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Cultivation of Reishi Mushroom *(Ganoderma lucidum)* on Sawdust of Different Tree Species

Kamal Hossain, Nirod Chandra Sarker, A. J. Kakon, Abdus Salam Khan and Saleh Ahmed

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Abstract

Mangifera indica (Mango), *Eucalyptus camaldulensis* (Eucalyptus), *Tectona grandis* (Teak), *Albizia richardiana* (Root Chambol), *Bombax ceiba* (Shimul), *Albizia procera* (Sheel Koroi), *Borasus flabellifer* (Taal) and mixed sawdust were evaluated as the substrate of *Ganoderma lucidum.* The mycelium growth rate and days to completion of mycelium running in spawn packet were different in the sawdust of different tree species. Considerable variation was found in the time of antler initiation, conk formation and development of fruiting bodies. No significant variation was observed in number of fruiting bodies. The highest biological yield (22.00 g/packet), dry yield (6.13 g/packet) and biological efficiency (11.00%) were observed in mixed sawdust followed by *Mangifera indica, Albizia procera and Albizia richardiana* while *Borasus flabellifer* sawdust performed poorly.

Key words: *Ganoderma lucidum,* sawdust, growth and yield.

INTRODUCTION

Reishi *(Ganoderma lucidum)* is one of the most famous traditional Chinese medicinal herb, is used as a healthy food and medicine in the Far East for more than 2000 years (Fang and Zhong, 2002). It is wood decaying mushroom occurring on conifers, hardwoods and monocotyledonous species throughout the world (Gottlieb *et al.,* 1998). It is normally cultivated on solid substrates or other lignocelluloses materials such as straw, sawdust and log (Riu *et al.,* 1997 and Stamets, 2000). A successful artificial cultivation of *Ganoderma lucidum* has been reported on most broad-leaf hardwood trees and commonly used species include oak, pecan, elder, choke cherry, and plum (Chen, 1999 and Chen and Chao, 1997). Moreover, *Ganoderma* species can be cultivated on the sawdust which may originate from different kinds of trees described by Wasser (2005) and Olei (2003). Hardwood sawdust is the basic substrate for the cultivation of most medicinal mushrooms (Chen, 1999) and the growth and development of them varied from one tree species to another (Ayodele, 2007). However, hardwood sawdust and wheat bran mixture may be used in production of *Ganoderma lucidum* (Peksen and Yakupoglu, 2009 and Yang *et al.,* 2003). In Bangladesh, very little information on various kinds of sawdust and bran in the cultivation of *Ganoderma lucidum* is available. A large amount of sawdust of *Mangifera indica, Eucalyptus camaldulensis, Tectona grandis, Bombax ceiba, Albizia richardiana, Albizia procera, Borasus flabellifer, Artocarpus heterophyllus and Dalbergia sissoo* etc tree species are available which are not yet tested as the substrate of *Ganoderma lucidum.*

The present study was therefore undertaken to identify the sawdust of suitable tree species for growing reishi mushroom.

MATERIALS AND METHODS

The experiment was conducted at the National Mushroom Development and Extension Centre, Sobhanbag, Savar, Dhaka during the months of March to August 2009. Eight different kinds of sawdust viz. *Mangifera indica* (Mango), *Eucalyptus camaldulensis* (Eucalyptus), *Tectona grandis* (Teak), *Albizia richardiana* (Root Chambol), *Bombax ceiba* (Shimul), *Albizia procera* (Sheel Koroi), *Borasus flabellifer* (Taal) and different kinds of mixed sawdust were used as treatments.

Spawn packet preparation: The substrates of spawn packets were prepared by using selected plant sawdust and wheat bran. Each spawn packet was prepared by mixing sawdust as treatment and wheat bran at the ratio of 2:1. Water was added to make the moisture content 60% and $CaCO_3$ was added at the rate of 0.2% of the mixture. Polypropylene bags of 7″×10″ size were filled with 500g of substrate mixture and their mouths were plugged by inserting water absorbing cotton with the help of plastic neck and rubber. The bags were autoclaved at 121 ^{0}C and 1.0 kg/cm^2 for 2 hours. After autoclaving and cooling, the bags were inoculated separately with the mother culture of *Ganoderma lucidum-6* at the rate of 1 teaspoonful per packet. Then the packets were incubated in the incubation room for mycelial growth.

Experimental condition: In incubation period, the inoculated packets were kept in almost dark at about 25 ^{0}C temperature. After completion of mycelium running, spawn packets were opened by square sized (1×1cm) cut on the single side middle abdomen of the packet and transferred to the culture room at 25-32 ^{0}C temperature, 85-95% relative humidity and 250-350 lux light. Water was sprayed 4-5 times per day and proper aeration was maintained in culture house to develop the fruiting bodies. The yield was obtained from a single flush in the harvest period.

Biological yield in g/packet was recorded by weighing the whole fruiting bodies. Dry yield in g/packet was recorded by weighing the fruiting bodies after drying and biological efficiency was determined for each packet by the following formula:

$$\text{Biological efficiency (\%)} = \frac{\text{Total biological yield (g)}}{\text{Total dry substrate used (g)}} \times 100$$

Data collection and statistical analysis: The experiment was laid out following completely randomized design (CRD) with 4 replications. Data on mycelium growth rate, days required for completion of mycelium running, antler initiation and conk formation, number of fruiting bodies, length of stalk, diameter of stalk, diameter of pileus, thickness of pileus, biological yield, dry yield and biological efficiency were recorded and analyzed following Gomez and Gomez (1984) using MSTAT-c computer program. Means separation were computed following Duncan's Multiple Range Test (DMRT) using the same computer program.

RESULTS AND DISCUSSION

Mycelium growth: Considerable variation was found in mycelium growth of *Ganoderma lucidum* in sawdust of different tree species (Table 1). The highest mycelium growth rate (0.43 cm/day) was found in *Eucalyptus camaldulensis* which was statistically similar to mixed sawdust (0.41 cm/day), *Mangifera indica* (0.40 cm/day) and *Bombax ceiba* (0.39 cm/day). The poor mycelium growth rate (0.33 cm/day) was found in *Borasus flabellifer*. Days required for completion of mycelium running (DRCMR) in spawn packet was strongly correlated with mycelium growth rate. The DRCMR in spawn packet ranged from 26.25 to 33.50. Significantly the lowest DRCMR (26.25) was found in *Eucalyptus camaldulensis* which was statistically similar to mixed sawdust (28.50 days) and *Bombax ceiba* (30.00 days) while highest DRCMR (33.50) was recorded in *Borasus flabellifer*. The poor growth of mushroom mycelium on *Borasus flabellifer* and some other wood species may be due to the fact that the mushroom could not produce appropriate enzymes that could hydrolyze and convert the substrate for its vegetative growth. This observation was also supported by Okhuoya *et al.* (1998) who reported that mushroom could not grow well on sawdust of some tree species.

Table 1. Effect of sawdust of different tree species on mycelia growth of *Ganoderma lucidum*

Sawdust	Mycelium growth rate in spawn packet (cm/day)	Days required for completion of mycelium running (DRCMR)
Mangifera indica	0.40 ab	29.25 cd
E. camaldulensis	0.43 a	26.25 e
Tectona grandis	0.36 bc	31.25 abc
Albizia richardiana	0.37 bc	31.75 abc
Bombax ceiba	0.39 ab	30.00 bcd
Albizia procera	0.36 bc	32.00 ab
Borasus flabellifer	0.33 c	33.50 a
Mixed sawdust	0.41ab	28.50 de
CV (%)	6.36	5.78

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Development of fruiting body: The reproductive growth of *Ganoderma lucidum* varied from one wood species to another (Table 2). The first antler initiation (from opening to primordia), within 3.75 days, was recorded on *Mangifera indica* sawdust which was statistically similar to all the treatments except *Tectona grandis* and *Borasus flabellifer* while it takes the longest time on *Borasus flabellifer* (11.75 days). The lowest time required from opening to conk development (10.25 days) was recorded both in *Mangifera indica* and mixed sawdust. The highest period of conk formation (21.00 days) was observed in *Borasus flabellifer* which was significantly higher to all the treatments. Number of fruiting bodies did not differ significantly in the sawdust of different tree species.

Size of fruiting body: Length and diameter of stalk of fruiting bodies produced on sawdust of different tree species ranged from 1.18 to 2.68 cm and 0.95 to 1.50 cm respectively (Table 2). The highest length of stalk (2.68 cm) was recorded on *Albizia* *procera* while highest diameter of stalk (1.50 cm) was found on *Bombax ceiba.* The least length of stalk (1.18 cm) and diameter of stalk (0.95 cm) were recorded in *Mangifera indica* and *Borasus flabellifer* respectively. The highest diameter of pileus (6.05 cm) was recorded in mixed sawdust which was statistically similar to all the treatments except *Borasus flabellifer* (4.00 cm). The highest thickness of pileus (1.53 cm) was recorded in *Albizia procera* which was statistically similar to all the treatments except *Tectona grandis* and *Borasus flabellifer*. The lowest thickness of pileus (1.13 cm) was observed in *Borasus flabellifer*.

Table 2. Effect of sawdust of different tree species on the development and size of fruiting bodies of *Ganoderma lucidum*

Sawdust	Days required for antler initiation	Days required for conk formation	Number of fruiting bodies	Length of stalk (cm)	Diameter of stalk (cm)	Diameter of pileus (cm)	Thick-ness of pileus (cm)
Mangifera indica	3.75 b	10.25 d	1.50 a	1.18 c	1.13 bc	5.13 ab	1.50 a
E. camaldulensis	4.00 b	11.25 cd	1.50 a	1.50 bc	1.35 ab	5.03 ab	1.48 a
Tectona grandis	9.75 a	16.50 b	1.00 a	2.35 ab	1.25 abc	4.58 ab	1.28 bc
Albizia richardiana	5.75 b	12.25 cd	1.50 a	1.65 bc	1.10 bc	5.73 a	1.38 ab
Bombax ceiba	5.25 b	14.50 bc	1.00 a	1.53 bc	1.50 a	4.88 ab	1.50 a
Albizia procera	6.50 b	13.00 cd	1.50 a	2.68 a	1.30 abc	5.60 ab	1.53 a
Borasus flabellifer	11.75 a	21.00 a	1.00 a	1.95 abc	0.95 c	4.00 b	1.13 c
Mixed sawdust	4.00 b	10.25 d	1.50 a	1.23 c	1.33 ab	6.05 a	1.50 a
CV (%)	27.82	15.64	34.72	36.53	18.11	20.22	9.36

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Biological yield, dry yield and biological efficiency: Significant difference was observed in biological yield, dry yield and biological efficiency of reishi mushroom on sawdust of different tree species (Table 3). The highest biological yield (22.00 g/packet) was obtained from mixed sawdust followed by *Mangifera indica* (20.50 g/packet), *Albizia procera* (19.25 g/packet) and *Albizia richardiana* (19.00 g/packet). *Borasus flabellifer* gave poorest yield (11.50 g/packet) which was statistically similar to *Tectona grandis*. Almost similar trend was observed in dry yield and biological efficiency of *Ganoderma lucidum* on the sawdust of different tree species. The biological efficiency was highest (11.00%) in mixed sawdust which was followed by *Mangifera indica* (10.25%), *Albizia procera* (9.63%) *and Albizia richardiana* (9.50%) while lowest biological efficiency (5.75%) was observed in *Borasus flabellifer*. The results are in agreement with Erkel (2009), who stated that yield and biological efficiency of *Ganoderma lucidum* varied widely, depending on the kinds of different sawdust, bran and their combinations.

Table 3. Effect of sawdust of different tree species on biological yield, dry yield and biological efficiency of *Ganoderma lucidum*

Sawdust	Biological yield (g/packet)	Dry yield (g/packet)	Biological efficiency (%)
Mangifera indica	20.50 ab	5.88 a	10.25 ab
E. camaldulensis	17.00 bc	4.38 b	8.50 bc
Tectona grandis	14.00 cd	3.13 cd	7.00 cd
Albizia richardiana	19.00 ab	5.00 ab	9.50 ab
Bombax ceiba	17.25 bc	4.25 bc	8.63 bc
Albizia procera	19.25 ab	5.13 ab	9.63 ab
Borasus flabellifer	11.50 d	2.63 d	5.75 d
Mixed sawdust	22.00 a	6.13 a	11.00 a
CV (%)	14.21	17.26	14.21

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

REFERENCES

Ayodele, S. M., Akpaja, E. O. & Anyiador, F. 2007. Evaluation of yield of *Lentinus squarrosulus* (Mont.) Singer on selected economic tree species. *Pak. J. Biol. Sci.* **10**(23): 4283-4286.

Chen, A. W. 1999. Cultivation of the medicinal mushroom *Ganoderma lucidum* (Curt.:Fr.) P. Karst. (Reishi) in North America. *Int. J. Med. Mushroom.* **1**: 263-282.

Chen, K. L. & Chao, D. M. 1997. Ling Zhi (*Ganoderma* species). **In: Chinese Medicinal Mycology.** (Ed.) K. T. Hsu, United Press of Beijing Medical University and Chinese United Medical University. Beijing, China. pp. 496-517.

Erkel E. I. 2009. The effect of different substrate mediums on yield of *Ganoderma lucidum* (Fr.) Karst. *Journal of Food, Agriculture & Environment.* **7**(3&4): 841-844.

Fang, Q. H. & Zhong, J. J. 2002. Effect of initial pH on production of ganoderic acid and polysaccharide by submerged fermentation of *Ganoderma lucidum. Process Biochemistry.* **37**(7): 769-774.

Gomez, K. A. & Gomez, A. A. 1984. **Statistical Procedures for Agricultural Research**, John Wiley and Sons. Inc. New York. pp. 304-307.

Gottlieb, A. M., Saidman, B. O. & Wright, J. E. 1998. Isoenzymes of *Ganoderma* species from South America. *Mycological Research.* **102**: 415-426.

Okhuoya, J. A., Akpaja, E. O. & Abbot, O. 1998. Cultivation of *Lentinus esquarrosulus* on sawdust of selected tropical tree species. *Int. J. Med. Mushroom.* **7**: 213-218.

Olei, P. 2003. **Mushroom Cultivation.** Backhuys Publishers, Leyden, The Netherlands. p. 429.

Peksen, A. & Yakupoglu, G. 2009. Tea waste as a supplement for the cultivation of *Ganoderma lucidum. World J. Microbiol.* Biotechnol. **25**: 611-618.

Riu, H., Roig, G. & Sancho, J. 1997. Production of carpophores of *Lentinus edodes* and *Ganoderma lucidum* grown on cork residues. *Microbiologia.* SEM. **13**: 97-103.

Stamets, P. 2000. **Growing of Gourmet and Medicinal Mushrooms.** 3rd Edn, Ten Speed Press, Berkeley, California, USA. p. 574.

Wasser, S. P. 2005. Reishi or Ling Zhi (*Ganoderma lucidum*). **Encyclopedia of Dietary Supplements**. pp. 603-622.

Yang, F. C., Hsieh, C. & Chen, H. M. 2003. Use of stillage grain from a rice-spirit distillery in the solid state fermentation of *Ganoderma lucidum*. Proc. Biochemistry. **39**(1): 21-26.

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Effect of Oyster Mushroom (*Pleurotus ostreatus*) on Hepatocellular Markers Alanine Aminotransferase and Aspartate Aminotransferase of Adult Human During Ramadan

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Abstract

The study was undertaken to investigate the effect of oyster mushroom (*Pleurotus ostreatus*) on the serum level of human hepatocellular enzymes such as Alanine Aminotransferase (ALT) and Aspartate Aminotransferase (AST) which are considered as common liver function tests (LFTs). The feeding of fresh oyster mushroom at the Ifter table during Ramadan fasting significantly decreased the serum levels of AST and ALT as compared to those of the control subjects. These results suggest that *P. ostreatus* may able to ameliorate human for hepatocellular functions significantly.

Key words: *P. ostreatus,* ALT, AST, Ramadan, Ifter.

INTRODUCTION

Mushroom is a nutritious food containing a lot of molecules which can improve health and disease status of the body. It is a good source of digestible proteins and fiber. It is a low calorie food with very little fat and sugar and with no starch and cholesterol. In addition vitamin and mineral content are riched in mushroom (De Roman, *et al.,* 2006 and Pathak, *et al.,* 1998). Mushrooms are not only sources of nutrients but have also been reported as therapeutic foods. Some compounds isolated and identified from mushrooms, show quite significant medicinal properties, such as immuno-modulatory, and protective of cardiovascular diseases, hepatoprotective, anti-fibrotic, anti-inflammatory, anti-diabetic, and antimicrobial activities (Wasser and Weis, 1999, Gunde- Cinoerman, 1999 and Ooi, 2000). Mushroom of *Pleurotus* species are rich in medicinal value and very much effective in reducing harmful plasma lipids and improving the levels of different cellular enzymes (*Alam et al.,* 2007). Although mushroom is one of the top priority foods in different countries, still it is not established as food in Bangladesh. But its popularity is increasing day by day due to its nutritious and medicinal value.

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It is generally known that lowering of serum cholesterol levels reduces the risk of atherosclerosis and improves liver condition. Identification and characterization of natural substances with hypocholesterolemic activity useful in diabetes prevention or treatment of hypercholesterolemia is still relevant to countries with persistent progression of hypercholesterolemia. Addition of oyster mushroom (*P. ostreatus*) to the diet effectively reduced cholesterol accumulation in serum and liver of adult human (Opletal *et al.*, 1997 and Jayakumar *et al.*, 2006).

Oyster mushroom increases the levels of reduced glutathione in the liver and stimulates the activities of catalase and glutathione peroxidase in the liver (Pathak *et al.*, 1998). It had been reported that isolated mushroom β-glucans from *P. ostreatus* lowered the serum cholesterol concentration (Bobek *et al.*, 1991).

Ramadan is the ninth month of lunar calender, when the Muslims prevent themselves from taking any food or drinks from dawn to dusk. It is believed that Ramadan improves health status. The body has regulatory mechanisms that reduce the metabolic rate and ensure efficient utilization of the body's fat reserves in times of hunger. Add to this the fact that most people assume a more sedentary lifestyle whilst fasting and the implication is that a balanced diet that is even less in quantity that normal will be sufficient to keep a person healthy and active during the month of Ramadan. So the addition of edible mushroom as an ifter item is a fruitful purpose to improve the health and disease status of body such as the status of liver by improving the traditional hepatocellular enzymes as ALT, AST.

ALT is a transaminase enzyme. It is also called serum glutamic pyruvic transaminase (SGPT) or alanine aminotransferase (ALAT). It is found in various bodily tissues, but is most commonly associated with the liver. It catalyzes the two parts of the alanine cycle. Estimation of ALT in plasma or serum is one of a group of tests known as liver function tests (LFTs) and is used to monitor damage to the liver parenchymal cells. AST also called serum glutamic oxaloacetic transaminase (SGOT) or aspartate aminotransferase (ASAT/AAT/AspAT) is an enzyme that is raised in the plasma in acute liver damage, as with liver cancer or hepatitis. It is also found in red blood cells, cardiac muscle, skeletal muscle, the pancreas, and the kidney. In LFTs, an elevated level of AST is a sign of serious liver damage, even before any other symptoms are seen in the patient (Annon., 2010a). AST is similar to ALT in that it is another enzyme associated with liver parenchymal cells. ALT is found predominately in the liver, with lesser quantities found in the kidneys, heart, and skeletal muscle. As a result, the ALT is a more specific indicator of liver inflammation than the AST, as the AST may also be elevated in diseases affecting other organs, such as the heart muscles in myocardial infarction, also in acute pancreatitis, acute hemolytic anemia, severe burns, acute renal disease, musculoskeletal diseases, and trauma. AST is commonly measured clinically as a part of diagnostic liver function tests, to determine liver health (Annon., 2010b). So the aim of this investigation is to evaluate the effect of mushroom on hepatic markers as AST & ALT of fasting subjects during Ramadan.

MATERIALS AND METHODS

The study was conducted during the period of 21st August 2009 to 17th September 2009 with the collaboration of Strengthening Mushroom Development Project, National Mushroom Development and Extension Center (NAMDEC), Sobhanbag, Savar, Dhaka.

Subjects: Total 108 subjects were included in the study. They were divided into two groups. In group-I, 54 subjects of 28 families aged (years) from 25 to 80 who were at the grip of the monitoring team wanting to be fast in the whole Ramadan. Among them 25 were male and 29 female. And in group-II, 54 normal both male and female volunteers aged from 27 to 75 also wanting to be fast in whole Ramadan were considered. In this group 27 were male and 27 female.

Selection criteria: The Subjects were clarified about the study and after getting their written consent they were included. The details history was taken from the subjects which included age, sex, occupation, educational status, marital status, family history and drug history. Patients suffering from acute illness and non fast persons were excluded.

In the study previously divided 2 groups were included. Group-II was studied without mushroom supplementation. If any drugs previously getting by the subjects, it was continued. Fifty grams of fresh *P. ostreatus* mushroom was ensured for each individual of group-I by the responsible workers daily by home visits or from the research center. The mushrooms were collected from NAMDEC. At the beginning of Ramadan, subjects were evaluated for health status. Fasting blood sample was collected for analysis of ALT and AST. Just after ending of Ramadan the subjects were evaluated and all the investigation procedures were repeated. ALT and AST were estimated by semi-auto analyzer (3000 evaluation) using the reagent kit (Atlas, England).

Statistical analysis: The recorded characteristics of the subjects during Ramadan fasting analyzed by standard statistical methods using computer software, SPSS package programme.

RESULTS AND DISCUSSION

In G-I who was supplemented with mushroom as ifter item, the mean ± SD serum ALT (U/L) before and after Ramadan was 17.87 ± 7.72 and 14.81 ± 5.42 respectively. A statistically significant mean difference of ALT ($p < 0.001$) observed in pre and post Ramadan state. The mean ± SD serum level of AST of pre and post Ramadan samples were 27.65 ± 10.50 and 24.59 ± 7.49 respectively. Here also a statistically significant mean difference between the two periods ($p < 0.01$) observed (Table 1).

Table 1. Evaluation of serum ALT and AST of G-I subjects who were supplemented mushroom in Ifter

Name of hepatocellular marker	Number of subjects (n)	Period of observation	Mean ± SD (U/L)	p
ALT	54	Pre Ramadan	17.87 ± 7.72	0.000
		Post Ramadan	14.81 ± 5.42	< 0.001
AST	54	Pre Ramadan	27.65 ± 10.50	0.002
		Post Ramadan	24.59 ± 7.49	< 0.01

Results show mean ± SD. Data were analyzed by Pair t test. Means were significantly different at $p<0.05$ at 95% confidence limit. (ALT= Alanine Aminotransferase and AST= Aspartate Aminotransferase).

In G-II who was not supplemented with mushroom as ifter item, the mean ± SD serum ALT (U/L) before and after Ramadan was 19.9 ± 14.58 and 22.1 ± 14.84 respectively. No statistically significant mean difference of ALT ($p > 0.05$) observed before and after Ramadan. The mean ± SD serum level of AST of pre and post Ramadan samples were 30.16 ± 14.36 and 30.98 ± 13.99, respectively. Here is also no statistically significant mean difference between the two periods ($p > 0.05$). In this observation it is seen that there is no reduction of both serum ALT and AST levels at post Ramadan state. Rather a small raise of these two plasma enzymes seen, ($p > 0.05$) although it is not statistically significant (Table 2).

Table 2. Evaluation of serum ALT and AST of G-I subjects who were not supplemented mushroom in ifter

Name of hepatocellular marker	Number of subjects (n)	Period of observation	Mean ± SD (U/L)	p
ALT	54	Pre Ramadan	19.9 ± 14.58	0.081
		Post Ramadan	22.1 ± 14.84	> 0.05
AST	54	Pre Ramadan	30.16 ± 14.36	0.574
		Post Ramadan	30.98 ± 13.99	> 0.05

Results show mean ± SD. Data were analyzed by Pair t test. Means were significantly different at $p<0.05$ at 95% confidence limit. (ALT= Alanine Aminotransferase and AST= Aspartate Aminotransferase).

Considering the obtained findings of the study it is observed that supplementation of a considerable amount (50 grams per day) of *P. ostreatus* regularly as ifter item (1 month) significantly reduces the hepatocellular enzyme AST and ALT in plasma in comparison to non mushroom supplemented control subjects. Although the exact mechanism is not clear but it might be due to presence of various hepatoprotective substances present in *P. ostreatus*. In a study Bobek *et al.* (1997) observed a significant reduction of cholesterol in serum (31-46%) and liver (25-30%) in Wister rats fed a diet containing 5% *P. ostreatus* for 52 weeks. These observations were supported by the findings of Hossain *et al.* (2003). They suggested that 5% *P. ostreatus* supplementation provides health benefits, at least partially, by acting on the atherogenic lipid profile in the hypercholesterolaemic condition. It is now established that excess lipid accumulation in the liver causes fatty change and ultimately responsible for hepatocellular injury.

In a study Jayakumar *et al.* (2006) observed that administration of the extract of *P. ostreatus* reduces significantly the plasma level of AST, ALT and Alkaline phosphatase (ALP) and increases significantly the hepatic concentration of antioxidant enzymes reduced glutathione (GSH), catalase (CAT), superoxide dismutase (SOD) and glutathione peroxidase (Gpx) on Carbon tetra chloride induced liver damage in male Wister rats.

Although lots of study conducted in different corner of the world with *P. ostreatus* but most of them were limited in animal subjects. This study was conducted among the targeted human population and is consistent with Bobek *et al.* (1997) and Jayakumar *et al.* (2006) which gives the guidelines of hepatoprotective effects of oyster mushroom.

REFERENCES

Alam, N., Hossain, M. S., Khair, A., Amin, S. M. R. & Khan, A. 2007. Comparative effects of mushrooms on plasma lipid profile of hypercholesterolaemic rats. *Bangladesh J. Mushroom*. **1**(1): 15-22.

Annonymous. 2010a. Alanine transaminase. Internet: en.wikipedia.org/wiki/Alanine_transaminase

Annonymous. 2010b. Aspartate transaminase Internet: en.wikipedia.org/wiki/Aspartate_ transaminase.

Bobek, P., Ozdin, L. & Galbavy, S. 1997. Dose and time dependent hypocholesterolemic effect of oyster mushroom *(Pleurotus ostreatus)* in rats. *Nutrition*. **14**(3): 282- 286.

Bobek, P., Ginter, P., Kuniak, L., Jourcovicova, M., Ozdin, L. & Cerven, J. 1991. Effects of mushroom *Pleurotus ostreatus* and isolated fungal polysaccharides on the serum and liver lipids in Syrian hamsters with hyperlipidemia. *Nutrition*. **7**: 105-108.

De-Roman, M., Boa, E. & Woodward, S. 2006. Wild-gathered fungi for health and rural livelihoods. *Proe. Nutr. Soe*. **65**(2): 190-7.

Gunde-Cinoerman, N. 1999. Medicinal value of the genus *Pleurotus* (Fr) P. Karst. *International J. Medicinal Mushroom*. **1**: 69-70.

Hossain, S., Hashimoto, M., Choudhury, E. K., Alam, N., Hussain, S., Hasan, M., Choudhuri, S. K., Mahmud, I. 2003. Dietary mushroom (*Pleurotus ostreatus*) ameliorates atherogenic lipid in hypercholesterolaemic rats. *Clin. Exptl. Pharmacol. Physiol*. **30**: 470–475.

Jayakumar, T., Ramesh, E. & Geraldine, P. 2006. Antioxidant activity of the oyster mushroom, *Pleurotus ostreatus*, on CCl_4-induced liver injury in rats. *Food Chem Toxicol*. **44**(12):1989-96.

Ooi, V. E. C. 2000. Medicinally important fungi. **In: Science and Cultivation of Edible Fungi**. (Ed) V. Griensven. Balkema, Rotterdam: pp. 41-51.

Opletal, L., Jahodár, L., Chobot, V., Zdanský, P., Lukes, J., Brátová, M., Solichová, D., Blunden, G., Dacke, C. G. & Patel, A. V. 1997. Evidence for the anti- hyperlipidaemic activity of the edible fungus *Pleurotus ostreatus*. *Br. J. Biomed. Sci.*. **54**(4): 240-3.

Pathak, V. N., Yadav, N. & Gaur, M. 1998. **Mushroom Production and Processing Technology.** Agrobios (India), Chopasani Road, Jhodhpur, 342002. p. 179.

Wasser, S. P. & Weis, A. L. 1999. Therapeutic properties of substances occurring in higher Basidiomycetes mushrooms: a modern perspective. *Crit. Rev. Immunol*. **19**: 65-95.

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Effect of Different Supplements and their Levels on Growth and Yield of Reishi Mushroom (*Ganoderma lucidum*)

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Abastract

The experiment was carried to study the effect of wheat bran (WB), rice bran (RB), maize powder (MP) and barleycorn powder (BP) supplements to sawdust at 10, 20, 30, 40 and 50% level on growth and yield of reishi mushroom. Significant variations were observed among the parameters studied. Days required from opening to antler initiation and antler to conk formation, numbers of fruiting bodies, diameters of pileus and thickness of pileus were significantly influenced by the supplements and their levels. The highest biological yield (26.75g/packet) was recorded in 30% level of RB. The highest biological efficiency and dry yield were also observed in 30% level of RB supplement which was statistically similar to 50% and 10% level of BP.

Key words: *Ganoderma lucidum*, supplements, yield and biological efficiency.

INTRODUCTION

Genoderma lucidum, one of the most famous traditional Chinese medicinal herbs, is used as a healthy food and medicine in Far East for more than 2000 years (Fang and Zhong, 2002). It contains different types of triterpenes and polysaccharides (Hsieh and Yang, 2004). Reishi mushroom is normally being cultivated in solid substrates such as grains or other lignocellulosic materials such as straw and sawdust (Riu *et al.*, 1997 and Stamets, 2000). Its cultivation on solid substrates and liquid medium has become essential to meet the increasing demands in the international market (Mizuno *et al.*, 1995 and Mayzumi *et al.*, 1997). Substrate supports the growth and development of mycelium and fruiting bodies (Chang and Miles, 1988) and different supplements added to the basal substrate improves growth and yield of mushroom (Hadwan *et al.*, 1997). Higher level of supplementation results higher yield (Yang *et al.*, 2003). Sucrose and wheat and rice bran are generally used as supplement (Chen, 1998). Bahukhandi (1990) used wheat bran, rice bran, oil seed meals, wheat flower, maize powder etc. as supplements in the cultivation of *Pleurotus* species. For reishi mushroom cultivation suitable supplements available in Bangladesh and their levels are not yet determined. This investigation was undertaken to find out the suitable supplements available in Bangladesh and to determine their best levels to sawdust.

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MATERIALS AND METHODS

The experiment was conducted in the National Mushroom Development and Extension centre, Sobhanbag, Savar, Dhaka during April 2009 to August 2009. Various nutritive materials such as wheat bran, rice bran, barleycorn powder, maize powder and five different levels of these supplements were use as treatments.

Spawn packet preparation: Spawn packets were prepared by sawdust mixed with supplements @ 10, 20, 30, 40 and 50 % of rice bran, wheat bran, maize powder and barleycorn powder respectively. Powder of $CaCO_3$ was added to the mixture at the rate of 0.2 % to maintain the pH level at 6.5 to 7. Water was added to make the moisture levels 65%. Polypropylene bags of 7" x 10" size were filled with 500 g mixture of substrate and their mouths were plugged by inserting water absorbing cotton with the help of plastic neck. The bags were autoclaved at 121^0C temperature and 1kg/cm^2 pressure for 2 hours. After autoclaving and cooling, the bags were inoculated with the mother culture of *Ganoderma lucidum* (Gl_4) at the rate of 1- 2 teaspoonfuls per packet. After inoculation, the packets were incubated in the laboratory at about 28 ± 2^0C temperature.

After completion of mycelium running, the spawn packets were opened by square sized (1x1 cm) cut on the single side middle abdomen of the packets and transferred to culture house at 30-36^{0}C temperature and 75-95% relative humidity. Fruiting bodies were harvested according to Royse (1996) when the caps become completely red and the white margin disappeared. Biological yield in g/packet was recorded by fresh weight of harvested mushroom. The biological efficiency was measured by the following formula.

$$\text{Biological efficiency (\%)} = \frac{\text{weight of fresh mushroom fruiting bodies}}{\text{weight of dry substrate}} x100$$

Dry yield in g/packet was recorded by weighing all the fruiting bodies of a packet after drying.

Statistical analysis: The experiment was laid out in a completely randomized design with four replications. Data on mycelium growth rate, days required to antler initiation, days required from antler initiation to conk formation, biological yield and dry yield were recorded and analyzed following Gomez and Gomez (1984) using MSTAT-c computer program. Means were separated and ranked by Duncan's Multiple Ranges Test (DMRT).

RESULTS AND DISCUSSION

The growth parameters, yield attributes and yield of reishi mushroom were significantly influenced by different supplements at different levels (Table 1). Mycelium growth rate varied from 0.45cm to 1.11cm/ day. The highest growth rate of mycelium (1.11 cm/day) was observed in S_2L_3 when rice bran at 30% level was added to sawdust which was significantly higher as compared to other treatments except S_2L_1, S_1L_2, S_3L_2, S_4L_3, S_1L_4, S_3L_4 and S_2L_5. The lowest growth rate (0.45 cm/day) was observed in S_4L_2 when barleycorn powder at 20% level was supplemented to sawdust. Similar results were reported by Triratana *et al.* (1991) where they stated that rice bran, ground corn and ground sorghum provide best mycelial growth and yield of *Ganoderma lucidum*.

The minimum days required from the opening to antler initiation (4.75) was observed in S_1L_1 where 20% wheat bran was added to sawdust which was statistically similar to all the treatment except S_2L_4 and S_3L_3. The maximum days required from the opening to antler initiation (14.50) was observed in S_3L_3 where 30% maize powder was added to sawdust. Amin *et al.* (2007) reported that *Ganoderma lucidum* took 4.25 - 6.13 days for antler initiation when it was grown on sawdust supplemented with 33.33% level of wheat bran.

The lowest days required from antler initiation to conk formation (2.75) was found in S_1L_2 where 20% wheat bran was added to sawdust which was statistically similar to all the treatments except S_2L_2 where 20% rice bran was added to sawdust.

The highest numbers of fruiting bodies (4.00) was recorded in S_3L_4 which was significantly identical to other treatments except S_3L_1, S_3L_2, S_3L_4 and S_4L_4. The lowest numbers of fruiting bodies (1.25) was found in S_3L_3 which was followed by S_3L_1, S_3L_2 and S_4L_4.

The length and the diameter of the stem were ranged from 1.18 to 3.50 cm and 0.80 to 2.78 cm respectively. The differences in length of stem and diameter of stem under various treatments were not significant (Table 1).

The diameter and thickness of pileus were ranged from 3.90 to 7.83 cm and 0.93 to 1.55cm respectively. The highest diameters of pileus (7.83 cm) was observed in S_4L_1 when 10% maize powder was added to sawdust which was statistically similar to S_2L_4, S_4L_5, S_3L_1 and S_2L_3 and the lowest diameters of pileus (3.90cm) was recorded in S_4L_2 which did not differ significantly from S_2L_2 and S_1L_2. The highest thickness of pileus (1.55 cm) was found in S_1L_4 when 40% wheat barn was added and the lowest thickness of pileus (0.93 cm) was observed in S_4L_2 when 20% maize powder was added to sawdust.

The biological yield of *Ganoderma lucidum* was significantly different at different levels of different supplements (Table 1). The highest biological yield (26.75g/packet) was recorded in S_2L_3 when 30% level of rice bran was added to sawdust which was statistically similar to all the treatment except S_4L_4. The lowest biological yield (9.75g/packet) was recorded in S_4L_2. Similar trend was observed in dry yield of reishi mushroom (Table 1) and the highest dry yield (10.88g/packet) was recorded in S_2L_3.

The biological efficiency of *Ganoderma lucidum* was highest (13.38%) in S_2L_3 when 30% level of rice bran was added to sawdust which was statistically similar to all the treatment except S_4L_4. The lowest biological efficiency (4.88%) was observed in S_4L_2 (Fig. 1).

Table 1. Effect of different supplements and their levels to sawdust substrate on growth, yield contributing characters and yield of reishi mushroom

Treatments	Mycelium growth rate (cm/day)	Days required from opening to antler initiation	Days required from antler initiation to conk formation	Number of fruiting body	Length of stem (cm)	Diameter of stem (cm)	Diameter of pileus (cm)	Thickness of pileus (cm)	Biological yield (g/packet)	Dry yield (g/packet)
S_1L_1	0.74b-f	5.75c	4.50ab	2.25a-c	2.65a	1.60a	4.85ab	1.15bc	14.75ab	6.38ab
S_1L_2	1.04ab	4.75c	2.75b	3.50ab	2.75a	1.45a	4.63b	1.43ab	20.75ab	8.00ab
S_1L_3	0.68c-f	5.25c	4.25ab	2.25a-c	2.93a	1.30a	5.38ab	1.30ab	17.25ab	6.50ab
S_1L_4	0.76a-f	5.50c	5.75ab	3.00a-c	2.55a	1.50a	5.58ab	1.55a	20.25ab	7.88ab
S_1L_5	0.69b-f	6.00c	4.25ab	3.25a-c	3.03a	2.78a	5.58ab	1.13bc	23.00ab	9.38ab
S_2L_1	1.03a-c	5.25c	3.75ab	2.50a-c	3.35a	1.60a	5.15ab	1.50ab	20.50ab	9.50a
S_2L_2	0.52ef	7.00bc	8.00a	2.75a-c	1.55a	1.90a	4.50b	1.38ab	18.00ab	6.88ab
S_2L_3	1.11a	7.25bc	4.00ab	3.25a-c	3.50a	2.15a	6.48ab	1.25a-c	26.75a	10.88a
S_2L_4	0.63d-f	12.50ab	5.00ab	2.25a-c	2.78a	2.10a	7.00ab	1.33ab	23.00ab	8.88ab
S_2L_5	0.88a-e	6.00c	4.50ab	3.25a-c	2.63a	1.58a	5.88ab	1.35ab	21.75ab	9.12ab
S_3L_1	0.47f	7.75bc	3.75ab	1.50bc	2.03a	1.85a	6.80ab	1.50ab	20.50ab	7.50ab
S_3L_2	0.90a-d	8.75bc	7.00ab	1.75bc	2.10a	1.63a	5.30ab	1.35ab	14.50ab	6.38ab
S_3L_3	0.53d-f	14.50a	6.75ab	1.25c	1.90a	1.78a	5.90ab	1.25a-c	13.50ab	6.00ab
S_3L_4	0,76a-f	6.75c	5.25ab	4.00a	1.70a	2.60a	5.75ab	1.48ab	21.75ab	8.75ab
S_3L_5	0.47f	7.75bc	4.25ab	2.50a-c	3.00a	0.88a	5.48ab	1.45ab	20.50ab	8.13ab
S_4L_1	0.68b-f	9.50a-c	5.25ab	2.25a-c	3.50a	2.75a	7.83a	1.38ab	25.75a	10.00a
S_4L_2	0.45f	8.50bc	4.25ab	2.00a-c	1.18a	0.80a	3.90b	0.93c	9.750b	4.00b
S_4L_3	0.79a-f	6.25c	5.25ab	2.75a-c	2.13a	2.08a	5.85ab	1.48ab	18.75ab	7.50ab
S_4L_4	0.58d-f	8.00bc	5.75ab	1.75bc	2.63a	2.35a	4.75ab	1.25a-c	16.75ab	6.38ab
S_4L_5	0.55d-f	6.50c	5.50ab	3.00a-c	3.08a	2.58a	6.98ab	1.25a-c	26.00a	10.75a
CV(%)	27.87	15.20	20.83	36.86	32.15	32.52	24.17	18.46	21.12	20.53

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

S_1= wheat bran, S_2 = rice bran, S_3 = maize powder, S_4 = barleycorn powder, L_1=10%, L_2=20%, L_3 = 30%, L_4 = 40% L_5 =50%

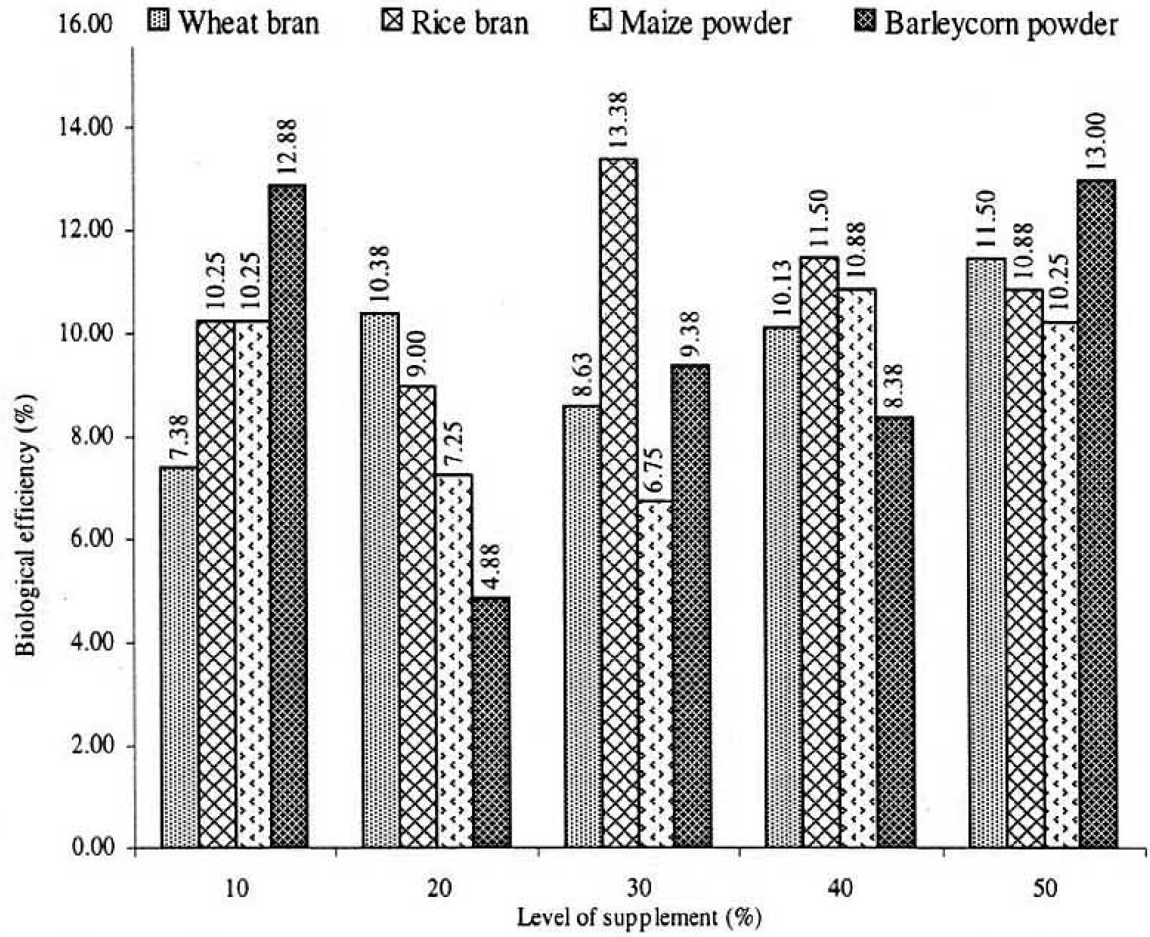

Fig. 1. Effect of different supplements and their different levels on the biological efficiency of *Genoderma lucidum*

REFERENCES

Amin, S. M. R., Sarker. N. C., Jamal. S., Basunia, M. A. & Rahaman, A. 2007. Study on the effect of opening patterns of spawn bag on the production of *Ganoderma lucidum*. *Bangladesh J. Mushroom*. **1** (2): 57-62.

Bahukhandi, D. 1990. Effect of various treatments on paddy straw on yield of some cultivated species of *Pleurotus*. *Indian Phytopath*. **43**: 471-472.

Chen, H. M. 1998. Reutilization of waste materials from a rice distillery for the cultivation of *Ganoderma lucidum*. M. Sc. Thesis. Tunghai University, Taiwan.

Chang, S. T. & Miles, P. G. 1988. *Pleurotus*- A mushroom of broad adaptability. **In: Edible Mushroom and Their Cultivation.** C B S Publishers & Distributors. Bhola Nath Nagar, Shahdara, Delhi-110032. pp. 265-275.

Fang, Q. H. & Zhong, J. J. 2002. Effect of initial pH on production of ganoderic acid and polysaccharide by submerged fermentation of *Ganoderma lucidum*. Proc. Biochem. **37** (7): 769-774.

Gomez, K. A. & Gomez, A. A. 1984. **Statistical Procedures for Agricultural Research.** 2nd ed., John Wiley and Sons. Inc. New York. pp. 304-307.

Hsieh, C. & Yang, F. 2004. Reusing soy residue for the solid-state fermentation of *Ganoderma lucidum*. *Bioresour. Technol.* **91**(1): 105-109.

Hadwan, H. A., Al- Jaboury, M. H. & Hassan. A. A. 1997. Suitability of different substrates and amendments on the cultivation of oyster mushroom. Collection of Thesis Meterials. S & T, Development, Environment and Resources. Proc. '96 (FUZHOU) International Symposium on the development of Juncao industry. pp. 215-221.

Mayzumi, F., Okamoto, H. & Mizuno, T. 1997. Cultivation of Reishi (*Ganoderma lucidum*). *Food Rev. Int.*, **13**: 365–82

Mizuno, T., Wang, G. Y., Zhang, J., Kawagishi, H., Nishitoba T. & Li, J. X. 1995. Reishi, *Ganoderma lucidum* and *Ganoderma tsugae*: bioactive substances and medicinal effects. *Food Rev. Int.*, **11**: 151–66.

Royse, D. J. 1996. **Specialty Mushrooms**. ASHS Pres, Arlington, V. A. pp. 464-475.

Riu, H., Roig, G. & Sancho, J. 1997. Production of carpophores of *Lentius edodes* and *Ganoderma lucidum* grown on cork residues. *Microbiologia* SEM **13**: 97-103.

Staments, P. 2000. **Growing gourmet and medicinal mushroom**. 3rd. ed., Olimpia, WA: Ten Speed Pres.

Triratana, S., Thaithatgoon, S. & Gawgla, M. 1991. Cultivation of *Ganoderma lucidum* in sawdust bags. ISMS Vol. 13. Part 2. Article 20 (Article abstract).

Yang, F. C., Hsieh, C. & Chen, H. M. 2003. Use of stillage grain from a ricespirit distillery in the solid state fermentation of *Ganoderma lucidum*. *Proc. Biochem.* **39**(1): 21-26.

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Effect of Packing Method and Size of Fruiting Body on the Shelf Life of Oyster Mushroom (*Pleurotus ostreatus*)

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Abstract
The experiment was carried out during December 2003 and February to March 2004 to identify the suitable packaging methods for increasing shelf life at ambient conditions and to determine the suitable size of fruiting body for storage. Five different packaging methods and six different sizes of fruiting bodies were used in the experiments. The significantly highest shelf life was recorded in polypropylene bags without perforation and plastic pots (2.44 days) at $23^0C \pm 1^0C$ temperature. The lowest shelf life was found in paper bags (1.13 days). The shelf lives of different sizes of fruiting body ranged from 1.75 to 3.38 days at $23^0C \pm 1^0C$ temperature. The significantly highest shelf life was found in larger sized fruiting body and it decreased with the decrease of sizes. Similar trend was observed at $30^0C \pm 1^0C$ and the lower shelf life was recorded in higher temperature.

Key word: Packing method, *Pleurotus ostreatus,* fruiting body and shelf life.

INTRODUCTION

Mushrooms are fleshy edible fungi containing about 85% to 95% per cent moisture (Pathak and Yadav, 1998). Like all fleshy fruits and vegetables, mushrooms are highly perishable because of their high moisture content and delicate nature and cannot be stored for more than 24 hours at ambient temperature (Kaushal and Sharma, 1995). Once the fruiting body matures, degradation process starts and it becomes un-consumable after some times. Development of brown colour is the first sign of deterioration and is a major factor contributing to quality losses. To send the mushroom to a distance market in fresh form, it is necessary to increase the shelf life of the mushroom. So, the present piece of work was undertaken to develop the techniques for increasing the shelf life of fresh oyster mushroom using different packing materials and different sizes of mushroom.

MATERIALS AND METHODS

Two independent experiments were conducted during December 2003 and February to March 2004 to determine the effect of packing material and size of fruiting body on shelf life of oyster mushroom. For these purposes, the mushroom fungi were grown on waste paper substrate supplemented with wheat bran at 2:1 ratio. The mixture was amended

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with calcium carbonate at 0.57%. The spawn packets were prepared and the mushrooms were cultivated according to Sarker *et al.* (2007). The mushroom was harvested after first flush and used for both the experiments. Hard and dirty base of each stalk of the fruiting body was cut off before packing.

In first experiment fruiting bodies were packed following different methods, viz. polypropylene bag without perforation (T_1), polypropylene bag with five pin hole perforation (T_2), polypropylene bag with 2 punch hole (50 mm) at the top (T_3), paper bag (T_4) and plastic pot with lid (T_5).

Just after harvest of the fruiting bodies of oyster mushroom, the hard and dirty lower part of stalk were removed by a scissors and stored in the packaging materials as mentioned above and kept on a wooden shelf of Plant Tissue Culture Laboratory of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh at ambient temperature.

In second experiment, sporophores of six different sizes were selected on the basis of pileus diameter and thickness of oyster mushroom. Diameter and thickness of pileus was measured in centimeter and multiplied by one another to have a common value. On the basis of the multiplied values the size was determined. Fruiting bodies of size 0.94, 1.68, 3.04, 3.12, 4.97 and 6.81 cm^2 were selected and packed in polypropylene bags at about 40 g per bag. After packing the mushroom was stored on the shelf in tissue culture laboratory.

The shelf life of the mushroom was determined by counting the days from harvesting to off colour and off-odour development. Four packets (replication) were used for each treatment. Both the experiments were conducted twice at 23 ± 1^0C and 30 ± 1^0C temperature. The experiments were laid out in single factor completely randomized design with 4 replications.

RESULTS AND DISCUSSION

Effect of packing method on shelf life: Significantly the highest shelf life of 2.44 days at 23 ± 1^0C and 2.06 days at 30 ± 1^0C was recorded when mushroom was packed in polypropylene bags without perforation (T_1) and in plastic pot with lid (T_5). At both temperature levels the second highest shelf life was recorded when packing was done in polypropylene bags with 5 pin head perforation (T_2) which was followed by bags with two punch holes (T_3). The lowest shelf was found when the mushroom was packed in paper bags (T_4) (Table 1).

In non perforated polypropylene bag and plastic pot with lid, the air movement is restricted. As a result, the physiological activities of living cells of mushroom fruiting body and the activities of mushroom decomposing microorganisms are lower in T_1 and T_5 due to lack of oxygen, which might be the cause of higher shelf life under these treatments.

In the packing methods, the shelf life of mushroom was significantly higher at 23 ± 1°C as compared to 30 ± 1°C (Table 1); because, at low temperature the physiological activity of mushroom is low and the activity of mushroom tissue degrading microorganisms is also low.

Table 1. Effect of different methods of packing on shelf life (day) of oyster mushroom (*Pleurotus ostreatus*) at two temperature levels

Treatment (T)	Shelf life (day) at two temperature levels		Difference
	23 ± 1°C	30 ± 1°C	
T_1= Polypropylene (pp) bag without perforation	2.44 a	2.06 a	0.38**
T_2= Perforated pp bag with 5 pinholes	1.44 b	1.13 b	0.31*
T_3= Perforated pp bag with 2 punch holes	1.25 bc	0.88 c	0.37*
T4= Paper bag	1.13 c	0.81 c	0.32*
T5= Plastic pot	2.44 a	2.06a	0.38**

** = Significant at 1% level, * = Significant at 5% level

The results regarding shelf life, as recorded in the present study are in the agreements with the findings of Minamide *et al.* (1981) who earlier reported that the shelf life of oyster mushroom (*Pleurotus ostreatus*) was approximately 14-20 days at 1°C, 10 days at 6°C and 2-3 days at 20°C. Rai and Sexena (1989) also reported the similar results in case of *Agaricus bisporus*. They found that the activity of polyphenol oxidase (catechol oxidase), which catalyses the browning reaction, at 15°C was almost twice than that at 10° and 5°C. It is concluded that increased browning at higher storage temperatures is due to the direct effect of temperature on enzyme activity.

Effect of size of mushroom on shelf life: At both the temperature levels, the minimum shelf life of mushroom was found when pileus size was 0.94 cm^2 (T_1) which was followed by the sizes 1.68 cm^2 (T_2) and 3.04 cm^2 (T_3). Significantly the highest shelf life was found under the pileus size of 6.81 cm^2 (T_6) at both temperature levels. Shelf life of the mushrooms under the treatments T_4 (3.12 cm^2) and T_5 (4.97 cm^2) was statistically similar and significantly higher as compared to T_1, T_2 and T_3 at 23 ± 1°C and to T_1 and T_2 at 30 ± 1°C (Table 2 and Fig. 1).

The results presented in Table 2 show that shelf life of mushroom ranged 1.25-3.38 days at 23 ± 1°C and 0.84- 2.63 days at 30 ± 1°C temperature under different sizes of pileus. Shelf life was increased gradually with the increase of size of mushroom. The relationship between shelf life and pileus size was linear and could be expressed by the regression equations $y = 0.3449x + 1.1747$ ($R^2 = 0.9243$) at 23 ± 1°C and $y = 0.2999x + 0.6739$ ($R^2 = 0.9513$) at 30 ± 1°C (Fig. 2) where y represented shelf life and x represented size of pileus. Shelf life was significantly higher at 20 ± 1°C as compared to 30 ± 1°C (Table 2).

The results of the present experiment showed the higher shelf life in case of large sized mushrooms. It indicated that large size fruiting bodies contain more hard tissue (hyphae) as compared to smaller fruiting bodies. It took longer time to decompose hard tissue as compared to soft tissues. As a result, shelf life is longer in case of larger fruiting bodies as compared to smaller ones.

Table 2. Effect of size of fruiting body on shelf life of oyster mushroom (*Pleurotus ostreatus*)

Size of pileus (cm^2)	Shelf life (day) at two temperature levels		Difference
	23 ± 1^0C	30 ± 1^0C	
$T_1 = 0.94$	1.25 e	0.81 e	0.73**
$T_2 = 1.68$	1.75 d	1.13 d	0.75**
$T_3 = 3.04$	2.25 c	1.63 c	0.75**
$T_4 = 3.12$	2.63 b	1.88 bc	0.62*
$T_5 = 4.97$	2.88 b	2.13 b	0.44*
$T_6 = 6.81$	3.38 a	2.63 a	0.62*

** = Significant at 1% level, * = Significant at 5% level

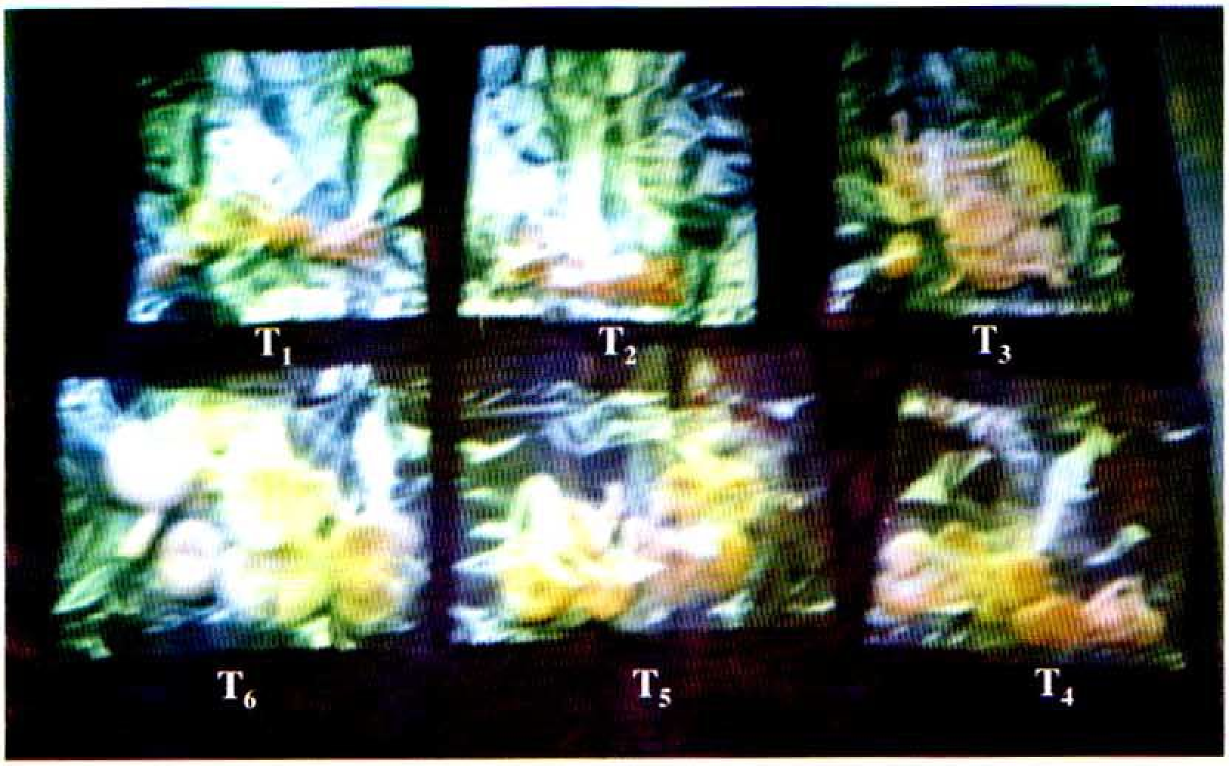

Fig. 1. Effect of different sizes of fruiting body on the shelf life of oyster mushroom ($T_1 = 0.94$ cm^2, $T_2 = 1.68$ cm^2, $T_3 = 3.04$ cm^2, $T_4 = 3.12$ cm^2, $T_5 = 4.97$ cm^2 and $T_6 = 6.81$ cm^2)

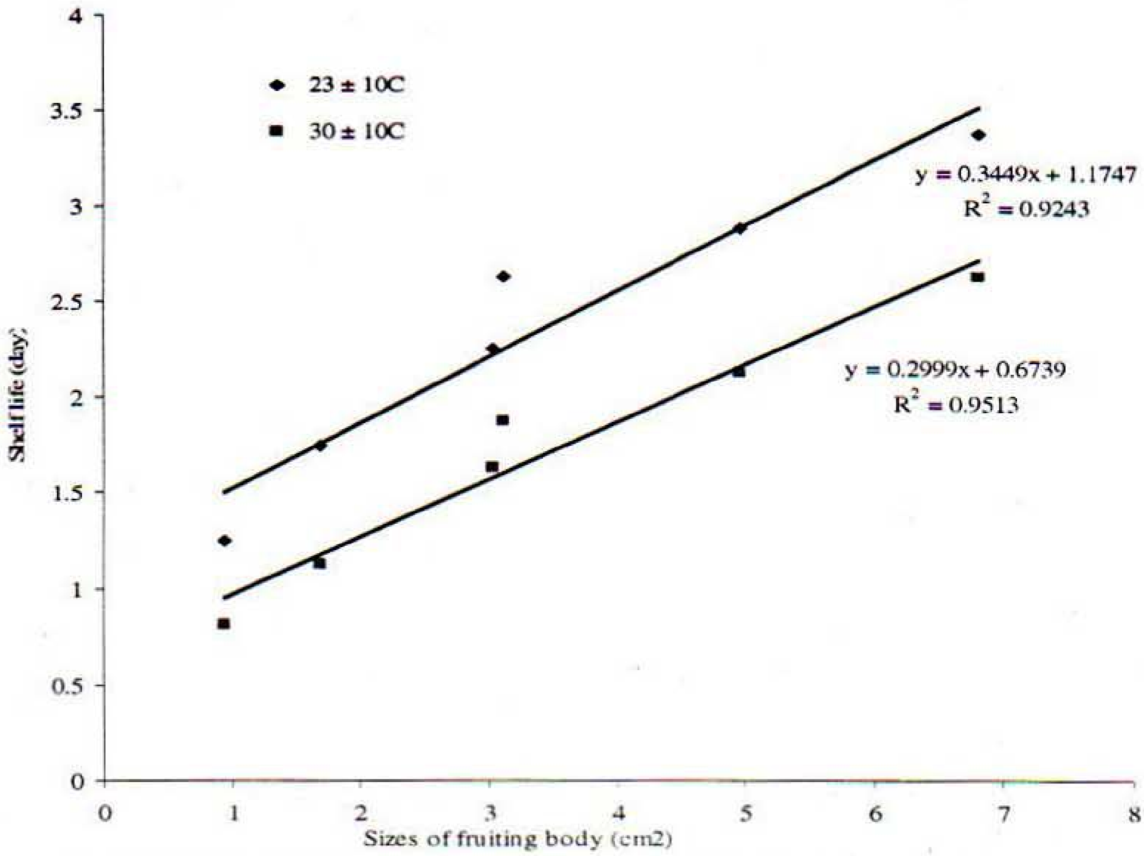

Fig. 2. Relationship between sizes of pileus and shelf life of oyster mushroom

Polypropylene bag and plastic pot are most suitable packaging materials for storage of oyster mushroom in ambient conditions and larger fruiting bodies have longer shelf life. Increased shelf life was recorded in lower temperature. Higher sizes of fruiting bodies may be recommended to store in lower temperature at polypropylene bag or plastic pot. Further research should be conducted on post harvest behavior of different types of mushroom.

REFERENCES

Kaushal, B. B. L. & Sharma, K. D. 1995. Post Harvest Technology of Mushroom. **In: Advances in Horticulture (Mushroom-volume 13)**. Eds. K. L. Chadha and S. R. Sharma. Malhotra Publishing House. New Delhi. pp. 553-566.

Minamide, T., Habu, T. & Ogata, K. 1981. Effect of storage temperature on keeping freshness of mushrooms after harvest. *J. Japanese Soc. Food Sci. and Tech.* 27(15): 281-287.

Pathak, V. N. & Yadav, N. 1998. Preservation and processing. **In: Mushroom Production and Processing Technology.** Agrobios (India). Jodhpur. pp. 138-141.

Rai, R. D. & Sexena, S. 1989. Biochemical changes during post harvest storage of button mushroom (*Agaricus bisporus*). *Curr. Sci.*. **59**: 508-510.

Sarker, N. C., Hossain, M. M., Sultana, N., Mian, I. H., Sirajul Karim, A. Z. M & Amin, S. M. R. 2007. Performance of Different Substrates on the Growth and Yield of *Pleurotus ostreatus* (Jacquin ex Fr.) Kummer. *Bangladesh J. Mushroom*. **1**(2): 9-20.

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Effect of Different Levels of Cow Dung with Sawdust on Yield and Proximate Composition of Oyster Mushroom (*Pleurotus ostreatus*)

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Abstract

Five different levels of cow dung (0% (Control), 5%, 10%, 15%, 20%) were evaluated as the supplement to sawdust substrate of oyster mushroom in the laboratory and mushroom culture house of the Department of Biochemistry, Sher-e-Bangla Agricultural University, Dhaka, during the month of February to July 2009. The mycelium run rate in spawn packet, the number of primordia/packet and weight of individual fruiting body varied significantly in different levels of supplements. The highest biological yield (217.70g), economic yield (213.00g) and dry yield (21.27g) per packet were recorded in sawdust supplemented with 10% level of cow dung. The highest biological efficiency (75.06%) and cost benefit ratio (8.41) were also recorded in the same treatment. The highest level of protein (31.30%), ash (8.41%) and crud fiber (24.07%) and lowest level of lipid (3.44 %) and carbohydrate (32.85%) were found in the mushroom grown on sawdust supplemented with 10% level of cow dung.

Key words: Cow dung, proximate composition and oyster mushroom.

INTRODUCTION

Oyster mushroom (*Pleurotus ostreatus* (Jackuin ex Fr.) Kummer) is large reproductive structures of edible fungi belong to genus *Pleurotus* under the family Tricholomataceae, order Agaricales and the class Basidiomycetes. It is a good source of protein, minerals and vitamins (Chang and Miles, 1989, Sarker, *et al.*, 2007a and Khan *et al.*, 2008). Mushroom production is a profitable agri-business. Substrate is an important factor for its cultivation. Substrate is a kind of medium which supports the growth, development and fruiting of mushroom (Chang and Miles, 1988). Sawdust is popular substrate of oyster mushroom and most of the farmers of Bangladesh grow it on sawdust. Any substrate without supplement is not good enough to give higher yield. Various supplements added to the basal substrate have been found to improve growth and yield (Hadwan *et al.*, 1997). Many scientists evaluated the performance of different agro wastes as supplement. Sarker *et al.* (2007b) used molasses and wheat bran as supplement to sawdust substrate and found 3% molasses combined with 30% wheat bran was the best supplement. Sarker *et al.* (2008) also evaluated the performance of poultry litter as the supplement to waste paper substrate for *Pleurotus ostreatus* cultivation and observed 30-40% level of poultry litter was the best in respect of yield and benefit cost ratio. But cow dung not yet tested as the

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supplement to any substrate of oyster mushroom. Now, the alternate nutrient materials are to be searched for lowering the cost of production.

Substrate plays an important role in nutrient content of oyster mushroom. Sarker *et al.* (2007a) observed a remarkable variation in nutritional content of oyster mushroom in different substrates. So, it is essential to find out the nutritional status of mushroom grown on sawdust supplemented with different levels of cow dung. Therefore, the present piece of work has undertaken to determine the best level of the cow dung supplement to sawdust for higher yield and better quality of oyster mushroom.

MATERIALS AND METHODS

The experiment was carried out at the laboratory and Mushroom Culture House (MCH) of the Department of Biochemistry, Sher-e-Bangla Agricultural University, Dhaka, during February to July 2009. Five different levels of cow dung (T_1= 0% (Control), T_2= 5%, T_3 = 10%, T_4= 15%, T_5 = 20%) were evaluated as the supplement to sawdust substrate of oyster mushroom. The experiment was laid out in Completely Randomized Design with three replications.

Preparation of spawn packet: Cow dung was mixed to sawdust according to the treatments. The spawn packets preparation, sterilization, inoculation and incubation were done using the method described by Sarker *et al.* (2007c). The size of each spawn packet was 500g.

Cultivation of spawn packet: Two ends, opposite to each other of the upper position of polypropylene (PP) bag were cut in "D" shape with a blade and opened by removing the PP sheet. The opened surface of substrate was scraped slightly with a blade for removing the thin whitish mycelial layer. Then the spawn packets were soaked in water for 15 minutes and inverted to remove excess water for another 15 minutes. The packets of treatment were placed separately on the floor of culture house and covered with a newspaper. In the culture house, light intensity of around 300-500 lux, temperature of 22°C to 25°C, relative humidity of 80-85% and proper ventilation were maintained. The first primordia appeared 3-5 days after scraping depending upon the levels of supplement. The harvesting time also varied depending upon the levels of supplement. Data were collected on mycelium run rate, days required from stimulation to primordia initiation, days required from primordia initiation to harvest, number of fruiting body/packet, weight of individual fruiting body, biological yield (g/packet), economic yield (g/packet), dry yield (g/packet) and biological efficiency (%). Dry yield and Biological efficiency were determined by the following formulas.

$$\text{Dry yield (g/500g packet)} = \text{Economic yield} \times \frac{\text{Oven dry weight of sample (g)}}{\text{Fresh weight of sample (g)}}$$

$$\text{Biological efficiency (\%)} = \frac{\text{Total biological yield (g)}}{\text{Total dry weight of substrate usesd (g)}} \times 100.$$

Proximate analysis of the mushrooms

Moisture and Dry mater: Moisture and dry matter were determined by following the formulas.

$$\text{Moisture (\%)} = \frac{\text{(Initial weight - Final weight)}}{\text{Weight of sample}} \times 100$$

Dry matter (%) = 100 – % Moisture content

Determination of Crude Fiber: Crude fiber (g/l00g sample) = [100-(moisture + fat)] × (We-Wa) / Wt. of sample (Raghuramulu *et al.*, 2003).

Total Lipid: Total lipid was estimated by using the method described by (Raghuramulu *et al.*, 2003).

$$\textbf{Lipid} = \frac{\text{weigh of ether extract} \times \text{Percentage of dried sample}}{\text{Weigh of the dried sample taken}}$$

Determination of Ash: Ash (%) = Wt. of ash × 100/ Wt. of sample taken (Raghuramulu *et al.*, 2003).

Determination of total Nitrogen: The total nitrogen was estimated by using the standard Micro kjeldhal procedure of AOAC (1975) and total crude protein was estimated by multiplying the nitrogen content by a factor of 6.25.

Determination of Ca, Mg, K, Fe, Zn and P: The content of Ca, Mg, K, Fe, and P was estimated by Perchloric acid digestion method as proposed by Yamakawa (1992).

Statistical analysis of data: The recorded data were analyzed statistically with the help of computer MSTAT-c programme and means following least significance difference test at 1% and 5% level of probability for interpretation of results as and when required (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Mycelium running rate, time from stimulation to primordial initiation and primordia initiation to harvest: The highest mycelium running rate was observed in T_4 (0.71 cm/day) and the lowest running rate of mycelium was observed in T_1 (0.50 cm/day).

The effect of the other treatments was statistically similar (Table 1). The highest duration from stimulation to primordia initiation was observed in T_1 (7.1 days) and it was lowest in T_4 (5.1 days). The duration from primordia initiation to harvest was lowest (3.2 days) in T_3 while it was highest in T_1 (5.3 days).

Table 1. Effect of different levels of cow dung with sawdust on mycelium running rate, time from stimulation to primordia initiation (days) and time from primordia initiation to harvest (days) of oyster mushroom (*Pleurotus ostreatus*)

Treatments	Mycelium running rate in spawn packet(cm)	Time from stimulation to primordial initiation (days)	Time from primordia initiation to harvest (days)
T_1	0.50c	7.1a	5.3a
T_2	0.63b	6.1b	4.1b
T_3	0.64b	5.2c	3.2c
T_4	0.71a	5.1c	4.1b
T_5	0.65b	5.2c	4.3b
LSD (0.05)	0.031	0.229	0.287
CV (%)	1.32	1.45	2.52

Means followed by same letter in a column do not differ significantly at 5% level of significance. T_1= 0% (Control), T_2= 5%, T_3 = 10%, T_4= 15%, T_5 = 20%

Number of primordia and fruiting body and weight of individual fruiting body: The treatments were statistically and significantly superior over control in terms of number of primordia/packet (Table 2). The highest number of primordia/packet (73.21) was observed in the treatment T_3 followed by T_4 (66.70) and it was lowest in T_1 (57.40). The other treatments were statistically similar (Table 2). The highest number of fruiting body/packet (60.42) was observed in treatment T_3 and the lowest number of fruiting body/packet (37.43) was recorded in treatment T_1. The weight of individual fruiting body in different treatment ranged from 1.91 to 2.99 g. The highest weight of individual fruiting body was observed in treatment T_4 (2.99 g) and it was lowest in treatment T_1 (1.91 g). The other treatments also performed better over the control in terms of weight of individual fruiting body (Table 2).

Table 2. Effect of different levels of cow dung with sawdust on the yield contributing characters of oyster mushroom (*Pleurotus ostreatus*)

Treatments	Number of primordia/ packet	Number fruiting body/ packet	Weight of individual fruiting body (g)
T_1	57.40d	37.43e	1.91d
T_2	63.83c	45.50d	2.68c
T_3	73.21a	60.42a	2.97a
T_4	66.70b	49.40b	2.99a
T_5	63.83c	48.20c	2.83b
LSD (0.05)	0.150	0.229	0.123
CV (%)	0.08	0.17	1.48

Means followed by same letter in a column do not differ significantly at 5% level of significance. T_1= 0% (Control), T_2= 5%, T_3 = 10%, T_4= 15%, T_5 = 20%

Biological yield, economic yield, dry yield and biological efficiency (%): Biological yield (g/packet), economic yield (g/packet), dry yield (g/packet) and biological efficiency (%) were calculated by weighing mushroom from 1st three flushes. The highest biological yield was found in treatment T_3 (217.7 g/packet) and it was lowest in T_1 (109.7 g/packet). The other treatments also performed significantly better over control in terms of biological yield (Table 3). Similar trend was observed in economic yield, dry yield and biological efficiency. The highest economic yield (213.00g/packet) and dry yield (21.27g/packet) per packet were recorded in T_3 where sawdust supplemented with 10% level of cow dung. The highest biological efficiency (75.06%) and cost benefit ratio (8.41) were also recorded in the same treatment.

Table 3. Effect of different levels of cow dung with sawdust on the yield, biological efficiency and benefit cost ratio of oyster mushroom (Pleurotus ostreatus)

Treatments	Biological yield (g)	Economic yield (g)	Dry yield (g)	Biological efficiency (%)	Cost benefit ratio
T_1	109.7e	104.0e	10.23e	37.82e	3.80d
T_2	171.0d	161.0d	15.13d	58.97d	6.53c
T_3	217.7a	213.0a	21.27a	75.06a	8.41a
T_4	200.0b	194.0b	19.10b	68.97b	7.46b
T_5	181.0c	171.0c	16.20c	62.41c	6.41c
LSD (0.05)	7.964	2.873	0.212	2.749	0.123
CV (%)	1.65	0.62	0.49	1.65	0.60

Means followed by same letter in a column do not differ significantly at 5% level of significance. T_1= 0% (Control), T_2= 5%, T_3 = 10%, T_4= 15%, T_5 = 20%

Effect on proximate composition

Moisture, dry matter, protein, lipid, ash, carbohydrate and crud fiber: The highest moisture percentage was observed in treatment T_2 (90.60) which was statistically similar to T_5 (90.52). The other treatments were statistically similar but the lowest moisture level was recorded in T_3 (90.01) (Table 4). Dry matter level in mushroom grown in different treatment varied from 9.98 to 9.40%. The highest dry matter percentage was observed in treatment T_3 (9.98) followed by T_4 (9.85) and T_1 (9.84). The highest content of protein was found in treatment T_3 (31.30%) followed by T_4 (27.70 %) and the lowest protein content was estimated in T_1 (11.31 %). The other treatments were statistically similar but better over control (Table 4). The lipid content of the mushroom decreased with the increase of supplements level. The lowest lipid percentage was estimated in treatment T_3 (3.44) followed by T_2 (3.47) and it was highest in T_1 (5.43) (Table 4). The highest percentage of ash was observed in the treatment T_3 (8.41) while it was lowest in T_1 (6.58). The other treatments were statistically similar but significantly better over control (Table 4). The findings of the present study were supported by Alam *et al.* (2007), who reported 8.28 to 9.02% ash in *Pleurotus spp.*

The lowest percentage of carbohydrate was recorded in treatment T_3 (32.85) where as it was highest in T_1 (58.38). The rest of the treatments were statistically similar but differed over control in respect to percent carbohydrate content (Table 4). Crude fibre varied from 20.31- 24.01 % (Table 4). The highest percentage of crud fiber was counted in treatment T_3 (24.01) followed by T_2 (23.64) and it was lowest in T_1 (20.31). The findings of the present study corroborate with the study of Alam *et al.* (2007) who reported 8.7g/100g to 23.29g/100g of fiber in *Pleurotus spp.*

Table 4. Effect of different levels of cow dung with sawdust on chemical composition of oyster mushroom (*Pleurotus ostreatus*)

Treatment	Moisture (%)	Dry matter (%)	Protein (%)	Lipid (%)	Ash (%)	CHO (%)	Crud fiber (%)
T_1	90.16b	9.84a	11.31d	5.43a	6.58b	56.38a	20.31d
T_2	90.60a	9.40b	25.66c	3.47c	8.13a	39.10b	23.64ab
T_3	90.01b	9.98a	31.30a	3.44c	8.41a	32.85c	24.01a
T_4	90.15b	9.85a	27.70b	4.26b	8.38a	37.80b	21.86c
T_5	90.52a	9.48b	25.93c	4.33b	8.1a	39.24b	22.40bc
LSD (0.05)	0.27	0.274	0.849	0.15	0.86	1.84	1.46
CV (%)	0.11	1.04	1.27	1.43	1.64	2.38	1.24

Means followed by same letter in a column do not differ significantly at 5% level of significance. T_1= 0% (Control), T_2= 5%, T_3 = 10%, T_4= 15%, T_5 = 20%

Effect on elemental content

Nitrogen, phosphorus, potassium, calcium, magnesium, sulpher and iron: The highest percentage of nitrogen was found in T_3 (5.01) followed by T_4 (4.43) and the lowest nitrogen percentage was counted in T_1 (1.81). The highest percentage of phosphorus was found in T_1 (0.92) and the lowest (0.84) was in T_4 and T_5 (Table 5). The highest percentage of potassium was obtained from treatment T_3 (1.39) and the lowest was in T_1 (1.12). The findings of the present study confirmed by the study of Sarker *et al.* (2007a) who found 1.3% potassium in oyster mushroom grown on sawdust based substrates. The percentage of calcium was highest in treatment T_3 (22.15) and the lowest in T_1 and T_5 (20.17). The rest of the treatments were statistically similar but superior over control (Table 5). The findings of the present study agree the findings of Alam *et al.* (2007) who found 22.15 to 33.7 mg/100g calcium in different varieties of oyster mushroom.

Table 5. Effect of different levels of cow dung with sawdust on mineral element of oyster mushroom (*Pleurotus ostreatus*)

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Fe (%)
T_1	1.81d	0.92a	1.12d	20.17c	18.15c	0.012	40.5c
T_2	4.12c	0.85bc	1.35b	21.15b	19.40b	0.037	43.4a
T_3	5.01a	0.88b	1.39a	22.15a	20.21ab	0.043	43.4a
T_4	4.43b	0.84c	1.25c	21.06b	20.50a	0.035	43.1a
T_5	4.15c	0.84c	1.15d	20.17c	19.30b	0.024	42.1b
LSD (0.05)	1.20	1.86	0.87	0.86	0.35	3.14	0.57
CV (%)	0.123	0.031	0.030	0.287	1.007	0.087	1.24

Means followed by same letter in a column do not differ significantly at 5% level of significance. T_1= 0% (Control), T_2= 5%, T_3 = 10%, T_4= 15%, T_5 = 20%

The highest percentage of magnesium was recorded in treatment T_4 (20.50) and the lowest was in T_1 (18.15) (Table 5). The findings of the present study corroborates with the study of Alam *et al.* (2007) who found 13.4 to 20.22 mg/100g of magnesium in different varieties of oyster mushroom. There was no significant difference among the treatments in case of sulfur content while it was lowest in T_1 (0.012%) and highest in T_3 (0.043%) (Table 5). The highest percentage of iron was recorded in T_2 and T_3 (43.4%) which was statistically similar to T_4 ((43.1%) and it was lowest (40.05) in T_1 (Table 5). The findings of the present study supported by the findings of Alam *et al.* (2007) who found 33.45 to 43.2 mg/100g iron in different varieties oyster mushroom.

REFFERENCES

Alam, N., Khan, M. A., Hossain, M. S., Amin S. M. R. & Khan, L. A. 2007. Nutritional Analysis of dietary Mushroom *Plerotus florida* Eger and *Plerotus sajor-caju* (Fr.) Singer. *Bangladesh J, Mushroom.* **1**(2): 1-7.

AOAC. 1975. Official Method of Analysis (12th. edn.) Association of Official Analytical Chemist., INC., III, North Nineteen Street, Suit 210, Arlington, VA22209 USA.

Chang, S. T. & Miles, P. G. 1988. **Edible Mushroom and Their Cultivation**. CRC Press, Inc. Boca Raton, Florida U.S.A. pp. 27, 83, 88.

Chang, S. T. & Miles, P. G. 1989. **Edible Mushroom and Their Cultivation**. First Indian edition. CRC Press, Inc., of Boca Raton, Florida, USA. pp. 201-216.

Gomez, K. A. & Gomez, A. A. 1984. **Statistical Procedures for Agricultural Research.** John Wiley & Sons, Inc. New York.

Hadwan, H. A., Al-Jaboury, M. H. & Hassan, A. A. 1997. Suitability of different substrates and amendments on the cultivation of Oyster mushroom. **Collection of Thesis Materials**. S & T, Development, Environment and Resources. Proc. '96 (FUZHOU) International Symposium on the development of Juncao industry. pp. 215-221.

Khan, M. A., Amin, S. M. R., Uddin, M. N., Tania, M. and Alam, N. 2008. Comparative study of the nutritional composition of oyster mushrooms cultivated in Bangladesh. *Bangladesh J. Mushroom.* **2**(1): 9-14.

Raghuramulu, N., Madhavan, N. K. & Kalyanasundaram, S. 2003. **A Manual of Laboratory Techniques.** National Institute of Nutrition. Indian Council of Medical Research, Hyderabad-500007, India. pp. 56-92.

Sarker, N. C., Hossain, M. M., Sultana, N., Mian, I. H., Sirazul Karim, A .J. M. & Amin, S. M. R. 2007a. Impact of different substrates on nutrient content of *Pleurotus ostreatus* (Jacquin ex Fr.) Kummer. *Bangladesh J. Mushroom.* **1**(2): 51-56.

Sarker, N. C., Hossain, M. M., Sultana, N., Mian, I. H., Sirazul Karim, A .J. M. & Amin, S. M. R. 2007b. Effect of molasses and wheat bran on the growth and Yield of oyster mushroom (*Pleurotus ostreatus* (Jacquin ex Fr.) Kummer). *Bangladesh J. Mushroom.* **1**(1): 39-44.

Sarker, N. C., Hossain, M. M., Sultana, N., Mian, I. H., Sirazul Karim, A .J. M. & Amin, S. M. R. 2007c. Performance of Different Substrates on the growth and Yield of *Pleurotus ostreatus* (Jacquin ex Fr.) Kummer. *Bangladesh J. Mushroom.* **1**(2): 9-20.

Sarker, N. C., Hossain, M. M., Sultana, N., Mian, I. H., Sirazul Karim, A .J. M. & Amin, S. M. R. 2008. Performance of poultry litter as a supplement to waste paper on growth, yield and quality of *Pleurotus ostreatus* (Jacquin ex Fr.) Kummer. *Bangladesh J. Mushroom.* **2**(1): 1-7.

Yamakawa, T. 1992. Laboratory method for soil science and plant nutrition. JICA- IPSA Project Publication. IPSA, Gazipur, Bangladesh. pp. 1- 14.

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Performance of Six Strains of Reishi Mushroom *(Ganoderma lucidum)* on Different Amounts of Substrate

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Abstract

Six strains of reishi mushroom (Gl_1, Gl_2, Gl_3, Gl_4, Gl_5 and Gl_6) were cultured on three different amounts of substrate (500g, 750g and 1000g in wet basis) to evaluate their growth and yield performance. Among the strains, remarkable variation was not found in mycelium growth and time required to antler initiation and conk formation. Days required to complete mycelium running and mushroom harvest were increased with the increases of amount of substrate. Maximum length and diameter of stalk as well as thickness and diameter of pileus was recorded in Gl_4. The highest biological yield (36.00g/packet) was obtained from Gl_4 when cultured on 750g substrate followed by the same strain on 1000g substrate (34.50g/packet). The lowest biological yield (20.00g/packet) was recorded in Gl_3 when cultured on 500 g substrate followed by Gl_5, Gl_6, Gl_1 and Gl_2 on 500g substrate. The highest biological efficiency (13.00%) was found in Gl_4 when 500g substrate was used and the least biological efficiency was exhibited in Gl_3 when cultured on 1000g substrate.

Key words: Strains of reishi mushroom, amount of substrate, growth and yield.

INTRODUCTION

Ganoderma lucidum is a species of Basidiomycetes which belongs to the family of Polyporaceae or Ganodermaceae. Its fruiting body is called "Reishi" in Japanese and "Lingzhi" in Chinese (Yang and Liau, 1998 and Wagner, 2003). It occurs in six different colours, while, red coloured one is most widely used in commercial cultivation in North America, China, Japan, Korea and Taiwan (Nasreen *et al.,* 2005). Many strains of *Ganoderma lucidum* fix the function of blood, skin and muscle. The biggest characteristics of the strains are their effectiveness as an immune modulator. The production of reishi mushroom can be varied with many factors including inherent genetic differences within strains. Some strains of reishi mushroom have a worldwide distribution in both tropical and temperate geographical regions (Arora, 1986). Some medicinally important reishi mushroom strains are available in Bangladesh but their performances have not been studied.

Mushroom production varies greatly on fruiting conditions, substrate selection and amount of substrates. Artificial cultivation technique of reishi mushroom has been developed on solid substrates using sawdust and agricultural wastes (Peksen and Yakupoglu, 2009 and Malarvizhi *et al.*, 2003). The cultivation of medicinal mushrooms largely increased due to the use of different sizes of polypropylene bags or containers (Smith *et al.,* 2002). But, for higher yield and better quality, specific information on the amount of sawdust for specific reishi mushroom strain is not available. Hence, it is subjected for growers to identify the best strain that grows on suitable amount of substrate. The aim of this investigation was to study the growth and yield performances of six strains of reishi mushroom available in Bangladesh and to standardize the amount of sawdust substrate for their cultivation.

MATERIALS AND METHODS

The experiment was conducted at the National Mushroom Development and Extension Centre, Sobhanbag, Savar, Dhaka during the months of April to August, 2009. Six strains of reishi mushroom such as Gl_1, Gl_2, Gl_3, Gl_4, Gl_5 and Gl_6 and three different amounts of substrate viz. T_1=500g, T_2=750g and T_3=1000g in wet basis were used as treatment.

Spawn packet preparation: The substrate of spawn packets were prepared by using sawdust and wheat bran at the ratio of 2:1 (dry basis). Water was added to make the moisture content 60% and $CaCO_3$ was added at the rate of 0.2% of the total mixture. Different sizes of polypropylene bags were filled with prepared substrate followed by above three amounts. After filling the bags, the mouths of the bags were plugged by inserting water absorbing cotton with the help of plastic neck and autoclaved at 121 ^{0}C and 1.0 kg/cm^2 for 2 hours. After autoclaving and cooling, the bags were inoculated separately with the mother culture of six strains of reishi mushroom. After inoculation, the packets were incubated in the laboratory at about 25±2 ^{0}C temperatures. In incubation period, whitish mycelia begin to grow on the substrate. The fully colonized packets were used for cultivation.

Experimental condition: After completion of mycelium running, spawn packets were opened by square sized (1×1 cm) cut on the single side middle abdomen of the packet and transferred to the culture room at 25-32^{0}C temperature and 80-90% relative humidity. Sufficient water was applied per day and proper aeration was maintained in culture house to develop the fruiting body. Biological yield in g/packet was recorded by weighing the whole fruiting bodies and biological efficiency was determined by the following formula:

$$\text{Biological efficiency (\%)} = \frac{\text{Total biological yield (g)}}{\text{Total dry substrate used (g)}} \times 100$$

Statistical analysis: The experiment was laid out following completely randomized design (CRD) with 4 replications. Data on mycelium growth rate, days required to complete mycelium running, antler initiation, conk formation and first harvest, number of fruiting body, length of stem, diameter of stem, diameter of pileus, thickness of pileus, biological yield and biological efficiency were recorded and analyzed following Gomez and Gomez (1984) using MSTAT-c computer program. Means separation were computed following Duncan's Multiple Range Test (DMRT) using the same computer program.

RESULTS AND DISCUSSION

Mycelium growth rate: Significant variation in mycelium growth rate was observed in six strains of *Ganoderma lucidum* (Table 1). The highest mycelium growth rate (0.39 cm/day) was recorded in Gl_5 which was statistically similar to Gl_6 (0.37 cm/day) and Gl_4 (0.35 cm/day). The lowest mycelium growth rate (0.32 cm/day) was recorded in Gl_1, Gl_2 and Gl_3.

Table 1. Mycelium growth rate of six strains of reishi mushroom on 500g of sawdust substrate

Strains of reishi mushroom	Mycelium growth rate (cm/day)
Gl_1	0.32 b
Gl_2	0.32 b
Gl_3	0.32 b
Gl_4	0.35 ab
Gl_5	0.39 a
Gl_6	0.37 a
CV (%)	7.05

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Days to completion of mycelium running, antler initiation, conk formation and first harvest: Days required to completion of mycelium running, antler initiation, conk formation and first harvest of tested strains were significantly influenced by different amounts of substrates (Table 2). The days required to completion of mycelium running (DRCMR) in spawn medium ranged from 26.50 to 48.75. The lowest DRCMR (26.50) was found in Gl_5T_1 followed by Gl_6T_1 and Gl_4T_1. The highest DRCMR (48.75) was recorded in Gl_2T_3. The DRCMR was increased with the increases of amount of substrate.

The minimum days required from opening to antler initiation (DROAI) (3.75) was observed in Gl_4 when cultured on 500g substrate (Gl_4T_1), which was statistically similar to all the treatments except Gl_1T_3, Gl_2T_2, Gl_2T_3, Gl_3T_3 and Gl_5T_3. The maximum DROAI (5.75) was observed in Gl_1T_3, Gl_2T_2 and Gl_2T_3. The lowest Days required from opening to conk formation (DROKF) (10.25) was recorded in Gl_4 when cultured on 500g substrate which was statistically similar to Gl_1T_1 and Gl_2T_1. The maximum DROKF (14.25) was found in Gl_5T_3 which was statistically similar to Gl_3T_3, Gl_1T_3, Gl_2T_3, Gl_5T_2, Gl_3T_2 and Gl_2T_2. In case of days required from opening to first harvest (DROFH), the minimum DROFH (37.25) was recorded in Gl_1 and Gl_4 when cultured on 500g substrate which was statistically identical to Gl_2T_1 and Gl_3T_1. The maximum DROFH (49.25) was recorded in Gl_2, Gl_5 and Gl_6 when cultured on 1000g substrate.

Table 2. Interaction effect of strains of reishi mushroom and different amounts of substrate on time required to complete mycelium running, antler initiation, conk formation and first harvest

Treatments	Days required to complete mycelium running (DRCMR)	Days required from opening to antler initiation (DROAI)	Days required from opening to conk formation (DROKF)	Days required from opening to first harvest (DROFH)
Gl_1T_1	31.25 d	4.00 bc	11.25 ef	37.25 h
Gl_1T_2	39.75 c	5.25 abc	12.00 cde	44.00 de
Gl_1T_3	47.25 ab	5.75 a	13.50 ab	47.25 bc
Gl_2T_1	31.75 d	4.75 abc	11.50 ef	38.00 gh
Gl_2T_2	40.25 c	5.75 a	13.00 a-d	43.75 de
Gl_2T_3	48.75 a	5.75 a	13.50 ab	49.25 a
Gl_3T_1	31.25 d	4.00 bc	12.25 b-e	39.00 fgh
Gl_3T_2	39.25 c	4.50 abc	13.00 a-d	44.75 de
Gl_3T_3	47.25 ab	5.50 ab	13.75 a	48.25 ab
Gl_4T_1	29.00 de	3.75 c	10.25 f	37.25 h
Gl_4T_2	39.50 c	4.75 abc	11.50 bcd	43.25 e
Gl_4T_3	46.75 ab	4.75 abc	12.25 b-e	47.00 bc
Gl_5T_1	26.50 e	4.00 bc	11.75 de	40.50 f
Gl_5T_2	38.75 c	4.75 abc	13.25 abc	45.50 cd
Gl_5T_3	45.50 b	5.50 ab	14.25 a	49.25 a
Gl_6T_1	28.75 de	4.25 abc	11.75 de	39.25 fg
Gl_6T_2	39.75 c	5.00 abc	12.00 cde	44.75 de
Gl_6T_3	48.00 ab	4.75 abc	12.25 b-e	49.25 a
CV (%)	6.42	18.99	13.16	4.97

In a column, means followed by a common letter are not significantly different at 5% level by DMRT. (T_1= 500g, T_2 =750g and T_3 =1000g)

Number of fruiting body: The number of fruiting bodies (NFB) ranged from 1.25 to 2.50 (Table 3). The highest NFB (2.50) was recorded in Gl_3 on 500g substrate which was statistically similar to Gl_4T_2, Gl_4T_1, Gl_4T_3 and Gl_1T_1. The lowest NFB (1.25) was recorded in Gl_1T_2, Gl_2T_1, Gl_2T_2, Gl_5T_2 and Gl_5T_3.

Length and diameter of stalk: The length and diameter of stalk were significantly different in different strains of *Ganoderma lucidum* when cultured on different amounts of substrate and ranged from 0.75 to 2.25 cm and 0.98 to 1.88 cm respectively (Table 3). The highest length of stalk (2.25 cm) was found in Gl_4 when cultured on 500g sawdust medium, which was statistically similar to all the treatments except Gl_1T_1 and Gl_1T_3. The lowest length of stalk (0.75 cm) was recorded in Gl_1 on 1000g substrate. In case of diameter of stalk, the highest diameter of stalk (1.88 cm) was observed in Gl_4 when cultured on 750 and 1000g substrates and the lowest diameter of stalk (0.98 cm) was observed in Gl_1 on 750g substrate.

Diameter and thickness of pileus: The diameter and thickness of pileus of six strains of reishi mushroom in different amounts of substrate were varied significantly (Table 3). The highest diameter of pileus (9.00 cm) was recorded in Gl_4 when cultured on 750g substrate which was significantly higher as compared to all the treatments except the same strain on 1000g substrate. The lowest diameter of pileus (4.55 cm) was observed in

Gl_3 when cultured on 500g substrate which did not differ significantly with other treatments except Gl_4T_1, Gl_4T_2 and Gl_4T_3. The highest thickness of pileus (1.78 cm) was recorded in Gl_4 when cultured on 1000g substrate which was significantly higher as compared to all the treatments except Gl_1T_1 and Gl_1T_2. The lowest thickness of pileus (1.45 cm) was recorded in Gl_1 on 500g substrate.

Biological yield: Appreciable variation was found in the biological yield of six strains of reishi mushroom on three different amounts of substrate (Table 3). The highest biological yield (36.00g/ packet) was recorded in Gl_4 when cultured on 750g substrate which was significantly higher than all the treatments except the same strain on 1000g substrate. The lowest biological yield (20.00g/ packet) was recorded in Gl_3 on 500g substrate which was followed by Gl_5, Gl_6, Gl_1 and Gl_2 on 500g substrate.

Table 3. Interaction effect of six strains of reishi mushroom and different amounts of substrate on yield and yield contributing characters

Treatments	Number of fruiting body (NFB)	Length of stem (cm)	Diameter of stem (cm)	Diameter of pileus (cm)	Thickness of pileus (cm)	Biological yield (g) (1st flush)
Gl_1T_1	1.75 abc	1.55 abc	1.33 abc	5.53 bc	1.45 d	22.25 def
Gl_1T_2	1.25 c	1.10 bc	0.98 c	5.50 bc	1.48 cd	26.25 bcd
Gl_1T_3	1.50 bc	0.75 c	1.25 bc	5.58 bc	1.55 a-d	26.75 bcd
Gl_2T_1	1.25 c	1.20 bc	1.33 abc	6.05 bc	1.60 a-d	22.50 c-f
Gl_2T_2	1.25 c	1.30 abc	1.25 bc	5.80 bc	1.68 a-d	26.00 b-e
Gl_2T_3	1.50 bc	1.85 ab	1.58 ab	5.75 bc	1.55 a-d	27.75 b
Gl_3T_1	2.50 a	1.30 abc	1.48 ab	4.55 c	1.68 a-d	20.00 f
Gl_3T_2	1.50 bc	1.63 abc	1.13 bc	5.28 bc	1.73 ab	23.25 b-f
Gl_3T_3	1.50 bc	1.25 abc	1.48 ab	5.60 bc	1.68 a-d	23.00 b-f
Gl_4T_1	2.00 abc	2.25 a	1.45 abc	7.00 b	1.48 cd	26.00 b-e
Gl_4T_2	2.25 ab	1.98 ab	1.88 a	9.00 a	1.73 ab	36.00 a
Gl_4T_3	1.75 abc	1.93 ab	1.88 a	8.70 a	1.78 a	34.50 a
Gl_5T_1	1.50 bc	1.78 ab	1.58 ab	5.95 bc	1.68 a-d	21.25 ef
Gl_5T_2	1.25 c	1.55 abc	1.20 bc	6.05 bc	1.70 abc	25.00 b-e
Gl_5T_3	1.25 c	1.83 ab	1.43 abc	5.45 bc	1.48 cd	25.50 b-e
Gl_6T_1	1.50 bc	1.25 abc	1.18 bc	6.13 bc	1.60 a-d	22.25 def
Gl_6T_2	1.50 bc	1.62 abc	1.03 bc	6.25 bc	1.68 a-d	27.25 bc
Gl_6T_3	1.50 bc	1.45 abc	1.48 abc	5.85 bc	1.68 a-d	27.75 b
CV (%)	35.44	16.36	14.43	13.37	9.26	11.56

In a column, means followed by a common letter are not significantly different at 5% level by DMRT. (T_1 : 500g; T_2 : 750g and T_3 :1000g)

Biological efficiency: Remarkable variation was observed in biological efficiency of six strains of reishi mushroom on different amounts of substrate (Fig. 1). The highest biological efficiency (13.00%) was obtained from Gl_4 when cultured on 500g substrate. The lowest biological efficiency (5.75%) was recorded in Gl_3 when cultured on 1000g substrate. The study revealed that, the biological efficiency of the strains used in this experiment is lower as compare to Erkel (2009) who reported the biological efficiency of *Ganoderma lucidum* was 20.85% when cultured on 1 kg poplar sawdust supplemented with wheat bran.

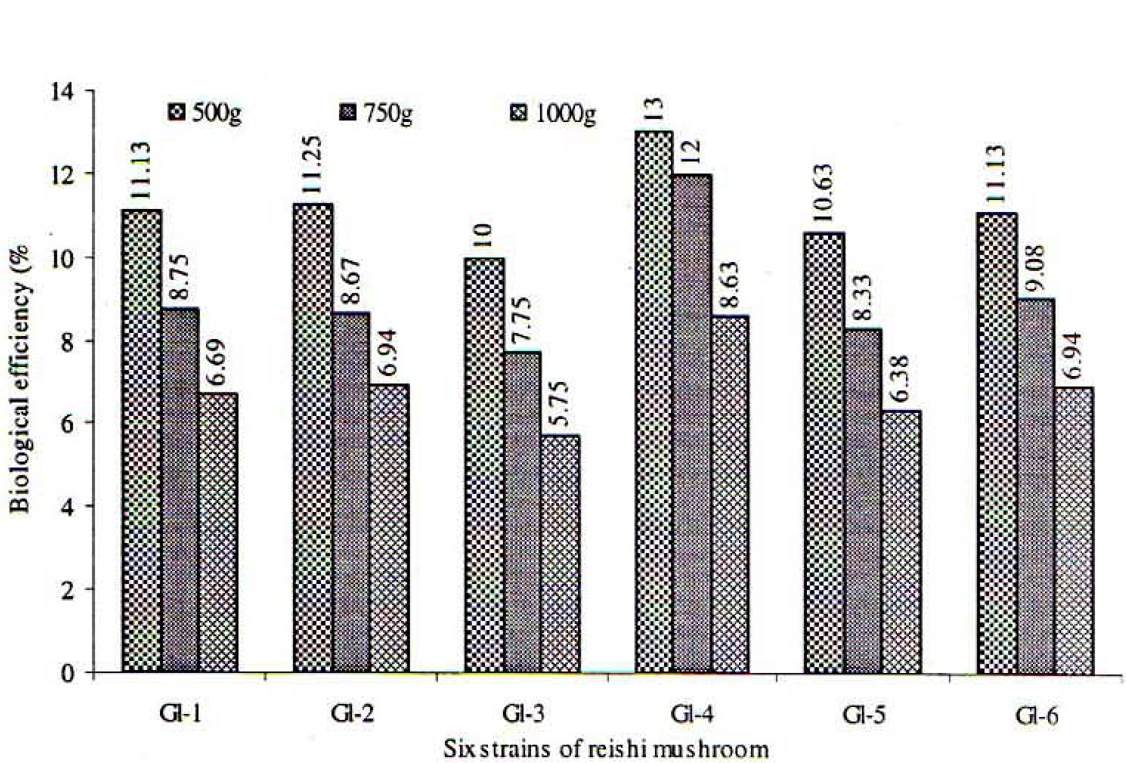

Fig. 1. Biological efficiency of six strains of reishi mushroom on different amounts of substrate

REFERENCES

Arora, D. 1986. **Mushrooms Demystified**: A comprehensive guide to the fleshy fungi. Ten Speed Press, Berkeley, Toronto. p. 959.

Erkel E. I. 2009. The effect of different substrate mediums on yield of *Ganoderma lucidum* (Fr.) Karst. *Journal of Food, Agriculture & Environment.* **7**(3&4): 841-844.

Gomez, K. A. & Gomez, A. A. 1984. **Statistical Procedures for Agricultural Research**. John Wiley and Sons. Inc. New York. pp. 304-307.

Malarvizhi, K., Murugesan, K. & Kalaichelvan, P. T. 2003. Xylamase production by *Ganoderma lucidum* on liquid and solid state culture. *Indian Journal of Experimental Biology.* **41**: 620-626.

Nasreen, Z., Kausar, T., Nadeem, M. & Bajwa, R. 2005. Study of different growth parameters in *Ganoderma lucidum. Micologia Aplicada International.* **17**(1): 5-8.

Peksen, A. & Yakupoglu, G. 2009. Tea waste as a supplement for the cultivation of *Ganoderma lucidum. World J. Microbiol. Biotechnol.* **25**: 611-618.

Smith, J. E., Rowan, N. J. & Sullivan, R. 2002. Medicinal mushroom: A rapid developing area of biotechnology for cancer therapy and other bioactivities. *Biotechnology Letters.* **24**: 1839-1845.

Wagner, R., Mitchell, D. A., Sassaki, G. L., Amazonas, M. A. L. A. & Berovic, M. 2003. Current techniques for the cultivation of *Ganoderma lucidum* for the production of biomass, ganoderic acid and polysaccharides. *Food Technol. Biotechnol.* **41**(4): 371-382.

Yang, F. C. & Liau, C. B. 1998. Effect of cultivating conditions on the mycelial growth of *Ganoderma lucidum* in submerged flask cultures. *Bioprocess Engineering.* **19**: 233-236.

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Performance of *Pleurotus citrinopileatus* on Different Agro-Wastes and Its Proximate Composition

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Abstract

Five lignocellulosic substrates (sawdust, paddy straw, cotton waste, sugarcane leaf and coir pith) were used for *Pleurotus citrinopileatus* cultivation. The utility value of the substrates was assessed in terms of growth rate, yield, cultivation period, and the biochemical profile of the cultivated mushrooms. The highest mycelial growth (0.81 cm/day) was recorded in paddy straw substrate and the lowest growth (0.46 cm/day) was found in cotton waste. The period of spawn run was the lowest (17 days) on cotton waste and coir pith and it was the highest (33 days) on sugarcane leaf. The highest biological efficiency (70.3%) and yield (140.3 g/packet) was recorded in sawdust and the lowest biological efficiency (41.5%) and yield (83.00 g/packet) was observed in coirpith. Hundred grams of dry *Pleurotus citrinopileatus* grown on different substrate contain 23.5-36.91 g carbohydrate, 30.27-36.63 g protein, 20.9-27.06 g fibre, 1.86-5.3 g fat and 5.1-11.8 g ash. The effect of different substrates on yield contributing characters such as stipe length, stipe thickness, pileus diameter and pileus thickness was significant. The longest stipe (3.67 cm) was observed in cotton waste and it was shortest (2.15 cm) in coir pith. The diameter of stipe ranged from 0.45 to 0.62 cm. Pileus diameter ranged from 3.6 to 5.02 cm, the largest being on sugarcane leaf (5.02 cm) and the smallest on coir pith (3.6 cm). Pileus thickness ranged from 0.45 to 0.60 cm.

Key words: Agro- wastes, *Pleurotus citrinopileatus*, yield and biological efficiency.

INTRODUCTION

Pleurotus citrinopileatus is a popular edible mushroom of bright-yellow colour. It contains useful antitumor polysaccharides (Zhang *et al.*, 1994 and Wang *et al.*, 2005) and it has antioxidant activities (Hu *et al.*, 2006). This mushroom enhances immunity and delay aging (Wang *et al.*, 2001). It is delicious in taste and rich in nutrients (Ghosh *et al.*, 1991). *Pleurotus spp.* (oyster mushrooms) are efficient decomposers and its multilateral enzyme system can biodegrades a large range of lignocellulosic wastes. But all the wastes are not suitable for every species of *Pleurotus*. Stamets (2000) reported that *Pleurotus citrinopileatus* can be grown on saw dust, paddy straw, cotton seed hulls, chopped corncobs, paper, banana fronds, sugarcane bagasse and peanut hulls. In Bangladesh, sawdust, banana leaves, cotton waste, banana pseudostem, paddy straw, sugarcane leaf, coir pith, paper waste (substrates of treatments) are available but the suitability of these wastes as substrates of *Pleurotus citrinopileatus* is not yet tested. Mushroom quality, specially the nutrient content of mushroom is dependent on substrate (Sarker *et al.*, 2007 a). To produce *Pleurotus citrinopileatus,* it is important to identify suitable substrate for better yield and higher quality. The study was undertaken to determine the suitability of different wastes as substrate of *Pleurotus citrinopileatus* and their effect on nutritional status of the mushroom.

METERIALS AND METHODS

Substrate preparation: Saw dust, paddy straw (*Oryza sativa*), sugarcane leaf (*Saccharum officinarum*), cotton waste (*Gossypium spp*), and coir pith (*Cocos nucifera*) were used as substrates. The plant materials were cut into small pieces (3-4 cm) and mixed with nutrient materials, wheat bran at the ratio of 4:1. Water was added to make the moisture content 60% and $CaCO_3$ was added at the rate of 0.2% of the total mixture. Polypropylene bags of 7″×10″ size were filled with 500g of substrate mixture and their mouth were plugged by water absorbing cotton and covered with brown paper and tied with a rubber band. Then bags were autoclaved at 121^0 C and 15 PSI for 2 hours and then allowed to cool. Each spawn packet was inoculated with the mother culture at the rate of two teaspoonfuls per packet. Bags were then incubated for mycelium running at 25 ± 2^0c temperature. After completion of mycelium running the spawn packets were transferred to culture house. The culture house activities performed following the method described by Sarker *et al.* (2007 b).

Nutrient analysis: The nutritive value of fruit bodies was determined in terms of crude protein (Burties & Ashwood, 2006), fat (Folch *et al.*, 1957), carbohydrate, fibre and total ash (Raghuramalu *et al.*, 2003).

Statistical Analysis: The experiment was laid out in Completely Randomized Designs (CRD) with 4 replications. Data on mycelium run rate, spawn run period, days to primordia initiation, total yield and biological efficiency were collected and analyzed following Gomez and Gomez (1984) using MSTAT-C computer Programme. Means were separated by Duncan's Multiple Range Test (DMRT) using the same computer program.

RESULTS AND DISCUSSION

The growth, yield and biological efficiency of *Pleurotus citrinopileatus* was significantly influenced by the substrates of different sources. The highest mycelial growth rate (MGR) (0.81 cm/day) was observed in paddy straw substrate which was significantly higher than other treatments and the lowest MGR (0.46 cm/day) was recorded in cotton waste (Table1). The lowest period of spawn run was 17 days in cotton waste and coir pith followed by paddy straw (22 days) and saw dust (29 days). The highest period for spawn run (33 days) was recorded in sugarcane leaf. The primordium initiation (PI) started within 21.25-37 days after spawn inoculation. The days required to PI was the lowest (21.25) in cotton waste followed by coir pith (23.50) and paddy straw (26.75) and the highest days required to PI (37.00) was recorded in sugarcane leaf. Similar results observed by Khanna *et al.* (1992) who reported that the primordial initiation was generally observed on the 24-30th day in *Pleurotus spp.*

Table 1. Effect of different agro-wastes on growth, yield and biological efficiency of *Pleurotus citrinopileatus*

Agro-wastes	Mycelium growth rate (cm/day)	Spawn run period (days)	Days to primordia initiation (PI)	Yield (g/packet)	Biological efficiency (BE) (%)
Saw dust	0.54 c	29.00 b	32.25 b	140.3 a	70.3
Cotton waste	0.46 d	17.00 d	21.25 e	107.0 b	53.5
Coir pith	0.67 b	17.00 d	23.50 d	83.00 c	41.5
Paddy straw	0.81 a	22.00 c	26.75 c	109.3 b	54.5
Sugarcane leaf	0.58 c	33.00 a	37 a	102.8 bc	51.4
CV (%)	4.61	4.09	2.47	13.38	

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

Highest yield (140.3 g/packet) was obtained from sawdust substrate. The second highest yield (109.3 g/packet) was recorded in paddy straw which was significantly higher than other substrates except coir pith. Coir pith gave the lowest yield (83.00 g/packet) (Table 1). Higher yield of *P. ostreatus* on sawdust was reported by Vetayasuporn (2006). Though Sarker *et al.*, (2007b) reported comperative higher yield in rice straw than sawdust. Hami (1990) also found similar results on oyster mushroom cultivation.

Biological efficiency ranged between 41.5-70.3% (Table 1). The maximum biological efficiency (70.3 %) obtained from saw dust followed by paddy straw (54.5%), cotton waste (53.5%), sugarcane leaf (51.4%) and coir pith (41.5%). Hami (1990) reported the maximum biological efficiency of *Pleurotus ostreatus* on sawdust substrate. Ragunathan *et al.* (1996) reported the biological efficiency of *Pleurotus citrinopileatus* in paddy straw 35.42%, coir pith 27.79% and sugarcane bagasse 38.63%. The higher the biological efficiency, the greater will be the suitability of the substrate for cultivation of that particular strain of mushroom.

Table 2. Effect of different agro-wastes on morphological characters of *Pleurotus citrinopileatus*

Agro-wastes	Length of stipe (cm)	Diameter of stipe (cm)	Diameter of pelius (cm)	Thickness of pelius (cm)
Saw dust	3.32 ab	0.50 abc	4.05 ab	0.47 b
Cotton waste	3.67 a	0.62 a	4.75 a	0.52 ab
Coir pith	2.15 d	0.45 c	3.6 b	0.52 ab
Paddy straw	2.75 c	0.47 bc	4.67 a	0.60 a
Sugarcane leaf	2.80 bc	0.60 ab	5.02 a	0.45 b
CV (%)	12.28	17.22	11.49	13.38

In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

The effect of different substrates on yield contributing characters such as stipe length, stipe thickness, pileus diameter and pileus thickness was significant (Table 2). The stipe length on different substrates ranged from 2.15 to 3.67 cm. The longest being on cotton waste (3.67 cm) and the shortest on coir pith (2.15 cm). Stipe thickness ranged from 0.45 to 0.62. cm. Pileus diameter ranged from 3.6 to 5.02 cm, the largest being on Sugarcane leaf (5.02 cm) and the smallest on coir pith (3.6 cm) and pileus thickness ranged from 0.45 to 0.60 cm.

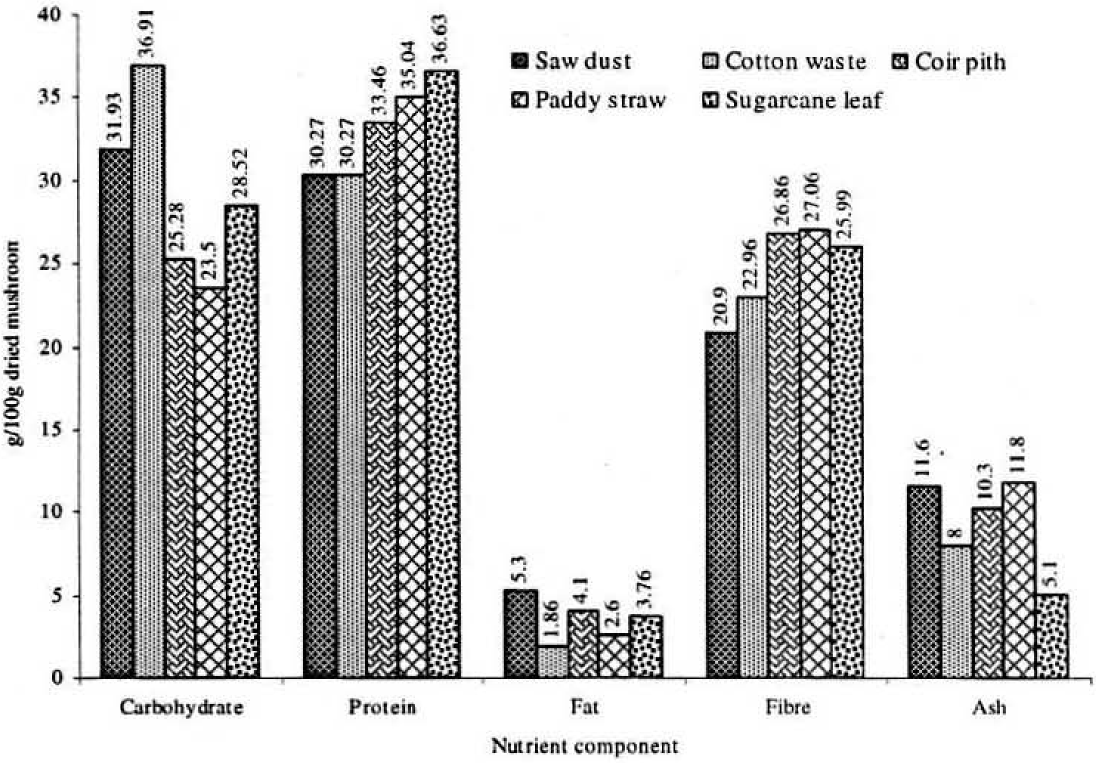

Fig. 1. Effect of different agro-wastes on nutritional value of *Pleurotus citrinopileatus*

The fruit bodies of *Pleurotus citrinopileatus* are rich in carbohydrates, proteins and minerals. Hundred grams of dry *Pleurotus citrinopileatus* grown on different substrate contain 23.5-36.91 g carbohydrate, 30.27-36.63 g protein, 20.9-27.06 g fibre, 1.86-5.3 g fat and 5.1-11.8 g ash (Fig.1). The protein content of *P. citrinopileatus* was the highest (36.63) when it was grown on sugarcane leaf but in this treatment the mineral content was lowest (5.1%). The highest carbohydrate content (36.91) was observed in the mushroom grown on cotton waste. Fat content was very low in all the treatments. Almost similar nutrient level of *P. citrinopileatus* was reported by Ragunathan *et al.* (1996) who observed that *Pleurotus citrinopileatus* containes 42.5-45.6% carbohydrate, 30-42.5% protein and 2.1-3.8% fat on different substrates.

REFERENCES

Burties, C. A. & Ashwood, E. R. 2006. **Teitz Fundamentals of Clinical Chemistry.** 5th ed., Reed Elsevier India Private Limited, New Delhi, India. pp. 348-349.

Folch, J., Lees, M., & Sloane-Stanely, G. H. 1957. A simple method for the isolation and purification of total lipids from animal tissues. *J. Biol. Chem.* **226**: 497-509.

Ghosh, N., Mitra, D. K & Chakravarty, D. K. 1991. Composition analysis of tropical white oyster mushroom (*Pleurotus citrinopileatus*). *Ann. Appl. Biol.* **118**:527–531

Gomez, K. A. & Gomez, A. A. 1984. **Statistical Procedures for Agricultural Research**, 2nd ed., Jonn Wiley and Sons. Inc. New York. pp. 304-307.

Hami, H. 1990. Cultivation of Oyster Mushroom on Sawdust of Different Woods. M. Sc. Thesis, University of Agriculture, Faisalabad, Pakistan.

Hu, S. H., Liang, Z. C., Chia, Y. C., Lien, J. L., Chen, K. S., Lee, M. Y. & Wang, J. C. 2006. Antihyperlipidemic and antioxidant effects of extracts from *Pleurotus citrinopileatus. J. Agric. Food Chem.* **54**: 2103-2110.

Khanna, P. K., Bhandari, R., Soni, G. L. & Garcha, H. S. 1992. Evaluation of *Pleurotus spp.* for growth, nutritive value and antifungal activity. *Indian J. Microbiol.*, **32**: 197-200.

Raghuramulu, N., Madhavan, N. K. & Kalyanasundaram, S. 2003. **A Manual of Laboratory Techniques.** National Institute of Nutrition. Indian Council of Medical Research, Hyderabad-500 007, India. pp. 56-58.

Ragunathan, R., Gurusamy, R., Palaniswamy, M. & Swaminathan, K. 1996. Cultivation of *Pleurotus spp.* on various agro-residues. *Food Chemistry.* **55**:139–144.

Sarker, N. C., Hossain, M. M., Sultana, N., Mian, I. H., Sirajul Karim, A. Z. M & Ruhul Amin, S. M. 2007a. Impact of Different Substrates on Nutrient Content of *Pleurotus ostreatus* (Jacquin ex Fr.) Kummer. *Bangladesh J. Mushroom*, **1**(2): 51-56.

Sarker, N. C., Hossain, M. M., Sultana, N., Mian, I. H., Sirajul Karim, A. Z. M & Ruhul Amin, S. M. 2007b. Performance of Different Substrates on the Growth and Yield of *Pleurotus ostreatus* (Jacquin ex Fr.) Kummer. *Bangladesh J. Mushroom*, **1**(2): 9-20.

Stamets, P. 2000. **Growing Gourmet and Medicinal mushrooms.** Ten Speed Press, California. p. 184.

Vetayasuporn, S. 2006. Oyster Mushroom Cultivation on Different Cellulosic Substrates. *Journal of Agriculture and Biological Sciences*, **2**(6): 548-551.

Wang, J. C., Hu, S. H., Liang, Z. C. & Yeh, C. J. 2005. Optimization for the production of water-soluble polysaccharide from *Pleurotus citrinopileatus* in submerged culture and its antitumor effect. *Appl. Microbiol. Biotechnol.* **67**: 759-766.

Wang, Q., Yan, L. L., Wang, Y. L. & Zhang, Y. J. 2001. Submerged culture of *Pleurotus citrinopileatus* and its determination. **5th Cross-Strait Conference on Mycology**. Taipei, Taiwan. pp. 8-12.

Zhang, J., Wang, G., Li, H., Zhuang, C., Mizuno, T., Ito, H., Suzuki, C., Okamoto, H. & Li, J. X. 1994. Antitumor polysaccharides from a Chinese mushroom,"Yuhuangmo", the fruitung body of *Pleurotus citrinopileatus. Biosci. Biotechnol. Biochem.* **58**: 1195-1201.

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Effect of Gibberilic Acid-3 on the Growth and Yield of *Pleurotus ostreatus*

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Abstract

Different levels of Gibberilic Acid-3 (GA_3) were sprayed in different growth stages of *Pleaurotus ostreatus* to evaluate their effect on the growth and yield of the mushroom. Days required from stimulation to primordia initiation, number and size of fruiting bodies, biological efficiency and economic yield of the mushroom were significantly influenced by different levels of GA_3 when applied in different growth stages. The highest economic yield (263g) and biological efficiency (132%) were obtained from a packet when GA_3 was applied at 10 ppm level in fruit body development stage. The lowest yield was recorded in control treatment.

Key words: *Pleaurotus ostreatus*, Gibberilic acid, application stages, growth and yield.

INTRODUCTION

The oyster mushroom (*Pleurotus ostreatus*) is a common delicious edible mushroom having various medicinal value (Yang and Jong, 1989). This mushroom is widely cultivated in Asia. However, at present it is now cultivated around the world for its nutritional and medicinal value and its easy to grow behaviour. In Bangladesh, this mushroom is being easyly cultivated on different substrates with satisfactory yield. To improve the performance of this mushroom use of plant growth regulator may be a alternative way. Dey (1996) reported that GA_3 at the rate of 5-15 mg/L is very effective to obtain a good yield. The highest yield was obtained by Ashrafuzzaman *et al.* (2005) from 15mg/L GA_3. (Halder *et al.,* 1998) found 9% increased yield over control by using 10mg/L IAA at the time of substrate peparation. But, Dey (1996) also reported that the plant growth regulator (PGR) at higher dose has lethal effect on mushroom producton which reduces the yield of mushroom. So, it is very important to determine the appropriate level of PGR. On the other hand, growth stage of mushroom is very important for application of PGR. Some scientist applied it during substrate preparation (Halder *et al.,* 1998) and some scientist applied it in the media of pure culture (Dey, 1996). For better performance the right time of application to be determined. So, the present study was undertaken to determine the appropriate level of PGR (GA_3) and the growth stage of mushroom to obtain the maximum yield in oyster mushroom.

MATERIALS AND METHODS

The experiment was conducted in the culture house of National Mushroom Development and Extention Centre, Savar, Dhaka, from December 2009 to March 2010. A plant growth regulator GA_3 with its six different levels such as 50 (T_1), 40 (T_2), 30 (T_3) 20 (T_4) 10 (T_5) and 0 (T_6) ppm was applied on three different growth stages such as during opening period by submerging the packets in GA_3 added water (S_1), during primordia initiation stage (S_2) and during fruiting body development stage (S_3) of *Pleurotus ostreatus*. Four replications for each treatment were maintained.

Spawn packets preparation: Sawdust was used as a main substrate and wheat bran was used as supplement. For each 500g packet, 116.7g sawdust, 58.23g wheat bran and 1g $CaCO_3$ were mixed and moisture was adjusted at 65% by adding water. The mixture was filled into heat tolerant polypropylene bags of 7"x 10" size and their mouths were plugged by inserting water absorbing cotton and covered with brown paper and tied with a rubber band. Then packets were autoclaved at 121°C and 15 PSI for 2 hour and then allowed to cool. Each packet was inoculated with the mother culture at the rate of two teaspoonfuls per packet. The inoculated packets were incubated in a dark room at about 25°C temperature for mycelium running. After 25 days of inoculation, when colonization was completed, the spawn packets were taken to the culture house.

Hormone Application and Cultivation Methods of *Pleurotus ostreatus:* The spawn packets were opened by 'D' shaped cut on the shoulder side and removed the sheet. The opened surface of substrate was scraped slightly with a blade for removing the thin whitish mycelial layer. The spawn packets that were taken for S_1 were soaked in six different levels of GA_3 added water. The packets were then placed separately side by side on the rack in the culture house. Six different levels of GA_3 added water was sprayed on the packets that were taken for S_2 and S_3 at primordia initiation stage and Fruiting body development stage respectively by a sprayer.

Cultural condition: The relative humidity of 80-90% and the temperature of 23-29°C were maintained by watering thrice a day in the room. Diffused day light and proper ventilation in culture house were maintained. After first harvest scraping and the above mentioned activities were done again. Watering and other operations were done as mentioned before.

Data collection: The experiment was laid out following Completely Randomized Design (CRD) with 4 replications. Data on days required from stimulation to primordia initiation, number of fruiting body, length of stipe (cm), diameter of stipe (cm), diameter of pileus (cm), thickness of pileus (cm), Biological efficiency (%), and economic yield (g/packet) were recorded.

Statistical Analysis: The data obtained from the experiment for every parameter were analyzed statistically using MSTAT-C computer program. The means were computed following Duncan's multiple Range Test (Gomez and Gomez, 1984) using the same computer program.

RESULTS AND DISCUSSION

The growth and yield of *Pleaurotus ostreatus* varied significantly by different levels of GA_3 and their application on different stages.

Days Required from Stimulation to Primordia Initiation (DRSPI): The Days Required from Stimulation to Primordia Initiation (DRSPI) ranged from 4.25 to 9.00 days (Table1). The highest DRSPI (9.00 days) was found in S_3T_4, S_3T_5, when 20 ppm, 10 ppm GA_3 was applied on fruiting body development stage and when no GA_3 was applied on three different stages. The lowest DRSPI (4.25 days) was found in S_1T_1 when 50 ppm GA_3 was applied during opening period by submerging the packets in GA_3 added water.

Number of fruitbodies: The number of fruitbodies ranged from 14.50-32.00 and varied significantly (Table1). The highest number of fruitbodies (32.00) was found in S_3T_2 and S_3T_3 when 40 ppm and 30 ppm GA_3 was sprayed on fruiting body development stage. The lower number fruitbodies (14.50) was found in S_1T_2 when 40 ppm GA_3 was applied during opening period.

Length of stipe: The length of stipe ranged from 3.60 to 4.90 cm (Table1). The highest length of stipe was found in S_3T_5 (4.90 cm) followed by S_1T_3 (4.85 cm) which was statistically similar to all the treatments except S_2T_4 and S_2T_2 (Table1) where the lowest length of stipe (3.60 cm) was found.

Diameter of Stipe: No significant difference was observed in the diameter of stipe and it was ranged from 0.82 to 1.52 cm (Table1). The diameter of stipe was recored 1.52 cm in S_2T_1 followed by 1.35 cm in S_2T_5 and lowest diameter of stipe was recored in S_3T_1 (0.82 cm) preceded by S_3T_2 (0.87 cm), S_1T_1 (0.92 cm) and S_3T_5 (0.92 cm).

Diameter of pileus: The diameter of pileus varied significantly (Table1). The highest diameter was found in S_2T_5 (8.20 cm) followed by S_3T_5 (8.17 cm) and the lowest diameter of pileus was recored in S_3T_2 (5.12 cm) preceded by S_3T_1 (5.37 cm) and S_1T_5 (5.75 cm).

Thickness of pileus: No significant difference was found among the treatments (Table1). The thickness ranged from 0.65 to 1.05 cm. The highest thickness was found in S_1T_1 (1.05 cm) followed by S_2T_5 (8.17 cm) and the lowest thickness was observed in S_2T_2 (0.65 cm) preceded by S_3T_1 (0.67 cm), S_2T_1 (0.70 cm) and S_2T_4 (0.70 cm).

Economic yield: The economic yield differed significantly under different treatments (Table1). The highest economic yield (263g) was found in S_3T_5 when 10 ppm GA_3 was applied on fruiting body development stage followed by S_1T_5 (259g) and S_3T_4 (258g). The lowest economic yield was found in S_3T_6 (190g) when no GA_3 was sprayed on fruiting body development stage preceded by S_1T_6 (195 g) and S_2T_6 (197g).

Table 1. Effects of different levels of GA_3 and the their time of application (growth stages of cultivation) on the growth, yield contributing character and yield of *Pleaurotus ostreatus*

Treatment	Days required from stimulation to primordia initiation	Number of Fruit Bodies	Length of stipe (cm)	Diameter of Stipe (cm)	Diameter of Pileus (cm)	Thickness of Pileus (cm)	Economic yield (g/packet)
S_1T_1	4.25 d	21.00 ab	4.32ab	0.92a	6.37ab	1.05a	200 def
S_1T_2	5.50 bcd	14.50 b	4.1ab	1.05a	6.87ab	0.85a	224 cde
S_1T_3	5.75 abcd	20.00 ab	4.85a	1.02a	6.55ab	0.87a	244 abc
S_1T_4	7.75 abc	20.75 ab	4.50ab	1.12a	6.45ab	0.70a	252 abc
S_1T_5	8.25 ab	23.25 ab	4.50ab	1.07a	5.75b	0.77a	259 ab
S_1T_6	9.00 a	21.00 ab	4.32ab	0.92a	6.37ab	1.05a	195 ef
S_2T_1	5.50 bcd	15.00 b	4.12ab	1.52a	7.25ab	0.70a	226 bcde
S_2T_2	4.50 cd	23.25 ab	3.60b	1.02a	6.55ab	0.65a	233 abcd
S_2T_3	5.25 bcd	20.25 ab	4.37ab	1.20a	6.77ab	0.82a	245 abc
S_2T_4	4.50 cd	25.25 ab	3.60b	1.20a	6.65ab	0.70a	246 abc
S_2T_5	7.25 abcd	16.00 b	4.25ab	1.35a	8.20a	1.02a	246 abc
S_2T_6	9.00 a	21.00 ab	4.32ab	0.92a	6.37ab	1.05a	197 ef
S_3T_1	5.00 bcd	27.25 ab	4.10ab	0.82a	5.37b	0.67a	206 def
S_3T_2	5.75 abcd	32.00 a	3.80ab	0.87a	5.12b	0.87a	254 abc
S_3T_3	5.50 bcd	32.00 a	4.50ab	1.07a	6.75ab	0.82a	255 abc
S_3T_4	9.00 a	25.25 ab	4.25ab	1.25a	7.12ab	0.82a	258abc
$S_3 T_5$	9.00 a	24.00 ab	4.90a	0.92a	8.17a	0.92a	263 a
S_3T_6	9.00 a	21.00 ab	4.32ab	0.92a	6.37ab	1.05a	190 f
CV (%)	12.27	3.65	6.76	15.18	10.42	12.59	2.38

In a column, means followed by a common letter are not significantly different at 5% level by DMRT. Growth stages, S_1= Opening period, S_2= Primordia initiation and S_3= Fruiting body development. Levels of GA_3, T_1=50, T_2=40, T_3=30, T_4=20, T_5=10 and T_6=0 ppm.

Biological efficiency: The biological efficiency of *Pleaurotus ostreatus* differed under different treatments (Fig. 1) by different levels of GA_3 and their application on different stages. The highest biological efficiency 132.00 % was observed in S_3T_5 when 10 ppm GA_3 was sprayed during fruiting body development stage then 130.50 % in S_1T_5 when 10 ppm GA_3 was applied during opening period by submerging the packets in GA_3 added water followed by S_3T_4 (130.00 %), S_3T_3 (129.00 %) and in S_3T_2 (128.00 %) when 20 ppm, 30 ppm and 40 ppm GA_3 was sprayed on fruiting body development stage respectively. The lowest biological efficiency was observed in S_3T_6 (96.50 %) when no GA_3 was applied on fruiting body development stage preceded by 99.0 % in S_1T_6 and 100 % in S_1T_1 and in S_2T_6.

From the above discussions the experiment revealed that the highest biological efficiency and economic yield was obtained in S_3T_5 when 10 ppm GA_3 was applied on fruiting body development stage, above this level the yield was decreased. The lowest biological efficiency and economic yield was recorded in S_3T_6 when no GA_3 was sprayed on fruiting body development stage. The result was almost similar to the findings of Dey (1996).

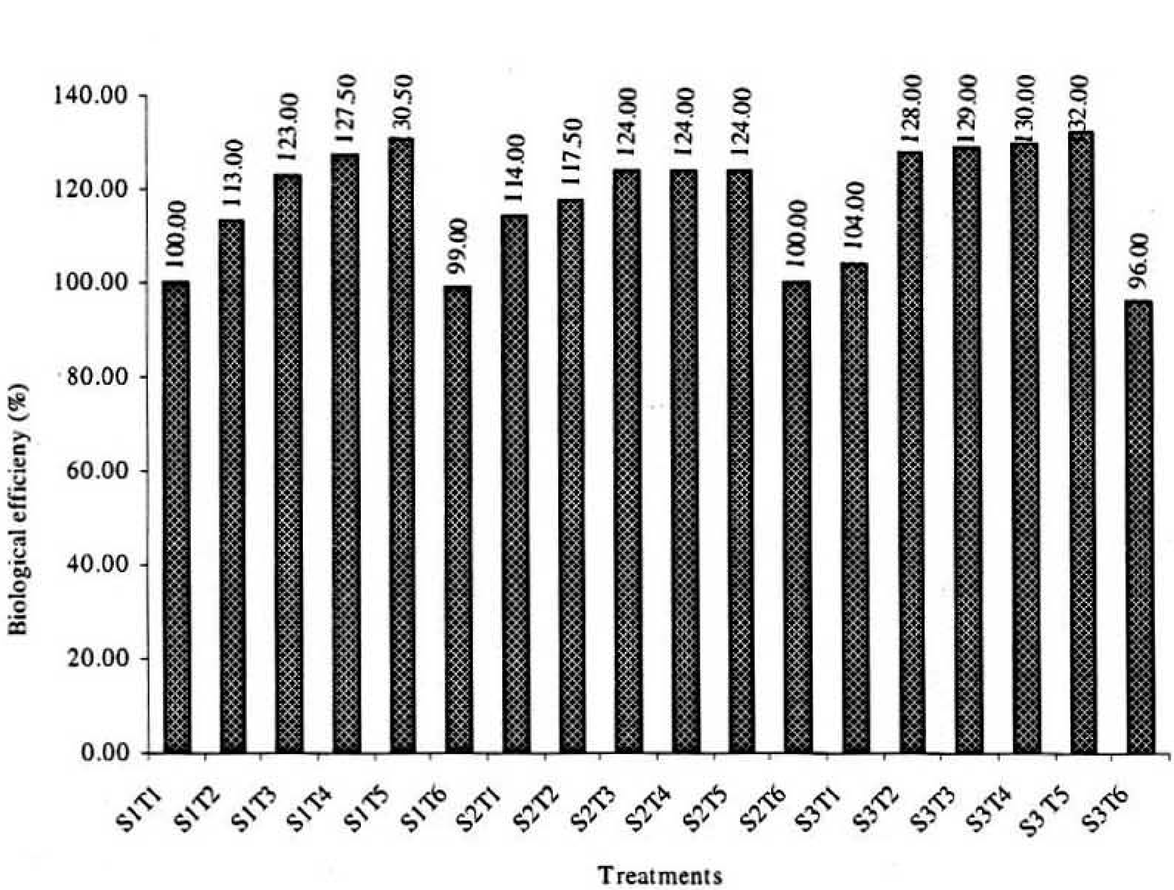

Fig.1. Biological efficiency of *Pleurotus ostreatus* influenced by different levels of GA_3 and their time of application (growth stages of cultivation) (Growth stages, S_1= Opening period, S_2= Primordia initiation and S_3= Fruiting body development. Levels of GA_3, T_1=50, T_2=40, T_3=30, T_4=20, T_5=10 and T_6=0 ppm)

REFERENCES

Ashrafuzzaman, M., Sultana, N., Hossain, M. M. & Main, I. H. 2005. Effect of three growth regulators on yield and protein content of oyster mushroom (*Pleurotus ostreatus*). *Bangladesh J. Life Sci.* **17**(2): 50-55.

Dey, B. C. 1996. Effect of growth regulators on the growth and yield of oyster mushroom (*Pleurotus sajor-caju*) (Fr.). M. S. Thesis. Department of Hrticulture. Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh. pp. 1-59.

Gomez, K. A. & Gomez, A. A. 1984. **Statistical Procedures for Agricultural Research**, 2nd ed., Jonn Wiley and Sons. Inc. New York. pp. 304-307.

Halder, A. K., Rahim, M. A., Chowdhury, M. S. H. & Haider, M. A. 1998. Effect of growth regulators on the growth and yield of mushroom. *Bangladesh J Agril . Res.* **23**(4): 677-684.

Yang, Q. Y. & S. C. Jong. 1989. Medicinal mushroom in China. **Mushroom Science. XII.** (Part I): 631-643.

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Effect of a Mineral Supplement on Growth, Yield and Nutritional Status of Oyster Mushroom (*Pleurotus ostreatus*)

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Abstract

The present investigation was conducted to find out the effect of wuxal super, a mineral supplement to sawdust substrate on growth, yield and quality of oyster mushroom (*Pleurotus ostreatus*). It is a liquid fertilizer containing macro-and micronutrients of plants. The spawn packets were soaked in 0.0, 0.1, 0.2, 0.3 and 0.4% solution of the supplement for 30 minutes. The maximum of 0.45% and 0.35% reduction in days to primordial initiation and time primordia initiation to harvest was obtained with 0.2% which was followed by 0.1 and 0.3%. On the other hand, maximum increase in numbers of primordia, total fruiting bodies and effective fruiting bodies per packet and weight of fruiting bodies was also maximal at 0.2% followed by 0.1%. The highest increases in biological and economic yield and biological efficiency of the mushroom on spawn packet were obtained with 0.2% followed by 0.1 and 0.3% of the supplement. These three treatments also caused considerable increase in protein, lipid, N, P, K and Fe contents of mushroom. Similar trends of increase in other parameters were recorded under those concentrations. The results showed that the most effective level of wuxal super was 0.2%, which was followed by 0.1 and 0.3%. Increase in its concentration more than 0.3% caused adverse effect on growth, yield and nutrient status of mushroom.

Key word: Wuxal super, mineral supplement and oyster mushroom.

INTRODUCTION

Oyster mushrooms (*Pleurotus ostreatus*) are large reproductive structures of edible fungi belong to genus *Pleurotus* under the class Basidiomycetes, the order Agraicales and the family Tricholomataceae. The edible parts of the fungi have high nutritive and medicinal values (Chang *et al.*, 1981). According to Chang (1982), the protein value of dried mushrooms is 30-40%. Mushrooms are good sources of niacin (0.3g) and riboflavin (0.4 mg). Mushroom is a good source of trypsin enzyme. They are also rich in the iron, copper, calcium, potassium, vitamin D, and folic acid, which are essential for human health. Mushrooms are valuable health food, which are low in calories, high in vegetable proteins, zinc, chitin, fiber, vitamins and minerals (Alam and Saboohi, 2001).

Commercial mushroom substrate is made from the cheapest waste products which are easily available. Supplements of mushroom substrate increase yield and quality of mushroom. The supplements are materials mostly enriched with carbohydrates, proteins, amino acid, macro- and micronutrient (Royse and Sanchez, 2008a, 2008b and Royse *et*

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al., 2008. MCSubstradd products are tuned on the nutritional needs of mushroom and complete the deficits in the compost of essential nutrients like nitrogen, carbohydrates or trace-elements. It gives higher yield (up to 30%) and offers a direct economical benefit for every mushroom grower. MCSubstradd products are based on a wide variety of protein sources, mainly from soybean meal and other vegetable origin that have been selected for their delayed release capacity of nitrogen (Anon., 2009a). Royse and Sanchez (2008b) tested 16 supplements of mushroom compost, including five crystalline amino acids, one amino acid blend, one egg white and four hydrolyzed proteins, Micromax (a micronutrient containing nine minerals) and four commercial supplements to find out their effect on mushroom yield and biological efficiency. They found that all of the supplements increase yield and quality of mushroom (Royse and Sanchez, 2008a, 2008b)

In Bangladesh, Mushroom substrates are made from agricultural wastes sawdust supplemented with lime, wheat bran and other materials (Sarker *et al.*, 2007a, 2007b). Wheat bran is a costly material and considered as a barrier for the extension of mushroom production in the country. Supplements of minerals are not normally added to mushroom substrate in the country. But use to supplements as sources of carbohydrates, proteins, marco-and micronutrients and minerals may increase yield and quality of the crop. Therefore, search for alternative supplements for the substrate is essential for extension of mushroom cultivation in the country.

Wuxal liquid fertilizers are true solutions of mineral salts and are plant physiologically effective additives. Raw materials are selected from the purest form to deliver high crop safety. It is a well balanced NPK liquid fertilizer supplemented with a full complement of macro- and micronutrients. The fertilizer is recommended as a general supplementary plant feed in high values crops (Anon., 2009b). Wuxal super may be a good mineral supplement to mushroom substrate for improving growth, yield and nutritional status of mushroom.

Considering the above facts, the present investigation was conducted to find out the effect of wuxal super, as a mineral supplement to mushroom compost on growth, yield and nutritional status of oyster mushroom (*Pleurotus ostreatus*).

MATERIALS AND METHODS

Application of wuxal super: Solutions of wuxal super were prepared in distilled water at the rate 0.0, 0.1, 0.2, 0.3 and 0.4% based on the gross product. Spawn packets were soaked in the solutions for 30 minutes. Standard methods were followed for preparation, Sterization, inoculation of spawn packet as described by Sarker *et al.* (2007a). The spawn packets were opened by cutting "D" shape with a blade and opened by removing the plastic sheet after which they are soaked in 3 liter wuxal super solution in a bucket for 30 minutes.

Growing of mushroom: After soaking, the excess water was drained off and the spawn packets were placed separately on the shelf of a culture house of Sher-e-Bangla

Agricultural University, Dhaka. The culture house was well ventilated having 80-85% relative humidity, 22°C to 25°C temperature and 300-500 lux light intensity. The spawn packets were arrange in the culture house following completely randomized design. Three spawn packets (replication) were used for each treatment. During growing period, water was sprayed regularly to maintain proper moisture level of the spawn packets.

Data collection: Duration from stimulation to primordial initiation and from primordial initiation to harvest was recorded. Dimensions of mature fruiting bodies yield attributing characters of mushroom were recorded after harvest. Dimensions of nature fruiting bodies yield and yield attributing characters of mushroom were recorded after harvest. Biological yield, economic yield, dry yield and biological efficiency of the mushroom on the spawn packet were computed using suitable formulae:

$$\text{Dry yield (g/packet)} = \text{Economic yield} \times \frac{\text{Oven dry weight of sample mushroom (g)}}{\text{Total fresh weight of sample mushroom (g)}}$$

$$\text{Biological efficiency (\%)} = \frac{\text{Total biological yield (g/packet)}}{\text{Total substrate weight (g/packet)}}$$

Chemical analysis of mushroom: Dry matter and moisture content of mushroom were determined by conventional methods using following the formulae:

$$\text{Moisture (\%)} = \frac{\text{(Initial weight - Final weight)}}{\text{Weight of sample}} \times 100$$

Dry matter (%)= 100 - % moisture content

Fiber content of mushroom was estimated by acid digestion (Dougall 2006). Total lipid was estimated by using the method described by Sandrina *et al.* (2009). Total ash content was determined using the following formula:

$$\text{Ash content (\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample taken}}$$

Total nitrogen content was estimated following standard Microjeldhal method (AOAC, 1975). Total protein content was determined by multiplying the nitrogen content by a factor of 6.25. Content of Ca, Mg, K, Fe and P was estimated by perchloric acid digestion method as proposed by Yamakawa (1992).

RESULT AND DISCUSSION

Days from stimulation to primordial initiation and from primordial initiation to harvest: The maximum duration from stimulation to primordial initiation and primordial initiation to harvest was observed under control (0.0%), where the wuzal super was not added. Use of the mineral supplement at 0.1 and 0.2% caused significant reduction in the duration of both parameters over control. The highest reduction was achieved with 0.2% followed by 0.1% (Table 1)

Number of primordia and total and effective fruiting bodies per packet: Use of wuxal super at all concentrations caused significant increase in number of primordia and total fruiting bodies per packet compared to control. The highest increase was achieved with the concentration of 0.2% followed by 0.1, 0.4 and 0.3%. Significantly the highest number of effective fruiting body was obtained with 0.2% wuxal super. Number of effective fruiting body at all other concentration including control was statistically similar (Table 1).

Table 1. Effect of different levels of wuxal super on primordia and fruiting body of oyster mushroom (*Pleurotus ostreatus*)

Wuxal super with concentration (%)	Duration (days)		Number /packet		
	Stimulation to primordial initiation	Primordia to harvest	Primordia	Total fruiting bodies	Effective fruiting bodies
0.0	6.90a	3.83a	67.33c	55.00c	50.00b
1	5.06bc	3.10d	76.33ab	64.33b	53.00b
0.2	3.80c	3.36bc	81.00a	70.00a	63.33a
0.3	6.06ab	3.36bc	73.67b	62.33b	51.67b
0.4	5.83b	3.70ab	76.33ab	63.00b	53.67b
CV%	3.40	4.44	2.67	0.28	2.75
LSD	1.621	0.3874	5.491	3.923	4.094

Values within the same column with a common letter do not differ significantly (P=0.05).

Dimension and weight of fruiting body: Length of the stalk was maximal at 0.0 % (control), which was statistically similar to the lengths recorded at 0.4 and 0.1% of wuxal super. Significantly the highest diameter of stalk and pileus and weight of individual fruiting body of mushroom was obtained with 0.2% wuxal super. The parameters under other treatments including control were statistically similar. Thickness of pileus varied from 0.40-0.48 cm and the variations were not significant (Table 2).

Table 2. Effect of different levels of wuxal super on dimension and weight of individual fruiting body of oyster mushroom (*Pleurotus ostreatus*)

Wuxal super with level (%)	Stalk length (cm)	Stalk diameter (cm)	Pileus diameter (cm)	Pileus thickness (cm)	Weight (g)
0.0	3.72a	0.73b	5.10b	0.40a	2.25b
0.1	3.62ab	0.77b	5.30b	0.43a	2.63b
0.2	3.30c	0.90a	5.60a	0.48a	2.84a
0.3	3.45b	0.80b	5.10b	0.42a	2.64b
0.4	3.65a	0.81b	5.30b	0.54a	2.58b
CV%	1.76	1.26	1.69	2.77	2.21
LSD	0.17	0.087	0.245	0.087	0.15

Values within the same column with a common letter do not differ significantly (P=0.05).

Yield and biological efficiency: All treat....nts with wuxal supper significantly increased biological and economic yield of mushroom over control. The highest increase in both the parameters was obtained with 0.2%, which was followed by 0.1%. Effect of two lower levels of the supplement was significantly different. Biological as well as economic yield at 0.3 and 0.4% was statistically similar but significantly lower compared to 0.2 and 0.1%. Significantly the lowest and the highest dry yield of mushroom per packet were recorded from control and the treatment with 0.2% of wuxal super, respectively. The dry yield under 0.1, 0.3 and 0.4% was statistically similar but significantly higher as compared to control. All treatments with the supplement increased biological efficiency of spawn packet over control. The highest efficiency was obtained with the highest concentration (0.2%), which was followed by 0.1%. The lowest biological efficiency was obtained with 0.3% followed by 0.4%. But effectiveness of two higher concentrations was statistically similar (Table 3)

Moisture and dry matter content: The moisture and dry matter content of oyster mushroom grown under different levels of wuxal super varied from 89.5 to 90.23 % and 9.77 to 10.46% respectively. The variations in both the parameters were not significant (Table 4).

Protein, lipid, ash and crud fiber content: Significantly the highest increase in protein content of mushroom over control was achieved with 0.2% of the supplement, which was followed by 0.1 and 0.4%. Efficacy of three levels to increase protein content was significantly different. The lowest protein content was found under control, which was statistically similar to protein content at 0.3% of the supplement. On the other hand only the level 0.3% gave significant increase in lipid content over control. Lipid content under other levels of the supplement and control was statistically similar. The lipid content at 0.3 and 0.4% wuxal supper was also statistically similar (Table 4). The highest ash content was found at 0.2%, which was statistically similar to 0.0, 0.1 and 0.3% of the supplement. The highest concentration of the wuxal super gave the lowest ash content. Percentage of crud fiber content in mushroom at 0.1 and 0.2% was statistically similar but significantly higher as compared to other treatments including control. Crud fiber content under two higher levels and control was not significantly different (Table 4).

Table 3. Effect of different levels of mineral supplements on yield and biological efficiency

Waxal super with level (%)	Biological yield (g/packet)	Economic yield (g/packet)	Dry yield (g/packet)	Biological efficiency (%)
0.0	171.7d	165.3d	16.53c	59.20d
0.1	201.3b	194.3b	19.00b	69.43b
0.2	230.7a	224.3a	23.47a	79.54a
0.3	195.0c	184.0c	18.43b	67.24c
0.4	197.0bc	187.0c	18.67b	67.93bc
CV%	0.96	1.01	1.58	0.96
LSD	5.258	5.270	0.831	1.815

Values within the same column with a common letter do not differ significantly (P=0.05)

Table 4. Effect of different levels of wuxal super on chemical compoistion of oyster mushroom (*Pleurotus ostreatus*)

Wuxal super with level (%)	Moisture content (%)	Dry matter content (%)	Protein content (%)	Lipid content (%)	Ash content (%)	Crud fiber content (%)
0.0	90.00a	10.00a	24.00d	3.85bc	7.80ab	25.83b
0.1	90.23a	9.77a	25.20b	3.75bc	7.88ab	27.13a
0.2	89.54a	10.46a	26.40a	3.45c	8.10aa	27.27a
0.3	89.98a	10.02a	24.00d	4.57a	7.53ab	26.33b
0.4	90.02aa	9.98a	24.50c	4.20ab	7.26b	26.10b
CV%	0.13	1.2	0.32	6.25	2.74	0.68
LSD	0.324	0.324	0.229	0.6766	0.581	0.497

Values within the same column with a common letter do not differ significantly (P=0.05)

Nitrogen, phosphorus, potassium, iron and zine content: Effect of different levels of wuxal super on nitrogen (N), phosphorus (P), potassium (K), iron (Fe) and zinc (Zn) content of mushroom are summarized in Table 5. Two lower levels of wuxal super (0.1% and 02%) increased N content significantly over control. The highest increase of N content was obtained with 0.2% followed by 0.1% of the supplement. Nitrogen content under the treatments with 0.0 (control), 0.3and 0.4% was statistically similar. The highest P content was observed at 0.2%, which was statistically similar to P content at 0.3, 0.4%, and 0.0%. All treatments with wuxal super gave significant increase in K content over control. The highest increase in K content over control was found at only 0.2% and 0.4%. Effectiveness of two concentrations to increase Fe content was statistically similar. Only treatment with 0.2% of the supplement caused significant decrease in Zn. Its content at 0.0, 0.1, 0.3 and 0.4% of the supplement was statically similar but significantly higher as compared 0.2%.

Table 5. Effect of different levels of wuxal super on individual element content of oyster mushroom (*Pleurotus ostreatus*)

Wuxal super with level (%)	Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)	Iron content (%)	Zine content (%)
0.0	3.84c	0.91ab	1.32d	41.00c	14.00a
0.1	4.03b	0.85b	1.37c	41.60bc	13.80a
0.2	4.22a	0.96a	1.42a	43.60a	13.10b
0.3	3.84c	0.92ab	1.38bc	40.00c	14.10a
0.4	3.92c	0.94ab	1.41ab	43.00ab	14.10a
CV%	0.36	3.73	0.82	1.51	1.28
LSD	0.086	0.086	0.027	1.733	0.482

Values within the same column with a common letter do not differ significantly (P=0.05)

In present study, it was found that wuxal super appreciably decrease in duration from stimulation to primodia initiation and primodia initiation to harvest. The maximum reduction was found at 0.2% followed by 0.1 and 0.3%. On the contrary, weight and dimensions of individual fruiting bodies, biological, economic and dry yield of mushroom increased due to soaking of spawn packet in 0.1, 0.2 and 0.3% of wuxal super solutions. The above three levels of the supplement also increased nutrient status of the mushroom, in terms of dry matter, ash, protein, lipid, N, P and K content. The most effective level was 0.2% to increase the above parameters over control, which was followed by 0.1 and 0.3%. The level highest (0.4%) showed adverse effect on those parameters.

The findings of the present investigation corroborate with the findings to many other investigators (Anon., 2009b and Royse and Sanchez, 2008a, 2008b). Generally commercial mushroom substrates are made from rice straw, wheat straw, hay, corn cobs, cotton seed hulls, gypsum, chicken manure and horse manures (Royse and Snchez, 2008a, 2008b). Supplements of the substrate increase yield and quality of mushroom. The supplements are materials mostly enriched with carbohydrates, proteins, amino acid, macro- and micronutrient (Royse and Sanchez, 2008a, Royse *et al.*, 2008, and Anon., 2009b). MCSubstratedd is a commercially used supplement. It increases up to 30% yield and others a direct economical benefit for every mushroom grower. MCSubstradd products are based on a wide variety of protein sources mainly from soybean meal and other vegetable origin that have been selected for their delayed release capacity of nitrogen (Anon., 2009a). Royse and Sanchez (2008b) tested sixteen supplements of mushroom compost, including five crystalline amino acids, one amino acid blend, one egg white and four hydrolyzed proteins, Micromax (a micronutrient containing nine minerals) and four commercial supplement to find our their our their effect on mushroom yield and biological efficiency of spawn packets. They found that all of the supplements increase yield and quality of mushroom and biological efficiency of spawn packet greatly. Alam (2007) found increased number of fruiting bodies, yield and nutrient status of oyster mushroom where spawn packets were treated with NAA. Yoshida *et al.* (1993) reported that the number of effective fruiting bodies was lower, but increased when the substrates was mixed with different supplements. The findings of the present study more or less matched with study of Bhuyan (2008). They found that the biological yield of *Pleurotus ostreatus* varied with supplement used.

REFERENCES

Alam, N., Khan, M. A., Hossain, M. S., Amin, S. M. R. & Khan, L. A. 2007. Nutritional Analysis of dietary Mushroom *Pleurotus florlda* Eger and *Pleurotus sajorcaj* (Fr.) Singer. *Bangladesh J. Mushroom*. **1**(2): 1-7.

Alam, S. M. & Saboohi, R. 2001. Importance of mushroom. Internet. http://www. pakistaneconomist.com/issue2001/issue40/i&e4.htm

AOAC. 1975. Official Method of Analysis (12^{th} edn). Association of Offical Analytical Chemist. INC., 111, North Nineteen Street, Suit 210. Arlington, VA22209 USA.

Anonymous. 2009a. MCSubstradd. FAQ about use of MCSubstradd ® mushroom supplement (fertilizer). Internet: http// www.mushroomsupplements.nl/page15.html

Anonymous. 2009b. Wuxal Sper. A liquid fertilizer by Aglikon, Germany. Internet: http://www.horticentre.co.nz/file/WUXAL-Super-HC-.pdf

Bhuyan, M. H. M. B. U. 2008. Study on preparation of low cost spawn packets for the production of oyster mushroom (*Pleurotus ostreatus*) and its proximate analysis. M.S Thesis, Department of Biochemistry, SAU, Dhaka- 1207.

Chang, S. T. & Miles, P.G. 1988. **Edible Mushroom and Their Cultivation** . CRC Press . Inc. Boca Raton, Florida U. S. A. pp. 27.83.88.

Chang, S. T. 1982. Cultivation of Volvariella Mushroom in Southeast Asia. **In: Trop Mushrooms: Biological Nature and Cultivation Methods.** The Chinese Univ. Press Hong Kong. pp. 135.-156.

Chang, S. T., Lau, O. W. & Cho, K. Y. 1981. The cultivation and nutritional value of *Pleurotus sajor-cuju. Eur. J. Appl. Microbiol. Biotechnol.***12** (1): 58-62.

Dougall, H. D. 2006. Observation on crude fibre estimation by acid digestion *J. Sci. Food Agri.* **9**(1): 1-7.

Royse D. J. & J. E. Sanchez. 2008a. Supplementation of first break mushroom compost with hydrolyzed protein. commercial supplements and crystalline amino acids. *World J., Microbiol. Biotech.* **24**: 1333-1339.

Royse D. J. & J. E. Sanchez. 2008b. Supplementation of second break mushroom compost with isoleucine leucine, valube, phenylalanine and Soypluse. *World J. Microbiol. Biotech.* **24**: 2011-2017.

Royse D. J., Sanchez, J. E., Beelman, R. B. & Davidson, J. 2008. Re-supplementing and recasing mushroom (Agaricus busporus) compost for a second crop. *World J. Microbiol. Bidotech.* **24**: 319-325.

Sandrina, A. H., Barros, L., Sousa, M. J., Matins, A. & Ferreira, I. C. F. R. 2009. Study and Characterization of selected nutrients in wild mushroom from Portugal by gas chromatography and high performance liquid chromatography. *Microchemical J.* **93** (2): 195-199.

Sarker, N. C., Hossain, M. M., Sultana, N., Mian, I. H., Sirazul Karim, A. J. M. & Amin, S. M. R. 2007a. Performance of Different Substrates on the growth and yield of *Pleurotus ostreatus* (Jacquin ex. Fr.) Kummer. *Bangladesh J. Mushroom.* **1**(2): 44-49.

Sarker, N. C., Hossain, M. M., Sultana, N., Mian, I. H., Sirazul Karim, A. J. M. & Amin, S. M. R. 2007b. Impact of different Substrates on Nutrient Content of Pleurotus ostreatus (Jacquin ex Fr.). Kummer. *Bangladesh J. Mushroom.* **1**(2): 35-38.

Yamakawa. T. 1992. Laboratory method for soil science and plant nutrition. JICA- IPSA Project Publication. IPSA, Gazipur. Bangladesh. pp. 1-14.

Yoshida, N., Takahashi, T., Nagao, T. & Chen, J. 1993. Effect of edible mushroom (*Pleurotus ostreatus*) cultivation on in vitro digestibility of wheat straw and sawdust substrate. *J. Japanese Soc. Grassland Sci.* **39**(2): 177-182.

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Effect of Casing Depth on the Growth and Yield of Button Mushroom (*Agaricus bisporus*)

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Abstract

The experment was conducted to determine the suitable depth of casing material (soil+sand, 3:1) in button mushroom cultivation and ten different depth (0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0 and 4.5 cm) were evaluated. The highest biological yield (470.50 g/2000g compost) and economical yield (445.30 g/2000g compost) were recorded in 4.0 cm thick casing material and the yields were lowest in 0.5 cm thick casing material. The maximum number of effective fruiting body (47.0) was found in 3.5 cm casing depth followed by 4.0 cm. The lowest number of fruiting body (18.0) was recorded in 0.5 cm casing depth. The biggest size of fruiting body (11.87 g) was observed in 2.0 cm casing depth followed by 1.0 cm casing depth and the smallest fruiting body (8.472g) was observed in 3.5 cm casing depth.

Key words: *Agaricus bisporus*, casing thickness, yield and biological efficiency

INTRODUCTION

Agaricus bisporus (Lange), commonly known as the white button mushroom is the most popular and widely cultivated mushroom in the world. Unlike oyster mushroom cultivation, *Agaricus bisporus* production involves an additional process called casing. Casing is a mixture designed to cover the nutritional composted substrate colonized with mycelium and has an essential function in stimulating and promoting the developments of sporophores (Pardo *et al.*, 2003 and Noble *et al.*, 2005). Casing soil is necessary to induce pinhead after incubation. It provides water to enable growth and development of fruiting bodies and regulates the flow of nutrients from compost to the developing fruiting bodies. The physical and chemical characteristics of casing soil have been emphasized by many scientists. The thickness of casing can play an important role in the yield and yield attributes of *Agaricus bisporus*. Trivedi *et al.* (1991) and Doshi *et al.* (1993) reported that 2.5 cm casing thickness was good for mushroom cultivation. But according to Tripathi (2005), casing layer should be 2.5 to 3.5 cm of thickness in case of casing soil and 2.5 to 5.0 cm of thickness in case of peat soil, spent compost and farm yard manure. Amin *et al.* (2007a) obtained higher yield using soil: sand (3:1) as casing material maintaining the depth of 3-4cm in Bangladesh where the effect of different depth was not studied. Therefore, it is very important to find out the suitable depth of casing layer for button mushroom cultivation to get higher yield and better quality. The aim of the study was to determine the individual effect of different depth of casing layer on the growth and yield of *Agaricus bisporus*.

MATERIALS AND METHODS

The research was conducted in the National Mushroom Development and Extension Centre (NAMDEC), Savar, Dhaka during November 2007 to February 2008.

Preparation of compost: Paddy straw was used as the main substrate of compost and it was prepared according to Amin *et al.* (2007b).

Spawning and incubation: Two kilograms of compost were mixed with 75 g of mother culture of *Agaricus bisporus* and poured in a polypropylene bag. The open top of the bags were covered with news papers and incubated in the incubation room at $24^0 \pm 2^0$C temperature for 20 days.

Casing: After completion of mycelium running, the open top of the spawn bags were covered with pasteurized casing soil (Soil + sand, 3:1) to the depth of 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0 and 4.5 cm. Watering after casing was done as suggested for commercial growth (Randle, 1984 and Shandilya, 1986).

Cropping and harvesting: After completion of mycelium running in the casing soil. the bags were transferred into the culture house where temperature below 16^0C and relative humidity above 90% were maintained. Mushroom was harvested before the fruiting body showed any detachment of the cap from the stipe. The yield of mushrooms and their parameters were recorded regularly.

Data analysis: The experiment was laid out following completely randomized design with 4 replications. Data were analyzed following MSTAT-C computer program. Means was computed following Duncan's Multiple Test (DMRT) using the same computer program.

RESULTS AND DISCUSSION

Days required to primordial initiation: The data regarding days required to primordial initiation are presented in Table 1. The lowest time for primordial initiation (14.25 days) was observed in 2.0 and 4.0 cm thick casing soil which was statistically similar to all the depth of casing soil except 0.5 cm (16.25 days). The highest time (16.25 days) was found in 0.5 cm casing depth. This result is almost similar to Amin *et al.* (2007b) who used 3.0 cm casing depth.

Days required to first harvest: Days required to first harvest did not show any significant variation and ranged from 19.50 to 21.50 days. The lowest time (19.50 days) was observed in 1.5 and 4.0 cm casing depth which was followed by 2.0 cm. The maximum time (21.50 days) was recorded in 0.5 cm casing depth.

Table 1. Effect of casing depth on the growth of *Agaricus bisporus*

Casing thickness (cm)	Days required to primordia initiation	Days required to first harvest	Days required for total harvest
0.0	-	-	-
0.5	16.25 a	21.50 a	44.00 f
1.0	14.50 ab	20.75 a	51.50 e
1.5	14.50 ab	19.50 a	57.25 d
2.0	14.25 b	19.75 a	50.00 e
2.5	16.00 ab	20.50 a	56.50 d
3.0	15.00 ab	20.25 a	66.50 bc
3.5	15.25 ab	20.75 a	62.25 c
4.0	14.25 b	19.50 a	69.50 ab
4.5	15.75 ab	21.25 a	72.25 a
CV (%)	7.19	9.0	5.34

In a column, means followed by a common letter are not significantly different at 5% level by DMRT. Here – mean no yield was found.

Days required for total harvesting: Days required for total harvest differed significantly and ranged from 44.00 to 72.25 days under different casing depth (Table 2). The harvesting period was shortest (44.00 days) in 0.5 cm casing depth which was significantly lower as compare to all the treatments. The highest harvesting period (72.25 days) recorded in 4.5 cm casing depth followed by 4.0 cm casing depth (69.50 days). Results of this study was almost similar to the results of Dhar *et al.* (1985), who reported the best results with 4 cm depth casing soil.

Number of effective fruiting bodies: The number of effective fruiting body in different casing thickness ranged 18.0 to 47.0 (Table 2). The highest number (47.0) was found in 3.5 cm casing depth followed by 4.0 cm. The lowest number of fruiting body (18.0) was observed in 0.5 cm casing depth followed by 1.0 cm (18.0).

Weight of fruiting body: Weight of fruiting body ranged from 8.47 to 11.87g. Statistically the highest weight (11.87g) was observed in 2.0 cm casing depth followed by 1.5 cm (10.48g) and 1.0 cm (10.45g). The lowest was weight of fruiting body was observed in 3.5 cm (8.472 g) casing depth.

Total biological and economic yield: Significant variation was observed in biological and economic yield of button mushroom in different casing depth. The biological and economic yield under different casing depth ranged 163.30-470.50 g/packet and 149.00-445.30g/packet respectively. The highest biological yield (470.50 g/packet) and economic yield (445.30 g/packet) was recorded in 4.0 cm casing depth. The lowest biological (163.30 g/packet) and economical (149.00 g/packet) yield was recorded under 0.5 cm casing depth. But no yield was recorded in zero casing material. Vijay *et al.* (1988) recorded the highest yield of 13.00 kg/100 kg compost in 5.1 cm casing treatment followed by 3.8 cm (12.99 kg) and the lowest yield 11.01 kg/100 kg compost was recorded in 2.5 cm casing thickness.

Table 2. Effect of casing depth on the yield attributes and yield of *Agaricus bisporus*

Casing thickness (cm)	Number of effective fruiting body	Weight of fruiting body (g)	Biological yield (g)	Economic yield (g)
0.0	-	-	-	-
0.5	18.00 e	9.095 bc	163.30 f	149.00 f
1.0	19.50 e	10.45 ab	203.30 e	191.80 e
1.5	27.00 d	10.48 ab	281.30 d	265.00 d
2.0	24.00 d	11.87 a	282.50 d	267.30 d
2.5	34.50 c	9.023 bc	310.30 cd	291.00 cd
3.0	37.50 bc	8.970 bc	335.30 c	309.80 c
3.5	47.00 a	8.472 c	396.80 b	375.00 b
4.0	45.50 a	10.34 b	470.50 a	445.30 a
4.5	40.25 b	9.252 bc	371.80 b	349.080 b
CV (%)	7.25	9.74	6.20	6.40

In a column, means followed by a common letter are not significantly different at 5% level by DMRT. Here – mean no yield was found.

RERERENCES

Amin, S. M. R., Sarker, N. C., Moonmoon, M., & Rahman, F. 2007a. Comparative study of different casing materials on growth and yield of button mushroom. *Bangladesh J. Mushroom.* **1**(1): 9-13.

Amin, S. M. R., Sarker, N. C., Rahman, F., Alam, N. & Khair, A. 2007b. Influence of Amount of Compost on the Growth, Yield and Yield Attributes of *Agaricus bisporus* (Lange) Singer. *Bangladesh J. Mushroom.* **1**(1): 23-27.

Dhar, B. L., Vijay, B., Upadhyay, R. C. & Sohi, H. S. 1985. Effect of casing thickness on yield of *Agaricus bisporus. Indian J. Mycol. Pl. Pathol.* **15**: VIII.

Doshi, A., Sharma, Sundar, S. & Trivedy, A. 1993. A promising edible mushroom for the tropies: *Calocybe indica* P. & C. *Mush. Information.* **10**: (95/14): 14-22.

Noble, R. & Dobrovin-Pennigton, A. 2005. Partial substitution of peat in mushroom casing with fine particle coal tailings. *Scientia Horticulturae.* **104**(3): 351-367.

Pardo, A., Juan, D. J. A. & Pardo, J. E. 2003. Performance of composted vine shoots as a peat alternative in casing materials for mushroom cultivation. *J. Food, Agriculture & Environment.* **1**(2): 209-214.

Randle, P. E. 1984. Supplementation of mushroom compost: *A review Mush. J.* **151**: 241-69.

Shandilya, T. R. 1986. Effect of different pasteurized compost on the yield of *Agaricus bisporus. Indian J. Pl. Pathology.* **4**(1): 89-90.

Tripathi, D. P. 2005. Casing materials and case running. In: **Mushroom Cultivation**. Oxford & IBH Publishing Co. Pvt. Ltd., Panchsheel Park, New Delhi. pp. 172-175.

Trivedi, A., Sharma, S. S. & Doshi, A. 1991. Cultivation of *Calocybe indica* under semi- arid conditions. Indian Mushrooms. pp. 166-169.

Vijay, B., Gupta, Y. & Upadhyay, R. C. 1988. Effect of casing thickness on yield of *Agaricus bisporus. Indian J. Mycol. Pl. Pathol.* **18**(2): 209-210.

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Comparative Study on the Growth and Yield of Oyster Mushroom (*Pleurotus ostreatus*) on Different Substrates

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Abstract

The experiment was carried out to investigate the growth and yield performance of oyster mushroom on water hyacinth, rice bran, sugarcane leaf and their combinations supplemented with 10% wheat bran. The fastest mycelium growth rate and the minimum time required for completion of mycelium running in spawn packet were observed from sugarcane leaf and the opposite results were from water hyacinth. The maximum number of effective fruiting body was obtained from the rice bran plus sugarcane leaf (1:1). The highest economic yield was harvested from rice bran plus sugarcane leaf (1:1) and the lowest yield was obtained from water hyacinth plus sugarcane leaf (1:1).

Key words: *Pleurotus ostreatus,* water hyacinth, rice bran, sugarcane leaf, growth and yield.

INTRODUCTION

Pleurotus ostreatus is one of the best known species among the oyster mushrooms (Chang and Miles, 1989) can be grown plant waste materials containing lignin, cellulose and hemicellulose (Chang and Miles, 1988). Lignin and cellulose containing materials such as sawdust, paddy straw, wheat straw, waste paper, cotton waste etc. are commonly used for the production of oyster mushroom (Yildiz and Ertekin, 1996). Generally, sawdust is used as a substrate for mushroom cultivation (Stamet, 2000) but the sawdust used in composting does not have adequate nitrogen and other components required for the fermentation process (Pathak and Yadav, 1998). Compounding mixture is, therefore, supplemented with nitrogen and carbohydrate sources to start this process (Pathak and Yadav, 1998). Wheat bran as supplement is used as a concentrate meal, supplying carbohydrates as well as nitrogen. Its nitrogen content may vary from 3-12% depending upon the source (Pathak and Yadav, 1998). Water hyacinth (*Eichornia crassipes*) has been considered as a potential substrate for mushrooms with a view of reducing its presence in aquatic sources (McGrath, 2003). It is listed as one of the most productive plants on earth and is considered the world's worst aquatic weed (Makhanu, 1996). Sugarcane leaf may also be used as substrate of oyster as it is available in the sugarcane

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mill zone of Bangladesh. The performance of rice bran as substrate and also as supplement may be tested. Therefore, considering the facts, the present experiment was undertaken to investigate the performance of different cheap and locally available substrates in the production of oyster mushroom as well as to find out economically feasible substrate(s) for the mushroom.

MATERIALS AND METHODS

The experiment was conducted in the Laboratory of Horticulture Center cum Mushroom Sub Centre, Department of Agriculture Extension (DAE), Khairtala, Jessore during the period from November 2008 to February 2009.

Preparation of pure culture: To obtain pure culture, PDA culture or tissue culture planting method was used. About 5 ml of PDA medium was poured in each test-tube followed by plugging. The medium was sterilized in an autoclave for 15 minutes at 121°C with 1.5 kg $/cm^2$ pressure. The sterilized PDA medium containing test-tubes were kept in a slanting position. These slanting test tubes were used for inoculation. Fresh juvenile mushroom fruiting bodies were used for tissue culture. Small piece of the internal tissue of the broken mushroom was cut and removed with a flamed needle. The needle with the tissue was then immediately inserted into a test-tube slant and the tissue was laid on the agar surface. The mouth of the test-tube was plugged with cotton plug. After 3 to 4 days, the agar surface was covered with a white mycelium.

Preparation of mother culture: The mother culture substrate was prepared by using good quality wheat grains and $CaC0_3$. At first, 300 g wheat grains and 1% $CaC0_3$ were mixed manually and packed tightly in 18x25 cm polypropylene (pp) bag. These packets were sterilized in an autoclave for one hour at 121 °C and 1.5 kg/cm^2 atmospheric pressure. After cooling the packets, a piece of pure culture measured 1x1 cm^2 was placed aseptically into the mouth of the each packet. All of these packets were plugged with cotton and placed in a dark growth chamber at 25±1 °C. After 15 to 20 days the packets became white due to complete mycelium running. The mother culture was then ready for inoculating spawn packets.

Preparation of spawn packet: For the growth of *Pleurotus ostreatus* seven different substrates were used with a control. These are as S_1=Water hyacinth, S_2=Rice bran, S_3= Sugarcane leaf, S_4=Water hyacinth: Rice bran (1:1), S_5=Water hyacinth: Sugarcane leaf (1:1), S_6=Rice bran: Sugarcane leaf (1:1), S_7=Rice bran: Water hyacinth: Sugarcane leaf (1:1:1) and Control=Sawdust: wheat bran: rice husk (8:4:1). Each of the substrate was supplemented with 10% wheat bran (except control), 0.2% calcium carbonate ($CaCO_3$) and about 65% water.

Water hyacinth (without root) and sugarcane leaves were chopped into small pieces of 1cm or less. They were dried well in the sun for 4-5 days so that they can be fragmented manually.

The materials were mixed thoroughly in a mixture machine by adding small amount of water gradually until the moisture content was around 65% - 70%. Polypropylene bags sized 25X8 cm were filled with 500g prepared substrate and packed tightly. A hole (about 5 cm) was made with a sharp-end bamboo stick at the centre for space to put the inoculums. They were plugged with cotton. The packets were sterilized in an autoclave for 1 hour at 120 °C and 1.5 kg/cm^2 and kept for 24 hours for cooling. One teaspoonful of mother culture was placed aseptically through the hole of each packet and each treatment was replicated 5 times. The packets were plugged with cotton and marked treatment wise. They were kept on the rack in an incubation room at 25±1°C under 70%-80% relative humidity. The packets were allowed to be completely colonized by mycelia.

Culture of spawn packet: After completion of mycelium running, two ends opposite to each other in the upper portion of the bags were opened with a blade by removing the plastic sheet in "D" shape. The opened surface of the substrate was scraped slightly with a teaspoon to remove the thin whitish mycelia. Then the spawn packets were soaked in water for 10 minutes. The packets were kept on the plastic tray for removing excess of water. The spawn packets were placed according to experimental design on the shelf and covered with gunny bag with proper ventilation. Water was sprinkled on the D-shaped cuts of the spawn packets to maintain 80-85% relative humidity of the culture house. Water spraying was done twice a day until the mushrooms were matured enough to be harvested. Temperature 22 °C to 27 °C, relative humidity 80-85% and proper ventilation at culture room were maintained for the development of fruiting body.

Data collection and statistical analysis: The experiment was laid out in Completely Randomized Design (CRD) with five replications and eight treatments. Data were collected on mycelium growth rate in spawn packet, time required for completion of mycelium running, duration from stimulation to primordia initiation, duration from stimulation to harvest, number of primordia, number of effective fruiting body, stalk length, stalk diameter pileus diameter, pileus thickness, biological yield and economic yield. Data on the yield and yield contributing characters were collected from first two flushes. The data were analyzed statistically by MSTAT-c programme. The treatment means were compared using Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Mycelium growth rate: Mycelium growth rate (MGR) in spawn packet ranged from 0.36 to 0.56cm/day on different substrates (Table 1). The fastest MGR (0.56 cm/day) was recorded from S_3 (sugarcane leaf) and the slowest (0.36 cm/day) was recorded from S_1 (water hyacinth) which was statistically similar to S_2 (rice bran). The maximum mycelium growth rate in spawn packet due to the presence of alpha-cellulose, hemi-cellulose, lignin and pectin was reported by Amin and Shahjahan (1994). The substrate water hyacinth gave lower MGR which might be due to presence of different kinds of polyphenolic substances in it as suggested by Wang (1982) and low content of cellulose.

Table 1. Effect of different substrates on mycelia growth of oyster mushroom

Substrates	Mycelium growth rate in spawn packet (cm/day)	Days required to completion of mycelium running in spawn packet
S_1	0.357 c	39.8 a
S_2	0.381 c	35.2 b
S_3	0.558 a	25.4 e
S_4	0.468 b	33.4 bc
S_5	0.481 b	31.0 cd
S_6	0.457 b	32.2 bc
S_7	0.496 b	29.8 cd
Control	0.495 b	27.2 de
CV (%)	4.77	7.05

In a column, means followed by a common letter are not significantly different at 5% level by DMRT. S_1=Water hyacinth, S_2=Rice bran, S_3= Sugarcane leaf, S_4=Water hyacinth: Rice bran (1:1), S_5=Water hyacinth: Sugarcane leaf (1:1), S_6=Rice bran: Sugarcane leaf (1:1), S_7=Rice bran: Water hyacinth: Sugarcane leaf (1:1:1) and Control=Sawdust: wheat bran: rice husk (8:4:1).

Days required to completion of mycelium running: Days required to completion of mycelium running in spawn packet varied significantly in different substrates and it ranged from 25.40 to 39.80 days (Table 1). The maximum time (39.80 days) was recorded from S_1 (water hyacinth) and the minimum time (25.40 days) was recorded from S_3 (sugarcane leaf) which was statistically similar to control. Bhatti *et al.* (1987) reported that the appreciable days to complete mycelium running of oyster mushroom in different substrates might be due to variations in their chemical composition and C: N ratio and the present experiment is agreed with their findings.

Days required from stimulation to primordia initiation: Variation in duration from stimulation to primordia initiation for *Pleurotus ostreatus* in different substrates differed significantly both in first and second flushes. In first flush, time required for primordia initiation ranged from 3.4 to 7.8 days in different substrates (Table 2). The maximum time (7.8 days) required for primordia initiation was recorded in S_1 (water hyacinth) which was statistically similar to S_3, S_5 and S_6 and the minimum time (3.4 days) was observed in control. In second flush, the duration ranged from 4.8 to 7.8 days (Table 2). The maximum of 7.8 days were required in S_5 (water hyacinth plus sugarcane leaf, 1:1) which was statistically similar with S_1, S_3 and S_6. The minimum time (4.8 days) was recorded in S_2 (rice bran) which was statistically similar with S_4 and control.

Small pinheads were formed 4-8 days after the spawn running. These results are in agreement with Shah *et al.* (2004) who found that the spawn heads appeared 6-7 days after the mycelium running. Ahmed (1998) stated that *P. ostreatus* completed mycelium running within 17-20 days on different substrates and pinhead formation was noted at 23-27 days. Murugesan *et al.* (1995) observed that the water hyacinth substrate took the longest time to reach the pinhead stage; their study is in agreement to the present study. Patra and Pani (1995) mentioned that oyster mushroom took 4-8 days for initiation of fruiting body and the present study consisted with their findings.

Days required from stimulation to mushroom harvest: Duration from stimulation to mushroom harvest in both first and second flushes varied slightly among the substrates. Duration from stimulation to harvest ranged 6.6 to 11.6 days and 8.4 to 12.2 days in first and second flushes, respectively (Table 2). The maximum time (11.6 days) was required in S_1 (water hyacinth) which was statistically similar to S_3, S_5 and S_6 and the minimum time was found in control (6.6 days). In second flush, the maximum time (12.2 days) was required for S_1 (water hyacinth) which was significantly higher as compared to all other substrates except S_5 and the minimum time (8.4 days) was required in S_2 (rice bran) which was statistically similar to control.

The result was identical to the findings of Bugarski *et al.* (1994). Baysal *et al.* (2003) also reported almost similar results. Nageswaran *et al.* (2003) found that harvesting of oyster mushrooms began within 13 days in water hyacinth and the combination of water hyacinth plus paddy straw resulted in harvesting time between the 13 and 17 days. The present experiment required 12 days for water hyacinth which may be due to using 10% supplemented wheat bran. The combination of water hyacinth and other substrates required less time than their findings.

Table 2. Effect of different substrates on the days required from stimulation to primordia initiation and mushroom harvest

Substrates	Days required from stimulation to primordia initiation		Days required from stimulation to mushroom harvest	
	1st Flush	2nd Flush	1st Flush	2nd Flush
S_1	7.8 a	7.4 ab	11.6 a	12.2 a
S_2	4.6 b	4.8 e	8.2 c	8.4 d
S_3	7.4 a	7.2 abc	10.8 a	10.4 b
S_4	5.6 b	6.0 cde	9.0 c	9.8 bc
S_5	7.4 a	7.8 a	11.4 a	11.0 ab
S_6	6.8 a	7.2 abc	10.4 ab	10.8 b
S_7	5.6 b	6.4 bcd	9.4 bc	10.2 b
Control	3.4 c	5.2 de	6.6 d	8.6 cd
CV (%)	9.56	11.01	7.22	7.53

In a column, means followed by a common letter are not significantly different at 5% level by DMRT. S_1=Water hyacinth, S_2=Rice bran, S_3= Sugarcane leaf, S_4=Water hyacinth: Rice bran (1:1), S_5=Water hyacinth: Sugarcane leaf (1:1), S_6=Rice bran: Sugarcane leaf (1:1), S_7=Rice bran: Water hyacinth: Sugarcane leaf (1:1:1) and Control=Sawdust: wheat bran: rice husk (8:4:1).

Number of primordia: In case of first flush, significantly highest number (109.2) of primordia was initiated on S_4 (water hyacinth plus rice bran, 1:1) which was statistically similar with S_6 and S_7 (Table 3). The lowest numbers (16.8) of primordia were initiated in S_1 (water hyacinth) which was statistically similar with S_5. The maximum number of primordia (71) of second flush was obtained from S_6 (rice bran plus sugarcane leaf, 1:1) and the minimum number (19.6) from S_1 (water hyacinth). The number of primordia varied significantly in different substrates. This might happen due to the presence of glucose, fructose and trehalose in the substrates as reported by Kitamato *et al.* (1995).

Number of effective fruiting body: The number of effective fruiting body in different substrates varied significantly in both flushes (Table 3). The maximum number (65.0) of effective fruiting body in first flush was produced from S_6 (rice bran plus sugarcane leaf, 1:1) over control and the minimum (12.6) from S_5 (water hyacinth plus sugarcane leaf, 1:1) which was statistically similar to S_1. In second flush, the maximum number (36.2) of effective fruiting body was produced from S_6 (rice bran plus sugarcane leaf, 1:1) and the minimum (14.8) from S_1 (water hyacinth) that was statistically similar with S_3, S_4 and S_5. Number of effective fruiting bodies reduced due to the reduction of nutrient in some substrates.

In the present study, a huge amount of abnormal fruiting bodies (10-75%) was found. The abnormal fruiting bodies may be due to the presence of fructose in the substrate, as reported by Kitamato *et al.* (1995). Sarker (2004) observed that the yield was higher due to higher number of fruiting body and lower yield due to lower number of fruiting body. His findings consisted with the results of the mentioned authors.

Stalk length: Stalk length of first flush ranged from 2.27 to 3.76 cm on different substrates. The longest stalk length was found in control (3.76 cm) which was statistically similar to S_6 and the shortest (2.27 cm) was observed on S_4 (water hyacinth plus rice bran, 1:1) which was statistically similar to S_1, S_2 and S_5. In the second flush, the longest stalk length was also found in control (3.85 cm) and the shortest (2.21 cm) stalk length was observed in S_4 (water hyacinth plus rice bran, 1:1) which was statistically similar to S_1 and S_2 (Table 3).

Stalk diameter: Stalk diameter ranged from 0.56 to 0.86 cm on different substrates. The largest stalk diameter was estimated in control (0.86 cm) and the smallest (0.56 cm) was observed from S_6 (rice bran plus sugarcane leaf, 1:1) which was statistically similar to S_3 and S_4 from first flush. The largest stalk diameter was found in control (0.72 cm) which was statistically similar to S_1 and S_7 and the lowest (0.56 cm) was S_6 (rice bran plus sugarcane leaf, 1:1) which was statistically similar to S_4 recorded from second flush (Table 3). In comparison between two flushes, stalk diameter decreased in second flush except in S_1, S_3 and S_4.

Pileus diameter: Pileus diameter of fruiting body produced on seven different substrates with control ranged from 3.51 to 5.89 cm found from first flush. The highest pileus diameter was recorded from control (5.89 cm) and the lowest (3.51 cm) from S_5 (water hyacinth plus sugarcane leaf, 1:1). In case of second flush, the highest pileus diameter was observed from control (5.74 cm) which was statistically similar to S_3 and lowest (3.71 cm) was recorded from S_2 (rice bran) which was statistically similar to S_5 from second flush (Table 3).

Pileus thickness: The highest thickness (0.55 cm) was observed in S_4 (water hyacinth plus rice bran, 1:1) which was statistically similar to S_1, S_3, S_6 and S_7. The lowest (0.34 cm) was observed from S_2 (rice bran) which was statistically similar to control in case of first flush. In case of the second flush highest thickness (0.55 cm) was observed from S_4 (water hyacinth plus rice bran, 1:1) which was statistically similar to S_1, S_5 and S_7. The lowest thickness (0.34 cm) was observed from S_2 (rice bran) which was statistically similar to control (Table 3).

Biological yield: There was significant variability of biological yield among different substrates. Biological yield of oyster mushroom grown on different substrates ranged from 34.35 to 104.0 g/packet (Table 3). The highest yield (104.0 g/packet) was obtained from S_6 (rice bran plus sugarcane leaf, 1:1) and lowest (34.35 g/packet) was obtained from S_5 (water hyacinth plus sugarcane leaf, 1:1) in first flush. In second flush, the highest biological yield was reported from control (80.44 g/packet) which was statistically similar to S_6 (76.49 g/packet) and the lowest (43.38 g/packet) was reported from S_5 (water hyacinth plus sugarcane leaf, 1:1) which was statistically similar to S_1 and S_2 (Table 3).

Economic yield: Economic yield of oyster mushroom on different substrates in first flush ranged between 31.7 to 100.4 g/ packet (Table 3). The highest yield (100.4 g/packet) was obtained from S_6 (rice bran plus sugarcane leaf, 1:1) which was statistically similar with S_4, S_7 and control. The lowest yield (31.70g/ packet) was harvested from S_5 (water hyacinth plus sugarcane leaf, 1:1). On the other hand, economic yield of second flush ranged between 40.37 to 75.77 g/ packet. The highest yield was reported from control (75.77 g/packet) which was statistically similar to S_6 (74.01 g) and the lowest yield (40.37 g) was reported from S_5 (water hyacinth plus sugarcane leaf, 1:1) which was statistically similar to S_1 and S_2. In comparison between two flushes, economic yield decreased in second flush except in S_1 and S_5. Nageswaran *et al.* (2003) and Sarker (2004) reported that water hyacinth was the only growth substrate that resulted in very poor yield. Rajarathnam *et al.* (1983) observed that prolonging the length of spawn run did not increase yield and extending the spawn run reduced the yield.

Table 3. Effect of different substrates on yield and yield contributing characters of *Pleurotus ostreatus*

Substrates	Number of primordia		Number of effective fruiting body		Stalk Length (cm)		Stalk diameter (cm)	
	1st flush	2nd flush	1st flush	2nd flush	1st flush	2nd flush	1st flush	2nd flush
S_1	16.8 e	19.6 d	15.0 f	14.8 d	2.46 d	2.49 de	0.68 b	0.68 ab
S_2	63.8 b	55.8 b	29.0 d	29.0 b	2.41 d	2.46 de	0.70 b	0.65 bcd
S_3	33.6 d	49.0 b	20.6 e	19.4 cd	2.87 c	2.93 c	0.59 c	0.62 cd
S_4	109.2 a	50.2 b	27.0 d	20.0 cd	2.27 d	2.21 e	0.58 c	0.60 de
S_5	17.4 e	30.6 c	12.6 f	17.4 cd	2.29 d	2.77 cd	0.71 b	0.64 bcd
S_6	102.4 a	71.0 a	65.0 a	36.2 a	3.66 a	2.52 b	0.56 c	0.56 e
S_7	106.6 a	52.6 b	53.0 b	21.8 c	3.27 b	3.36 b	0.67 b	0.66 abc
Control	52.6 c	38.8 c	44.0 c	29.8 b	3.76 a	3.85 a	0.86 a	0.72 a
CV (%)	7.91	11.49	7.48	11.95	4.16	5.85	6.77	4.37

Table 3. Continued

Substrates	Pileus diameter (cm)		Pileus thickness (cm)		Biological yield (g/packet)		Economic yield (g/packet)	
	1st flush	2nd flush	1st flush	2nd flush	1st flush	2nd flush	1st flush	2nd flush
S_1	4.49 c	4.48 b	0.498 ab	0.498 ab	44.56 e	47.59 de	40.65 e	44.87 d
S_2	3.61 d	3.71 c	0.337 d	0.340 c	59.30 d	45.44 de	55.80 d	42.70 de
S_3	5.20 b	5.53 a	0.480 ab	0.467 b	73.10 c	57.06 bc	69.30 c	53.80 bc
S_4	4.49 c	4.67 b	0.522 a	0.545 a	81.77 b	52.66 cd	77.46 b	49.54 cd
S_5	3.51 d	3.75 c	0.435 bc	0.489 ab	34.35 f	43.38 e	31.70 f	40.37 e
S_6	4.48 c	4.59 b	0.452 abc	0.456 b	104.0 a	76.49 a	100.4 a	74.01 a
S_7	4.59 c	4.73 b	0.504 ab	0.487 ab	80.56 b	63.37 b	76.99 b	60.13 b
Control	5.89 a	5.74 a	0.374 cd	0.370 c	84.39 b	80.44 a	78.09 b	75.77 a
CV (%)	6.56	4.45	9.11	4.94	6.00	8.12	6.41	7.33

In a column, means followed by a common letter are not significantly different at 5% level by DMRT. S_1=Water hyacinth, S_2=Rice bran, S_3= Sugarcane leaf, S_4=Water hyacinth: Rice bran (1:1), S_5=Water hyacinth: Sugarcane leaf (1:1), S_6=Rice bran: Sugarcane leaf (1:1), S_7=Rice bran : Water hyacinth : Sugarcane leaf (1:1:1) and Control=Sawdust: wheat bran: rice husk (8:4:1).

REFERENCES

Ahmed, S. 1998. Performance of different substrates on the growth and yield of oyster mushroom (*Pleurotus sajor-caju* (Fr.) Singer). MS Thesis. Dept. of Hort. BSMRAU, Gazipur-1706, Bangladesh.

Amin, M. N. & Shahjahan, M. 1994. A study of the jute sticks of CVL-1, O9897 and S-718 for using pulp and paper materials. *Bangladesh J. Sci. Ind. Res.* xxix. **3**:21.

Baysal, E., Pker, H., Yalinkilic, M. K. & Temiz, A. 2003. Cultivation of oyster mushroom on waste paper with some added supplementary materials. *Bioresour. Technol.* **89**(1): 5-7.

Bhatti, M. A., Mir, F. A. & Siddiq, M. 1987. Effect of different bedding materials on relative yield of oyster mushroom in the successive flushes. *Pakistan J. Agril. Res.* **8**(3): 256-259.

Bugarski, D., Gvozdenovic, D., Takae, A. & Cervenski, J. 1994. Yield and yield components of different strains of oyster mushroom. *Savremena poljoprivreda* (in Serbian). **42** (1): 314-318.

Chang, S. T. & Miles, P. G. 1988. **Edible Mushroom and Their cultivation**. CRC Press, Inc., of Boca Raton, Florida, USA. pp. 27-88.

Chang, S. T. & Miles, P. G. 1989. Pleurotus- A mushroom of broad adaptability. In: **Edible Mushrooms and Their Cultivation.** CRC Press, Inc., of Boca Raton, Florida, USA. pp. 265-275.

Gomez, K. A. & Gomez, A. A. 1984. Statistical Procedure for Agricultural Research. 2nd ed. John Wiley and Sons, New York. p. 680.

Kitamato, Y., Horkoshi, T., Hosio, N. & Ichikawa, Y. 1995. Nutritional study of fruiting-body formation in *Psilocybe panaeoliformis, Trans. Mycol. Soc. (Japan).* **16**(3): 268.

Makhanu, S. 1996. What is this water hyacinth? JKUAT environment association newsletter, JEAN, Nairobi. 46-49.

McGrath, P. 2003. Water hyacinth spawns mushroom enterprise. New Agriculturalist, Earthscan, UK. 12-16.

Murugesan, A. G., Vijaya lakshi, G. S., Sukumaran, N. & Mariappan, C. 1995. Utilization of water hyacinth for Oyster mushroom cultivation. *Bioresour. Technol.* **51** (1): 97-98.

Nageswaran, M., Gopalakrishnan, A., Ganesan, M., Vedhamurthy, A. & Selvaganapathy, E. 2003. Evaluation of Waterhyacinth and paddy Straw waste for culture of oyster mushrooms. *J. Aquat. Plant Manage.* 41: 122-123.

Pathak, V. N. & Yadav, N. 1998. Preservation and processing **In: Mushroom Production and Processing Technology.** Agrobios (India), Jodhpur, pp. 134-151.

Patra, A. K. & Pani, B. K. 1995. Yield response of different species of Oyster mushroom (*Pleurotus* spp.) to paddy straw. *Current Agril. Res.* **8**: 11-14.

Rajarathnam, S., Bano, Z. & Patwardhan, M. V. 1983. Post-harvest physiology and storage of white oyster mushroom *Pleurotus flabellatus*. *J. Food-Tech.*. **18**(2): 153-162.

Sarker, N. C. 2004. Production technology of oyster mushroom (*Pleurotus ostreatus*) suitable for Bangladesh and its nutritional and post harvest behavior. Ph. D. Dissertation. Bangabandhu Sheikh Mujibur Rahman Agricultural university. Gazipur-1706. Bangladesh. p. 221.

Shah, Z. A., Ashraf, M. & Ishtiaq, M. C. 2004. Coparative study on cultivation and yield performance of Oyster mushroom (*Pleurotus ostreatus*) on different substrates (Wheat straw, Leaves and Sawdust). *Pakistan J. Nutrition.* **3**(3): 158-160.

Stamet, P. 2000. **Growing Gourmet and Medicinal Mushroom.** Ten Speed Press, Berkeley, Toronto. p. 45.

Wang, C. W. 1982. Cellulitic enzymes of *Volvariella volvaceae*. **In: Tropical Mushroom Biological Nature and Cultivation Methods.** (Eds) S. T. Chang and T. H. Quimio. The Chinese University Press. Hongkong. p. 172.

Yildiz, A. & Ertekin, A. S. 1996. An experimental study of mycelia development periods of some *Pleurotus* species. *Mush. Res.* **5**: 81-88.

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