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ENHANCING MUSHROOM PRODUCTION USING PHYSICAL TREATMENTS PRIOR TO FRUITING BODY FORMATION

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ABSTRACT

There is an increasing world demand for mushrooms as their culinary uses and nutritional benefits become more widely known. The grey oyster mushroom (*Pleurotus sajor-caju*) is an edible mushroom commercially cultivated in Malaysia. In this study, the effects of high sound intensity, bright light, low temperature (5°C) and electrical shock on the growth, yield and physico-chemical properties of the mushroom was investigated. The results showed that mushroom cultures treated with bright light, high sound intensity and cold temperature produced spawn more rapidly, requiring a shorter time for the mycelium to fill up the substrate bag as compared with the control. An electric shock was observed to be the most effective treatment that promoted the earliest emergence of pinheads and formation of fruiting bodies. Besides, mushroom treated with electrical shock treatment showed higher yield which was twice more compared to control. For the color of the mushroom, cold treatment showed the lightest color with the highest yellow intensity (b* value) compared to other treatments, whilst mushroom without any physical treatment had the highest red intensity (a* value). Different physical treatments applied did not show any significant effect on texture, moisture, ash, protein and crude fiber contents. In conclusion, among all the physical treatments, electrical shock was the best treatment as it took a shorter spawning time with the greatest yield of mushroom production.

Key words: Grey oyster mushroom (*Pleurotus sajor-caju*), physical treatments, growth performance, physico-chemical properties

INTRODUCTION

Mushrooms are regarded as a macro-fungus with a distinctive fruiting body which can be either epigeous or hypogeous and large enough to be seen with the naked eyes and to be picked by hand (Chang and Miles, 1992). Mushrooms grow wild in nature raging from cold to sandy deserts on all types of pastures, forest, and watery lands and appear in all seasons, mostly during the rainy weather, wherever organic matter or its decomposition products are available (Kapoor, 1989).

In Malaysia, grey oyster mushroom (*Pleurotus sajor-caju)* is the most popular mushroom species since it can be cultivated within a wide range of temperatures and on different natural resources and agricultural wastes (Asghar *et al*., 2007). It requires light for its fruiting bodies formation where the pattern of catalyses activity of fungus during response towards illuminating with visible light was a drop in activity during the first hours and followed by return in its former level and then another drop in catalyzes activity (Danay *et al*., 2000).

Farmers had spotted extra grown-up mushroom around a lightning hit point (Tsukamoto *et al*., 2005). It is also reported that yield of shiitake mushroom (*Lentinula edodes*) was increased by electrical stimulation (Mibuchi and Yamamoto, 1984). The aim of this study is to investigate the effects of different physical treatments namely high sound intensity, bright light, cold temperature (5°C) and electrical shock on the growth performance, yield and physico-chemical properties of grey oyster mushroom.

MATERIALS AND METHODS

A mixture of sawdust, rice bran, calcium carbonate in the ratio of 100:10:1 and water were used as substrate. The mixed medium was then filled into polypropylene bags. The bags were compacted into a cylindrical shape and closed using necks and

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lids and sterilized at 121°C for 30 min using an autoclave. After sterilization the bags were cooled overnight and ready to be inoculated with *P. sajor-caju* culture. The inoculated bags were incubated (spawn running) in the mushroom house at 28-30°C; 80-90% relative humidity (RH) and ~30% light until mycelia has completely covered the bags.

Physical treatments of high sound intensity was done using firecrackers (75 decibels) to give the sound shock needed to mimic the low frequency of thunderstorm sound. Bright light from car spotlight was used to mimic the thunderstorm lightning. Cool room with temperature of 5°C was used to give a low temperature shock. While car's battery of 12V was used for electrical shock treatment. All the physical treatments were done at interval of ten days starting from the inoculation day until mycelium fill up the bag (up to 30 days).

The growth performances of mushroom from each different agro-waste residues were determined in terms of mycelium growth during spawning and the number of days for complete colonization of substrate (full bag). The days taken for the pin head emergence and fruiting body formation were also observed and recorded. The yield was measured in term of percentage biological efficiency.

Color measurements were done on the cap or pileus of mushroom using Minolta Chromameter. Presented in L* [lightness], a* [greenness (-) to redness (+)], and b* [blueness (-) to yellowness (+)] values. Texture of fresh mushrooms was determined by using Texture Analyzer using P/2 stainless steel probe. Moisture determination was done by heating an amount of mushroom in an oven at 105°C for 4-5 hr. Ash was determined by heating sample in a Muffle furnace for 6 hr at 550°C until a white residue of constant weight was obtained. Crude fiber of mushroom was determined by using Fibertec System 2021 FibreCap. Protein content in the mushroom was determined using the Kjeldahl method, which involves digestion, distillation, and titration steps. The percentage of nitrogen was converted to protein through multiplying by a factor of 5.99.

This study used completely randomized design (CRD) with five replicates of each treatment. The data obtained were analyzed using one-way analysis of variance (ANOVA) with post-hoc Tukey test. The statistical program used was SPSS.

RESULTS AND DISCUSSION

Fig. 1 shows that there were significant differences in the growth rate of mycelium subjected to different physical treatments. Control treatment took the longest time of 40.6 days to complete spawning of 16 cm length of the mushroom bag. Faster time were taken by the physically treated bags where high sound intensity treatment only took 23.6 days followed by bright light treatment (23.8 days), cold temperature treatment (24.2 days) and electrical shock treatment (25.8 days). Atri *et al*. (2012) reported that all mushrooms species exhibited

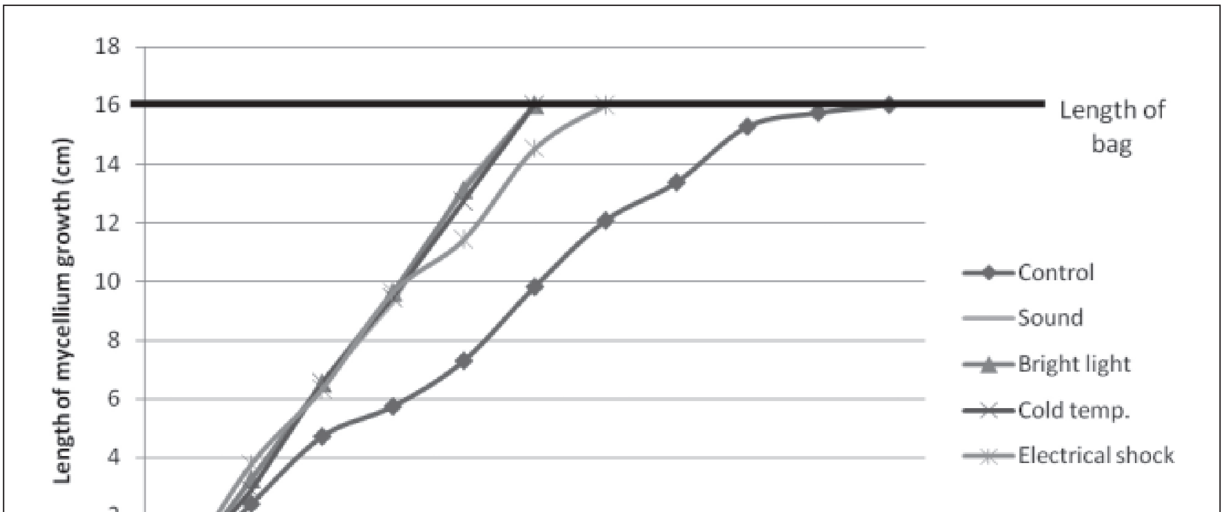

Fig. 1. The growth performance of grey oyster mushroom (*Pleurotus sajor-caju*) subjected to different physical treatments.

different mushroom growth pattern while *P. sajor - caju* showed a growth rate of 1.2 cm/day.

Fig. 2 shows the results for the number of days for mycellium to fill up the bag. There were significantly ($p<0.05$) longer time required for mycelium to fill up the bag for control compared to physically treated bags. Control took 47.2 days, whereas electrical shock, cold temperature, bright light and sound treatments took almost half the time (25.4 to 27.4 days). However, there was no significant difference ($p>0.05$) observed among different physical treatments. The average time for mushroom to fill up 12 inch of mushroom bag was about 2 months as reported by Atri *et al.* (2012). Pinhead emergence is an important factor in mushroom cultivation. Pinhead emergence indicate the initial stage of fruting body formation. Fig. 2, shows the differences in the time taken for pinhead emergence for each treatments. Treatment with electrical shock showed significantly ($p<0.05$) the shortest time taken for pinhead emergence which is 2.4 days, followed by sound, light, cold and the longest was control (6.6 days).

Days for fruiting body formation was counted from the day pinhead emergence until the mushroom pileus had properly developed. Result showed that there was almost same number of days taken for fruiting body formation (Fig. 2). The insignificant difference ($p>0.05$) among the treatments might due to the same mushroom species.

Yield is one of the important aspects to consider in mushroom cultivation. Higher yield will result in higher profit to farmers. In this experiment, the yield was calculated in term of percentage biological efficiency. Table 1 shows the results of the harvested yield of grey oyster mushroom from different treatments. There were significant differences ($p<0.05$) observe among all the treatments. The yield from electric shock treatment was significantly ($p<0.05$) higher which have the mean yield of 74.9% compared to other treatments. This was followed by sound, light, cold and control treatments which have mean yield of 66.93%, 64.43%, 55.37% and 36.41% respectively. Mibuchi and Yamamoto (1984) had reported that the yields of shiitake mushroom (*Lentinula edodes*) increases twice by using electrical stimulation.

Mushroom subjected to different physical treatments were also compared in term of its pileus color. The color L* values represent the lightness of the color which range from 0 (black) to 100 (white). Based on Table 1, the mushrooms from cold temperature treatment have the lightest color compared to other treatments. Color a* values ranged from -60 (green) to +60 (red). The results obtained showed that there were differences in the color a* value among those mushrooms. Table 1 shows that control mushrooms have the highest a* values of 6.09 compared to other treatments. This followed by light (5.73), electrical shock (5.48), cold

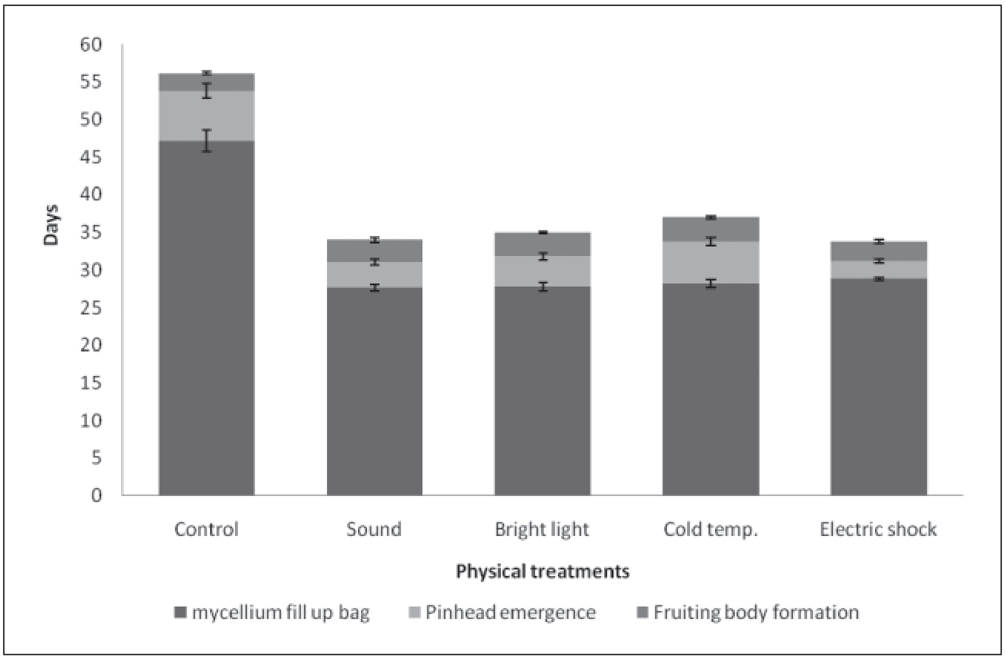

Fig. 2. The number of days for mycelium to fill up the bag, pinhead emergence and fruiting body formation of grey oyster mushroom (*Pleurotus sajor-caju*) subjected to different physical treatments.

Table 1. The yield and physical properties of *Pleurotus sajor-caju* subjected to different physical treatments

Substrates	Biological efficiency (%)	Color			Firmness (N)
		L*	a*	b*	
Control	36.41 ± 7.16^{d}	55.38 ± 3.39^{b}	6.09 ± 0.52^{a}	14.32 ± 0.28^{b}	77.69 ± 17.11^{a}
Sound	66.93 ± 6.38^{ab}	56.99 ± 1.03^{b}	4.87 ± 0.33^{c}	14.70 ± 0.61^{b}	62.18 ± 8.48^{a}
Bright light	64.43 ± 3.51^{b}	51.40 ± 2.09^{b}	5.73 ± 0.42^{ab}	14.81 ± 0.28^{b}	61.19 ± 12.64^{a}
Cold temp.	55.37 ± 4.36^{c}	74.78 ± 3.08^{a}	5.09 ± 0.15^{c}	15.81 ± 0.05^{a}	61.95 ± 11.84^{a}
Electric shock	74.91 ± 2.48^{a}	57.45 ± 0.34^{b}	5.48 ± 0.20^{ab}	14.17 ± 0.23^{b}	66.59 ± 20.43^{a}

Values are means ± standard deviation. The same superscript within the same column are not significantly different at 5% level (p<0.05).

Table 2. The chemical properties of *Pleurotus sajor-caju* subjected to different physical treatments

Substrates	Moisture (%)	Ash (%)	Protein (%)	Crude fiber (%)
Control	84.74 ± 2.84^{a}	4.76 ± 0.19^{a}	11.84 ± 1.36^{a}	0.81 ± 0.0010^{a}
Sound	87.54 ± 0.58^{a}	4.73 ± 0.06^{a}	13.94 ± 1.33^{a}	0.81 ± 0.0064^{a}
Bright light	86.77 ± 0.54^{a}	4.78 ± 0.09^{a}	11.66 ± 1.94^{a}	0.81 ± 0.0015^{a}
Cold temp.	84.53 ± 1.26^{a}	4.64 ± 0.09^{a}	12.01 ± 1.83^{a}	0.81 ± 0.0010^{a}
Electric shock	86.73 ± 0.28^{a}	4.79 ± 0.08^{a}	15.49 ± 4.41^{a}	0.81 ± 0.0015^{a}

Values are means ± standard deviation. The same superscript within the same column are not significantly different at 5% level (p<0.05).

temperature (5.09) and the least was sound (4.87). Color b* value indicates blue (-60) and yellow (+60). Table 1 shows that there were significant differences (p<0.05) among treatment where cold temperature treatment have the highest b* value of 15.81 compared to other treatments.

Firmness is defined as force needed to break or penetrate the flesh. Table 1 also shows that there was no significant difference (p>0.05) among all the treatments. This might probably due to the same species of oyster mushroom that was used in this experiment. The firmness values obtained was in the range of 77.69 gm to 61.19 gm.

Mushrooms generally have high moisture content which accounts for their short shelf life as they deteriorate easily after harvest if preservative measures are not employed. However, when harvested at full maturity they become tough and almost leathery (Fasidi and Kadiri, 1993). From Table 2, there was no significant difference (p>0.05) in moisture content among mushrooms subjected to different treatments. The moisture content ranges from 87.54% to 84.53%. This result is in agreement with the study by Adedayo (2011), which reported that the moisture content of *Pleurotus tuber-regium* and *Lentinus subnudus* raging from 78-89%. While Crisan and Sands (1978) reported that mushrooms in general contain 90% water and 10% dry matter.

Ash content indicates all the minerals that cannot be evaporated. The percentage of ash content in the mushroom subjected to different physical treatments also showed no significant difference (p>0.05) among each other (Table 2). The values range from 4.79% to 4.64%. The fruiting bodies of mushrooms are characterized by a high level of well assimilated mineral elements. Major mineral constituents in mushrooms are K, P, Na, Ca, Mg and elements like Cu, Zn, Fe, Mo, Cd form minor constituents (Bano and Rajarathanam, 1982; Bano *et al*., 1981; Chang, 1982).

Results in Table 2 also shows that there was no significant difference (p>0.05) in the protein content among all the treatments. This might be due to the same species of mushroom used in this study. As reported by Bano and Rajarathanam (1982), protein content of mushrooms depends on the composition of the substrate, size of pileus, harvesting time and mushroom species.

The crude fiber content obtained from mushrooms subjected to different physical treatments also showed no significant difference (p>0.05). This might also be due to the same mushroom species being used. Mushrooms have an average of 7.4% crude fiber content (Orgundana and Fagade, 1981).

CONCLUSION

Different physical treatments had effects on the growth performance and yields of oyster mushroom. Light, sound, and cold treatments showed the shortest time taken for mycelium spawning. The time taken for mycelium to fill up the bags was faster for mushroom subjected to sound and light treatments. The electrical shock treatment took the shortest time for pinhead emergence, fruiting body formation and it is also the fastest in overall spawning until fruiting bodies formation. Besides, it also gave the highest yield. Treatment of cold temperature showed the lightest pileus color and the highest b* value (yellowness) where control showed the highest a* value (redness). The postharvest quality of texture, moisture, ash, protein and crude fiber contents did not show any difference in all the mushrooms subjected to different physical treatments.

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