and humidity control, ventilation management, pest and disease control, etc., to ensure the efficient growth of edible fungi. After the implementation of the project, it is expected to produce 3 million bags of mulberry branch edible fungi bags annually, 300,000 kg of dry mulberry branch black fungus, and an annual output value of 12 million yuan. The project is expected to generate an annual income of 3 million yuan.

We can calculate the green economic benefits of a project based on its expected costs and benefits using the return on investment formula:

$$\mathrm{ROI} = \frac{(\mathrm{R} - \mathrm{C})}{\mathrm{I}} \times 100\%$$

Where R is the total annual income of the mulberry branch edible fungus project, C is the total annual cost of the mulberry branch edible fungus project, I is the total investment of the mulberry branch edible fungus project.

From the data Table 2 of this project, we can know that the total investment is about 6.71 million yuan, so the return on investment is calculated as follows:

$$\mathrm{ROI} = \frac{(\mathrm{R} - \mathrm{C})}{\mathrm{I}} \times 100\% \approx 44.7$$

The results show that the green economic benefits of the project are highly feasible, can recover costs in a relatively short period of time, and bring stable returns.

Using discarded mulberry branches from agricultural production to cultivate edible fungi reduces air pollution caused by mulberry branch burning. The World Health Organization (WHO) and IHME's Global Burden of Disease study estimate that air pollution causes 7 million and 6.7 million deaths each year, respectively [9]. At the same time, biodegradation reduces the burden of agricultural waste on the environment [10]. To further analyze the environmental benefits of

Table 2. Investment in plant equipment for mulberry edible fungi.

Name		Total price (yuan)
Sterilization equipment (a total of RMB 269,000)	Stainless steel normal pressure sterilizer	164000
	Sterilization turnover vehicle	64000
	Boiler	29000
Mixing and bagging equipment (122,000 yuan)	Horizontal cabin screening conveyor	8000
	Raw material mixer	25000
	Storage mixer	28000
	Four spiral circulation feeders	18000
	Fully automatic, electronically controlled bagging machine	28000
	Electronically controlled cradle machine	8000
	Water supply system	3000
	Bagging table	1000
	Production line power control system	3000
Transportation equipment (150,000 yuan)	Forklift	40000
	Forklift	80000
	Lift	30000
Ventilation equipment (15,000 yuan)	Ventilators, ventilation pipes, etc.	15000
Cooling equipment (340,000 yuan)	Cooling room and culture room	350000
Liquid inoculation line	Fermentation tanks, conveyor belts, inoculation guns, etc.	120000
Crusher (16,000 yuan)	Crusher	16000
Laboratory equipment (20,600 yuan)	Uv lamp	4000
	Clean bench	4000
	Air shower	2600
	Other small laboratory equipment	10000
Clean room	Pre-cooling and 400 square meters of 10,000-level purification equipment	50000
Mushroom rack	1200 Pieces of bacteria rack	600000
Turnover basket	40,000 Turnover baskets	280000
Site leveling	-	250000
Site hardening	-	210000
Steel structure workshop	-	536000
Bagging workshop	-	37500
Electric gates and walls	-	50000
Water and electricity installation	-	50000
Internal functional division of the factory	-	360000
Special power substation equipment	300 kw	250000
Fungus cultivation greenhouse	30 acres	956800
Smart glass greenhouse	1600 sqm	1320000
Smart irrigation system	1 set	290000
Agricultural roads	400m	68000
Introducing new varieties of fungus	5	300000
Other expenses (50,000)	Monitoring, offices and equipment, promotional panels, etc.	50000
Total		6710900

Source: developed by the author based on [Investment information of the mulberry edible fungus project of Yuexi County Siyuan Ecological Agriculture Co., Ltd.].

this project, the carbon reduction calculation formula can be used:

$$C = M \times E$$

Where C is the amount of carbon emissions reduced (tons of CO_2), M is the mass of mulberry branches that were replaced and incinerated (tons), E is the amount of CO_2 released by incinerating 1 ton of mulberry branches (assuming about 1.5 tons of CO_2/ton of mulberry branches).

Assuming that the project can replace the incineration of 600,000 tons of mulberry branches each year, the carbon emission reduction is calculated as follows:

$$C = 600000 \times 1.5 = 900000\ tCO_2$$

At the same time, the use of mulberry branches for cultivation can reduce and replace the use of sawdust substrates used in the traditional cultivation of edible fungi, thereby saving energy consumption. The energy-saving benefits can be calculated by the following formula:

$$E_s = (E_t - E_r) \times Q$$

Where E_s is the amount of energy saved (MJ), E_t is the energy consumed in the production of traditional substrates (MJ/ton), E_r is the energy consumed in the production of mulberry branch substrates (MJ/ton), Q is the total amount of mulberry branch substrates used (tons).

Assuming that the energy consumption of traditional substrate production is 2000 MJ/ton, the energy consumption of mulberry branch substrate production is 1200 MJ/ton, and the project uses 600,000 tons of mulberry branch substrate per year, the energy saving benefits are calculated as follows:

$$E_s = (2000 - 1200) \times 600000 = 480\ million$$

The results show that, given that 1 kWh is equal to 3.6 megajoules (MJ), the project can save about 480 million MJ of energy per year, equivalent to reducing electricity consumption by about 133 million kWh.

Conclusions

Cultivating edible fungi using discarded mulberry branches is an important practice of the agricultural circular economy. It not only realizes the resource utilization of waste, but also promotes the development of the edible fungi industry. Studies have shown that this model can reduce CO_2 emissions, save energy consumption of electricity, and further reduce the energy demand of agricultural production. In addition, this model increases the economic added value of discarded mulberry branches, reduces environmental pollution, promotes the benign cycle of the ecosystem, effectively helps achieve the national "carbon neutrality" goal, and supports the healthy and green development of agricultural and forestry ecosystems [11]. A large amount of residues and products need to be effectively managed to obtain economic and environmental benefits. Waste collection, transportation, and recycling or value-added channels to biofuels, fertilizers, biochar, industrial chemicals, and other products are crucial to maintaining a circular and sustainable bioeconomy [12]. The project does not emit pollutants during production, and the products are green food. The by-products of the waste mushroom sticks can be used as feed and organic fertilizer. They are taken from nature and returned to nature, with significant ecological benefits. By developing mulberry branch edible fungi, effectively implementing waste management and utilization, and reducing the use of fertilizers and pesticides, the environmental situation will be further improved and will also bring obvious economic benefits. In the future, the optimization and promotion of relevant technologies should be strengthened, and policy support should be encouraged to promote the widespread application of this model, thereby promoting the management and utilization of agricultural waste and promoting the sustainable development of the green circular economy.

Conflict of Interest

The authors declare no conflict of interest.

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