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The Most Suitable Growing Environment for Flammulina Mushrooms

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Abstract: Flammulina velutipes is the edible mushroom with the longest history of artificial cultivation in China, and has a wide market. This paper will explore the most suitable growing environment of flammulina velutipes from the aspects of temperature, nutrition, light and so on, so as to provide theoretical background for the growth of flammulina velutipes yield.

Keywords: Flammulina Velutipes; Growing Environment.

1. Flammulina Market

Flammulina velutipes is one of the edible mushrooms with the longest history of artificial cultivation in China.[1] As a widely loved vegetable, flammulina mushrooms are not only an important source of nutrients, but also have great potential [2] in drug development. Flammulina velutipes is rich in protein, vitamins, dietary fiber, minerals, polysaccharide, mucopolysaccharide, stericin, flammulina velutipes, etc. It has high nutritional value, and has anti-tumor, anti-fatigue, antibacterial, anti-inflammatory and antiviral effects. It is deeply loved [3] by people. In 2018, the output of flammulina velutipes in China reached 2.5756 million tons, and has become the fifth largest edible mushroom variety in China. This paper will analyze the influence of different environmental factors, explore the most suitable growth environment of flammulina velutipes from many aspects, and provide theoretical background for the growth of flammulina velutipes output.

2. Growth Process of Flammulina Mushroom

The factory production of flammulina velutifolia has a cultivation cycle of about 55d, which is mainly divided into nine stages: cultivation material configuration → bottling → sterilization → cultivation seed inoculation → mycelium culture → tickle and bud promotion → inhibition culture → growth → harvesting and packaging.

2.1. Environmental Factors Affecting the Growth of Flammulina Velutipes

2.1.1. Influence of Temperature

Flammulina belongs to low-temperature fruiting fungi. Its spores form and germinate mycelia in large numbers at 15 ~ 25℃. Mycelia can generally grow in the range of 3 ~ 34℃, and the optimal growth temperature is 20 ~ 23℃. It was provedby experiments that the mycelia of flammulina have a strong low temperature tolerance and can still survive after 138 days at -21℃. However, flammulina is not resistant to high temperature, although the mycelia can sprout but not eat food at 32℃, the mycelia will stop growing above 34℃. Therefore, in the natural conditions of mycelia culture must pay attention to the indoor temperature.[1] Artificial cultivation should be combined with the local natural temperature, generally from 10 to December or the next year from 2 to March can be cultivated.[4]

2.1.2. Influence of Humidity

Flammulina belongs to the hygrophilic fungi, and the mycelia can grow normally in the medium with 60% ~ 80% water content. The moisture content of the culture medium is 70%, and the mycelium grows the fastest. Too much or too little water in the culture material will affect the growth of mycelia. When the water contentis too high, mycelia will grow slowly or even not long. Even if the fruiting bodygrows, the base of the stalk is easy to change color. If the moisture content of the culture material is less than 60%, the mycelium will be thin, poorly developed and gray in color. The relative humidity of the air also has certain requirements, mycelium growth stage should be controlled at 60% ~ 70%, humidity is too large, the pollution rate increases, the fruity body development stage should be controlled at 80% ~ 90%.[5]

2.1.3. Influence of Light

Flammulina is a photophobe fungus, mycelium can grow under dark conditions, but the fruit body differentiation stage must be stimulated by light, and studieshave shown that light can strongly inhibit the size of the cap of the white flammulina, which can effectively improve the commercial value[6] of the white flammulina. Generally, when the stalk length is 0.5cm ~ 1.0cm, it is necessary toincrease light. In the golden mushroom fruiting body above the appropriate block of sunlight, with a small amount of astigmatism, gap light can be weak light irradiation, can stimulate the stalk of the golden mushroom long, and maintain the appearance of color, improve the quality [7] of mushrooms.

2.1.4. Influence of pH

The growth of flammulina requires slightly acidic environmental conditions, so the pH will be adjusted to about 6 when the culture material is prepared, and it will become slightly acidic through natural fermentation in the later stage. Although mycelium can grow in the pH range of 3.0 ~ 8.4, the optimal pH is 4.0 ~ 7.0. Too much acid or alkali in the medium is not conducive to the growth of mycelia, and even leads to slow development of fruiting bodies in the later stage, especially when pH is too small, mycelia will stop growing and cannot germinate. It is better [7] to grow in the pH 5.0 ~ 6.0 environment at the growth stage of fruiting body.

3. Effect of Different Treatment Temperature on the Quality of Flammulina Velutifolia

3.1. Influence of Drying Temperature

3.1.1. Flammulina Mushroom Root Introduction

The root of flammulina velutipes is a by-product produced after harvesting the edible part of flammulina velutipes, accounting for about 10% to 15% of the totalbody mass of flammulina velutipes. The cellulose content of flammulina root is high, but it is often discarded because of poor taste and difficult to chew. China alone produces more than 200,000 tons of flammulina root waste every year, and the output of flammulina root waste in developed regions such as Europe, America, Japan and South Korea is even higher.[8] Due to the lack of effective processing technology, flammulina mushroom root is usually used as fertilizer, fuel or directly discarded, which not only causes a waste of resources, but also pollens the environment. It is reported that the flammulina mushroom root is rich in protein, polysaccharide, flavor nucleotides, vitamins and minerals, so the flammulina mushroom root can be used for polysaccharide, protein and other activesubstances extraction, or as a food ingredient added to pastry, soup, can also beused as feed, bedding applied to animal husbandry industry. However, due to the large water content of flammulina mushroom root, it is not suitable for preservation and transportation, and it needs to be dried into powder[9] before processing and utilization.

3.1.2. Effects of Different Drying Temperatures on the Nutrient Composition and Taste Characteristics of Dried Flammulina Root

The roots of flammulina velutipes were dried by electric blast drying oven, moisture tester and AL204 electronic sky level instrument. Using HS-SPME-GC-MS, E-nose and other methods to analyze and measure the mushroom root, the results are obtained.

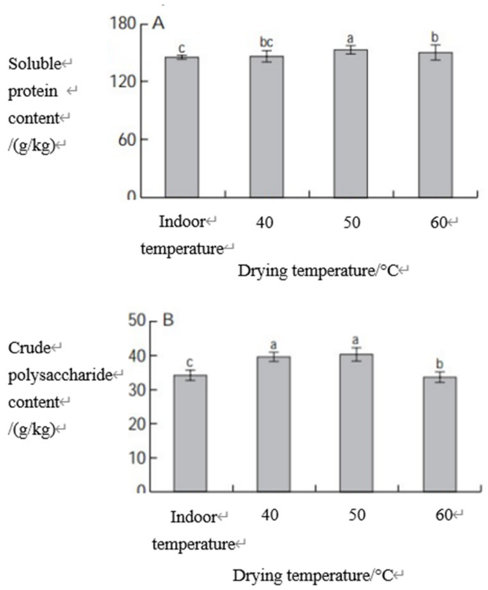

Fig 1. Contents of soluble protein(A) and crude polysaccharides(B) in dried F. velutipes roots prepared at different drying temperatures

As shown in FIG. 1A, the soluble protein content in the mushroom root sample first increased and then decreased with the increase of drying temperature. The soluble protein content in flammulina root after drying at room temperature and 40, 50 and 60 ℃ was 145.12, 146.55, 153.78 g/kg and 150.00 g/kg,[10] respectively. The effect of drying temperature on crude polysaccharide content in flammulina root samples was shown in FIG. 1B. The crude polysaccharide content in flammulina root after drying at room temperature was 34.10 g/kg. The crude polysaccharide content in the roots of flammulina velutipes dried at 50 ℃ was the highest, which was 40.21 g/kg, and there was no significant difference between the roots of flammulina velutipes dried at 40 ℃ and 50 ℃ ($P > 0.05$). The crude polysaccharide content in the roots of flammulina velutipes dried at 60 ℃ was the lowest (33.63 g/kg), which was significantly lower than that at 50 ℃ ($P < 0.05$).[11]

Equivalent umami concentration (EUC) is often used to evaluate the umami equivalent [12] produced by the synergistic effect of amino acids and 5 '-nucleotides in edible fungi. The higher the EUC, the better the umami quality. The total amino acid content of Flaminovelum root increased first and then decreased with the increase of drying temperature. The total amino acid content of room temperature drying was the lowest (93.01 g/kg), and that of 50℃ treatment was the highest (99.93 g/kg). The soluble protein content /(g/kg) crude polysaccharide content /(g/kg) free amino acid content /(g/kg) at room temperature and the total 5 '-nucleotide content in the roots of Flammulina acutum dried at 40, 50 and 60℃ were 3.32, 3.43, 3.64 g/kg and 3.29 g/kg, respectively. The total content of 5 '-nucleotides in the roots of Flammulina velutipes dried at 50℃ was significantly higher than that in the other temperature treatment groups ($P < 0.05$). The highest EUC (697.43 g/100 g md) and the best umami quality were found in flammulina roots dried at 50℃. This was followed by 60℃ (627.12 g/100 g md) and 40℃ (610.10 g/100 g md) treatment of flammulina root, and room temperature drying of flammulina root had the lowest EUC (529.63 g/100 g md).[11]

3.2. Influence of Storage Temperature

Flammulina velutifolia was stored at 4 ℃, 25 ℃ and 40 ℃ respectively, and its water content, rehydration ratio, polysaccharide content, appearance and microstructure were detected regularly. UV-3802 proportional double beam UV-VIS spectrophotometer, ME204E electronic balance, HH-S6 electric constant temperature water bath and other instruments and equipment were used to determine the polysaccharide content of flammulina velvetoi by phenol-sulfuric acid method and water content by water meter. The test data were processed by Microsoft Excel 2016 and analyzed by Sigmaplot 12.5 software to obtain the results.

Under different storage temperatures, the water content of Flammulina velutifolia increased first and then decreased. After 2 months of storage (60d), the rehydration ratio of flammulina velutifolia remained stable at 4℃, while the rehydration ratio of 25 ℃ and 40 ℃ groups decreased significantly. The polysaccharide content of flammulina velutifolia decreased first and then gradually increased, and the higher the storage temperature was, the more obvious the polysaccharide content decreased, and the polysaccharide content tended to be stable from 2 to 6 months after storage. Storage temperature has a great influence on the sensory and microscopic structure of flammulina vellum. The higher the storage temperature, the easier the sensory quality of flammulina vellum is to deteriorate, rot and deteriorate, lose its commercial value, its surface folds are serious, and the lamellar structure increases under microscopic observation. 4℃

is the more appropriate storage temperature[13] for flammulina vellum.

4. Different Crop Cultivation Materials

At present, the golden mushroom cultivation raw materials are mainly wood chips, and cottonseed shell, bagasse, sorghum shell, wine trough and other crops,but with the rapid development of edible fungi industry, various raw materials will inevitably appear or have appeared shortage, which has a certain impact on the production of edible fungi. The cultivation of edible fungi with crop straw and oil crop by-products can broaden the utilization channel of raw materials, improve the utilization rate of raw materials, and increase the added value of products, which is of great[14] significance.

4.1. Effects of Different Carbon Source Raw Materials on Nutrient Composition of the Fruiting Body of Flammulina Velutipes

According to the effects of adding different kinds of raw materials on the growth and development of flammulina velutifolia, the optimal formula of each rawmaterial (bean stalk 25%, peanut seedling 20%, cotton wood 20%) was selected to determine the nutritional composition of the fruit body. The protein content of flammulina velutifolia treated by 20% peanut seedling and 20% cotton wood was higher. The fat content of 25% soybean stalk and 20% peanut seedling treatment group was higher.

The fruit bodies of each treatment contained 16 kinds of amino acids, among which glutamic acid content was the highest, followed by aspartic acid, and histidine content was the lowest. The total amino acids of 25% soybean straw, 20% peanut seedling and 20% cottonwood were all higher.

4.2. Effects of Different Nitrogen Sources on Nutrients of the Fruiting Bodies of Flammulina Velutipes

The protein content of 13% castor meal, 8% cottonseed meal and 10% rapeseed meal in the fruit body was significantly higher than that of other treatments; Thecontents oftotal sugar and ashwere lower or nosignificant than those of control. The fat content of fruit body treated with 13% castor seed meal and 10% rapeseed meal was significantly higher than that of control, and the fat content of fruit body treated with 8% cottonseed meal was significantly lower than that of control.

The content of 8 essential amino acids in the fruit bodies of 13% castor seedmeal, 8% cottonseed meal and 10% rapeseed meal was higher than that of the control, respectively 29.05%, 11.67% and 29.29%; The proportion of essential amino acids in total aminoacids was highest with 10% rapeseed meal treatment, followed by 13% castor meal treatment. [14]

5. Effects of Different Light Conditions on the Growth of Flammulina Velutipes

Light is an important environmental factor in the growth and development of edible fungi, which not only plays an important role in the stage from vegetative growth to reproductive growth of edible fungi mycelium, but also has an obvious effect[15] on the growth of fruiting bodies. LED light source is a new type of semiconductor light source, because of its high luminous efficiency, low heat, long life and other advantages, it has been widely used in[6] agricultural lighting system, so it is necessary to explore the LED light source on the factory production of white flammulina mushroom. With white flammulina velutifolia as the material, orthogonal test was used to explore the influence of light quality, light time and light intensity of LED light source on the output and quality of white flammulina velutifolia in factory production. The results showed that the best combination of LED light source in the process of fruiting body differentiation was white light, light intensity was 290 lx for 6 h, the yield of flammulina was 399 g/ bottle, and the rate of A-grade mushroom was as high as (93 ± 1) %; The best combination of LED light source in the process of fruition body growth was blue light, light intensity was 439 lx, the yield of flammulina was 400 g/ bottle, andthe yield of grade A was (95 ± 1) %. [16]

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