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Influence of waste paper supplementation to wheat straw on the growth of the oyster mushroom *Pleurotus sajor caju*

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ABSTRACT

Mushroom cultivation is an economically feasible bio-technological process for conversion of various lignocellulosic wastes in to protein rich nutritious food. This study was conducted with the aim of evaluating the suitability of waste paper supplemented with wheat straw and wheat bran for Oyster mushroom cultivation. Therefore, an experiment with different concentration of waste paper supplemented with wheat straw and wheat bran were evaluated for cultivation of *Pluerotus sajor caju* and their effect on productivity and biological efficiency (BE). Maximum BE (94.92%) was obtained in the treatment waste paper (50%) + wheat straw (25%) + wheat bran (25%) while a minimum BE of 56.82% was achieved when waste paper was used alone for the cultivation of mushroom. The study revealed that waste paper along with wheat straw and wheat bran can be successfully used for oyster mushroom production as a promising alternative to wheat straw.

Keywords: Oyster mushroom, cultivation, waste paper, wheat bran, yield

Mushrooms are regarded as functional foods since they provide additional health advantages over and beyond the conventional nutrients. Mushrooms are rich in folic acid, vitamins B1, B3, B5, B12, C, and D, as well as protein, fibre, minerals like iron, zinc, phosphorus, potassium, selenium, and calcium (Cheung, 2010). Mushrooms have very low salt levels and are low in calories, fat, cholesterol, and gluten. Recent research has shown that mushrooms have a wide range of medicinal characteristics and health advantages, including the ability to decrease cholesterol and act as an antioxidant, anticancer, and diuretic (Garcha *et al*., 1993).

Diversification in any system imparts sustainability and traditional agriculture must be diversified in order to ensure handsome and regular income for the farmer. Growing mushrooms is an indoor activity done on agricultural wastes cheaply and amply available with farmers. Under natural climatic conditions, mushrooms can be grown during a specific season while under controlled climatic conditions mushrooms can be produced all round the year.

Different species of *Pleurotus* (*P. oesteratus*, *P. sapidus*, *P. florida*, *P. sajor-caju*, *P. djamor*, *P. eous*, *P. citrinopileatus*, *P. flabellatus*, *P. eryngii,* etc.) come in a variety of colours, including white, grey, yellow, pink, and are frequently grown and consumed in the different parts of the world including China, Japan, India and other East Asian countries (Sánchez, 2010; Singh *et al*., 2022). Oyster mushroom contains a large number of unique myco-chemicals that are beneficial to human health (Deepalakshmi and Sankaran, 2014). With a stalk on one side and gills on the lower side, it has an oyster or large spoon-like

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morphology. Its cultivation technology is simple, but it requires attention to key crucial procedures, including moisture content, hygiene and other agronomic practices to achieve optimum mycelial growth and fruiting. A variety of substrates and temperatures can be used to cultivate this mushroom. Also, different species can be grown in temperatures ranging from 10-30°C.

Substrates have significant effect on mycelial growth and fruiting in oyster mushroom (Rizki and Tamai, 2011). This is mostly due to the carbon, nitrogen, and C/N ratio, mineral, pH, and moisture level of the substrate that influence yield performance of oyster mushroom. Additionally, the thickness of the substrate bag, the porosity of the substrate, and its size has significant impact on mushroom production (Bandura *et al.*, 2021). Cereal straw, sawdust, sugarcane bagasses, grasses, logs, and wood shavings are some of the substrates that are most frequently utilized for mushroom production (Bitew and Mandefro, 2018). Paper, other agro-by-products such old coffee grounds and corn stalks, coffee trash, soy bean straw, groundnut shell, and waste from the fruit and vegetable industries are some more substrates. Moreover Oyster mushroom crop is less affected by pest and diseases (Tesfaw *et al.*, 2015).

During this study, we tried to observe the effect of combinations of waste paper and wheat straw on the yield of oyster mushrooms (*Pleurotus sajor caju*) with additional supplemental nutrients.

MATERIAL AND METHOD

The substrates used during the study are scrap paper, wheat straw and wheat bran in different combinations (Table 1). The study was conducted at the Department of Plant Pathology's Mushroom Research Laboratory at the B.A. College of Agriculture, Anand Agricultural University, Anand, Gujarat.

Table 1. Combination of substrates used for oyster mushroom cultivation

Treatment	Combination of substrate used
T_1	Waste paper (25%) + wheat straw (75%)
T_2	Waste paper (50%) + wheat straw (50%)
T_3	Waste paper (25%) + wheat straw (50%) + wheat bran (25%)
T_4	Waste paper (50%) + wheat straw (25%) + wheat bran (25%)
T_5	Waste paper (100%)
T_6	Wheat straw (100%)

Spawn preparation

Wheat grain was thoroughly rinsed with tap water three to four times to remove contaminants before being used to prepare spawn. After soaking, the wheat grains were cooked in order to gently soften them without causing them to explode. Calcium carbonate (0.5%) and gypsum (2%) were mixed to boiled grains and filled in polypropylene bags (250g/bag). The bags were autoclaved for 120 minutes at 22 lb psi. The bags were cooled and inoculated with pure oyster mushroom culture in a laminar flow (Pal *et al*., 2017). The inoculated bags were incubated for 15 days at 25 °C or till complete mycelia colonization (Fan *et al*., 2000).

Substrate preparation, sterilization, bag filling and spawning

Different treatments comprising waste paper, wheat straw and wheat bran were filled in poly propylene bags and autoclaved at 121°C for 30-40 minutes. The substrate was distributed uniformly in 35 x 55 cm plastic bags and spawned @ 2% (Caral *et al*., 2013). 10-15 holes were made using a wooden stick for the air exchange in the bags.

Incubation and spawn run

The bags were incubated at 25$\pm$2°C for spawn run. Water was sprayed twice daily to maintain humidity (70-85 percent). The bags were completely colonized by fungal mycelium in 15 to 20 days and completely colonized bags were cut open. Observations were taken on pinhead formation (days), first harvest (days), and yield up to three harvests. Days taken were noted for the first, second, and third harvests.

Harvesting

Harvesting was done once the fruit body reached an ideal size and margins started curling upward. Weight of the harvested mushrooms in each bag was recorded till the three harvests. Final yield of the mushrooms and their biological efficiency were calculated for each bag. Yield parameters were measured in terms of number of flushes and yield of flushes on the different substrates, as well as number of days for spawn run, first appearance of pinhead, maturity of fruit bodies and the number of days for fruit body maturation. The biological efficiency (BE) of each crop was calculated as per Chang *et al*. (1981).

$$\text{Biological efficiency} = \frac{\text{Fresh weight of mushroom}}{\text{Dry weight of substrate used}} \times 100$$

RESULTS AND DISCUSSION

Days required for completion of spawn run

Spawn run duration in different treatments ranged from 16.8 to 21.2 days (Table 2). It was observed that treatment T_4 {waste paper (50%) + wheat straw (25%) + wheat bran (25%)} had the shortest incubation time of 16.8 days followed by treatments T_3 {waste paper (25%) + wheat straw (50%) + wheat bran (25%)}. Maximum days 21.2 were required for spawn run in treatment T_6 wheat straw (100 percent). Besufekad *et al*. (2020) reported good growth and yield of oyster mushroom in groundnut processing waste while Bhandari *et al.* (2017) got good quality oyster mushrooms on lignocellulosic wastes i.e. paddy straw, wheat straw, and soybean straw. Positive relationships between yield and nitrogen content were reported by Zied *et al*. (2019).

Days required for pin head formation

Observation on days taken to pin head formation was taken in different treatments (Table 1). The results showed that the treatment T_4 waste paper {(50 percent) + wheat straw (25%) + wheat bran (25%)} took the minimum days (7.2) closely followed by T_3

Table 2. Effect of different substrate and supplements on days required for spawn run

Treatment	Spawn run days	Days to Pin head formation	Days to first harvest	Days to second harvest	Days to third harvest
T_1	19.0	10.2	34.20	47.60	61.00
T_2	20.6	9.8	35.60	49.20	63.00
T_3	17.8	7.4	30.20	44.20	58.40
T_4	16.8	7.2	29.00	42.40	56.40
T_5	20.4	9.4	33.40	47.40	61.20
T_6	21.2	9.4	34.40	48.20	62.00
Sem	0.351	0.224	0.557	0.695	0.954
CD	1.025	0.653	1.625	2.029	2.784
CV%	4.069	5.618	3.796	3.343	3.545

{waste paper (25 %) + wheat straw (50 %) + wheat bran (25 %)}. The maximum number of days (10.2) for pinhead formation was recorded in the treatment T_1 {waste paper (25 %) + wheat straw (75 %)}. Wu *et al*., (2019) studied use of peanut straw for the production of *P. pulmonarius* supplemented with wheat bran and $CaCO_3$. Pal *et al*. (2017) assessed the impact of various substrate supplements on yield. According to their findings, adding cottonseed meal to wheat straw resulted in quick mycelial colonization (10.50 days after inoculation), took shortest time period for pinhead initiation (13.67 days).

Days required for harvest of mushroom

During the study, days needed for the first, second, and third harvests were recorded, and the results are shown in Table 2. The results showed that the minimum number of days required for the first, second, and third harvests was recorded in treatment T_4 {waste paper (50 %) + wheat straw (25 %) + wheat bran (25%)} i.e. 29, 42.40, and 56.40 days, respectively, while maximum time taken in Treatment T_2, which was 35.60, 49.20 and 63.00 days for the first, second, and third harvests, respectively. Pal *et al*. (2017) studied effect of various substrate supplements on yield. They reported a high yield 77.65 % on wheat straw supplemented with cottonseed meal.

Yield and biological efficiency

The results with respect to flush-wise yield and biological efficiency are summarized in Table 3. Amongst all the treatments, T_2 produced the highest yield of fresh mushrooms (949.2g/ kg dry substrate) with a BE of 94.92% (Fig 1), followed by the treatment T_3 with a yield of 854.4g/kg dry substrate (85.44%). Waste paper alone (T_6) treatment resulted in the lowest yield (568.2 g/kg dry substrate) with BE of 56.82%. This study indicates that the supplementation of substrates with low protein content is crucial to promoting the growth and production of mushrooms. Substrate augmentation is a technique employed in the production of *Pleurotus* sp. to boost yield (Dhanda *et al*., 1996). According to Zied *et al*. (2019), yield and Nitrogen content have positive associations as indicated by increased biological efficiency of 61% in *P. ostreatus* production by the addition of groundnut waste or groundnut de-oiled cake. Hoa *et al*. (2015) reported significant impact of total C, total N, C/N ratio, pH, EC, and mineral content on the colonization of mycelium, fruit body development, biological efficiency, nutritional and

Table 3. Effect of different substrate and supplements on harvest and biological efficienc

Treatments	1st Harvest (g)	2nd Harvest (g)	3rd Harvest (g)	Total yield (g)	Biological Efficiency (%)
T1	307.4	255.00	117.0	679.4	67.94
T2	301.2	300.00	162.0	763.2	76.32
T3	382.4	305.00	167.0	854.4	85.44
T4	421.2	333.00	195.0	949.2	94.92
T5	325.6	308.00	170.0	803.6	80.36
T6	256.2	225.00	87.0	568.2	56.82
Sem	4.85	4.36	2.96	11.38	
CD	14.15	12.74	8.63	35.87	
CV%	3.262	3.393	4.419	3.60	

Fig. 1. Development stages of *Pluerotus sajor caju* on waste paper+wheat straw + wheat bran

mineral composition in *P. ostreatus* and *P. cystidiosus*.

CONCLUSION

The present study showed that supplementing 50% waste paper with 25% wheat straw and 25 % wheat bran produced the highest yield and biological efficiency in oyster mushroom compared to the other treatments. It also proved to be better in terms of mycelial growth and substrate colonization. Therefore, wheat bran and wheat straw supplementation of waste paper substrate can be recommended to oyster mushroom growers in India for mushroom production.

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