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Efficacy of different substrates on the growth, yield and nutritional composition of oyster mushroom- *Pleurotus florida* (Mont.) Singer

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Abstract
The research experiment was carried out to evaluate the effect of different substrates on the growth and yield of oyster mushroom (*Pleurotus florida*) to find out the best alternative substrates that support the growth of oyster mushroom, produces the maximum yield with highest biological efficiency and nutritional contents. A total of seven treatments replicated five times were taken under the complete randomize design. The minimum time taken for mycelium run (15 days) was in T_0 Wheat (control) and maximum was observed in T_2 Cardboard (21 days). Primordium initiation was observed on 17^{th} – 26^{th} days. The maximum time from primordial stage to harvesting stage was recorded in T_2 cardboard (35 days). Maximum yield was obtained on T_3 Banana leaves (915.23 g) with highest biological efficiency (91 %). Moisture content was found high in T_1 Grass (92 %) and showed maximum protein (30.20 %) in T_6 Cardboard + Banana leaves and highest carbohydrate in T_0 Wheat (4.46 %). The lipid contents were found maximum in T_6 Cardboard + Banana leaves (0.88g). Therefore, it can be concluded that Banana leaves substrates individual as well as in combination proved to be best for cultivation of *P. florda*.

Keywords: Oyster mushroom, lignocellulosic substrates, yield, biological efficiency

Introduction
Oyster mushroom, *Pleurotus* spp. a macro fungus with a distinctive fruiting body, is a unique biota which assembles its food by secreting degrading enzymes. The genus *Pleurotus* (oyster mushroom) is an organoleptic fast growing fungus, which decomposes the complex organic materials to generate simpler compounds for its nutrition (Chang and Miles, 1991) [6]. Since centuries, mushrooms have been recognized as important food item and their usage is being increased day by day for their significant role in human health, nutritional and medicinal properties (Mshandete, 2011) [19]. *Pleurotus* spp. are also rich in medicinal values and so provide a wide variety of medicinal properties and they are effective against certain life threatening diseases. Major medicinal properties attributed to oyster mushrooms include anticancer, antibiotic, anti-inflammatory antiviral activities, immune- modulator effect and blood lipid lowering effects (Lavi *et al*., 2010) [15]. An attractive feature of oyster mushrooms is that they can utilize a large variety of agricultural waste products and and transform the lignocelluloses biomass in to high quality food, flavor and nutritive value (Bano and Rajarathanam, 1982) [3].
Pleurotus florida belongs to family Pleurotaceae and it is commonly called as Dhingri in India. This mushroom is an edible mushroom having excellent flavor and taste. Its productivity is maximum in a short time providing more protein per unit area than any other area. *Pleurotus florida* produces metabolites of medicinal and pharmacological interest, such antioxidant antimicrobials, immune stimulants and antitumor activities (Nayana and Janardhanan, 2000; Manpreet *et al*., 2004; Elmastas, 2007) [20, 17, 7]. Among the numerous species of mushroom, oyster mushrooms (*Pleurotus florida*) are more advantages in terms of easiness in cultivation, role in biodegradation and bio-remediation, production of extracellular enzymes and neutraceuticals (Rashad *et al*., 2009) [24]. Mushrooms are still cultivated on a small pockets on a specific substrate and yield potential is not satisfactory. In the present study *P. florida* was cultivated on wheat straw, grass, cardboard and banana leaves on single and mixed bed consisting of equal amounts of these substrates in polythene bangs. The yields of mushroom, biological efficiency and nutrient composition of the mushrooms were analysed.

Materials and methods
The experiment was carried out during the months of October-January (2016-2017). The pure culture of *Pleurotus florida was* procured from TRCSC (Technology, Resource Communication and Service Centre), Jamshedpur, Jharkhand India.

Inoculum multiplication, substrate preparation, inoculums of substrates, maintenance of beds and for harvest, the methods proposed by (Survase, 2012; Vijay and Sohi, 1987) [28, 30]. Yield of mushrooms and their biological efficiency was determined by using the formula (Siddhant *et al*., 2013) [27]. The fruit bodies were analysed for their moisture content (Raghuramulu *et al*., 2003) [23], protein (Lowry *et al*, 1951) [16], carbohydrate (Hedge and Hofreiter, 1962) [10] and lipid (Folch *et al*., 1957) [9]. The data for the characters considered in this experiment statistically analysis following the complete randomized design (CRD).

Results and discussions

As per the findings of this study, the growth of *P. florida* mycelia was relatively faster on wheat straw (control) (15 days). It was compared with the other substrates and found that Grass + Cardboard (15.80 days) was about approaching control. Whereas the longest spawn running was observed in case of Cardboard (21 days). This is comparable with other similar studies elsewhere. Biswas and Biswas (2015) [5], reported the completion of spawn running on wheat straw waste to be 14 days, while, Lalithadevi *et al.* (2014) [14] recorded between 16-25 days on paddy straw. The difference in days for full mycelia running on different substrates might be due to variation in their chemical composition and C:N ratio as reported by Bhatti *et al*. (1987) [4]. The results recorded on spawn running on different substrates were almost similar to the findings of Shah *et al*. (2004) [25]. Tan (1981) [29] reported that the spawn running took 16-25 days after inoculation. The variation in the number of days taken for a spawn to complete colonization of a given substrate is a function of the fungal strain, growth conditions and substrate type.

The pinhead formation was observed following the invasion of substrates by mycelia growth. The pinheads appeared fastest in Grass + cardboard (17.20 days) than other substrates. There is difference in the appearance of pinheads of different substrates. The time required for the formation of pinheads is comparable with other similar studies. Ahmed (1998) [1] reported pinhead formation of oyster mushroom cultivated in different substrates to be between 23 and 27 days from spawning, while Fan *et al*. (2000) [8], reported it to be 20-23 days. Tan (1981) [29] recorded 23-26 days for the appearance of pinheads. Patra and Pani (1995) [21] recorded 20-24 days on paddy straw.

It was observed from this study that the overall cropping period for *P. florida,* the time elapsed between spawn seeding and harvesting (maturity of fruiting bodies), varied for each of the different substrates used: ranging from 21.20 to 35 days. This implies that with regard to the cropping period, Grass + Cardboard (21.20 days) is the preferred substrate for early harvesting of *P. florida*. Grass + Banana leaves (28.40 days) was observed to be similar with Wheat (control) (29 days). In this regard, other studies came-up with varying results of cropping periods. The difference in the period for the maturity of pinheads was reported by many investigators. Khan *et al*. (1981) [12] reported 21-28 days for the maturity of pinheads in cotton boll locules. Khanna and Garcha (1981) [13] recorded 20 to 24 days for the maturity of pinheads on paddy straw and Tan (1981) [29] observed a month (30 days) for the maturity of pinheads on cotton waste.

The study confirmed that the use of different substrates brought about a significant ($P<0.05$) effect on yield (biological and economic yield) of *P. florida.* The yield was maximum in Banana leaves recorded (915.23g) with biological efficiency of (91 %) which was compared with other substrates and found that highest yield was obtained in Banana leaves followed by wheat (control) (87.1o %). While the least was obtained from Cardboard (498.56g). Similarly biological efficiency (BE) also varied significantly among the different substrates used. Bhatti *et al*. (1987) [4] observed the highest yields from with shortest incubation period in case of wheat straw. It was generalized from the data that first flush yield was highest in all treatments followed by second and third flush. Other scientists also recorded similar results. Tan (1981) [29] got three flushes. Jiskani (1999) [11] reported that one kg of dry substrate can produce one kg of fresh mushroom which is the 100% substrate dry weight. The difference in results between this finding and other workers may be due to environmental factors, physiological requirements, controlled, semi controlled conditions, e.g. constant humidity, light temperature etc. The difference in time was observed for the formation of pinheads, maturation of fruiting bodies, period between flushes, number of flushes and yield. Similar by-products have variable may be due to fungal species, spawn rate and the use of supplement added to the substrates.

The results of moisture, protein, carbohydrate, and total lipid contents of *P. florida* are depicted in Table: 2. The freshly cultivated *P. florida* contains high moisture content. Moisture percentage in mushroom depends on the maturity of fruiting bodies, species and storage condition and during packaging or processing. The present study revealed that the highest moisture content was observed in Grass (92%) followed by Grass + Cardboard (90.60%) and Cardboard (90%). Whereas the least was recorded in case of Banana leaves (81.20%).

The protein from cardboard + banana (30.20%) had the highest protein content which was significantly different from other substrates while mushroom from Cardboard (19.70%) had the lowest protein content. These results are in consonant with the report of Ashraf *et al.* (2013) [2]. Protein content of the mushroom mycelium can be controlled by the amount of Nitrogen supplied in the growth media. The Carbon: Nitrogen influences the protein and the fat content in the mushroom mycelium (Shah *et al*., 2004) [25]. They differ according to species but this difference also depends on the substratum, atmospheric conditions, age and part of the fruitification. Carbohydrate content of *P. florida* was found maximum on Wheat (control) (4.47%), followed by Cardboard + Banana leaves (4.16%). These results are confirmed with the findings of Patil *et al*. (2008) [22].

Lipid content of all seven investigated substrates showed significant variation. The highest lipid content was found in cardboard + Banana leaves (0.88g) and lowest in Grass (0.42g). Similar studies were carried out by (Shah *et al*., 1997) [26] who reported lipid content in *Agaricus bisporus* and *Pleurotus ostreatus* as 2.6kg and 1.8kg, respectively. It was therefore observed from the study that out of three nutritional constituents of the *Pleurotus florida* viz. ptrotein, carbohydrates and lipids, the carbohydrates was found at highest concentration in all the investigated substrates. Manzi *et al*. (2001) [18], that the chemical composition of mushrooms determines their nutritive value and this nutritive value differs from one species of mushroom to another and that depends upon the nature of substrate, atmospheric conditions, stage of development of the mushroom and part of fruiting body used besides the conditions of storage after harvest.

Table 1: Effect of different substrates on spawn run, primordial initiation, primordial stage to harvesting stage, yield and biological efficiency of *P. florida*.

Treatments	Average number of mycelium run days*	Average number of pinhead initiation days*	Average number of primordial stage to harvesting stage days	Average Yield (kg/bag)***	BE (%)
T_0 (W S)	15.00	23.00	29.00	871.45	87.10
T_1 (Grass)	19.00	25.00	33.00	536.00	53.60
T_2 (CB)	21.00	26.20	35.00	498.56	49.80
T_3 (BL)	17.00	22.20	28.00	915.23	91.50
T_4 (G + CB)	15.80	17.20	21.20	850.1	85.10
T_5 (G + BL)	16.00	22.60	24.40	820.65	82.00
T_6 (CB +BL)	17.00	19.00	22.00	867.54	86.30
F-test	S	S	S	S	S
S.Ed.	0.424	0.374	0.529	20.517	0.447
CD (0.05)	0.877	0.770	1.097	42.015	0.918

* Bag- 1 kg Substrate. **Average of 5 replications

Table 2: Effect of different substrates on the moisture (%), Protein (%), Carbohydrate (%) and Lipid (g) content of *Pleurotus florida.*

Treatments	Moisture (%)	Protein (%)	Carbohydrate (%)	Lipid (g)
T_0 (WS) control	85.00	25.20	4.46	0.88
T_1 (G)	92.00	24.23	3.63	0.42
T_2 (CB)	90.00	19.70	3.01	0.39
T_3 (BL)	81.20	27.56	4.30	0.86
T_4 (G + CB)	90.60	22.32	4.32	0.49
T_5 (G + BL)	88.80	27.40	3.87	0.59
T_6 (CB + BL)	86.00	30.20	4.16	0.88
F-test	S	S	S	S
S.Ed.	0.489	0.634	0.128	0.04
CD (0.05)	1.003	1.750	0.267	0.021

* Bag- 1 kg Substrate. **Average of 5 replications.

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Conclusion
Grass and Cardboard gave the good result as mixed substrates compared to individual substrates. Banana leaves, single and in combination supported the growth of *P. florida* better than Grass and Cardboard and produced a significantly higher yield and biological efficiency. It is also proved to be better in terms of mycelia density, time required for mycelia sunning, pinhead formation and development of fruiting bodies. Banana leaves single and in combination showed a highest protein content which can be substitute for expensive fish and meat which is mostly unaffordable by most as a result of poverty. Carbohydrate contents did not show significant differences. Thus, the Banana leaves can be a best alternative and replacement of traditional substrates.

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