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Effect of Rape Straw on the Growth of *Flammulina velutipes*

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Abstract. In order to develop the new raw materials for cultivation of *Flammulina velutipes* and the resource utilization of rape straw, the mycelial growth, fruiting body growth and economic benefits of *F. velutipes* was studied in eight kinds of medium formulas (A, B, C, D, E, F, G, H) designed to cultivate *F. velutipes* with rape straw as the main material. Results shown that the hyphae of *F. velutipes* in treatment E, F and D were the strongest, and in treatment H was weak. Compared with CK, the mycelial growth rate of the eight formula media was significantly increased, and treatment E was the fastest. The average yield of treatment F was the highest, followed by treatment E. According to various indicators, the formula suitable for the growth of *F. velutipes* was F formula (68% rape straw, 20% cottonseed hull, 10% bran, 1% sucrose and 1% superphosphate). Cultivation of *F. velutipes* with rape straw can shorten the cultivation period of hyphae and the bud period and fruiting time of fruiting bodies, and increased economic and environmental benefits.

INTRODUCTION

China is the world's largest rapeseed producer. Rape straw is the main by-product of rapeseed production with 1.5 ratio of grass to valley (the ratio of rape straw yield to rapeseed yield) [1]. According to the statistics of the Food and Agriculture Organization of the United Nations (FAO), the total output of rapeseed in China in 2013 was 14.4 million tons [2], and the converted rape straw was about 21.6 million tons. Rape straw is rich in organic matter such as cellulose, hemicellulose, lignin and protein [3]. Rape straw is an important biological resource, but the lignin in the straw is poor in water solubility, and the structure is dense and stable, and hard to be degraded [4]. In order not to affect the growth of the crops, the rape straw is mainly burned, the utilization rate is low and the environment is polluted [5].

The use of microorganisms degrading lignin (generally white rot fungi) to decompose lignocellulosic biomass for further utilization is a better method for utilizing agricultural product production or processing by-products [6]. *Flammulina velutipes* is not only a fungus with high nutrition, good quality, high edible and medicinal value [7], but also a white rot fungus with a variety of lignin cellulose degrading enzymes, which can destroy the cell wall structure of straw, degrade the lignin in straw, fully expose cellulose and hemicellulose, and improve the nutrition value utilization rate of straw [8].

At present, the reported straw raw material for the cultivation of *F. velutipes* in cottonseed hulls is rape straw [9-10], wheat straw [11], Corn stalk [12], Soybean straw [13], and so on. Whether a medium is suitable for the cultivation of an edible fungus is usually examined by its effect on the growth of edible fungi hyphae and fruiting bodies [14]. Replacing cottonseed hulls with rape straw can promote the growth of hyphae. The growth rate of hyphae after rape straw replacing cottonseed hull is higher than that of hyphae after wheat straw replacement [15].

It is of great significance to use rape straw instead of cottonseed hull to cultivate edible fungi to reduce the production cost of edible fungi, expand the utilization of rape straw, and reduce the waste of resources and environmental pollution caused by straw burning. Therefore, this paper studied the cultivation of *F. velutipes* by different substitution ratios of rape straw, and investigated its effects on the growth of Flammulina velutipes hyphae and the yield of fruiting bodies, and discussed the feasibility of using rape straw to cultivate edible fungi.

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MATERIALS AND METHODS

Strains

The test strain of *F. velutipes* was provided by the Microbiology Laboratory of Leshan Teachers College.

Rape Straw

Used fresh, dry, clean, mold-free rape straw. Cut the rape stalk into 1 cm pieces, soaked it in 0.5% lime water for 10 h, and rinsed with water to pH value 7, wring it out until it was not dripping, sprinkled it, mixed it with bran, phosphate fertilizer and sucrose. The water content of the culture material was controlled at about 65%.

Test Method

The test method used in this experiment was based on a randomized block design with 8 treatments A, B, C, D, E, F, and H and 1 control (CK) (Table 1), 3 replicates, and bottle culture.

TABLE 1. Formulas of seven medium (percentage)

Treatment	Rape straw	Cottonseed husk	Bran	Sucrose	Superphosphate
A	18	70	10	1	1
B	28	60	10	1	1
C	38	50	10	1	1
D	48	40	10	1	1
E	58	30	10	1	1
F	68	20	10	1	1
G	78	10	10	1	1
H	88	0	10	1	1
CK	0	88	10	1	1

The mycelial growth length was measured at 10 days, 15 days and 20 days after inoculation. The mycelial growth rate was calculated, and the mycelial growth, hyphal traits, full bottle time, mushrooming time, and yield of each fresh mushroom were recorded, and the biological efficiency, ratio of production value to bottle cost was calculated.

RESULTS

The Effect of Different Substitution Ratio of Rape Straw on Mycelial Growth of *Flammulina velutipes*

The effect of different substitution ratio of rape straw on mycelial growth of *F. velutipes* had significant differences (Table 2 and Table 3). From the perspective of mycelial growth, the hyphae of D, E, and F formulas were the strongest, A, B, C, G, and CK were stronger, and H was weaker. The mycelial growth speed of formula A, B, C, D, E, F, G, and H was faster than CK, and the difference was significant with CK. The formula E was the fastest, and the bottle was full in 20 days. The mycelial growth speed of formula A, B, C, D, E, F, G, and H were better than that of CK because formula A, B, C, D, E, F, G, and H, all contained rape straw, which can significantly improved the physical and chemical properties of the medium to conducive to mycelial growth. There was no significant difference in hyphal properties, hyphae of all formulas were very dense and tidy.

TABLE 2. The effect of different substitution ratio of rape straw on mycelial growth of *Flammulina velutipes*

Treatment	Mycelium growth potential	Mycelial traits	Full bottle time (d)
A	+++	Dense, tidy, white	24
B	+++	Dense, tidy, white	24
C	+++	Dense, tidy, white	23
D	++++	Dense, tidy, white	21
E	++++	Dense, tidy, white	20
F	++++	Dense, tidy, white	21
G	+++	Dense, tidy, white	22
H	++	Dense, tidy, white	23
CK	+++	Dense, tidy, white	25

TABLE 3. The effect of different substitution ratio of rape straw on mycelial growth rate of *Flammulina velutipes* (mm/d)

Treatment	0-10 d	0-15 d	0-20 d
A	3.57gE	4.43fF	4.77eE
B	3.77fD	4.53fF	4.90eE
C	3.87fD	4.75eE	5.19dD
D	4.62bB	5.87bB	6.08bB
E	4.87aA	6.47aA	6.31aA
F	4.51cB	5.71cC	6.07bB
G	4.23dC	5.38dD	5.74cC
H	4.09eC	5.41dD	5.71cC
Control	2.87hF	3.95gG	4.32fF

There were significant differences in the effects of different substitution ratios on the growth rate of *F. velutipes* hyphae. There was also a significant difference in the growth rate of *F. velutipes* hyphae at different times after inoculation (Fig. 1). Hyphae of *F. velutipes* growed fastest in treatment E, followed by in treatment D and F at 10 days, 15 days and 20 days after inoculation.

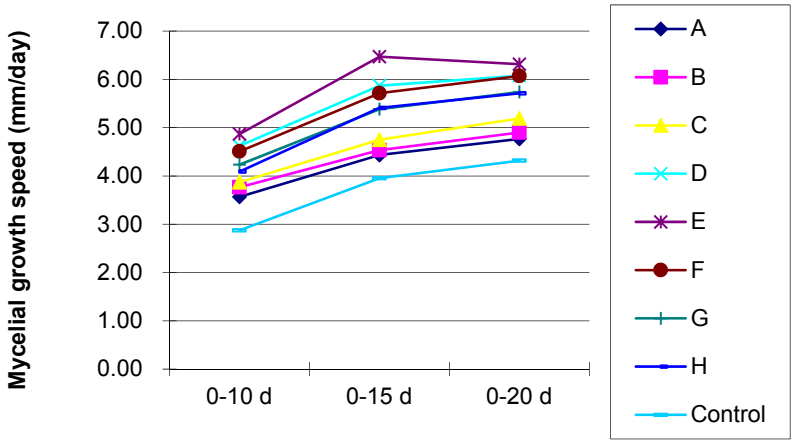

FIGURE 1. Mycelial growth rate of *Flammulina velutipes* in different substitution ratio of rape straw

Effects of Different Substitution Ratios of Rape Straw on the Development of Fruit Body of *Flammulina velutipes*

The different substitution ratios of rape straw had significant effects on the growth and development of *F. velutipes* fruit bodies (Table 4). As can be seen from Table 4, formula A had the shortest bud period, but the longest mushrooming time was 46 days, which was the same as CK; The mushroom time is the shortest, but the bud period is longer; the formula B, C, D, E FG bud period is generally 16 to 17 days, and the mushrooming time is 36 to 40 days.

TABLE 4. Effects of different substitution ratios of rapeseed straw on the development of fruit body of *Flammulina velutipes*

Treatment	Reminders bud stage(day)	Fruiting time(day)	Fruiting body texture	Average yield (g/bottle)	Biological efficiency (percent)
A	13	46	hard	81.7fF	71.5eD
B	14	45	hard	85.7eE	73.5dC
C	15	44	hard	94.6cC	75.5bB
D	16	40	hard	99.4bB	79.5aA
E	17	43	hard	100.9aA	79.6aA
F	17	39	hard	98.9bB	80.3aA
G	17	36	hard	79.0gG	63.5fE
H	19	35	hard	50.9hH	39.3gF
CK	16	44	hard	93.4dD	74.5cBC

Effects of Different Substitution Ratios of Rapeseed Straw on the Ratio of Out to Put

The different substitution ratios of rape straw had significant effects on total cost per bottle, ratio of out to put, and fresh mushroom yield per bottle (Table 5). As can be seen from table 5, there had a higher ratio of production value to investment cost in both treatment F and treatment E.

TABLE 5. Effects of different substitution ratios of rapeseed straw on the ratio of out to put

Treatment	Total cost (yuan/bottle)	Ratio of out to put	Fresh mushroom yield (kg/bottle)
A	0.36	7	0.41
B	0.35	7	0.42
C	0.34	8	0.47
D	0.3	10	0.49
E	0.26	20	0.87
F	0.18	31	0.92
G	0.14	17	0.4
H	0.13	12	0.25
CK	0.36	8	0.5

DISCUSSIONS AND CONCLUSION

Because of the good aeration of rapeseed straw, the cultivation of *F. velutipes* with rape straw can significantly improved the physical and chemical properties of the culture medium, which was conducive to the growth of mycelium, and shortened the culture period of the hyphae and the bud period and fruiting time of the fruit body to some extent. The mushroom was marketed 7 to 9 days ahead of schedule, thus increasing economic benefits.

Results had shown that treatment F was most suitable for the growth of *F. velutipes*. The composition of the treatment F was 68% rape straw, 20% cottonseed husk, 10% bran, 1% sucrose and 1% superphosphate. The results

had shown that it was feasible to produce *F. velutipes* with rape straw, which not only reduces the production cost of edible fungi, but also expands the range of edible fungi cultivation materials.

According to the composition of treatment F, about 1.2 kg of *F. velutipes* can be produced for every 1 kg of rape straw. When the yield of rape straw was 6 000 kg.hm^{-2}, it could produce 7 200 kg.hm^{-2} of *F. velutipes*, which can increase the income of farmers by 7 200 kg.hm^{-2}. In addition, the use of rape straw to cultivate *F. velutipes* solved the problem of environmental pollution caused by rape straw burning, and reduces the amount of chemical fertilizer used in existing crops, which helps to improve the agricultural ecological environment. This technology was of great significance for adjusting the agricultural industrial structure, improving the overall efficiency of agriculture, improving people's lives and promoting local economic development, increasing local fiscal revenue, and promoting reemployment projects.

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