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Evaluation of Paddy Straw Varieties on the Cultivation and Nutritional Value of Two Oyster Mushroom Species

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Abstract: *Pleurotus* is a versatile genus belonging to white-rot basidiomycete fungi and well known for their complexity of the enzymatic system and prominent lignocellulolytic property, member of this genus can colonize a wide range of agro-wastes. Two different oyster mushroom species namely *P. eous* and *P. florida* were successfully cultivated on paddy straw substrate. Comparative analyses of different parameters including biological efficiency (BE), protein, carbohydrate, crude fiber and fat contents of fruit bodies of the mushroom were evaluated. The highest protein (21.1±0.1 mg/g), vitamin (14±0.1mg/g), crude fiber (5.13±0.01 and nitrogen (.41±0.008%) contents were recorded in the paddy straw variety CO43. However, the utmost level of carbohydrate (14.4±0.1mg/g) was found in ADT36 followed by CO43 (13.9±0.1mg/g), amino acid (20.6±0.1mg/g) in CO43, lipid (9.3±0.1) was found in CO43. According to biological efficiencies, nutrition and mineral content obtained from *P. florida* was superior strain than *P. eous*. On the basis of the observation of the present study, it is recommended that the use of CO43 paddy straw substrate is suitable for cultivation of oyster mushrooms and for better nutrients.

Keywords-Oyster mushroom; paddy straw substrates; cultivation; bio-efficiency; nutritional values.

1. INTRODUCTION

Oyster mushroom is an edible mushroom, contains ample amount of phosphorous, iron, protein, lipid, riboflavin and thiamine. Oyster mushroom fresh fruiting bodies indicates a high quantity of moisture (90.8%), whereas dry as well as fresh oyster mushrooms are rich in carbohydrate (57.6%), protein (30.4%), fiber (8.7%), fat (2.2%) and ash (9.8%) with 345 kilocalories energy value on 100 g dry weight. Mushrooms are superlative source of minerals and protein and also known as the vegetarian's meat. They can grow in a wide range of temperatures (Khan and Garch, 1984).

One reason for the great interest in species of *Pleurotus*, besides their taste, nutritional status and secretion of enzymes, which involved in the degradation of all the three key categories of polysaccharides found in the biomass of agricultural crop residues such as lignin, cellulose and hemicellulose. Therefore, they are capable of growing on a wide range of substrates. The oyster mushroom grows under natural conditions on dead woody branches of trees. It needs moderate temperatures between 22 and 28°C for its growth - (Zhang et al. 2000). The *Pleurotus* spp. produce several medicinal and pharmacologically interested metabolites, such as antimicrobials, immunostimulants, antioxidants and antitumourals (Israilides et al. 2008). This mushroom is also known as "wood decaying fungus". Following species of genus *Pleurotus* have been cultivated so far are *P. ostreatus, P. flabettatus, P. sajor-caju, P. cryrgil, P. sapidus, P. cornucopiae,* etc. paddy straw is used as feed for ruminants and wide range of uses such as manure, thatching, paper pulp, alcohol, mats, poultry litter and mushroom production. Paddy straw is one of the rich lignocellulosic renewable waste materials in the world which contains 32-47% cellulose, 19-27% hemicellulose and 5 - 24% lignin (Saha, 2003; Karimi et al., 2006). The present study was carried out to evaluate different paddy straw substrates (ADT36, AST18 and CO43) for oyster mushroom cultivation (*Pleurotus eous* and *P. florida*) in terms of yield, biological efficiency and nutritional values and effect of different paddy straw substrates on stipe length, pileus size, days required for first flush and total yield were also analyzed.

2. MATERIALS AND METHODS

2.1 **Collection of *Pleurotus* strains:** *Pleurotus eous* and *P. florida* was obtained from the Department of Plant Pathology, Tamilnadu Agricultural University (TNAU), Coimbatore. The selected strains were cultured on potato dextrose agar (PDA) medium and slant cultures were also maintained for further analysis.

2.2. **Preparation of spawn bags:** One kilogram of sorghum grains were half boiled, dried and mixed

with 20 g of $CaCO_3$. 350 g grains were filled into the 8×24 cm poly-propylene bags. The filled bags were plugged with non-absorbent cotton and sterilized. After cooling, the bags were inoculated with mycelia of *Pleurotus eous* and *P. florida* and incubated at 27ºC±2ºC for 12-15 days. After incubation, the mycelial colonization of the mushroom species were observed in the spawn bags and stored in refrigerated condition for further use.

2.3. **Preparation of mushroom bed:** For the cultivation of oyster mushroom, three different varieties of paddy straw namely ADT36, AST18 and CO43 substrates were collected from Aalakudi and Budalur villages, Thanjavur District, Tamilnadu. After sun drying, rice straw was fragmented into small pieces (less than three centimeter particle size) with a sterile sickle. The substrates for mushroom bed preparation were prepared as prescribed by Vijayakumar *et al.* (2008). Then polypropylene bags (25×18 cm) were filled with 500 g prepared substrate and packed tightly. A hole of 3 to 5 cm was made with pointed steel at the centre for space to put the inoculums. The packets were sterilized in the autoclave for 15 min at 120°C with 1.5 kg/cm^2 atmospheric pressure and were kept 24 h for cooling. One teaspoonful of mother spawn cultures containing mycelia was placed aseptically through the hole of each packet separately and each treatment was replicated 4 times. The packets were then marked treatment wise with a marker pen and were kept on the self at 25±1°C for 15 days under 80% to 85% relative humidity and were allowed to complete the whitish mycelial growth (Das, 2015).

2.4. **Cropping:** When the mycelia fully covered the substrates after 15 days, the bags were torn apart to open the substrates. The compact substrates were moisturized at least twice a day by sprinkling fresh water. After 7–8 days of the opening of bags, small size pin heads (4-5 cm in diameter) appeared on all sides of the bags. These pinheads attained the full size in about 2-3 days and when fruiting body fully matured then they were harvested. The pin heads appearance time was also recorded.

2.5. **Ventilation:** The oxygen needed for the fruiting bodies development was fulfilled by running fan with regular intervals.

2.6. **Recording of Data:** The data for the following parameters were recorded in four replicates.

Days for completion of spawn running: Data on spawn running was recorded in days on different substrates.

2.7. **Appearance of pinhead:** After the completion of spawn running the pinheads appearance of *Pleurotus eous* and *P. florida* were observed. The data was recorded in days taken from spawning to the appearance of pinheads in each substrate for two mushroom species.

2.8. **Days required for first harvest:** It was determined by counting the days which were required for well developed fruiting body formation from pin head initiation and number of fruiting body was recorded. Thickness of pileus, diameter of pileus, length of stalk and diameter of stalk was also recorded by using a slide caliber.

2.9. **Flush wise yield:** The weight of mushroom in gram was recorded in flushes. The first and respective harvesting done at maturity and the yield of different flushes of fruiting bodies was noted.

2.10. **Total yield:** The total yield of basidiocarp was measured for each treatment. The accumulations of three flushes were noted as the total mushroom yield.

2.11. **Weighing:** The fresh weight of basidiocarp at each harvest was taken. The total yield is expressed in terms of bio-efficiency being percentage weight of the mushroom on dry weight of substrate.

$$\text{Percentage of bio-efficiency} = \frac{\text{Dry weight of substrate}}{\text{Fresh weight of mushroom}} \times 100$$

Then the harvested mushroom samples were subjected to proximate and mineral contents analyses.

2.12. **Nutrient analysis:** Fruiting bodies of *Pleurotus* species such as *P. eous* and *P. florida* strains were analyzed for nutritional composition according to the Association of Official Analytical Chemists (Cuniff, 1995). The contents of moisture, protein (Lowry et al., 1951) lipid, ash, carbohydrate, crude fiber and vitamins were determined. The evaluated minerals including nitrogen, calcium, magnesium, potassium, phosphorus, copper, zinc and iron. Values for N were determined using the micro Kjeldahl apparatus; Ca, Mg, Cu, Fe, and Zn values were obtained using an atomic absorption spectrophotometer; P values and K values were determined after standardizing against respective elements by spectrophotometer and flame photometer respectively (Cuniff, 1995).

2.13. **Statistical analysis:** All experiments were conducted in nine replicates (3 sets x 3 batches) and

the parameters were given as mean ± SD. Both mean and SD were performed using the statistical package within Microsoft Excel Version 2010.

3. RESULTS AND DISCUSSION

Two oyster mushroom *Pleurotus* species such as *P. eous* and *P. florida* were cultivated by using three varieties of paddy straw including ADT36, AST18 and CO43 as substrates. *P. eous* completed its spawn running within 10-11 days on different paddy straw substrates, whereas *P. florida* completed its spawn running after 16-17 days. Days required for pinhead formation could be significantly influenced by substrate complexity, moisture content, temperature and etc. In *P. eous*, pin head formation was initiated during 12th day in AST18 substrate, but the pinhead was appeared in 13th and 14th day in ADT36 and CO43 substrates respectively. In the case of *P. florida*, 18 days required for pinhead formation in ADT36 and AST18, whereas CO43 was allowed on 19th day only (Table 1).

Table 1. Days for completion of spawn running and pinheads formation of *Pleurotus* spp. on different substrates

Name of the mushroom	Paddy straw substrates	Spawn run (Days)	Pinhead formation (Day)	Mean no. of Fruit bodies
P. eous	ADT36	10	13	13.1 ± 0.15
	AST18	10	12	10.65 ± 0.04
	CO43	11	14	11.13 ± 0.06
P. florida	ADT36	16	18	10.5 ± 0.05
	AST18	16	18	10.16 ± 0.08
	CO43	17	19	11.53 ± 0.06

Length of stalk, diameter of stalk, diameter and thickness of pileus of *Pleurotus* species were compared after 30 days age of spawn, and reported that *P. florida* was yield better results than *P. eous* on almost all the paddy straw substrates. But the substrates like ADT36 and AST18 were allow the *P. eous* to produce maximum diameter of stalk (Fig. 1). The accumulations of three flushes yield were noted as the total mushroom yield. The paddy straw substrate CO43 permitted the fruit bodies of *P. florida* and *P. eous* up to 937±13.16 g and 923±19.2 g respectively in all the three harvest. The biological efficiency of different substrates was calculated as 92±1.9, 89±0.6 and 85±2.1% in *P. eous* and percentage of bio-efficiency of *P. florida* was 93.7±1.3%, 90.3±0.5% and 89.1±1% in CO43, ADT36 and AST18 respectively. Compared with two species and three substrates, *P. florida* grown on CO43 gave better biological efficacy than other substrates (Table 2). In contrast to these results, Vijayakumar et al. (2008) reported that *P. florida* took 16-21 days for the running of spawn, 20-27 days for formation of pinhead, 24-34 days for the formation of fruit bodies with 11-22 numbers of fruits bodies formation on various agro-waste substrates. Similar results were also reported by Obodai et al. (2003) on the growth and yield of *Pleurotus ostreatus* using different lignocellulosic by products.

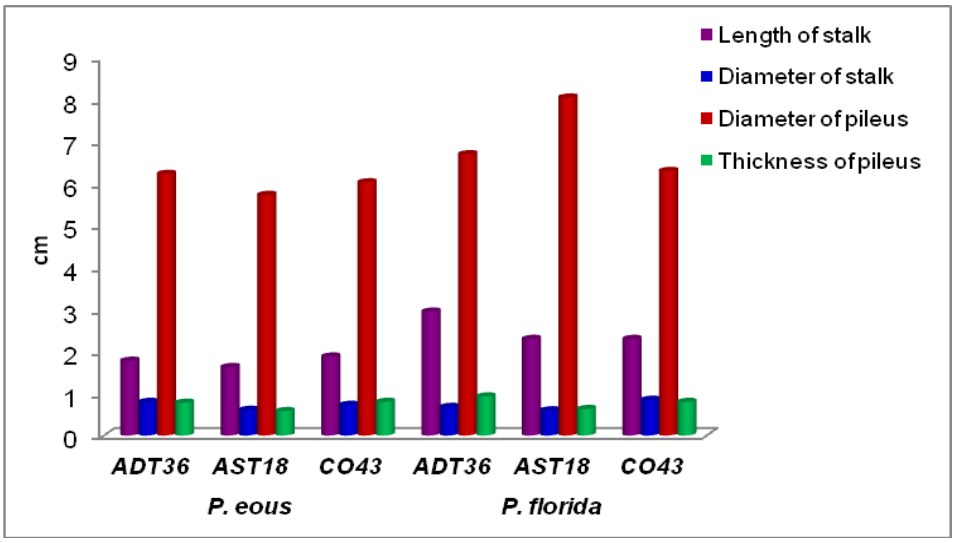

Fig. 1. Morphometric analysis of *Pleurotus* species

Table 2. Biological efficiency of *Pleurotus* sp. using various paddy straw substrates

Name of the mushroom	Paddy straw Substrates	Mushroom production (g)			Total production (g)	Bio-efficiency (%)
		1st harvest	2nd harvest	3rd harvest		
P. eous	ADT36	399±9.7	299±8.6	191±4.4	890±6.8	89±0.6
	AST18	403±17.7	323±8.8	132±6.3	859±21	85±2.1
	CO43	458±27.7	309±5.8	156±14.4	923±19.2	92±1.9
P. florida	ADT36	491±9.7	264±14	148±25.4	903±5.5	90.3±0.5
	AST18	470±5.8	314±5	106±8.6	891±10.8	89.1±1
	CO43	500±12.4	313±9.5	124±17.2	937±13.16	93.7±1.3

3.2. Proximate composition of *P. eous* and *P. florida*

Nutrient compositions of the two test mushroom species were analyzed when the fruit bodies developed from three paddy straw substrates. The highest protein content (21.1±0.1 mg/g) was found in *P. florida* when cultivated using CO43 paddy straw as a substrate, followed by AST18 (20±0.1 mg/g) and ADT36 (20.7±0.1 mg/g), in case of *P. eous*, maximum protein content was found with ADT36 (4.3±0.1 mg/g), followed by CO43 (4.1±0.1 mg/g) and the lowest protein content (3.9±0.1 mg/g) was found in AST18 (Table 3). Similar type of results was also reported by Syed et al. (2009) on the biological efficiency and nutritional contents of *Pleurotus florida* cultivated on different agro-wastes.

The highest carbohydrate amount (14.4±0.1 mg/g) was found in *P. eous* when cultivated on ADT36, followed by CO43 (13.9±0.1 mg/g) and AST18 (13.73 ±0.1 mg/g). Another mushroom *P. florida* had high content of carbohydrate (10.2±0.1 mg/g) grown on CO43, followed by ADT36 (10±0.1 mg/g) and AST18 (9.6±0.1 mg/g) (Table 3). These results are in consonant with the report of Akindahunsi and Oyetayo (2006). The highest amino acid content (20.6±0.1 mg/g) was observed in *P. eous* on CO43, whereas *P. florida* had only 9.4±0.1 mg/g amino acid when grown on AST18. Vitamin content was observed maximum (14±0.1 mg/g) in *P. florida* when it was cultivated using AST18 and CO43 as substrate, but vitamin content of the *P. eous* was 9.6±0.1 mg/g observed under ADT36 (Table 3). The findings of the present study are corroborated with the report of Teichmann et al. (2007).

Both mushroom species *P. eous* and *P. florida* had their highest lipid contents as 9.3±0.1 mg/g and 4.7±0.1 mg/g respectively in their fruit bodies when

they were cultivated on CO43 substrate. Likewise, highest crude fiber of *P. florida* (5.13±0.01 mg/g) and *P. eous* (5±0.01 mg/g) were observed from CO43 substrate (Table 3). The findings of the present study were coincided with the report of Alam et al. (2007). The ash content of *P. eous* recorded in this study was 5.4±0.01 mg/g on CO43, and *P. florida* had 5.28±0.01 mg/g of ash in their fruit bodies developed on ADT36 (Table 3). The values of ash content of the present study were close to the previous report of Ragunathan et al. (1996). The maximum moisture content (89.95%) was observed in *P. florida* on CO43 substrate, correspondingly, *P. eous* also had 88.93±0.01% of moisture content in the same substrate (Table 4). The results of the present study are coincided with the earlier report of Manzi et al. (1999). Disparity to this, Iqbal et al. (2016) reported high ash and moisture contents in sorghum straw than rice straw.

Table 3. Nutrient contents of *Pleurotus sp.* on various paddy straw substrates

Name of the mushroom	Substrates	Proteins mg/g	Carbohydrates mg/g	Amino acids mg/g	Vitamin mg/g	Lipids mg/g	Crude fibre mg/g	Ash mg/g
P. eous	ADT36	4.3±0.1	14.4±0.01	20.4±0.1	9.6±0.1	9.1±0.1	4.8±0.01	5.3±0.01
	AST18	3.9±0.1	13.7±0.01	19.6±0.1	9.3±0.1	9±0.1	4.9±0.01	5.2±0.01
	CO43	4.1±0.1	13.9±0.01	20.6±0.1	9.3±0.1	9.3±0.1	5±0.01	5.4±0.01
P. florida	ADT36	20.7±0.1	10±0.1	9.1±0.1	13.9±0.1	4.3±0.1	4.9±0.01	5.28±0.01
	AST18	20±0.1	9.6±0.1	8.8±0.1	14±0.1	4.2±0.1	4.9±0.01	5.26±0.01
	CO43	21.1±0.1	10.2±0.1	9.4±0.1	14±0.1	4.7±0.1	5.13±0.01	5.2±0.01

Mineral content is also important for the nutritional value of mushrooms. The mushroom provides a reasonable amount of minerals in comparison with vegetables (Guillamon et al., 2010). The evaluated mushrooms of the present study differed in the contents of minerals. Maximum nitrogen (4.41±0.008%) and phosphorous (0.88±0.003) contents of *P. florida* was found in CO43 and AST18 respectively, but the higher nitrogen (4.37±0.02%) and phosphorous (0.86±0.008%) contents of the *P. eous* was observed in ADT36 paddy straw substrate. The maximum percentage of potassium and magnesium contents was recorded as 1.28±0.01% and 16.96±0.008% found on CO43 and AST18 respectively for *P. eous,* but the higher contents of the potassium and magnesium contents was found as 1.25±0.005% and 19.9±0.008% on ADT36 and CO43 respectively for *P. florida* (Table 4). The similar data were already reported by Chang et al. (1981) and Alam et al. (2007).

P. eous contained the highest percentage of iron (44.70±0.03%), zinc (30.24±0.03%) and calcium (33.33±0.1%) in AST18 and CO43. Noticeable quantity of iron (44.68±0.005%) and calcium (32.51±0.008%) and zinc (27.96±0.005%) of *P. florida* was found in CO43 and AST18 paddy straw substrate respectively (Table 4). Similarly, Khan et al. (2013) studied the nutritional value of *Pleurotus* (*flabellatus*) *djamor* (R-22) cultivated on sawdusts of different woods. Among six different substrates tested for the cultivation of *Pleurotus ostreatus*, sawdust with rice bran and other substrates were contain higher contents of minerals (Onyeka et al., 2018). The highest amounts of nitrogen, phosphorus and potassium contents of fresh and spent paddy straw were observed in CO43, followed by ADT36 and AST18. The NPK contents of the substrate were reduced when they used for the cultivation of mushroom (Table 5). The most spent substrates from oyster mushroom have been found to be nutritionally rich with respect to its NPK contents. Spent mushroom substrate not only improves soil fertility but also helps in the turf establishment which depends on the rate of application in soil.

Table 5. Comparative analysis of NPK content in fresh and spent different paddy straw substrate

Straw substrate	Nitrogen content mg/g		Phosphorus content mg/g		Potassium content mg/g	
	Fresh straw	Spent straw	Fresh straw	Spent straw	Fresh straw	Spent straw
ADT36	1.244±0.001	0.96±0.001	0.783±0.001	0.41±0.001	1.426±0.001	1.105±0.001
AST18	1.245±0.001	0.95±0.001	0.781±0.001	0.42±0.001	1.424±0.001	1.103±0.001
CO43	1.247±0.001	0.97±0.001	0.785±0.001	0.42±0.001	1.426±0.001	1.105±0.001

4. CONCLUSION

The present study has concluded that all the three paddy straw substrates supported the growth of the mushroom namely *P. eous* and *P. florida*, but the CO43 substrate is better for rice nutritional composition in mushroom than other substrates. The exploitation of spent mushroom substrate for the management of environment, agriculture and production of recyclable energy requires strict watch on its physical, chemical and microbiological properties.

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CONFLICT OF INTEREST

Authors declare no conflict of interest

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Table 4. Effect of different paddy straw substrates on mineral contents of *Pleurotus* sp.

Name of the mushroom	Paddy straw substrate	Moisture (%)	N (%)	P (%)	K (%)	Mg (%)	Fe (%)	Zn (%)	Ca (%)
P. eous	ADT36	88.64±0.01	4.37±0.02	0.86±0.008	1.15±0.01	16.31±0.008	41.04±0.03	21.07±0.03	32.57±0.1
	AST18	88.53±0.01	4.1±0.02	0.81±0.008	1.23±0.01	16.96±0.008	44.70±0.03	30.24±0.03	29.23±0.1
	CO43	88.93±0.01	4.12±0.02	0.83±0.008	1.28±0.01	14.66±0.008	40.75±0.03	18.69±0.003	33.33±0.1
P. florida	ADT36	89.46±0.003	4.36±0.008	0.84±0.003	1.25±0.005	13.6±0.008	42.25±0.005	27.85±0.005	27.64±0.008
	AST18	89.37±0.003	4.27±0.008	0.88±0.003	1.16±0.005	14.6±0.008	41.56±0.005	27.96±0.005	30.37±0.008
	CO43	89.95±0.003	4.41±0.008	0.83±0.003	1.23±0.005	19.9±0.008	44.68±0.005	21.04±0.005	32.51±0.008