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RESEARCH ARTICLE

Evaluation of Different Substrates for Yield and Yield Attributes of Oyster Mushroom (*Pleurotus ostreatus*) in Crop-livestock Farming System of Northern Ethiopia

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Abstract:

Background:

In Tigray region of Ethiopia there is high rate of malnutrition which is severely affecting productivity of households. Cultivation of edible mushrooms can help to diversify income and mitigate malnutrition in the region.

Aim:

A laboratory experiment was carried out at Aksum University, northern Ethiopia aimed at evaluating the yield and yield attributes response of oyster mushroom to five types of substrates namely cotton seed hull, teff straw, barley straw, sesame stalk and sawdust.

Methods:

The experiment was set up in a Completely Randomized Design (CRD).

Results:

Findings of the experiment revealed that the type of substrate significantly ($P \leq 0.05$) affected days to mycelium invasion, days to pinhead formation, days to fruiting bodies formation and yield of Pleurotus *ostreatus*. Cotton seed hull was fastest in days to mycelium invasion with 15.66 days although in statistically parity with teff straw, barley straw and sesame stalk. Besides, cotton seed hull gave shortest days to pinhead formation, and days to fruiting bodies formation with 20.33 and 22.33 days respectively. The highest yield of 2170.33 gm kg^{-1} of substrate was obtained at cotton seed hull followed by barley straw which gave 1486.90 gm kg^{-1} of substrate and Teff straw which gave 1264.74 gm kg^{-1} of substrate.

Conclusion:

The experiment highlighted that cotton seed hull and barley straw can be used for mushroom production in the study area.

Keywords: Growth, Malnutrition, Mushroom, Production, Waste, Cultivation.

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1. INTRODUCTION

Worldwide, malnutrition is an underlying cause for deaths of more than 3.5 million children under the age of 5 each year [1]. About 178 million children around the world are stunted with 90% lives in 36 countries including Ethiopia [2]. Moreover, Ethiopian population is increasing at an alarming rate and in the near future, there will be a shortage of land for food production. Poor countries like Ethiopia are caught in a vicious circle of poverty, shortage of food and nutritional disorder. Erratic rainfall, shortage of land, low yield of traditional crops and low nutritional status of most crops especially in protein are among the causes of the aforementioned problems. Ethiopia has witnessed encouraging progress in reducing malnutrition over the past decade. However, baseline levels of malnutrition remain so high that the country must continue to make significant investments in nutrition [1]. Malnutrition is one of the main public health and developmental problems in

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the country. Demographic and Health Survey (DHS) report of 2011 has revealed that about 44%, 10% and 29% of children under five were stunted, wasted and underweight [3]. When it comes to Tigray, the prevalence of children under five for stunting, wasting and underweight were 51%, 10% and 35%, respectively [3]. Moreover, there is high malnutrition in the region which has negatively affecting productivity of the population in both urban and peri-urban areas [3]. Food and Security Vulnerability Assessment conducted by the Central Statistics Agency and the World Food Program revealed that the poverty line and food poverty line of Tigray region was 24.5% and 30%, respectively [3].

Agricultural production is one important means of achieving food and nutrition security. Food self-sufficiency can be brought about through diversification of production and consumption. Therefore, strategies of agricultural production that do not require large area of land are gaining popularity [4]. One such strategy is the cultivation of edible mushrooms which are nutritious food and help to diversify farm income generation [5]. Nowadays, the demand for mushrooms in Ethiopian cities is increasing [6]. The techniques used in the production system can also be handled by the poor, disabled people and women [7].

Mushroom is a fungus that is rich in protein and a high yielder that remains safe from natural calamities. Mushrooms are rich in protein compared with other vegetables, and its production can be one of the most promising and highly desirable activities in developing countries to reduce protein malnutrition [8, 9]. On a dry weight basis, protein content ranges between 21-30%. High concentration of lysine in mushroom protein makes it an ideal food to supplement the cereal diet for overcoming the lysine deficiency. Mushroom provides the highest amount of proteins. This is because mushroom could be produced 4-6 times a year. In addition, mushrooms supply carbohydrates, vitamins (B, C, D and K) and minerals like Ca, Na, P, and K [10]. They have medicinal properties such as anti-cancer, anti-cholesterol, and anti-tumor functions. They are useful against diabetes, ulcer and lung disease [11].

Furthermore, mushrooms are potential contributors to the world food supply since they have the ability to transform nutritionally worthless wastes into protein-rich food. Oyster mushrooms are rather easy to grow on a small scale on a wide range of substrates and different climatic conditions. They are characterized by the rapidity of growth under a wide range of temperature, the ability to colonize substrate in short duration and the potential to tolerate higher concentration of carbon dioxides, which acts as a protection against competitor molds [10]. Furthermore, it is fast growing, requires no casing, less fragile than others and has market in the dry form as well [12]. They are by far the easiest and least expensive to grow and are the clear choice for gaining entry into the mushroom industry.

In Tigray regional state of Ethiopia, there is an abundance of agricultural waste products which in some areas is normally discarded while mushrooms can be successfully cultivated. Moreover [13], highlighted that mushrooms have the capacity to transform agricultural waste into nutritious food and offer great opportunities for addressing the region's food security challenges. Hence, improvement is required on the present nature of technical knowledge for sustainable mushroom yield through maintaining (low-cost) mushroom cultivation, availability of requisite raw materials (substrates of diverse origin) is mandatory. Besides, at present, in the central zone of the Tigray region, particularly in Aksum town and its surroundings, there is no modern way of mushroom production. Moreover, there is no research available on yield or other related attributes of oyster mushroom in relation to organic substrates for growing mushrooms in the study area. Accordingly, it has been suggested that there is no research on the substrate, mushroom type and other appropriate technology in Ethiopia [12]. Therefore, the overall objective of the experiment is to evaluate different organic substrates on the yield and yield attributes of Oyster mushroom in cereal farming system of Aksum, central zone of Tigray, northern Ethiopia.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The study was conducted at Aksum university biotechnology laboratory located in Aksum town central zone of Tigray region, Northern Ethiopia. Axum town is situated at 38034' and 39025' east, and 13015' and 14039' north at an altitude of 2050 m.a.s.l with sub humid agro-ecology receiving a rainfall range of 300 to 800mm/annum. The area is mainly characterized with clay type of soil and commonly grown crops of Teff, Wheat, Barley and Faba bean. Aksum together with Lalay maychew district is characterized by crop-livestock type of farming system.

2.2. Substrate Collection and Preparation

The substrates were collected from different areas of central and western zones of tigray region. Consequently, five substrates teff straw, barley straw, sesame stalk, saw dust and cotton seed hull were used as potential substrates for Pleurotus *ostreatus* mushrooms cultivation. All substrates were cleaned with tap water and air dried while sesame, tef and barley straw substrates were chopped into pieces of about 2-4 cm size. All naturally dried substrates were subjected to three days of sun drying as a correction factor to balance the natural difference in percentage water holding capacity. Consequently, the substrates were soaked in water overnight and then sterilized by steam under the temperature range of 70 - 80°C [14]. The substrates were then spread on the clean plastic covered floor for evaporation of excess moisture and when the water stopped dripping the straw was considered as the ready stage for spawning.

2.3. Spawning, Spawn Run and Harvesting

Substrates were spawned with 80gm seed of Pleurotus *ostreatus* mushroom in heat resistant transparent plastic bags of 40 cm X 60 cm filled with 1 kg moist substrate. Approximately, ten holes were made on each bag for adequate aeration and the plastic bags were tied and incubated in the dark in a well-ventilated room. After spawning, the bags were kept about 20 cm apart in a crop room at a temperature of 25ºC to 30ºC and humidity of 80-90%. Fruiting body started shortly after the substrate fully impregnated with mycelia growth. The humidity of the growing room was maintained at high humidity by sprinkling water on the floor and side hanging sacks twice a day. Harvesting was performed by gently pulling or twisting the mushrooms from the substrate. Harvesting was continued as long as the mycelium remained white and firm, and a total of three flushes were harvested.

2.4. Treatments and Experimental Design

This experiment comprised of five types of substrates. The substrates were saw dust, barley straw, tef straw, sesame straw and cotton seed hull. The experiment was set in a Completely Randomized Design (CRD) with three replications. Pleurotus *ostreatus* mushroom spawn was obtained from the YD Plant Micro-propagation PLC in Mekele city, capital of Tigray regional state of Ethiopia.

2.5. Data Collected

The following data were collected during the study

- Days for the Completion of Invasion of Mycelium (MI) on different substrates
- Appearance of Pin Heads Formation (PHF)
- Days for Fruiting Bodies Formation (FBF) from the day of spawning of different substrates
- Total yield: Data on the weight of mushrooms from each substrate blocks at first, second and third flush harvesting stages were recorded separately and their total weight was considered as total yield. The sensitive balance was used to measure the weight.
- Biological efficiency: the weight of each dry substrate and total fresh mushroom weight per bag was recorded separately and then the biological efficiency (BE) of oyster mushrooms in each substrate was calculated by the formula of [15]:
- Production rate: On the basis of biological efficiency on each substrate and the time taken in days from spawning to harvesting, the production rate (PR) of oyster mushrooms in each substrate was calculated as described by the formula of [12]:

PR = BE / Time

2.6. Data Analysis

The collected data were subjected to Analysis of Variance (ANOVA) and means were separated using Fisher's Least Significant Difference (LSD) at 5% probability level [16].

3. RESULTS AND DISCUSSION

3.1. Mycelium Invasion

Table **1** showed that substrates significantly ($p<0.05$) affected days to mycelium invasion ($p<0.05$). Days to mycelium invasion of 15.66 was obtained at cotton seed hull and sesame straw substrates although in statistical parity with barley straw and teff straw. However, longer time of 20 days was observed at saw dust substrate (Table **1**). Similarly, [17] highlighted that Sawdust took longer days for mycelium invasion while teff straw took less time (15.44 days) for mycelium invasion (MI), although statistically not significant with bean pod husk and wheat straw. Moreover, it was reported that Pleurotus *ostreatus* completed spawn running in 17- 20 days on different substrates [18]. According to a study [19], the difference in the length of days taken to complete mycelium running of oyster mushroom on different substrates might be due to a variation in the chemical composition and the C: N ratio of substrates.

Table 1. effect of substrate type on mycelium invasion, pin head formation and days to fruiting body formation.

Substrates	Days to Mycellium Invasion	Days to Pin Head Formation	Days to Fruiting Body Formation
Cotton seed hull	15.66^{b}	20.33^{d}	22.33^{d}
Barley straw	16.66^{b}	26.00^{b}	28.00^{b}
Teff straw	16.33^{b}	24.00^{c}	26.33^{c}
Saw dust	20.00^{a}	29.00^{a}	31.00^{a}
Sesame stalk	15.66^{b}	24.66^{c}	26.66^{c}
F-test	**	***	***
LSD	1.48	1.28	0.91
CV	**4.84**	**2.75**	**1.79**

Means with the same letter within a column are statistically non-significant at $P \leq 0.05$ according to Fishers' LSD

3.2. Pin Head Formation

Pin head formation of Oyster mushroom was significantly ($p<0.05$) affected by the different substrates (Table **1**). Cotton seed hull took shorter time (20.33 days) to pinhead formation while sawdust took longer time (29 days) for pinhead formation (Table **1**). In line with the findings, a study [20] highlighted that short pinning duration of 18 days was observed with cotton seed hull while sawdust takes a longer duration of 24 days. Moreover, a study indicated that Pleurotus *ostreatus* takes 23 - 27 days for pinhead formation [18]. The difference in the number of days taken to complete pinhead formation in Pleurotus *ostreatus* mushroom on different substrates might be due to the variation in the nutrient availability of the substrates, the temperature and RH of cropping room during the transferring of the bags [19, 21].

3.3. Days For Fruiting Bodies Formation

It was observed that substrates significantly ($p<005$) affected days to fruiting body formation ($p<005$) (Table **1**). Days to fruiting body formation occurred earlier in Cotton seed hull substrate with 22.33 days while sawdust took longer time of 31 days for fruiting body formation (Table **1**). In line with the findings, maximum days for fruiting body formation of oyster mushroom were observed with sawdust substrate [20]. A previous study indicated that fruiting bodies of Pleurotus *ostreatus* appeared after 22 - 35 days of inoculation with sawdust [22]. However, it was indicated that fruiting body formation after spawning occurred earlier in teff straw followed by wheat straw while bean pod husk and dried Khat leaves took longer for fruiting body formation, which might be due to high nitrogen content of the substrates [17]. Dis-similarity in time for fruiting body formation might be due to the type of substrates and their nutrient compositions [23].

3.4. Consecutive Flush Yields and Total Pleurotus *Ostreatus* Mushrooms Yield

The yield of Oyster mushrooms in each flush and the total mean yield for each substrate are presented in Table **2**. The highest yield was obtained with cotton seed hull in the 1st and 2nd flushes while the lowest was observed with sesame stalk and sawdust substrates in all the three flushes of harvests. In the 3rd flush, the highest yield was obtained at barley straw followed by cotton seed hull substrate (Table **2**). In all flushes of harvest, a declining trend in yield was observed from the first to third flush of harvest. This could be due to the diminishing nutrient content of substrates mushrooms consumed during growth. Contrary to the present experiment, a study [20] indicated that teff straw was not suitable for oyster mushroom production.

Total yield of oyster mushroom was significantly ($p<0.05$) affected by the different substrates (Table **2**). A high yield of 2170.33 g kg^{-1} of dry substrate was obtained in Cotton seed hull substrate while the lowest yield of 838.43 g was obtained at sawdust substrate (Table **2**). Similarly, 100% Cotton seed hull substrate gave better yield of Pleurotus *ostreatus* [22]. Another study reported a significant variation in the total yield of oyster mushrooms among different substrates [17]. Moreover, the highest yield of 810.10 g kg^{-1} for dry substrate was obtained for dried bean pod husk while sawdust resulted in lowest yield of 454.40 g kg^{-1} for dry substrate [17]. This result was in line with that of [24], who reported a yield of about 800 gram fresh mushrooms per kg of dry substrate under normal conditions. The difference in yield might be due to the nutrient composition of the substrates. Similarly, different substrates yield different levels of mushroom which is due to the difference in the biological and chemical composition of the different substrates [25]. Moreover, a study indicated that C: N ratio of the substrates used for the cultivation, affected the yield performance of Pleurotus *ostreatus* of mushroom [26].

3.5. Biological Efficiency of Substrates

Table **2** showed that biological efficiency was significantly ($P<0.001$) affected by the different substrates tested. The highest biological efficiency of 72.34% was obtained for Cotton seed hull substrate followed by barley straw (49.56%). However, the lowest biological efficiency of 26.77% was observed for sesame stalk substrate which is in statistical parity with that of sawdust substrate which gave 27.62% biological efficiency. Similarly, 73.8% bioconversion efficiency of oyster mushroom was obtained for cotton seed waste supplemented with 1% wheat bran [12]. Biological efficiency range of 73 to 100 was reported by [24]. Moreover, lower biological efficiency of 15.14% of mushrooms grown on sawdust substrate [17]. A previous study grew oyster mushroom on *Lantana camara* and wheat straw and reported a biological efficiency of 36% and 54.8% respectively [27]. In contrary, maximum biological efficiency of Pleurotus *ostreatus* mushroom was observed for sawdust substrate [28]. The variation in the biological efficiency of substrates might be due to the characteristics of the substrates. Moreover, it was suggested that the variation in biological efficiency of oyster mushroom may be due to the different substrates' composition [29]. Variation in the biological efficiency of different substrates was due to low lignolytic and cellulonitic activity of the substrates used for mushroom production [30].

3.6. Production Rate

Production rate was significantly ($P<0.001$) affected by the substrate (Table **3**). The highest production rate of 3.24 was observed at cotton seed hull substrate followed by barley straw which gave 1.77. However, the lowest production rate of 0.89 was obtained at sawdust substrate and is in statistical parity with sesame stalk substrate which gave a production rate of 1.0 (Table **3**). Similarly, a study indicated a higher production rate of 3.18 for bean pod husk substrate while the lowest production rate of 0.67 was obtained at sawdust substrate [17].

Table 2. Effect of substrate type on consecutive flushes and total yield of Pleurotus *ostreatus* mushrooms

Substrate	Yield at 1st Harvest	Yield at 2nd Harvest	Yield at 3rd Harvest	Total Yield
Cotton seed hull	1181.63^{a}	768.70^{a}	220.00^{b}	2170.33^{a}
Barley straw	743.47^{b}	435.07^{b}	308.36^{a}	1486.90^{b}
Teff straw	764.89^{b}	325.82^{c}	174.03^{c}	1264.74^{c}
Saw dust	399.03^{c}	328.90^{c}	100.67^{d}	828.60^{d}
Sesame stalk	355.67^{c}	324.37^{c}	123.20^{d}	803.23^{d}
F-test	***	***	***	***
LSD	77.52	57.35	27.25	101.21
CV	**6.84**	**5.80**	**7.81**	**4.10**

Means with the same letter within a column are statistically non-significant at $P \leq 0.05$ according to Fishers' LSD

Table 3. Effect of substrate on biological efficiency and production rate of Pleurotus *ostreatus* mushrooms

Substrate Type	Biological Efficiency	Production Rate
Cotton seed hull	72.34^{a}	3.24^{a}
Barley straw	49.56^{b}	1.77^{b}
Teff straw	42.16^{c}	1.60^{c}
Saw dust	27.62^{d}	0.89^{d}

(Table 3) cont.....

Sesame stalk	26.77^{d}	1.00^{d}
F-test	***	***
LSD	3.37	0.17
CV	**4.10**	**5.18**

Means with the same letter within a column are statistically non-significant at P ≤ 0.05 according to Fishers' LSD

CONCLUSION

Identifying a suitable substrate for mushroom production is an important task for improving food security and protein deficiency. Days for mycellilum invasion, days for pinhead formation and fruiting bodies formation and overall yield of Pleurotus *ostreatus* mushroom was significantly affected by the substrates tested. Thus, cotton seed hull substrate gave the highest yield followed by barley and teff straw substrates respectively. Therefore, these substrates could be used as potential substrates for mushroom production in the study area.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No animals/humans were used for studies that are the basis of this research.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

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REFERENCES

[1] NNP. National Nutrition programme. Government of the Federal Democratic Republic of Ethiopia 2013; p. 74.

[2] Black RE, Allen LH, Bhutta ZA, *et al.* Maternal and child under nutrition: Global and regional exposures and health consequences. Lancet 2008; 371(9608): 243-60.

[3] Annonoums. Assessment report on Nutrition intervention status of the agriculture sector and training needs assessment on nutrition multi-sectoral linkages and nutrition sensitive agriculture. Report compiled by: UNICEF Mekelle Field Office & Agricultural Extension Services 2014. Tigray region BoARD

[4] MOARD (Ministry of Agriculture and Rural Development). Ethiopia's Agriculture Sector Policy and Investment Framework: Ten Year Road Map (2010-2020), Mushroom Growers Handbook 1. Korea: Oyster Mushroom Cultivation 2010; p. 300.

[5] Kakon AJ, Choudhury MBK, Saha S. Mushroom is an Ideal Food Supplement. J Dhaka Nati Med Coll Hos 2012; 18(1): 58-62. [http://dx.doi.org/10.3329/jdnmch.v18i1.12243]

[6] Dawit A. Wild Mushrooms and Mushroom Cultivation Efforts in Ethiopia,. Addis Ababa University, Addis Ababa, Ethiopia, 2014.

[7] Nair (Tan) NG. Marshall E Make money by growing mushroom. Rome, Italy: Food and Agricultural Organization 2009.

[8] Quimio TH, Chang ST, Roysee DJ. Technical Guidelines for Mushroom Growing in the Tropics (FAO Plant Production and Protection Papers). FAO, Rome, Italy 106.

[9] Chaube HS. Nutritional and Medicinal Values of Mushrooms. Pantngear, India: University of Agriculture and Technology 1995; pp. 7-8.

[10] Kimenju JW, Odero GOM, Mutitu EW, Wachira PM, Narla RD, Muiru WM. Suitability of Locally Available Substrates for Oyster Mushroom (*Pleurotus ostreatus*) Cultivation in Kenya. Asian J Plant Sci 2009; 8(7): 510-4. [http://dx.doi.org/10.3923/ajps.2009.510.514]

[11] Shah MZ, Ashraf M, Ishtiaq MC. Comparative study on cultivation and yield performance of oyster on Different Substrates (Wheat Straw, Leaves, Saw Dust). Pak J Nutr 2004; 3: 158-60. [http://dx.doi.org/10.3923/pjn.2004.158.160]

[12] Dawit A. Mushroom Cultivation: a Practical Approach, Berhanena Selam printing Enterprise. Addis Ababa, Ethiopia 1998; pp. 43-186.

[13] Mahé S, Roos N, Benamouzig R, *et al.* Gastrojejunal kinetics and the digestion of [15N]beta-lactoglobulin and casein in humans: the influence of the nature and quantity of the protein. Am J Clin Nutr 1996; 63(4): 546-52. [http://dx.doi.org/10.1093/ajcn/63.4.546] [PMID: 8599318]

[14] Oei P, Van BR. Small-scale mushroom cultivation: Oyster, Shiitake and wood ear mushrooms. 1st ed. Wageningen, The Netherlands: Digigrafi 2005; p. 87.

[15] Chang ST, Lau OW, Cho KY. The cultivation and nutritional value of *Pleurotus sajur-caju*. European J. Appl Microbiol Biotechnol 1981; 12(1): 58-62. [http://dx.doi.org/10.1007/BF00508120]

[16] Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research, . second. New York 1984; p. 704.

[17] Kidane M. Effect of different organic substrates and their pasturalization method on yield and quality of oyster mushroom (Pleurotus sajur- caju) MSc. Thesis Haramaya University, Ethiopia, 2005.

[18] Ahmed I, Syed RA. Economic Viability of Mushrooms cultivation to Poverty Reduction in Bangladesh. Trop Subtrop Agroecosystems 2008; 8(1): 93-9.

[19] Bhatti MA, Mir FA, Siddiq M. Effect of different bedding materials on relative yield of oyster mushroom in the successive flushes. Pak J Agric Res 1988; 8(3): 256-9.

[20] Mekonnen H, Semira T. Suitability of locally available substrates for oyster mushrooms cultivation in Mekelle City, Tigray, Ethiopia. Sky J Food Sci 2014; 3: 047-51.

[21] Dunkwal VY, Jood S. Effect of substrates on nutrient composition of oyster mushroom (*Pleurotus sajor-caju*). J Dairy Foods Home Sci 2009; 28: 132-6.

[22] Emiru B, Zenebech K, Kebede F. Effect of Substrates on the Yield, Yield Attribute and Dietary Values of Oyster Mushroom (*Pleurotus Ostreatus*) in the Pastoral Regions of Northern Ethiopia. Afr J Food Agric Nutr Dev 2016; 16(4): 11199-218. [http://dx.doi.org/10.18697/ajfand.76.15695]

[23] Ahlawat OP, Raj D, Sagar MP, Gupta P, Vijay B. Effect of recomposted spent mushroom substrate on yield and quality of cauliflower (*Brassica oleracea L.* var. botrytis). Mushroom Res 2006; 15(2): 149-52.

[24] Tripathi PP. Mushroom Cultivation. New Delhi: Oxford and IBH 2005; pp. 18-217.

[25] Ragunathan R, Swaminathan KSM. Nutritional status of *Pleurotus* spp. grown on various agro-wastes. Food Chem 2003; 80(3): 371-5. [http://dx.doi.org/10.1016/S0308-8146(02)00275-3]

[26] Yildiz A, Karakaplan M. Evaluation of Some Agricultural Wastes for the Cultivation of Edible Mushrooms (*Pleurotus ostreatus var.* Salignus). J Food Sci Technol 2003; 40(3): 290-2.

[27] Vats SK, Sood RP, Gulati A, Sharma OP. *Lantana camara* L. - A lignocellulosic substrate for cultivation of *Pleurotus sajor caju.* Bioresour Technol 1994; 48(1): 49-52. [http://dx.doi.org/10.1016/0960-8524(94)90135-X]

[28] Mondal SR, Rehana J, Noman MS, Adhikary SK. Comparative study on growth and yield performance of oyster mushroom (*Pleurotus florida*) on different substrates. J Bang Agric Univ 2010; 8(2): 213-20. [http://dx.doi.org/10.3329/jbau.v8i2.7928]

[29] Islam MZ, Rahman MH, Hafiz F. Cultivation of Oyster Mushroom (*Pleurotus flabellatus*) on different substrates. Int J Sustain Crop Product 2009; 4: 45-8.

[30] Wang D, Sakoda A, Suzuki M. Biological efficiency and nutritional value of *Pleurotus ostreatus* cultivated on spent beer grain. Bioresour Technol 2001; 78(3): 293-300. [http://dx.doi.org/10.1016/S0960-8524(01)00002-5] [PMID: 11341691]