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Acceleration of Five Types Edibel Wood Mushroom Production through Varied Harvest Synchronization Temperature Settings

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Abstract

The aim of this research was to get synchronization temperature from five types of edible wood mushrooms that can produce together in one mushroom house. The method used in this research is Split Plot Design. The Main Plot is the harvest synchronization temperature (T) consisting of 5 (five) levels covering:$t_1 =$ 5°C ; $t_2 =$ 10°C ; $t_3 =$ 15°C ; $t_4 =$ 20°C; $t_5 =$ 25°C. The second plot is the mushroom species (S) consisting of 5 (five) levels covering: $s_1 =$ white oyster mushroom; $s_2 =$ red oyster mushroom ; s_3 = brown oyster mushroom ; $s_4 =$ wood ear mushroom; $s_5 =$ Shiitake. The results concluded: The combined of (T) and (S) for the accelerated production of five species of wood fungi covering white oyster mushroom (Pleurotus ostreatus), red oyster mushroom (Pleurotus flabelatus), brown oyster mushroom (Pleurotus obolonus), wood ear mushroom (Auricularia polytrica), and shiitake (Lentinus edodes), The harvest synchronization temperature of five types of edible wood mushrooms which can produce together lies in the range 13,5°C up to 19°C; with biological efficiency value of each: 62,9%; 45,3%; 34.6%; 59,7%; and 50,1%.

Keyword: Pleurotus ostreatus, Pleurotus flabelatus, Pleurotus obolonus, Auricularia polytrica, Lentinus edodes.

1. Introduction

Mushrooms are fleshy fruiting bodies that are considered one of the delicious fruits, and are commonly produced worldwide. They are a rich source of carbohydrates, proteins, vitamins, and minerals. Mushrooms grow on decayed organic matters rich in lignin, cellulose, and other complicated carbohydrates. Large quantities of agro-industrial wastes that are produced worldwide often cause environmental and health problems (Garg and Gupta, 2009). In addition, the ever-growing need of cheap nutritious food, and the lack of protein in developing countries led to the development of the mushroom cultivation industry (Kholoudet et al., 2014).

Mushrooms are recognized as important food items from ancient times. Usages of mushrooms are increased day by day because of the significant role in human health and nutrition (Khan et al., 2005). Mushrooms are good source of protein, vitamin and minerals. It is known for its broad range of uses as food and medicine. High nutritional values of Oyster mushroom have been reported. It has protein (25 - 30%), fat (2,5%), sugar (17 - 44%), mycocellulose (7 - 38%) and mineral; potassium, phosphorus, calcium and sodium of about 8 - 12% (Stanley, 2011). Shiitake mushrooms of 100 g dry weight of fruit body, there are protein (13,4 – 17,5 g) , fat (4,9 – 8,9 g), carbohydrate (67,5 – 78,0 g), fiber (7,3 – 8,0 g), ash (3,7 – 7,0 g) and calories (387 – 392 Kal). The essential lipid content is about 70% determined by unsaturated fatty acids such as linoleic acid (53 – 67%). While the content of unsaturated fatty acids is about 72 - 80% of total fatty acid content. Vitamins contained in 100 g of dry fruit body weight of mushroom included niacin (54,9 mg), thiamin 7,8 mg, riboflavin 4,9 mg, vitamin C 9,4 mg, ergosterol and provitamin D_2 0,27%.

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Another compound whose role is very important is lentinan that is a water-soluble polysaccharide which in its molecular formula isβ – 1,3 glucan; β – 1,6 andβ - 1,3 glucopyranoside, which have the ability to againsttumor and cancer. The highest lentinan content will be obtained on the stem near the hood and the hood, while the remaining stem is dominated by fiber that prevents the occurrence of bowel cancer (Chang and Miles, 2004).

Shiitake (Lentinus edodes) is also the first medicinal mushroom to enter the realm of modern biotechnology. It is the second most popular edible mushroom in the global market which is attributed not only to its nutritional value but also to possible potential for therapeutic applications (Bisen et al., 2010).

Oyster mushroom group besides containing high nutrients also contains compounds lovastatin. Lovastatin ($C_{24}H_{36}O_5$) is one of the potentially used drug for the reduction of blood cholesterol levels. Lovastatin competitively inhibits the 3-Hydroxy- 3 -methyl glutaryl Co enzyme A (HMG CoA) reductase enzyme which acts as a rate limiting step in the cholesterol bio synthesis for the conversion of cholesterol. Present study investigateing the possible production of lovastatin from pleurotus ostreatus culture (Laksshmanan and Radha, 2012).

Viscous dietary fibers were shown to alleviate postprandial blood glucose. Auricularia polytricha (wood ear mushroom, WEM) contains rich amount fibers and water extract WEM was highly viscous. WEM extracts can also suppress the activity of α-amylase which may thus inhibit the digestion of polysaccharides. Since WEM extract exhibited the ability to adsorb glucose and to suppress the activity of α-amylase, it might contribute a beneficial effect on postprandial levels of blood sugar (Ni-Jung Wu et al., 2014).

Edible wood mushrooms with the advantages as mentioned above, have limitations of the different grow in environmental characteristics. As a result edible mushrooms can not be cultivated in one place. Environmental temperature that support the growth and production have unequal ranges. Taking note of that matter is to look for the point of temperature synchronization so that wood fungi can produce together. To improve the productivity, nutritional value and shortening mushroom production periods several techniques, substrates, cultivation conditions and strains have been tested. Some studies show that supplementation with nitrogen source increases the biomass and mushroom's productivity (Curvetto et al., 2002; Shashirekha et al., 2005).Based on the background of the problems studied are formulated as follows: How are the five types of edible wood fungi that include white oyster mushroom (Pleurotus ostreatus), red oyster mushroom (Pleurotus flabelatus), brow oyster mushroom (Pleurotus obolonus), wood ear mushroom (Auricularia polytrica), and shiitake (Lentinus edodes); can produce together on one mushroom house.

2. Materials and Methods

The research has been conducted at the Integrated Laboratory of Faculty of Agriculture and Central Laboratory of Islamic University of Malang from May to November 2016. Spawn of 5 types of mushrooms made with direct eksplan planting method that is done by taking part of the stem and put in a petridish (Sugianto, 2007). Petridish that has been filled by eksplan placed in the refrigerator with temperature 10^{o}C for 2 days. Bottled spawns that are ready to be filled with a mixture which consisting of 20% rice seed, 10% barn, 1,5% gypsum, 0,5% calcium carbonate ($CaCO_3$) and 40% water. The bottle is covered with plastic and sterilized using an autoclave at 121^{o}C, for 20 minutes after a constant temperature. For 10 days after the inoculation of the surface of the planting substrate will begin to overgrown white mycelium. Stages of making the planting substrate (bag-log) with mixture of 47,0% sawdust of albasia wood, 10% bran, 0,5% calcium carbonate ($CaCO_3$), 1,5% gypsum, 0,5% corn flour, 0,5% SP-36 and 40% water. The mixing results are put into a 0,03 mm PP plastic bag, each bag-log weighs 1,25 kg. Bag-log sterilized with stem for 3 with temperature 121^{o}C, pressure 15 pounds.

The method used in this research is Split Plot Design. The main plot is the harvest synchronization temperatur (T) consisting of 5 (five) levels covering: t_1 = 5^{o}C ; t_2 = 10^{o}C ; t_3= 15^{o}C ; t_4 = 20^{o}C; t_5 = 25^{o}C. The second plot is the mushroom species (S) consisting of 5 (five) levels covering: s_1 = white oyster mushroom; s_2 = red oyster mushroom ; s_3= brown oyster mushroom ; s_4 = wood ear mushroom; s_5= Shiitake. The combination of these two factors was obtained by 25 treatments and each treatment unit was repeated 6 times. The inoculated bag-logs are arranged according to the treatment on the box that has been made in such a way that the temperature is adjusted. The observed variables include: the mycelium time fulfill the media of bag-log observed from spawn inoculation to white log-bag; The total fruit body fresh weight (TFBFW) is calculated by adding the first harvest to the fifth harvest; biological efficiency (BE) is calculated using the formula BE = TFBFW / Weight of substrate x 100% (Sugianto, 2007).

3. Results and Discussion

3.1 Growth Pattern of Mycelium

The time it takes for the mycelium to fulfill bag-log due to the increasing temperature sett shows varying results in 5 types of wood mushrooms. In siitake mushrooms the time needed to fulfill bag-log is faster compared to other mushroom that is 32 days after inoculation with temperature 15°C, whereas for the type of white oyster mushroom, red oyster and substrate ear mushroom can grow full by mycelium at temperature 20°C. Temperatures 5°C and 10°C show that the growth of mycelium of 5 types of mushrooms is slow to fulfill the media. The brown oyster mushroom takes 82 days, while shiitake mushrooms take up to 49 days (Figure 1). The growth pattern of shiitake mushroom mycelium at temperature 15°C reaches the fastest but at 20°C and 25°C slows back. The rate of growth of mycelium is strongly influenced by the suitability of substrates, temperatures and carbon compounds derived from the process of fiber degradation by enzymes contained mushroom mycelium itself.

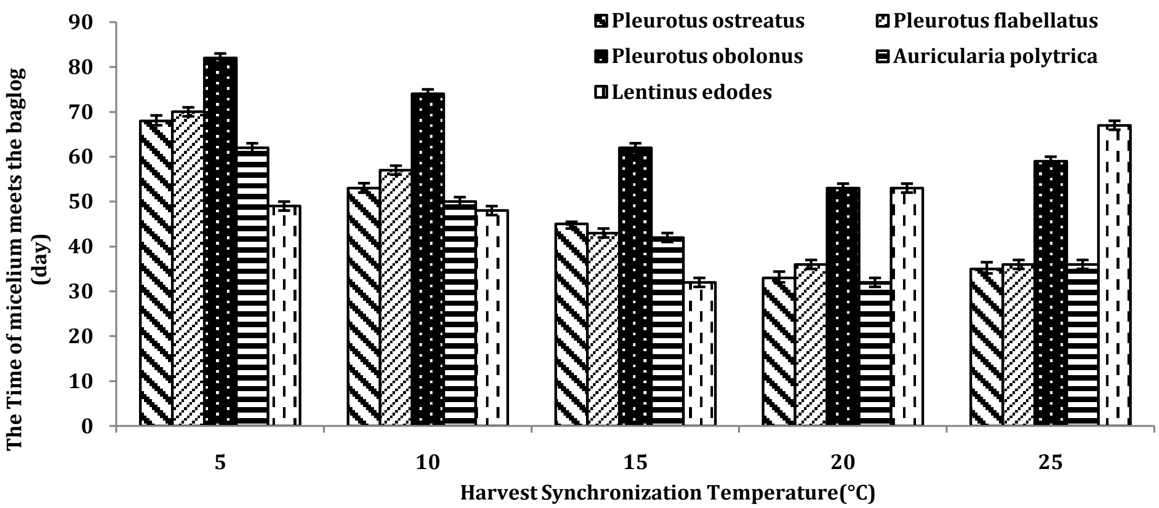

Figure 1. Pattern of Mycelium Growth of 5 Types of Edible Mushroom With Harvest Synchronization Temperature (°C)

Supplemental initial nutrients such as bran, cornmeal, gypsum, calcium carbonate, etc., have a role as a stater on the growth of mycelium. The maximum time required for mycelium to fulfill bag-log is marked by the opening of the bag-log cover, the purpose is to make oxygen can enter and absorbed by the mushroom mycelium to help form the fruit body. Carbon dioxide and water as a result of bioconversion are discharged through aeration and if this is not done it causes the growth of the fruit body to be inhibited and the mushroom fruit body cap becomes yellow and dry. Mycelia of pleurotus species are well known to colonize various lignocelluloses materials due to their extensive enzyme systems capable of utilizing complex organic compounds, which occurs in organic matter residues (Tisdale et al., 2006; Mane et al., 2007).

3.2 Total Fruit Body Fresh Weight (TFBFW)

The pattern of quadratic graphs in Figure 2, obtained the equation for white oyster mushrooms (Y_1) = -3,67 X^2 + 126,20 X – 346,40 with R^2 = 0,911 and X optimum = 17,2°C ; red oyster mushrooms (Y_2) = -2,03 X^2 + 70,91 X – 104,10 with R^2 = 0,882 and X optimum = 17,5°C ; brown oyster mushrooms (Y_3) = -1,44 X^2 + 54,15 X – 173,42 with R^2 = 0,681 X optimum = 18,8°C; woodear mushrooms (Y_4) = -3,44 X^2+ 127,80 X +476,30 with R^2= 0,923 and X optimum = 18,6°C ; shitake (Y_5) = -3,77 X^2 + 101,98 X + 130,66 with R^2 = 0,804 and X optimum = 13.5°C.

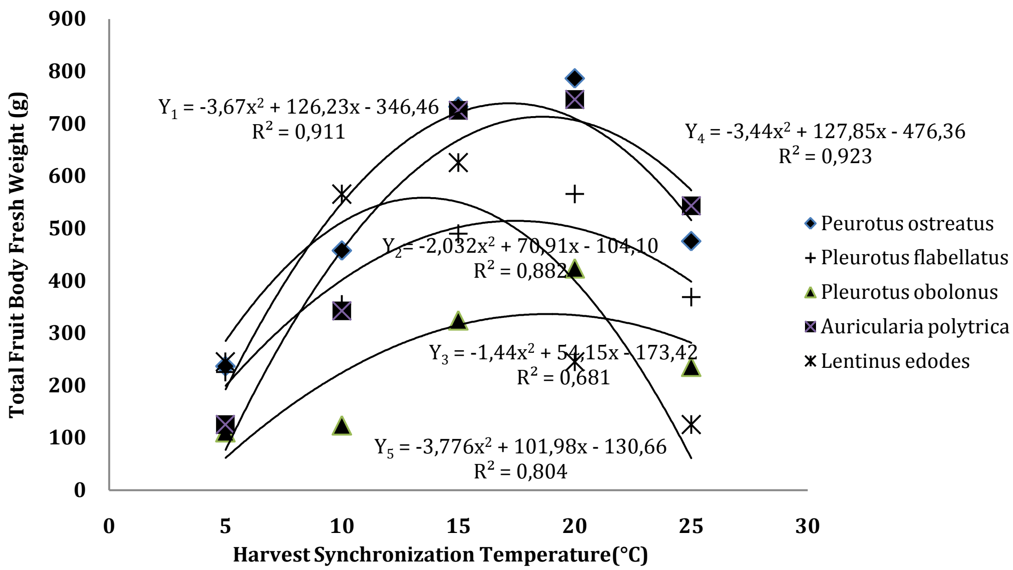

Figure 2. Pattern of the Total Fruit Body Fresh Weight (TFBFW) of 5 Types of Edible Mushroom with Harvest Synchronization Temperature (°C)

These equations show that the optimum temperature of the 5 types of mushrooms lies in the range of 13,5°C to 18,6°C. This temperature range triggers the formation of fruit bodies that affect 5 species of wood mushrooms can produce in one place. The ability of the mushroom to produce the fruit body is always followed by the ability to absorb the hexose phosphate produced from the bioconversion process. Temperature is an important factor that affects the growth of mushrooms. Temperature extremes is temperatures which located below the minimum temperature and above the maximum temperature that causes white oyster mushrooms to not grow. While, among the minimum and maximum temperatures are the optimum temperatures that cause the mushroom to grow and develop at the highest biological efficiency rates. Temperature extremes is very influential on the distribution of strains or fungal species, so that each strain has a specific distribution pattern (Sugianto, 2007; Islam et al., 2009).

Based on the temperature range, the mushroom can be grouped into three, namely psychrophiles mushroom, mesophiles mushroom and thermopiles mushroom. Psychrophiles group is a mushroom that has a minimum temperature below 0°C, the optimum temperature between 0 - 17°C and at temperatures above 20°C mushrooms are not able to live. Mesophiles fungi group has a minimum temperature above 0°C, maximum temperature below 50°C and optimum temperature between 15 - 40°C. The last groupis thermophile groups which has a minimum temperature above 20°C, a maximum temperature of 50°C or more and an optimum temperature of about 35°C or more. White oyster mushrooms include the second group of mesophiles mushroom for the growth of mycelium, the appropriate temperature range is 7 - 37°C and optimum 26-26°C; for the formation of the fruit body the required temperature range 12 - 30°C. Inner compost temperatures were measured as an indicator of microbial activity within the compost piles as described by Colak (2004). These measurements were made at 24 hour intervals. The qualitative characteristics of the finished compost which include color, softness and greasiness were observed at the end of the composting process as described by Mshandeteand Cuff (2008). Based on the results of white oyster mushroom research requires the appropriate environment and nutrition, the desired temperature 20 - 30°C, the optimum temperature for growth of mycelium is 22°C and to stimulate the growth of fruit body, desired temperature 15 - 20°C with light rather bright (Sugianto, 2007). Temperature play a role in supporting enzyme activity, according to the collision theory that the higher of the temperature, the reaction will be faster, because the collision between molecules is more frequent. In enzymatic reactions this remains valid but not absolute. It is important to remember that all enzymes are proteins with all their characteristics. Among other things that at high temperature protein will have denaturation so it will cause loss of physical and chemical characteristics and its function. As well as with enzyme, when it has experienced denaturation will lose its function as a catalyst. The required temperature for the reaction to take place optimally is called the optimal temperature (Laksshmanan and Radha, 2012).

Similar trends of increasing yield with increasing supplement level to a certain optima have been reported on pad straw substrate supplemented with different supplements (Patil et al., 2011).

3.3 Biological Efficiency (BE)

Quadratic curve for biological efficiency (BE) variable in Figure 3 shows the function equation of 5 types of mushrooms, each having a different optimum point, the equation for white oyster mushrooms (Y_1) = -0,29 X^2 + 10,08 X – 27,62 with R^2 = 0,910 and X optimum = 17,2°C; red oyster mushrooms (Y_2) = -0,15 X^2 + 5,36 X– 8,44 with R^2 = 0,787 and X optimum = 18,1°C; brown oyster mushrooms (Y_3) = -0,12 X^2 + 4,40X– 14,30 with R^2 = 0,674 and X optimum = 19,0°C; wood ear mushrooms (Y_4) = -0,27 X^2 + 10,22 X +38,12 with R^2 = 0,923 and X optimum = 18,7°C; shiitake (Y_5) = -0,30 X^2 + 8,17 X + 10,56 with R^2 = 0,803 and X optimum = 13.5°C.

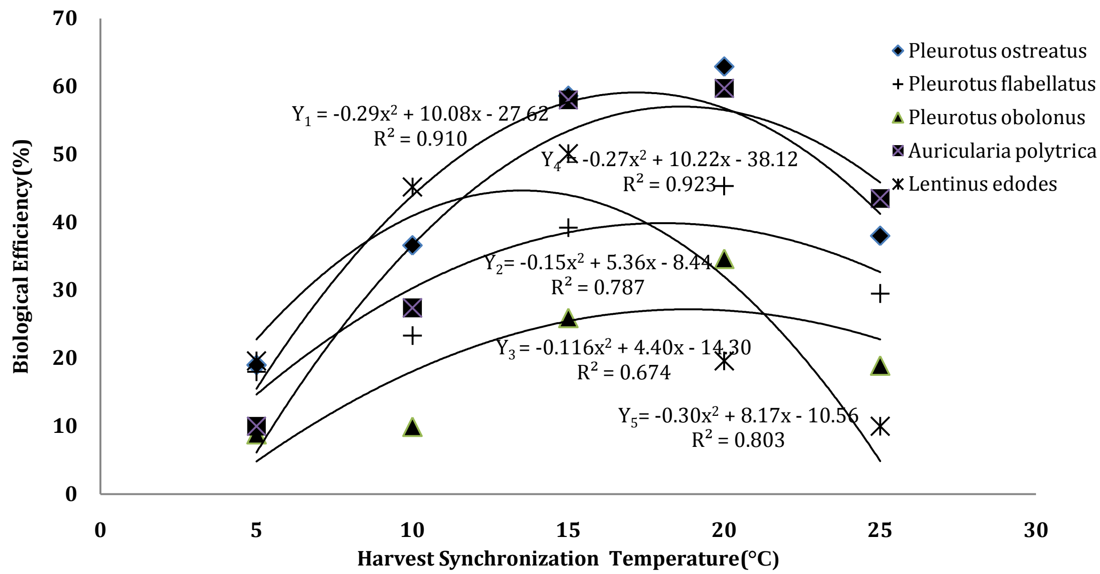

Figure 3. Biological Efficiency of 5 Types of Wood Mushroom with Harvest Synchronization Temperature (°C)

The value of biological efficiency reflects the ability of the mushroom to convert the substrate into the mushroom fruit body consumed. If the high value indicates that the mushroom fruit body is harvested more than the residual of the substrate inside the bag-log. This is very beneficial for farmers or managers. The optimum biological efficiency rating for the five types of mushroom is located at a temperature of 13,5°C to 19°C. The most decisive factor of increasing the value of biological efficiency is the availability of nutrients in the substrate. Supplemental nutrients play a role in helping the metabolism process in the body of wood mushroom (Chang and Miles, 2004). Biological efficiency depends on the total weight of the fruit body produced, the substrate can not be converted by the mycelium mushrooms maximally because the value is low which resulted in the amount of substrate residual production in the bag is still large. This condition is experienced by the mushroom which grown on the substrate at 5°C temperature. Shiitake mushrooms are not able to produce optimal fruit body at 25°C. Substrate is one of the important parameter in mushroom cultivation as mushrooms depend on substrates for nutrition to support the growth of mycelium and development into mushroom fruiting bodies. For the growth and penetration of the mycelium into basal substrates which ultimately influences fruiting of mushrooms, the structure and porosity levels (oxygen availability) of substrate are important factors to be considered (Philippoussis et al.,2002).

4. Conclusions

The results concluded: The combined of (T) and (S) for the accelerated production of 5 species of wood fungi covering white oyster mushroom (Pleurotus ostreatus), red oyster mushroom (Pleurotus flabelatus), brown oyster mushroom (Pleurotus obolonus), wood ear mushroom (Auricularia polytrica), and shiitake (Lentinus edodes). The harvest synchronization temperature of 5 types of edible wood mushrooms that can produce together lies in the range 13,5°C up to 19°C; with biological efficiency value of each: 62,9%; 45,3%; 34.6%; 59,7% and 50,1%.

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