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COMPARATIVE STUDY ON THE GROWTH AND YIELD OF *Pleurotus ostreatus* (Jacq. Fr.) MUSHROOM ON DIFFERENT SUBSTRATES

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Abstract:

Pleurotus ostreatus also known as oyster mushroom, oyster mushroom is a widely cultivated edible fungus that has various nutritional and medicinal benefits. In this paper, we report the cultivation of *Pleurotus ostreatus* on different substrates, such as paddy straw, soyabean straw, and redgram straw, and compare their growth parameters, such as yield, biological efficiency, and moisture content. We also perform Fourier transform infrared (FTIR) spectroscopy on the harvested mushrooms to analyze their chemical composition and functional groups. The results show that soyabean straw is the most suitable substrate for *Pleurotus ostreatus* cultivation, as it produces the highest yield (206.96 g/2030.85g), biological efficiency (62.20%), and moisture content (81.3%). paddy straw and redgram staw produce lower yields (174.02g/1771.36g and 120.03g/2458.76g, respectively), biological efficiencies (42.21% and 32.40%, respectively), and moisture contents (85.7% and 89.8%, respectively). The FTIR spectra of *Pleurotus ostreatus* reveal the presence of various functional groups, such as hydroxyl, amine, amide, and carbonyl, which indicate the presence of carbohydrates, proteins, and other organic compounds. The FTIR analysis also shows that the chemical composition of *Pleurotus ostreatus* varies depending on the substrate used for cultivation, which may affect its nutritional and medicinal properties.

Key word- Cultivation, Biological efficiency, Moisture, FTIR.

Introduction:

Mushrooms, being a unique form of macrofungi characterized by their distinguishable fruiting bodies, have evolved to obtain their sustenance through the secretion of enzymes capable of degrading complex organic matter. This process involves breaking down substrates derived from household and agricultural waste, transforming them into simpler compounds suitable for consumption. However, improper disposal of these waste materials can lead to environmental contamination and poses potential health risks. The responsible management of mushroom cultivation and waste disposal is crucial to mitigating these adverse consequences. In essence, certain resources are present in undesirable locations and at unfavorable times, yet they could be leveraged by mushroom cultivation to its advantage. Specifically, mushroom farming stands out as the sole economically viable biotechnological strategy for transforming organic plant residues from forests and agricultural operations into valuable products (Wood and Smith, 1987). Notably, this process involves using the ecological benevolence of mushroom mycelium, which produces a diverse array of complex extracellular enzymes capable of degrading and utilizing lignocellulose waste materials, thereby reducing environmental contamination.

Recent scientific investigations have uncovered the remarkable potential of mushroom mycelium to promote environmental recovery (myco-restoration) via various mechanisms such as myco-filtration (utilizing mycelial networks to clean water), myco-forestry (utilizing

mycelium to reforest areas), myco-remediation (utilizing mycelium to remediate polluted sites), and myco-pesticides (utilizing mycelium to control invasive insect populations) (Stamets, 2005). These approaches may lead to the creation of a balanced ecological system without any lingering adverse effects associated with fungal utilization. In addition to their ability to convert lignocellulose waste materials into edible mushrooms, fungi can also produce valuable nutraceuticals that supply essential nutrients, including high-quality protein, minerals, and vitamins, thereby complementing the human diet and promoting overall wellbeing. The consumption of mushrooms offers a nutritional profile comparable to that of eggs, milk, and meat, making them an attractive and sustainable source of sustenance.

The bioactive substances extracted from therapeutic mushrooms would enhance humans' immune systems and improve their quality of life. Mushrooms contain a high concentration of vital amino acids that are close to what the body demands. Mushrooms are also easy to digest and low in cholesterol (Oei, 2003). After mushroom harvesting, the spent substrate, which is entangled with many mushroom threads (together referred to as mycelia), can be used as animal feed (more palatable), bio fertilizer for soil fertility enrichment, and biogas (Alice and Kustudia, 2004). Mushroom farming may also be a labor-intensive agricultural activity that aids those in need of work and money, particularly young people and women in developing countries. Because mushrooms are often fast-growing organisms, mushroom farming can give immediate benefits to society as a short-term agricultural business. While most primary production methods are frequently hampered by land availability, producing mushrooms takes up relatively little space since they may be stacked using shelf-like culture systems. As a result, under integrated rural development initiatives, the pastime of mushroom farming is expected to evolve into a large cottage enterprise. This would benefit small-scale farmers, landless laborers, and other economically disadvantaged people of communities (Shah *et al.,* 2004). With this rationale, the current study was initiated to investigate how the application of various organic wastes, in this example, paddy straw, soybean straw, and Red Gram straw, affected the potential development and yield performance of oyster mushrooms. The study's goal is to analyze the viability of mushroom growing in the study region for the aim of improving local people's livelihoods and facilitating the adoption of technologies for oyster mushroom production utilizing agricultural wastes.

Materials and Methods:

Study area and experimental materials:

The research was conducted at Govt. V. Y. T. PG Autonomous College Durg, Hemchand Yadaw University, from December 2022 to February 2023. The substrate quality of three distinct substrates, Paddy Straw, Soyabean Straw, and Red Gram Straw, was evaluated for the purpose of producing oyster mushrooms. The Durg district collected red gram, soybean, and paddy straw. *Pleurotus ostreatus* (Jacq. Fr.) Kumm spawn was obtained from the mushroom department of the Indira Gandhi Krishi Vishwavidyalaya in Raipur.

Processing of the substrate and spawning:

For 05 days, the substrates were left to dry in the sun. Chemical sterilization uses three main types of substrates: paddy straw, soya bean straw, and Red Gram straw. 20L of water, 20ml of formaldehyde, and 7.5g of 50% WP carbendazim should be mixed together. Then, soak each

substrate in water overnight. After an overnight soak, airs dry the substrate for a few minutes. Take the polythene bags and evenly spread the substrate (45 x 30 cm) into each one. Fill the bags with fully developed spawn and re-distribute the substrate equitably. Straw that has been pasteurized and contains 2% spawn is packaged in bags. Prepare a large number of beds in the same way, and fasten the bags. The bags were then lightly packed in preparation for spawn runs (development).The sacks were then punctured to allow the mycelium to breathe. Spawned bags were placed closed on racks in neat and tidy positions. Water was sprayed on the walls and floor twice daily to manage the temperature (17-28°C) and humidity (65-85%).It took 18 to 24 days for the bags to be entirely covered in white mycelium. The spawn run period to complete colonization and the mean radial growth per week were also reported.

Harvesting of the mushroom:

After the spawn run was completed, the bags were placed on horizontal racks in a cropping house, a wooden frame building covered in woven matting. The bags were then unzipped, and the mats were watered twice daily to increase humidity and stimulate fruit body formation. The temperature was 26-28°C, and the relative humidity was 90-95%. The number of days that passed until the mushroom emerged for the first time was recorded. The biological efficiency, or BE, was calculated using the weight of fresh mushrooms represented as a percentage of the dry weight of the substrate.

Data collection and analysis:

The mushroom's development and growth were monitored on a daily basis. It was recorded how many days it took from inoculation to fully formed mycelium, how long it took from opening the plastic bags to pinhead for motion, and how long it took from releasing the bags to the first round of harvesting. A slide caliper was used to quantify growth parameters such as stipe length (cm), stipe diameter (cm), pileus diameter (cm), and pileus thickness (cm) before each harvest. Additional yield metrics were recorded at the time of harvest, including the total fresh weight (g) of the mushrooms and the number of fruiting bodies per bunch. Mature fruiting bodies (white in color, with up curving pileus) were collected by slicing the base with a sharp blade slightly above the substrate's surface. During the experiment, the initial harvesting of mushrooms was done across all substrate types. To test mushroom growing performance on various substrates, yield and biological efficiency were assessed.

In this study, two distinct methods were employed to quantify the yield and efficiency of fungal production. Specifically, biological yield (g) was measured by directly weighting the complete clusters of fruiting bodies without separating them from their supporting stalks, whereas economic yield (g) involved isolating each individual fruiting body from its stalk base before measurement. To calculate biological efficiency (%), the former methodology was employed, with the resulting value representing the proportion of total mycelial mass that was actualized as fruiting bodies.

$$B.E. = \frac{FWm(g)}{DWs(g)} \text{ X } 100\%$$

Where, B.E. is Biological Efficiency (%); FWm is total weight (g) of fresh mushroom yield, and DWs is dry weight of substrate (g).

Then, analysis of variance (ANOVA) was computed using SPSS version 20, and mean values of all the parameters and the standard errors of each parameter were separated using LSD at 5 % level of significance.

Moisture analysis:

Twenty gram of fresh mushroom was weighed into a weighed moisture box and dried in an oven at 100~105° C and cooled in a dessicator (Raghuramulu *et al.,* 2003). The process of heating and cooling was repeated till a constant weight was achieved. The moisture content was calculated as following equation:

$$Moisture(\%) = \frac{(\text{initial weight} - \text{final weight})}{\text{weight of sample}} X\ 100$$

Result and Discussions:

Colonization and Fruit Initiation Period:

According to Figure 1, the total amount of time required for various stages of fungal development - including mycelial growth, primordium initiation, and fruiting body maturation - has been depicted. Specifically, this graph illustrates how long it takes for fungi to spread and colonize different types of substrate, such as soybean straw (which took 14 days), rice straw (taking 15 days), and red gram straw (requiring 19 days).

The duration for pinhead formation during this experiment differed depending on the type of substrate used, taking anywhere from 17 to 33 days after spawning. Pinhead development progressed rapidly in soybean straw (17 days), followed by paddy straw (21 days), while it took slightly longer in red gram straw (28 days). Additionally, analyzing the density of mycelium revealed that soybean straw had a higher concentration of mycelium when compared to paddy straw and red gram straw.

In keeping with previous findings, the duration until fruiting body maturation differed across crop residues, ranging from approximately 21 days for soybean straw to 24 days for paddy straw. Similarly, the cropping period for these substrates was found to be around 32 days, which falls within the previously reported range for Red Gram straw.

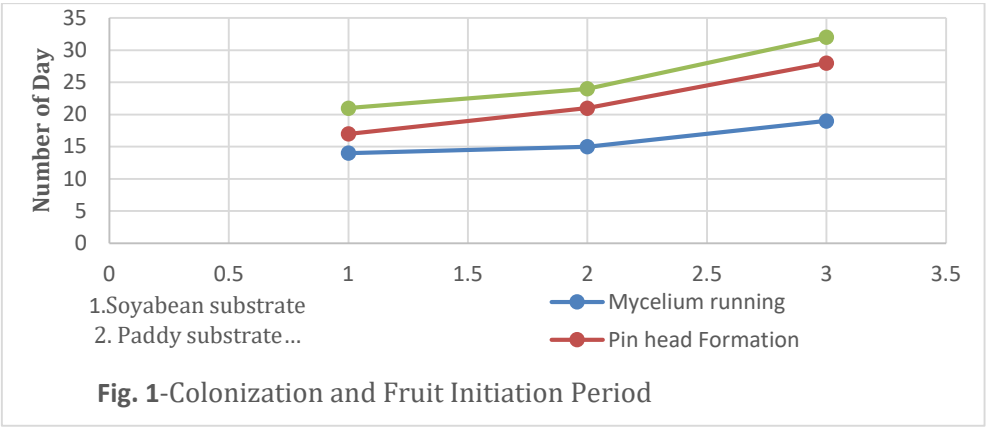

Fig. 1-Colonization and Fruit Initiation Period

Biological Yield:

In this study, the yield components (or attribute traits) of oyster mushrooms grown on different substrates were examined through statistical analysis as depicted in Table 1. Our findings indicate that the product derived from Red Gram Substrate exhibited superiority in terms of both the diameter and thickness of the cap and stem dimensions. Additionally, there was an observable increase in the number of well-developed fruiting bodies for these same substrates compared with those cultivated using other materials. Notably, our data revealed that the quantity of fruiting bodies was considerably greater when cultured on Paddy Substrate rather than any other substratum tested; conversely, the fewest fruiting bodies were observed when grown on Soybean Substrate. To assess the overall biomass production, mature fruiting bodies of the oyster mushroom were collected and their weight measured before being used to calculate the biological yield (in grams).

Table no. 1: Yield attributes of *Pleurotus ostreatus* grown on different substrates-

Parameters	Paddy Substrate	Soyabean Substrate	Red gram substrate
No. Of Fruiting Bodies	**19**	**13**	**12**
Pileus diameter(cm)	**6.85**	**7.84**	**9.44**
Pileus thickness(cm)	**0.59**	**0.38**	**0.51**
Diameter of Stipe(cm)	**1.34**	**1.25**	**1.59**
Length of stipe(cm)	**1.64**	**1.8**	**2.78**

Mean values under the same category that bear different superscript letters are significantly different($a<0.05$).

Biological Efficiency:

By measuring and expressing the percentage of biomass generated per unit of dry weight of substrate (biological yield) as a ratio of biological efficiency, the effectiveness of substrate conversion during mushroom growing was assessed. Table 2 illustrates how this metric uncovered significant differences in the relative effectiveness of several substrates for the growth of mushrooms. Soybean-based substrates were found to have the highest biological efficiency, whereas Red Gram substrates had the lowest values.

Table no. 2- Biological efficiency of *Pleurotus ostreatus* on different substrate

Substrates	Substrate(Bag) weight(g)	Substrate dry weight(g)	Weight of fresh mushroom (g)	Biological efficiency (%)
Paddy	1771.36	412.20	174.02	42.217%
Soya bean	2030.85	332.72	206.96	62.202%
Red gram	2458.76	370.43	120.03	32.402%

Mean Value under the same column that bear different superscript letters are significantly different (a<0.05)

Moisture Content:

According to Table 3, the moisture content of oyster mushrooms (*Pleurotus ostreatus*) ranged from 80 to 89%. Specifically, the highest moisture content was observed in fruiting bodies cultivated on red gram substrates (89.8%), followed by those grown on paddy substrates (85.7%). Conversely, the lowest moisture content was detected in oyster mushrooms cultivated on soybean substrates (81.3%).

Substrates	Fresh Mushroom Weight(g) With moisture box	Fresh Mushroom Weight(g)	Dry Mushroom weight(g) With moisture box	Dry Mushroom weight(g)	Total Moisture Contents (%)
Paddy	64.46	20	47.32	2.86	85.7%
Soya bean	69	20	52.74	3.74	81.3%
Red gram	64.83	20	46.86	2.03	89.85%

Table no. 3: Moisture content of oyster mushrooms (*Pleurotus ostreatus*).

F.T.I.R. assessment:

In this study, Fourier transform infrared (FTIR) spectroscopy was employed to investigate the structural changes in paddy straw, soybean straw, and red gram straw following their exposure to different conditions. The resulting FTIR spectra were analyzed in the fingerprint region (4000-600 cm-1) to identify the functional groups present in these biomasses. Notably, the peaks observed within this frequency range corresponded to lignin and polysaccharides, as shown in Table 4. The spectral features in the range of 1680–1560 cm^{-1} represent the C=C and C=O stresses of the lignin aromatic chain (1631cm^{-1}), the C–O stretching of the lignin aromatic skeleton vibration (1586 cm^{-1}) and the O–H deformation of the absorbed water (1643 cm^{-1}). The bands at 1371 cm^{-1} represent symmetrical and asymmetrical C-H deformation vibrations of cellulose and hemicelluloses. The C–O stretching of band cellulose and hemicelluloses at 1030 cm^{-1}, and the C–OH bending vibration of xylan. A broad absorption band in the range of between 3650 and 3250 cm^{-1}, indicating hydrogen bond. This band confirms the existence of hydrate (H2O), hydroxyl (-OH), ammonium, or amino.

Wavenumbers and their assignments:

Wavenumber (cm^{-1})	Peak assignment	References
1030–1050	C-O stretching (hemicellulose and cellulose), C-OH bending in xylan	21,35,41
1371.40	C-H symmetric and asymmetric deformation in cellulose	8,1
1376	chlorogenic acids (esters formed by quinic acid and certain trans-cinnamic acids)	33
1586.54	C-O aromatic skeletal vibrations in lignin	20,8,6
1631.42	C=C and C=O stretching in the lignin aromatic ring, absorbed water in the cellulose	44,21,20
2922.40	C-H and CH_2 stretching, unconjugated C=O in Xylans(hemicelluloses)	22,26
3257.93	Stretching O-H symmetric	12,37

Table 4. Evaluation of wavelengths in FTIR spectra of the substrates according to previous literature studies.

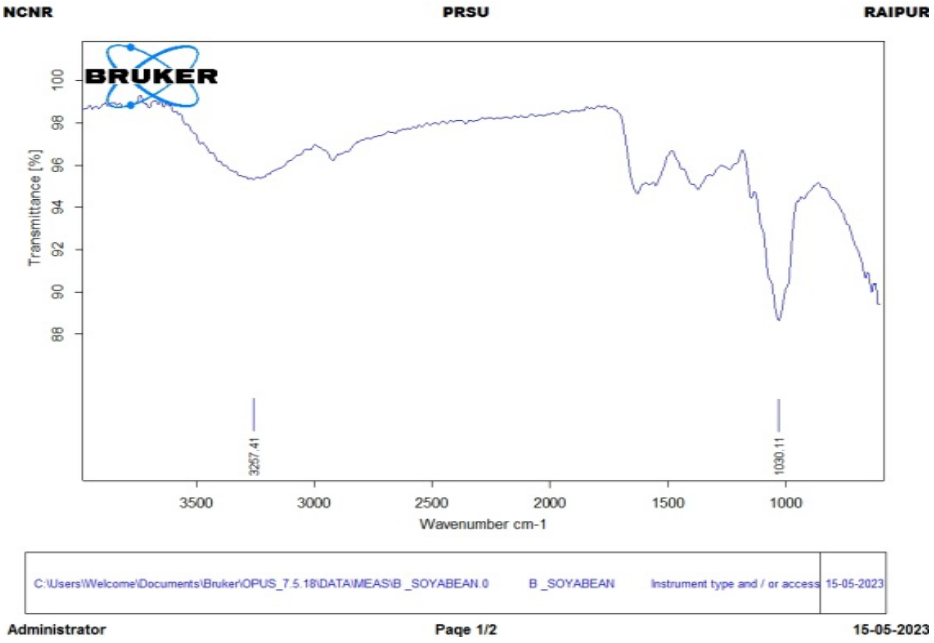

Fig No. 2: FTIR Spectra of Soyabean substrate fruiting bodies.

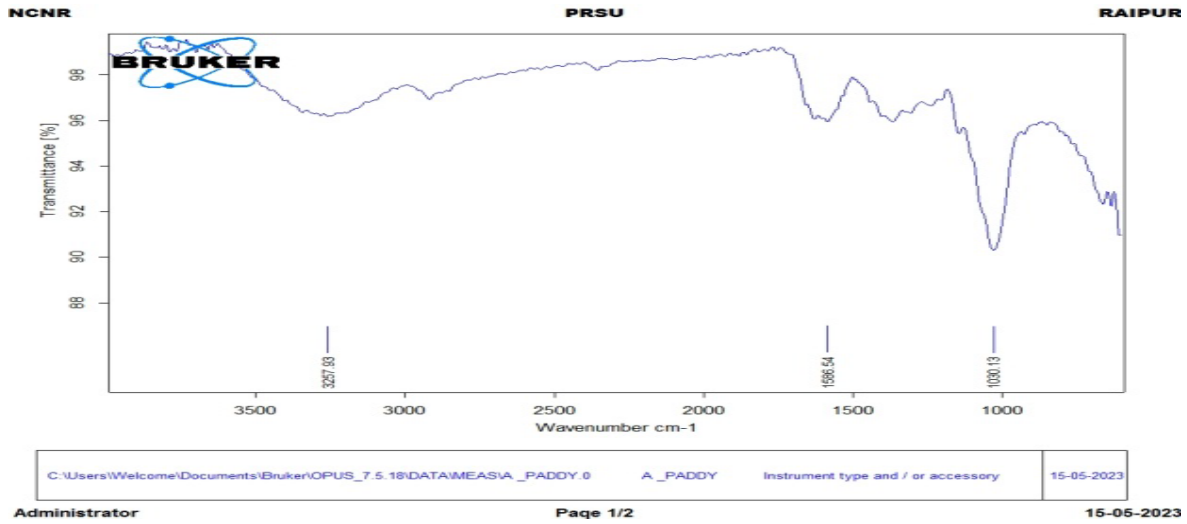

Fig No. 3: FTIR Spectra of Paddy substrate fruiting bodies.

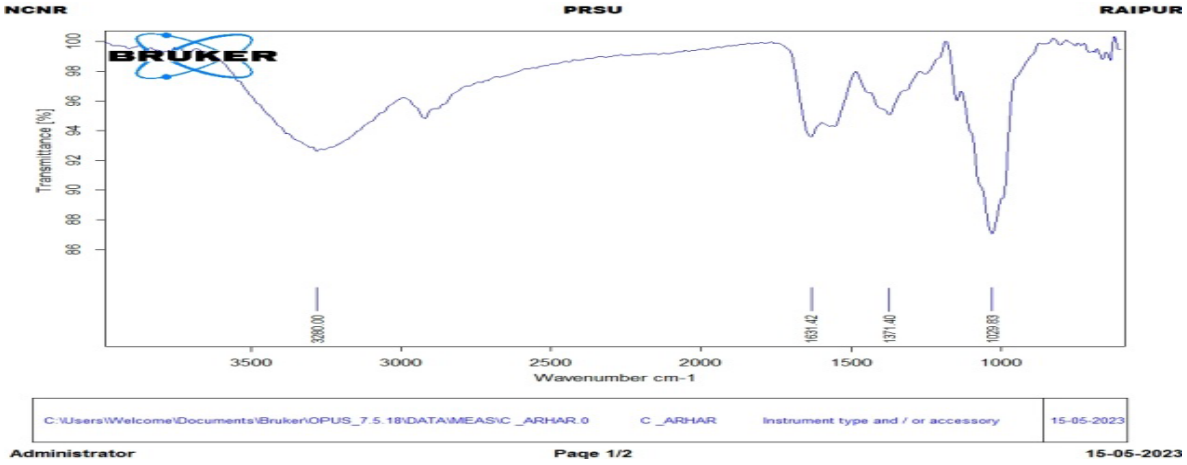

Fig no. 4: FTIR Spectra of Redgram(Arhar) substrate fruiting bodies.

In analytical graph of FTIR, significant peaks were made between 1600-1820 cm^{-1} that shows the presence of Carbonyl groups. There are peaks between 2850 to 2929 cm^{-1} that indicates the presence of methyl group.

Conclusion:

Based on the findings of this investigation, it is apparent that the optimal substrates for the cultivation and expansion of the oyster mushroom (*Pleurotus ostreatus*) are paddy straw and soybean straw. These two substrates exhibited superior performance in terms of productivity when compared to other additives such as red gram. Future research may focus on optimizing environmental conditions, including temperature and humidity, to further enhance the growth and development of the oyster mushroom under controlled conditions.

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