Effects of Electrical Shock and Blue LED Treatments on the Growth, Yield and Quality of Grey Oyster Mushrooms (*Pleurotus sajor-caju*)

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Abstract. Grey oyster mushrooms (*Pleurotus sajor-caju*) is an edible mushroom cultivated in Malaysia mainly due to its high nutritional and medicinal value. The demand of *Pleurotus sajor-caju* in local and foreign market rises continuously. In this study, the effect of electrical shock treatment and exposure to blue color LED on the growth, yield and quality of *Pleurotus sajor-caju* was investigated. There were 6 sets of electrical shock and blue LED treatments applied during spawning and production phase. Mushroom bags which did not receive any treatment were served as Control. The effect of electrical shock and blue LED treatments were observed in the aspects of mycelium growth rate, number of days taken for mycelium to fill-up the bag, pinhead emergence and fruiting body formation. There were significant enhancement in the yield for grey oyster mushroom for the bag treated with Electric and Blue LED, in the total fresh weight of fruiting bodies, number of fruiting bodies, percentages of biological efficiency and substrate utilized for every 100 g mushrooms produced. Therefore, the mushroom bags which were treated with electrical shock and blue LED is the best compared to the other treatments due to significant higher rate of mycelium growth, relatively higher yield and good quality of mushroom.

1. Introduction

Grey oyster mushrooms is the most popular in Malaysia since it can be cultivated within various ranges of temperatures and different substrates like agricultural wastes and natural resources which rich in lignocellulosic materials [1]. It contains high contents of carbohydrates, fibres, vitamins B1, B2, A and C [2]. Over the last 30 years, the trading of mushroom showed significant rise especially for the dried and fresh mushrooms and this trend causes the mushroom industry in Malaysia grows steadily [3].

However, the shortage of supply of mushroom is one of the problems faced by Malaysia where the production of local mushroom is only sufficient to supply for local markets [4]. For agriculture sector in Malaysia, the application of electrical shock treatment and blue colour LED is still considered a new invention and most of the mushroom cultivator lack of new production technology in mushroom cultivation. Besides, they also lack of relevant knowledge and skills on the ways to improve the cultivation and production of mushrooms [5].
Lack of research in controlling period of mushroom production and yield had led to inconsistencies of mushroom supplies. A study revealed that light intensity and wavelength can influence hyphae aggregation, sporulation and the formation of fruiting body and primordial of oyster mushroom [6].

2. Materials and methods
The cultivation of grey oyster mushroom began with the preparation of substrate bag with a mixture of calcium carbonate, rice bran and sawdust of 1: 10: 100. 100 ml of water was added into the dry substrate. Each polypropylene bag contained 500 g of substrate (dry weight basis) and sterilization was performed in autoclave for 30 minutes at 121˚C. The sterilized bags was cooled down in laminar flow overnight before inoculation. The inoculation process took place by through transfer of 10 to 15 g of mushroom spawns into mushroom bags.

All mushroom bags were labelled according to types of treatment and were arranged on the racks in mushroom cultivation chambers with suitable conditions for spawn-running process. Electrical shock treatment was applied on mushroom in spawning and production stages with the aid of electrical voltage adapter of 12 V and wire or cable with clips for 10 s. Blue LED light was used to emit blue light and the mushroom bags was exposed to light source in production phase only. Both treatments of blue LED light and electrical shock were combined to compare the effect of both treatments on the growth and yield of mushrooms to either one of the treatment as shown in Table 1.

Table 1. Sets of Physical Treatments in Both Spawning Phase and Production Phase in Grey Oyster Mushroom

| Spawning Phase of Grey Oyster Mushroom | Production Phase of Grey Oyster Mushroom |
|---------------------------------------|----------------------------------------|
| No Treatment (Control)                | No Treatment (Control)                  |
| Electrical Shock Treatment            | No Treatment                            |
| Electrical Shock Treatment            | Electrical Shock Treatment              |
| No Treatment                          | Blue LED Treatment                      |
| Electrical Shock Treatment            | Blue LED Treatment                      |
| Electrical Shock Treatment + Blue LED | Electrical Shock Treatment + Blue LED   |

The mycelium consumed 30 to 45 days to fill up the mushroom bags. The temperature of mushroom cultivation chamber was maintained at 28˚C to 30˚C with relative humidity level was set at 75 to 85 %. During this process, approximate 10 % light was required [7]. The mushroom bags were transferred to mushroom house once the bags were fully filled with mycelium. The caps of mushroom bags were opened and they were placed horizontally on the racks in mushroom house for pinhead emergence and fruiting body formation. Harvesting process was performed by pulling the matured fruiting bodies from the substrate bags and the bags were closed back with caps and left for 7 days for subsequent fruiting cycle.

For growth performance, the number of days used by mycelium to fill up the bags, pinhead emergence and formation of fruiting body was recorded starting from date of inoculation. For yield analyses, the total fresh weight of fruiting bodies harvested were weighed using a digital balance and the number of fruiting bodies were counted and recorded. The percentage of biological efficiency from yield of mushrooms per weight of substrate were calculated after 5 times of harvesting for each bag where 500 g of substrate were used as standard weight. The substrate utilization efficiency was determined by weighing and recording the weight of substrate bag for 5 harvesting cycles.

For analyses of physic-chemical properties, the smallest and largest fruiting bodies were chosen for measurement of pileus diameter. The colour properties from 3 different points on the surface of pileus were measured for the values of L’, a’ and b’ with a chromameter. The firmness of fruiting bodies is measured by using texture analyser TA.XT plus (Stable Macro Systems) with the addition of P/2 stainless steel probe. Moisture content for pileus and stem of mushroom was determined by weighing.
3. Results and discussion

3.1. Growth Performance

The mycelium growth rate subjected to compare between different sets of electrical and blue LED treatment as shown in Figure 1. The mushroom bags were standardized to 24.6 cm. From Figure 1, mushroom bags which received Electric and Blue LED treatment had significantly (P<0.05) shown the fastest time for mycelium to reach 24.6 cm which was on day 30th while control took the longest period (40 days) to reach 24.6 cm. Table 2 shows the growth performance of grey oyster mushroom.

For the number of days taken for mycelium to fill-up the bag, mycelium from the bags treated with Electric and Blue LED had significantly (P<0.05) took the shortest time (30 days) to fill-up the bags. However, there were no significant difference (P>0.05) among all sets of treatments for days taken for pinhead emergence and fruiting body formation. The time recorded for pinhead emergence was in the range of 1 to 4.2 days while time recorded for fruiting body formation was in the range of 1.8 to 5.2 days.

Previous study stated that electrical stimulation played an important role in the growth and development of fungi where the presence of electric field influenced the direction of hyphal extension, sites of germ tube formation and branching and also the frequency of branching and germination. Previous study also found out that there was interaction between electrical shock treatment and mycelium during mycorrhiza formation [8].

![Figure 1](image_url)

**Figure 1.** The mycelium growth rate of *Pleurotus sajor-caju* subjected to different sets of electric and blue LED treatment.

| Treatment               | Length of Mycelium Growth (cm) |
|-------------------------|---------------------------------|
| Control-GOM             |                                 |
| ElectricNoLED           |                                 |
| NoElectricLED           |                                 |
| ElectricElectric        |                                 |
| ElectricLED             |                                 |

**Table 2.** The Number of Days for Mycelium to Fill-up Mushroom Bag of Pleurotus sajor-caju, Days of Pinhead Emergence and Days of Fruiting Body Formation Subjected to Different Sets of...
Table 3. The Number of Days for Mycelium to Fill-up Mushroom Bag of Pleurotus sajor-caju, Days of Pinhead Emergence and Days of Fruiting Body Formation Subjected to Different Sets of Electrical and Blue LED Treatments.
### Table 4. The Substrate Utilization Efficiency for Every 100 g Mushrooms Produced by Different Sets of Electrical and Blue LED Treatments.

| Set of Treatments          | Substrate Utilization Efficiency (%) |
|----------------------------|--------------------------------------|
| Control                    | 146.52±1.430                        |
| Electric No LED            | 204.34±9.491                        |
| Electric Electric          | 218.61±6.364                        |
| No Electric LED            | 254.09±9.790                        |
| Electric LED               | 260.22±11.578                       |
| Electric (Electric+LED)    | 179.43±2.797                        |

Note: Values are means of 5 replicates. Means (n=5) ± standard deviation. 

| Set of Treatments          | Smallest Pileus Diameter (cm) | Largest Pileus Diameter (cm) |
|----------------------------|-------------------------------|-------------------------------|
| Control                    | 2.860±0.092                  | 7.520±0.201                  |
| Electric No LED            | 5.340±0.400                  | 10.220±0.228                 |
| Electric Electric          | 4.160±0.142                  | 10.480±0.245                 |
| No Electric LED            | 5.720±0.493                  | 11.160±0.323                 |
| Electric LED               | 5.280±0.503                  | 10.320±0.175                 |
| Electric (Electric+LED)    | 4.320±0.266                  | 12.600±0.420                 |

Note: Values are means of 5 replicates. Means (n=5) ± standard deviation. 

### 3.3 Physical Analyses.

From Table 5, there were no significant difference (P>0.05) observed for the category of smallest pileus diameter among all the treatments and this is due to the same species of oyster mushroom used [9]. However, mushroom bags that experienced electrical and light stimulation had significantly displayed significantly higher pileus diameter compared to control in the category of largest pileus diameter.

### Table 5. The Pileus Diameter (cm) of Pleurotus sajor-caju by Different Sets of Electrical and Blue LED Treatments.

### 3.4 Texture.
Texture (firmness) is the force required to penetrate or break the flesh of the mushroom [9]. From table 6, there were significant differences (P<0.05) observed among all the treatments. Bags treated with electric light and electric (Electric+LED) had shown significantly higher value of firmness compared to other bags and whereas control recorded the lowest value of firmness. Previous study stated that LED treatment had produced significantly more firm pileus compared to control. Therefore, mushroom that shown higher firmness value is considered as high quality mushroom as its fruiting body did not break easily during packaging and thus improving the quality and shelf life of oyster mushroom [11].

3.5 Colour
The colour characteristics of harvested mushrooms were analysed in terms of L* value, a* value and b* value. Colour L* values represent the lightness of the colour ranged from 0 (black) to 100 (white). The values of colour a* ranged from -60 (green) to +60 (red) while the values of colour b* ranged from -60 (blue) to +60 (yellow) [7]. From table 6, there were significant difference (P<0.05) observed among all the treatments for the values of colour L*, colour a* and colour b*. For the values of colour L*, bags treated with no electric LED displayed significantly higher value of 73.094 compared to other treatments. However, bags treated with electric and No LED and electric electric significantly showed the higher values of colour a* and colour b* (5.206 and 72.32 respectively) compared to other treatments.

Table 6. The Values of Color L*, a* and b* and Firmness of Pleurotus sajor-caju Subjected to Different Sets of Electrical and Blue LED Treatments.

| Set of Treatments | Color L* value | Color a* value | Color b* value | Firmness (gf) |
|-------------------|----------------|----------------|----------------|---------------|
| Control           | 70.209±0.350ab| 4.594±0.042b  | 14.938±0.054b | 51.83±1.015c |
| Electric No LED   | 62.626±0.495c | 5.206±0.047c  | 14.481±0.053c | 59.04±1.105b |
| Electric Electric | 70.836±0.462ab| 4.161±0.054c  | 15.574±0.040a | 72.32±0.475a |
| No Electric LED   | 73.094±0.200c | 3.512±0.069d  | 14.719±0.051bc| 55.22±0.888bc|
| Electric LED      | 68.946±0.519b | 3.703±0.046d  | 14.022±0.043d | 56.70±0.838bc|
| (Electric+LED)    | 69.997±0.400ab| 3.907±0.039cd | 14.597±0.042bc| 66.75±0.457a |

Note: Values are means of 5 replicates. Means (n=5) ± standard deviation.

a-d : Values bearing the different superscript within the same column are significantly different at 5% level (P<0.05)

3.6 Moisture Content
Normally mushrooms consist 90% of water and 10% of dry matter [9]. From Table 7, the moisture content of pileus were higher than that of stem for all types of bags. The moisture content of stem and pileus that undergo electrical and blue LED stimulation had significantly shown higher mushroom content compared to control. Previous study stated that the high light-emitting efficiency of LED produced less emission of heat rays which contribute to better retention in the moisture content of mushroom fruiting bodies. The moisture content is influenced by several factors like cultivation environment, postharvest environment, mushroom strain, mushroom age, nature of substrate applied in water holding capacity [11].

Table 7. The Pileus and Stem Moisture Content of Pleurotus sajor-caju Subjected to Different Sets of Electrical and Blue LED Treatments.

| Set of Treatments | Pileus Moisture Content (%) | Stem Moisture Content (%) |
|-------------------|-----------------------------|---------------------------|
| Control           | 84.940±0.412b               | 68.287±1.415b             |
| Electric No LED   | 90.260±0.206a               | 81.630±0.075a             |
| Electric Electric | 90.743±0.339a               | 84.680±0.433a             |
No Electric LED | 90.677±0.086<sup>a</sup> | 82.007±1.317<sup>a</sup>
Electric LED | 90.640±0.185<sup>a</sup> | 80.463±0.349<sup>a</sup>
Electric (Electric+LED) | 91.317±0.128<sup>a</sup> | 78.540±0.855<sup>a</sup>

Note: Values are means of 5 replicates. Means (n=5) ± standard deviation.

- : Values bearing the different superscript within the same column are significantly different at 5% level (P<0.05)

4. Conclusion
From the study, mushroom bags which treated with electrical shock and blue LED showed positive effect on the growth performance of grey oyster mushroom in terms of mycelium growth rate, days of mycelium filled-up the bag, days of pinhead emergence and days of fruiting body formation. In terms of total fresh weight of fruiting bodies, number of fruiting bodies, percentages of biological efficiency and substrate utilized for every 100 g mushrooms produced, bags treated with electric and blue LED, Electric Electric, Electric (Electric+LED) and No Electric LED gave better yield and substrate utilization than control. In terms of the physico-chemical properties of the mushroom, mushroom bags that were treated with electrical and blue LED, Electric Electric, Electric No LED and Electric No LED displayed higher quality compared to control in the aspect of pileus size, moisture content of pileus and stem and firmness. However, the quality of mushroom that received treatment differed significantly in terms of color analysis. Therefore, the treatment of Electrical and Blue LED is recommended because it resulted in the highest mycelium growth rate compared to other treatments, higher yield compared to control and Electric and No LED and better quality of mushroom produced.

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