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Browning technology for shiitake in sawdust using LED source

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ABSTRACT: The incorporation of Shiitake culture into sawdust is a widely utilized technique that can assist in reducing the cost and time consumption associated with oak cultivation. In sawdust cultivation, browning of the surface mycelia is an important stage with respect to the utility and longevity of the sawdust media. Surface browning forms a protective coating on the substrate, which can inhibit the invasion of pathogens and suppress water evaporation. Several different light sources (red LED, white LED, blue LED, and fluorescent light) were used and the intensity of illumination was carefully controlled (1.5, 10.5, 20.5 μmol/m^{2}s for LEDs and 10, 100, 300 lux for the fluorescent light) to induce browning. The light sources were regulated via a 1 h on/off cycle in a controlled room environment at a temperature of 20°C, 60% humidity, and 1200 ppm CO_2 concentration for 60days.The browning effect varied depending on the source and the intensity of illumination. This effect was most effectively induced at 1.5 μmol/m^{2}s for the red and blue LEDs. All light sources induced less browning at the highest intensity of illumination. This indicates that intensity values higher than 20.5 μmol/m^{2}s in the case of the LEDs and 300 lux for the fluorescent light are not effective. After harvesting of the fruit bodies, we measured the weight, length, and width of the pileus and stipe in addition to their chromaticity and hardness. Treatment with 1.5 μmol/m^{2}s blue LED produced the best harvest with the highest average chromaticity, weight (21.2 g), stipe length (30.8 mm), and hardness (377.9 g), with a fine length and width of the pileus.

KEYWORDS: Browning, LED, Sawdust, Shiitake

Shiitake mushroom is a white rot fungus belonging to the basidiomycetes which are mainly saprotroph on broad-leaved trees, and it is produced and consumed mainly in East Asia including Korea, Japan and China. In addition, Shiitake have been used for edible and medicinal purposes since they have distinctive flavors and aromas, and since their production and consumption are increasing every year in Korea, they can be said to be very high value for economic value (Hong, 1980; Park and Lee, 1997; Sanchez, 2004). Shiitake has nutrients as protein, fat, carbohydrate, vitamin, and mineral (Jong and Birmingham, 1993). Shiitake have been harvested for at least 1800 years, growing naturally on a wide variety of hardwood species including Fagaceae and is mainly cultivated using oak wood (Bruhn *et al.*, 2009). In the case of logs growing, it takes a long time and high cost to harvest the first mushroom because it takes a long time to grow mycelia. On the other hand, sawdust cultivation has almost the advantage of being able to utilize 100% of the wood resources compared with the logs cultivation, the cultivation period is much shorter, the recovery rate is high, and it requires less cost and labor. Also, it can mechanize cultivation process (Koo *et al.*, 2013). Sawdust can produce relatively large quantities of fruit body because it directly controls the moisture and nutrient content (Kim *et al.*, 2016). In the case of Korea, the study on sawdust cultivation has been started since the 1980s. Recently, the mushroom farm production using sawdust cultivation has been increasing (Choi and Jung, 2008). When the mycelium grows completely in the Shiitake cultivation using sawdust, it becomes white, and when the mushroom is produced in this state, the yield of the mushroom is reduced due to contamination of various bacteria. Therefore, it is

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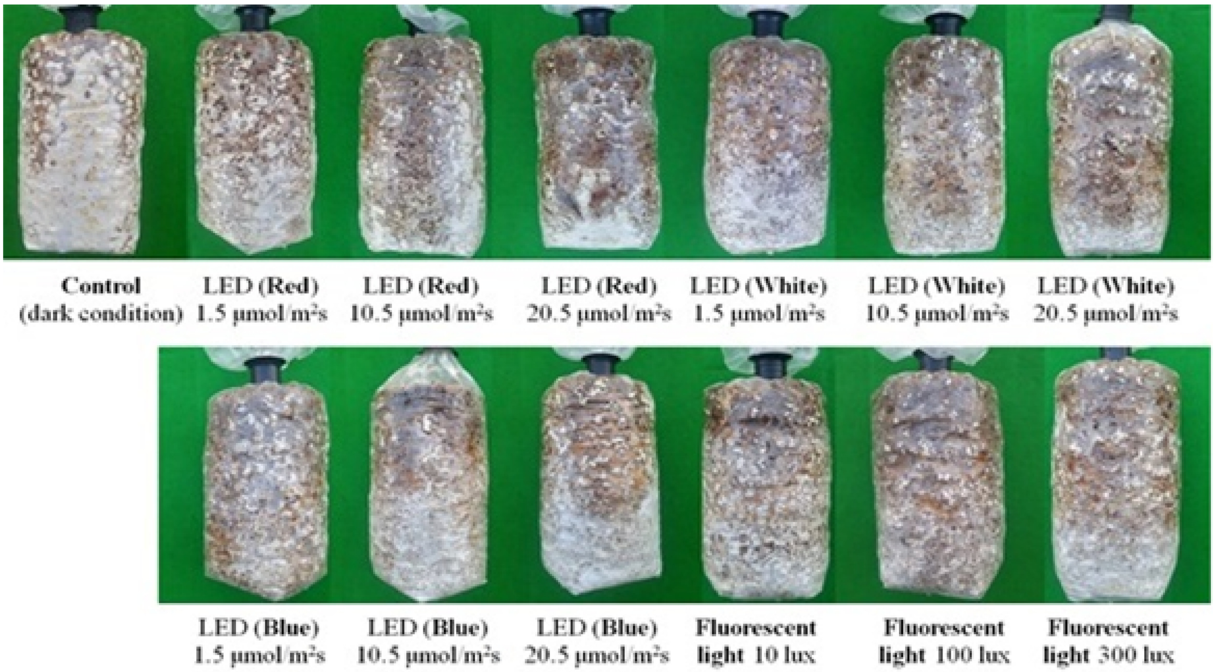

Fig. 1. Lateral photo of light treated Shiitake culture in sawdust

important to carry out a browning operation to artificially form a coating on the surface of the medium, which can serve as the epidermis of the tree, such as logs. The change of browning of the medium prevents the contamination of various bacteria by blocking the contact with the outside air and suppresses the evaporation of water in the medium, thereby helping to generate mushrooms. Therefore, the change in the browning of the sawdust medium is a very important step for the elevation productivity and substantiality. In this study, we tried to find the light that can harvest the upper surface of the upper product while having excellent browning effect by using various light and intensity.

Browning Effects of Medium by Source and Intensity of Light

We could see the color difference clearly between control (dark) condition and light treated conditions (Fig. 1). In control condition, only partial browning was formed on the top of the medium. Full browning could be seen in light treated conditions, but there are some variations of browning on the bottom of the medium, depending on the light source and intensity. And then, we observed that color-difference meter was used to measure L, a, b value. L-value is a lightness index (white is calibrated to be 100), a and b value represent chromaticness. Browning was most effective in 1.5 μmol/m^{2}s for red and blue LED. All light sources showed less browning in highest intensity of illumination, which indicates that higher than 20.5 μmol/m^{2}s for LEDs or 300 lux for fluorescent light are not effective (Table 1).

Table 1. Effect of difference light source and intensity

Light source	Illumina-tion	L	a	b
LED (Red)	1.5	32.9^{d}(11.4)	6.34^{a}(1.08)	10.38^{a}(1.98)
	10.5	35,53^{cd}(6.4)	5,87^{abc}(0.81)	10.23^{a}(1.66)
	20.5	40,89^{cd}(9.51)	5,2^{c}(0.92)	10.79^{a}(1.51)
LED (White)	1.5	37,28^{cd}(9.02)	5,57^{abc}(0.88)	10.9^{a}(1.4)
	10.5	34,92^{cd}(6)	6,39^{a}(0.92)	10.96^{a}(1.87)
	20.5	38,81^{cd}(12.03)	5,34^{c}(1.09)	10.73^{a}(1.82)
LED (Blue)	1.5	32,48^{d}(7.9)	6,3^{ab}(0.88)	10.21^{a}(1.43)
	10.5	38,81^{cd}(10.39)	5,37^{bc}(1.05)	10.63^{a}(1.49)
	20.5	42,24^{c}(13.92)	5,71^{abc}(1.8)	11.58^{a}(1.42)
Fluorescent light	10	41,3^{cd}(8.23)	5,35^{c}(0.85)	11.33^{a}(1.82)
	100	36,17^{cd}(9.09)	6,16^{abc}(1.02)	11.03^{a}(1.36)
	300	56,04^{d}(10.1)	4,11^{d}(0.99)	11.6^{a}(2.51)
Control (dark condition)		80,25^{a}(5.13)	0,82^{c}(0.57)	10.76^{a}(2.21)

Table 2. Measured characteristics of harvested fruit bodies

Light source	Illumination	Weight (g)	Pileus		Stipe		Hardness (Peak stress, g)
			Diameter (mm)	Thickness (mm)	Length (mm)	Thickness (mm)	
LED (Red)	1.5	14.1	54.6	15.4	28.4	10.5	353.1
	10.5	13.9	52.0	14.8	27.8	10.3	346.5
	20.5	16.1	52.9	16.8	28.3	12.3	330.3
LED (White)	1.5	12.7	50.3	14.4	30.3	9.8	254.1
	10.5	14.1	52.8	14.6	27.2	11.2	341.7
	20.5	13.9	51.8	15.9	23.3	12.0	338.8
LED (Blue)	1.5	21.2	52.5	15.6	30.8	11.7	377.9
	10.5	14.8	52.2	16.4	25.7	10.0	283.9
	20.5	16.0	53.6	17.3	24.5	13.8	347.8
Fluorescent light	10	13.4	52.2	13.9	26.1	10.8	298.6
	100	15.2	52.3	14.6	27.9	11.4	311.4
	300	14.5	48.8	13.6	25.0	11.6	290.5
Control(dark)		13.9	52.8	17.3	29.0	12.1	347.0

The Difference in Growth by Source and Intensity of Light

We examined the difference in growth between different light sources and intensity by measuring weight, width, pileus thickness, length, stipe thickness and hardness (Table 2). As a result, the weight, length, and hardness of the 1.5 μmol/m^{2}s for blue were the best growth, and the width and the thickness were not significantly different from the control.

As a result of all the experiments, it was concluded that the suitable wavelength for the cultivation of Shiitake (Sanjo 701) was blue light, and it is considered that the applicable study for Shiitake mushroom production site should be continued through more suitable light quantity and energy efficiency analysis.

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