JERE, *Volume 10, No.1 (63-70),* Special Issue on Bioprocess & Biosystem Engineering and their Downstream Processing

Statistical Assessment on Utilization of Paddy Straw for Oyster Mushroom Production

Maisara A. M. Akhir[1] and Nazirah M. Waseem[2]

[1,2] *School of Bioprocess Engineering, Universiti Malaysia Perlis, 02600 Arau, Perlis, Malaysia.*

ABSTRACT

In this article, authors studied about the utilization of the waste paddy straw for oyster mushroom production incorporated with an effective microorganism (EM) and Agricultural lime. It was found that Paddy straw mixed with 4 ml EM showed the best results for higher biological efficiency which is 4.7%. While the shortest growing days was showed by sample consisting 2 ml of EM plus 15 g lime which is 31 days. Biological efficiency was increased with the increment of the EM volume, while the growing days of oyster mushroom decrease when the number of EM increases. Furthermore, the lime sample also showed a quite higher biological efficiency, which is 4%. Effective microorganisms give the most significant effect on the biological efficiency and growing days of oyster mushroom by increasing the biological efficiency while reducing the growing days.

Keywords: Oyster Mushroom, Paddy Straw, Biological Efficiency, Lime, Statistical Design of Experiment.

1. INTRODUCTION

Growing mushroom can help in reducing poverty and build up livelihoods through the generations of a fast yielding and nutritious source of food and a reliable source of income. Since it does not require access to the land, growing mushroom is applicable for rural farmers. Organic wastes such as, waste from paddy field and from Palm oil mill can be reused to gain the profit and also can prevent the environmental pollutions. The used substrate can then be composted and applied directly back to the soil.

Oyster mushroom (*Pleurotus ostreatus*) has the ability to bioconvert various lignocelluloses materials. This is due to the presence of its lignocellulolytic enzymes, also named fibrolytic enzymes, including laccase, xylanase, and cellulase which help it to convert cellulose and lignin into useful carbohydrates such as glucose for energy [1-2]. The plant waste, such as sawdust, paddy straw, palm oil bunches, can be used for oyster mushroom production without requiring an expensive processing method and enrichment materials. Any agricultural waste that contains cellulose and lignin is a possible substrate for growing this fungus [3-4].

For mushroom cultivation using paddy straw, the presence of effective microorganisms (EM) and lime are important for the nutrient enrichment media from paddy straw for the mushroom to grow. However, determination of the optimum quantities of EM and lime for the substrate preparation is not yet discussed. Thus, it is crucial to study the optimum amount of EM and lime in order to produce a high yield of mushroom and also to investigate, how these catalyst or treatments affect the mushroom growth.

*Corresponding Author: *maisaraazad@unimap.edu.my*

2. MATERIAL AND METHODS

For preparation of mushroom substrates, the method was adopted from Sahana (2014) and Josephine (2015), 1 kg of paddy straw was soaked for 24 hours in 6 litre water with 0, 4 ml and 2 ml of EM and 0, 30 g and 15 g of lime, where 0 amount of lime and EM act as control [5-6]. This process is to allow the paddy straw to absorb as much nutrient from each sample composition. After soaking process, the paddy straw was drained for about 6 hours. This is to make sure the paddy straw is moist for mushroom growth. Then, the paddy straw was placed inside the plastic bag with a dimension of 31cm x 46 cm. The Figure 1(a) and (b) show the soaking and draining process of the paddy straw, respectively.

After that, the mushroom spawns were placed inside the plastic bag layer by layer. The first layer of the substrate consists of the moist paddy straw, which will act as the growing media for the mushroom. After that, the spawns were sowed inside the plastic bag. These steps were repeated until 4 layers of dried paddy straw and 3 layers of mushroom spawn were prepared.

After the 7th layers had been prepared, several holes were made around the plastic bag where the spawns were placed. The purpose of this holes is a channel for the oyster mushroom to grow and facilitate primordial initiation [5]. Figure 1(c) shows the packaging of the substrate. All of the samples were placed in a dark room because mycelial grows 3-4 times faster than under light [7]. The factors such as temperature, light, humidity and sterility of the environment need to be monitored so that the growth of the mushroom will occur. Nayak et al. (2015) stated that the temperature of 25°C was found the optimum for mushroom growth due to the decrease in enzymatic activity of the fungus [5]. Thus, the temperature of the dark room was controlled at 25 to 27°C and the relative humidity was at 80% - 90%. Mushrooms were harvested when the mushroom cap surface was flat to slightly up-rolled at the cap margins. After harvesting process, the mushrooms produced were weighed for the biological efficiency response and the total growing days of the mushroom was recorded.

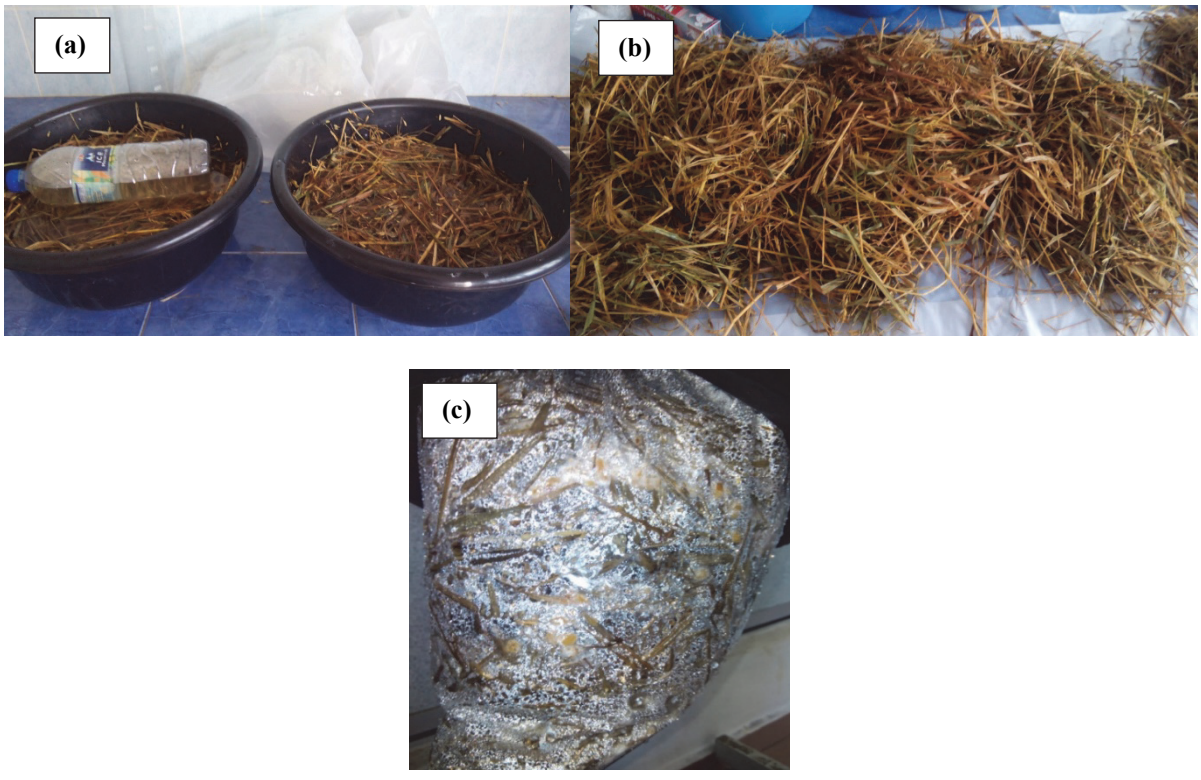

Figure 1. (a) Soaking, (b) draining process of Paddy straw and (c) packaging of the substrate.

The data were analysed using two factorial design (2^k) using Design of Expert software with 2 replications. The DOE is common to be used to find 'optimum values' for the factors in experiments [8]. The data was collected and analysed to study how different treatments of paddy straw can affect the growth process (Biological efficiency and growing days) of mushroom. In addition, these data also was used to compare and select the appropriate compositions of EM and lime for the growth of the oyster mushroom. The biological efficiency was calculated to determine yield potential of mushrooms from the different sample using equation (1) [9].

$$\text{Biological efficiency (\%)} = \frac{\text{Fresh weight of mushroom}}{\text{Weight of dry substrate}} \text{ x } 100 \quad (1)$$

3. RESULTS AND DISCUSSION

The results of the factorial design for biological efficiency and growing days responses of the mushroom production using paddy straw are shown in Table 1. The statistical effect of variables was calculated within 95% confidence interval. The highest percentage of biological efficiency obtained (4.7%) when EM was at its highest levels. The standard deviation and the R-squared for the response are listed in Table 2. The R-squared values represent the amount of variation in the data. When the objective of the experiment is to optimize, higher *R*-squared values are important, implying that the polynomial model is a very good predictor of the response. The higher the *R*-squared values are, the better the polynomial is at either describing the system or making predictions about the system. For this response, the *R*-squared value of approximately 98 % for biological efficiency response and 95% for growing day response as shown in Table 2, indicate that this polynomial is a very good description of the relationship between these two factors and the responses. Biological efficiency (%) and growing day (Day) can be express by equation (2) and (3) where A is the volume of EM (ml), and B is the weight of lime (g).

$$\text{Biological Efficiency (\%)} = +2.21 - 0.41*A + 0.046*B - 1.85 * A * B \quad (2)$$

$$\text{Growing days (Days)} = +36.50-11.50* A-12.50 * B-12.50 * A * B \quad (3)$$

Table 1 Experimental results of 2^k full factorial design with two replications

	Factor 1	**Factor 2**	**Response 1**	**Response 2**
Run	**A:EM**	**B:Lime**	**Biological Efficiency**	**Growing Day**
	(ml)	**(g)**	**(%)**	**(Days)**
1	0	0	0.8	49
2	0	0	0.66	49
3	4	0	4.33	46
4	4	0	4.7	46
5	0	30	4.0	60
6	0	30	3.2	50
7	4	30	0	0
8	4	30	0	0
9	2	15	3	31
10	2	15	2.6	35

Table 2 Statistical parameters of the responses

Parameters	Standard deviation	R-Squared
Biological Efficiency	0.31	0.98
Growing Day	3.41	0.95

Figure 2 shows the predicted values of biological efficiency and growing day generated by the DOE versus actual values graph and the perturbation plot. From Figure 2(a) and (c), it can be said that the experimental data are in a good agreement with the model prediction by DOE software since all points distributed closely to the predicted linear line. On the other hand, the perturbation plot (Figure 2b and 2c) gives information on which factors that have the most influence on the biological efficiency and growing day based on the gradience of the linear line. The highest gradience value of the factor implies the most significant effect on the studied response.

Referring to Figure 2(b), the most influenced parameter to the biological efficiency of mushroom production is B, the mass of lime, followed by A, the volume of EM. Furthermore, this plot implies that the positive gradient of all variables indicated that the proportional linear relationship between these variables with the biological efficiency of mushroom. On the other hand, from Figure 2(d), the volume of EM give significant effect on growing day for mushroom cultivation with the positive linear relationship. However, parameter B which is a mass of lime has a negative linear relationship which means increasing amount of lime will reduce the growing day for mushroom. This is because EM is a crucial material to break down the complex structure of the paddy straw while lime just needed in a small amount to balance the pH of the paddy straw [10-11].

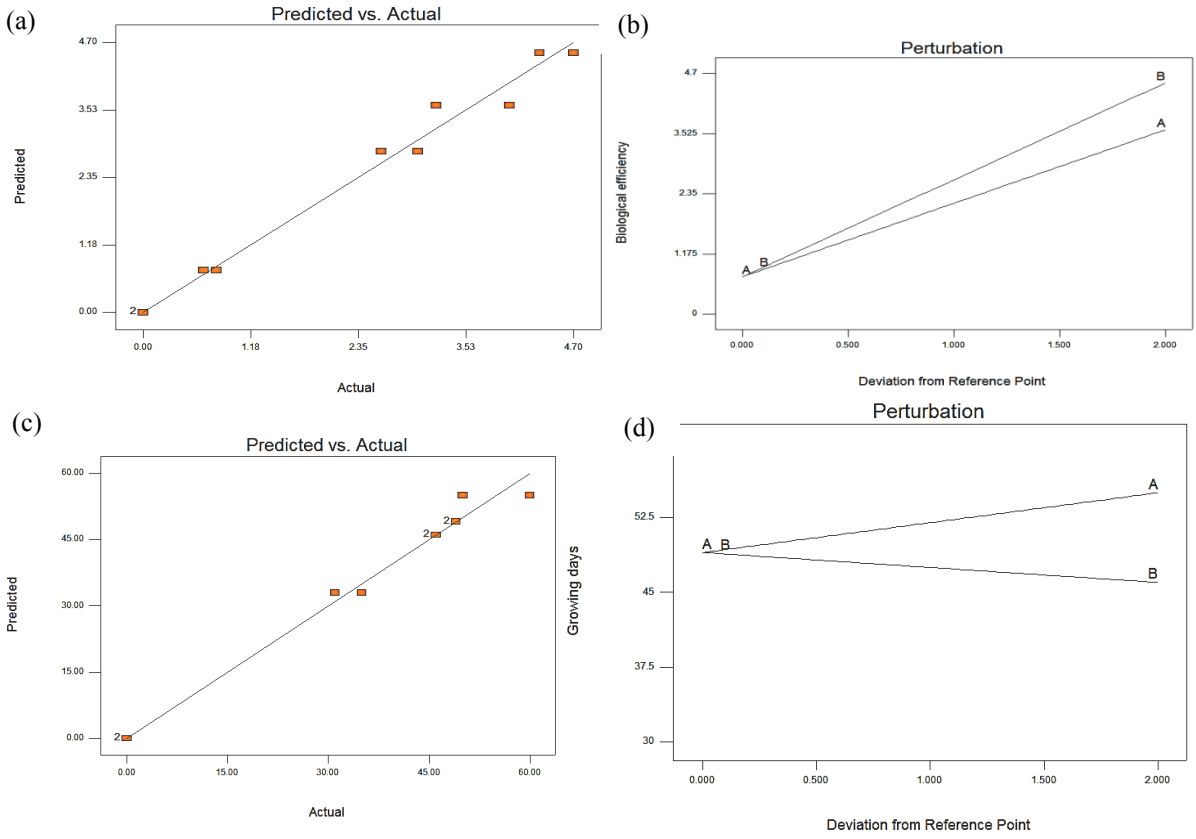

Figure 2. (a) Predicted values and (b) Pertubation plots for biological efficiency; (c) Predicted values and (d) Pertubation plots for growing day.

The samples 1 and 2 which only consist paddy straw without EM and lime shows longer time to complete colonizing which is 49 days. This is because there is no catalyst to speed-up the process of the decomposition of the paddy straw, while in other samples the time taken for the oyster mushroom will be shorter but varied according to the composition of EM and lime in the sample. EM plays a vital role in producing oyster mushroom because it accelerates the decomposition of the paddy straw. For the sample of 2 ml EM with 15 g lime it also showed the positive result because the biological efficiency is quite higher which is 3% and the growing days is shorter (31 days). But if the volume of the EM is increased to 4 ml of EM the biological efficiency will be higher (4.7%).

Based on the results obtained, it shows that oyster mushroom unable to grow in 4 ml of EM and 30 g of lime. This might be due to unsuitable growth condition for mushroom cultivation using paddy straw. But, it can be seen that oyster mushroom can grow in either lime and EM treatment. Although the biological efficiency for 30 g lime is almost 4% close to 4 ml of EM sample which is 4.7%, but it took a longer time (60 days) to grow mushroom than 4 ml of EM (46 days). It is concluded that oyster mushroom will give more yield and a higher biological efficiency (4.7%) on paddy straw waste containing a high amount of 4 ml of EM. Besides giving higher biological efficiency this composition will also produce healthy, thicker, and fresh mushrooms. This is because EM act as a catalyst to speed-up the reaction to grow the mushroom faster and also it encourages the quick breakdown of organic substances and suppress harmful micro-organisms [1]. While lime gives minor effect on the growing days of oyster mushroom because its function is to control the pH of the cultivation media, so that the media is not too acidic nor too alkaline for the mushroom to grow [7,12]. Figure 3 shows the mushroom production with 4 ml of EM.

Figure 3. Mushroom production with 4 ml of EM without the presence of lime.

Figure 4 shows the 3D response surface plot for oyster mushrooms biological efficiency. The highest weight of mushroom can be obtained when the value of EM is at the highest level (4 ml). On the other hand, the lowest biological efficiency of mushroom was obtained when there is highest EM (4 ml) and lime (30 g). This is because EM helps in improvement of the average yield of mushrooms as well as the number of cropping season and increases the rate of the decomposition of the substrate while lime is required to make sure that pH level is optimum for the oyster mushroom [1]. That is shown in the Figure below although the lime is in the smaller amount the mushroom still can grow with the help of EM.

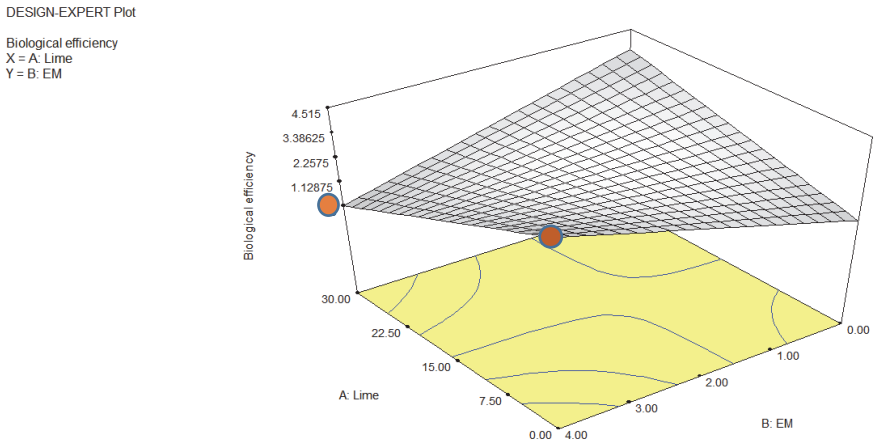

Figure 4. 3D Response Surface for Oyster mushrooms Biological Efficiency.

4. CONCLUSION

Different levels of lime and EM were studied in substrate preparation for the effective cultivation of Oyster mushroom (*Pleurotus* spp.). From this research results, it can be seen that EM and lime gives a positive effect on the oyster mushroom growing on paddy straw. The mushroom produced are healthy and grow in a short period of time (31 days). The results obtained from this study showed that the treatment with 4 ml of EM and 2 ml of EM plus 15 g lime showed the best composition than the others sample. 4 ml of EM samples show the higher biological efficiency which is 4.7% and for less growing days 2 ml of EM plus 15 g lime sample produce mushroom only in 31 days. Effective microorganisms give the most significant effect on the biological efficiency and growing days of oyster mushroom by increasing the biological efficiency while reducing the growing days. Thus, lime gives effect only in increasing the biological efficiency of oyster mushroom.

ACKNOWLEDGEMENTS

The author is grateful to School of Bioprocess Engineering, University Malaysia Perlis for providing the facilities to carry out the research. The research is funded by Short Term Grant STG/2016/9001-00553.

REFERENCES

[1] A. F. Condor Golec, P. González Pérez & C. Lokare. (2007). Effective Microorganisms: Myth or reality? Rev. peru. biol. 14(142), 315–319.

[2] A. Tesfaw, A. Tadesse & G. Kiros. (2015). Optimization of oyster (Pleurotus ostreatus) mushroom cultivation using locally available substrates and materials in Debre Berhan, Ethiopia. *J. Appl. Biol. Biotechnol.*, 3(01), 015-020.

[3] D. K. Bhattacharjya, R. K. Paul, M. N. Miah & K. U. Ahmed. (2014). Effect of different saw dust substrates on the growth and yield of oyster mushroom. *J Agric Vet Sci*, 7(2), 38–46.

[4] W. C. Victor and W. Ifeanyi. (2012). The Effect of Nutrient Concentration on the Yield of Mushroom (Pleurotus Osttreatus). *Greener Journal of Agricultural Sciences*, 3(6), 437-444.

[5] Nayak, K. B., V, Bathmarajan, Nanda & A. (2015). Effect of substrate and environmental parameters on the production of oyster mushroom in Pondicherry. Der Pharm. Lett., 7(8), 74–79.

[6] R. M. Josephine. (2015). Review Article a Review on Oyster Mushroom (Pleurotus Spp). *International Journal of Current Research,* 7(01), 11225-11227.

[7] E. H. Quaicoe, C. Amoah, M. Obodai & G. T. Odamtten. (2014). Nutrient Requirements and Environmental Conditions for the Cultivation of the Medicinal Mushroom (Lentinula Edodes) (Berk.) In Ghana. *Int. J. Sci. Technol. Res.*, 3(12), 45–50.

[8] D. Granato & V. M. de Araújo Calado. (2013). The use and importance of design of experiments (DOE) in process modelling in food science and technology. *Math. Stat. Methods Food Sci. Technol.*, 1–18.

[9] Z. Girmay, W. Gorems, G. Birhanu & S. Zewdie. (2016). Growth and yield performance of Pleurotus ostreatus (Jacq. Fr.) Kumm (oyster mushroom) on different substrates. AMB Express, 6(1), 1–7.

[10] D. Bao *et al.* (2013). Sequencing and Comparative Analysis of the Straw Mushroom (Volvariella volvacea) Genome. PLoS One, 8(3).

[11] M. K. Biswas & M. Layak. (2014). Techniques for Increasing the Biological Efficiency of Paddy Straw Mushroom (Volvariella Volvacea) in Eastern India. Food Sci. Technol., 2(4), 52–57.

[12] M. W. Khan, M. A. Ali, N. A. Khan, M. A. Khan, A. Rehman & N. Javed. (2013). Effect of Different Levels of Lime and Ph on Mycelial Growth and Production Efficiency of Oyster Mushroom (Pleurotus Spp.)., *Pakistan Journal of Botany*, 45(1), 297–302.