

## Original Article

### Effect of Different Sawdust Substrates on the Growth, Yield and Proximate Composition of White Oyster Mushroom (*Pleurotus ostreatus*)

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**ABSTRACT:** The present study was to analyze the effect of different sawdust substrates namely *Magifera indica* (Mango tree, T<sub>1</sub>), *Albizia saman* (Rain tree, T<sub>2</sub>), *Tectona grandis* (Segun tree, T<sub>3</sub>), *Gmelina arborea* (Gamari tree, T<sub>4</sub>), *Swietenia mahagoni* (Mahogany tree, T<sub>5</sub>) and mixture of all five tree sawdust (T<sub>6</sub>) with wheat bran 30% and 1% lime on the growth, yield and proximate composition performance of *Pleurotus ostreatus* (white oyster mushroom). The experiment was laid out in single factor Completely Randomized Design (CRD). The highest average number of fruiting body per packet (57.20) was observed in T<sub>5</sub>, whereas the lowest (47.00) was found in T<sub>2</sub>. The highest average weight of fruiting body (4.45 g) was observed in T<sub>5</sub> while the lowest (3.76 g) was recorded in T<sub>4</sub>. The highest biological yield (227.68 g) was found in T<sub>5</sub>, while the lowest (204.78 g) was observed in T<sub>4</sub>. The highest economic yield (207.58 g) was recorded in T<sub>5</sub>, while the lowest (181.96 g) was found in T<sub>4</sub>. The highest benefit cost ratio (BCR) (4.25) was observed in T<sub>5</sub>, whereas the lowest (3.62) was found in T<sub>4</sub>. The highest moisture content (87.77%) was observed in T<sub>4</sub>, while the lowest (85.84%) in T<sub>5</sub>. The highest dry matter content (14.16%) was observed in T<sub>5</sub>, whereas the lowest (12.23%) was recorded in T<sub>4</sub>. The highest protein content (24.97%) was found in T<sub>5</sub>, while the lowest (24.12%) was observed in T<sub>4</sub>. The highest lipid content (6.15%) was observed in T<sub>5</sub>, while the lowest (5.72%) was recorded in T<sub>4</sub>. The highest calcium content (17.33 mg/100 g) was found in T<sub>6</sub>, while the lowest (15.72 mg/100 g) was recorded in T<sub>4</sub>. The highest magnesium content (14.50 mg/100 g) was observed in T<sub>5</sub>, while the lowest (13.35 mg/10) was observed in T<sub>4</sub>. The highest iron content (47.46 mg/100 g) was found in T<sub>1</sub>, while the lowest (44.89 mg/100 g) was recorded in T<sub>4</sub>.

**KEYWORDS:** *Pleurotus ostreatus*, Growth, Yield, Proximate composition, Sawdust, Spawn, White oyster mushroom

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## INTRODUCTION

Mushroom usually umbrella like bodies belongs to the class Basidiomycetes and order Agaricales in fungal classification. It has been used as a food and

medicine by different civilizations since immemorial time due to its delicious taste and dietetic qualities. Mushroom has qualities like lowering the blood cholesterol level, defense

against cancer and invigorating hair growth. The fresh mushroom has contained about 85-90% moisture, 3% protein, 4% carbohydrates, 0.3-0.4% fats and 1% minerals and vitamins. *Pleurotus* species are very much effective in reducing harmful plasma lipids and thus reduce the chance of atherosclerosis and other cardiovascular and artery-related disorders<sup>1</sup>. As a vegetable, mushroom can play an important role to meet up the nutritional requirements of the population of our country.

Interests in cultivation of edible mushrooms (*Pleurotus ostreatus*) is thus gaining importance rapidly which can create working area, employment opportunity in urban and rural area<sup>2</sup> and also ensure the availability of it's at low price and for recycling of agricultural wastage<sup>3-5</sup>. There are 2000 species of prime edible mushrooms of which about 80 have been grown experimentally and among them 20 species cultivated commercially and 4-5 species cultivated in industrial scale throughout the world<sup>6</sup>. Only some species of mushrooms are now cultivated in Bangladesh and *Pleurotus ostreatus* are very popular<sup>7</sup>.

Mushroom substrates may be defined as a kind of lingo-cellulosic material which supports the growth, development and fruiting of mushroom<sup>8</sup>. However, supplementation of the substrates with various materials is recommended prior to spawning for enhancement of the yield of mushrooms. To improve growth and yield of mushroom, various supplements can be added to the substrates<sup>9</sup>. It is well known that, mycelium growth and mushroom production both are affected by cellulose, hemicelluloses and lignin proportions along with nitrogen content of the cultivating substrate<sup>10</sup>.

Sawdust is produced in a large scale by the saw-mill industries as a byproduct. As a result, it is readily available and a possible alternative for solving the cultivation problem of mushrooms. Reports on the cultivation of mushrooms on solid substrates such as sawdust and different agricultural wastes such as rice bran, wheat bran, sugarcane bagasse, rice husks, coconut fiber, peanut hulls, banana leaves etc. can be found in the literature<sup>11-16</sup>. Few works have been done on the performance of different species of oyster mushroom grown on the agricultural byproducts, wastes, grasses as substrates in mushroom cultivation is of recent history in Bangladesh. Cultivation of oyster mushrooms (*Pleurotus.spp.*) has been provoked by the environmental conditions of Bangladesh<sup>17-18</sup>. There are different

type of sawdust which influences differently in respect to growth, yield and proximate composition of mushroom. That is why it is necessary to find out the suitable sawdust for attaining maximum economic return in mushroom cultivation.

Thus, the objective of this work was to evaluate influence of locally available sawdust of different trees with wheat bran 30% and 1% lime on growth, yield and proximate composition so as to find out the suitable sawdust substrate for cultivation of *Pleurotus ostreatus*.

## MATERIALS AND METHODS

**Experimental Location and Materials:** The experiment was carried out at the Mushroom Culture House (MCH), Biochemistry laboratory of the Department of Biochemistry, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh and National Mushroom Development and Extension Center (NAMDEC) laboratory, Savar, Dhaka, Bangladesh. All the chemicals used were collected from Merck (Germany), Wako Pure Chemicals Industries Ltd. and JHD (China). The samples were weighted by electric balance (KEY: JY-2003; China) and heated in a muffle furnace (Nebetherm: Mod-L9/11/c6; Germany). The amount of minerals in the samples were determined by atomic absorption spectrophotometer (analytikjenanov AA 400P; Germany), flame photometry (PFP7; Germany), and spectrophotometer (HALO BD-20S; Germany). Mother culture of white oyster mushroom (*Pleurotus ostreatus*) was collected from National Mushroom Development and Extension Center (NAMDEC), Saver, Dhaka, Bangladesh.

**Cultivation and Harvesting of *Pleurotus Ostreatus* Mushroom:** *Pleurotus ostreatus* white mushroom was grown on different sawdust substrates, namely, *Magifera indica* (Mango tree, T<sub>1</sub>), *Albizia saman* (Rain tree, T<sub>2</sub>), *Tectona grandis* (Segun tree, T<sub>3</sub>), *Gmelina arborea* (Gamari tree, T<sub>4</sub>), *Swietenia mahagoni* (Mahogany tree, T<sub>5</sub>) and mixture of all five tree sawdust (T<sub>6</sub>) supplemented with 30% wheat bran and 1% lime in the spawn packets<sup>19-21</sup>. The experiment was laid out in single factor Completely Randomized Design (CRD). Sterilization, cultivation, and harvesting of the oyster mushroom (*Pleurotus ostreatus*) were performed on spawn packets following literature<sup>22-24</sup>.

**Sterilization Procedure:** In the laboratory, all of the apparatuses, equipment, metallic instruments,

glassware and culture media were sterilized in the autoclave at 121 °C about 1 hour at 1.5 kg/cm<sup>2</sup> pressure strictly for maintaining sterility. The culture room of the laboratory was cleaned by gently washing with detergent followed by 70% ethyl alcohol regularly. Before inoculation, laminar airflow cabinet was sterilized using ultra violet light for 30 minute keeping blower active. All inoculation measures were carried out in the laminar airflow cabinet to avoid contamination. The cabinet was exposed on the UV light for 30 minutes before use. All the instruments and equipment used were sterilized with alcohol before use.

**Production of Oyster Mushroom (*P. ostreatus*):**

**Preparation of PDA Media:** At first, 250 g potatoes were washed, peeled and sliced to prepare 1000 ml PDA media. Then peeled and sliced potatoes were boiled in water to make them soft and also filtered through a cheese cloth and further water was added to get 1000 mL media. After adding 18 g agar and 20 g dextrose, it was heated and stirred for about 45 minutes. Then 10 mL media was taken into each of test tube and mouths of the test tubes were plugged with cotton and brown paper. After that all the test tubes were sterilized in an autoclave for 20 minutes at 121 °C and 1.5 kg/cm<sup>2</sup> and kept in slanting position for having maximum space for the organism in pure culture to proliferate.

**Tissue Culture:** To obtain pure culture, a small piece of tissue was collected from the fruiting body of mushroom, *Pleurotus ostreatus* and placed on the sterilized PDA medium under aseptic condition in a laminar flow cabinet. It was then kept for 7-10 days in an incubator under 25 °C for sufficient mycelial growth. These pure cultures were used for the entire experiment.

**Preparation of Mother Spawn:** Mother culture substrate was prepared by using sawdust. Sawdust was sieved and sun dried. The mother culture substrate was prepared by sawdust and wheat bran in 2:1 ratio with 0.1% calcium carbonate. Then it was mixed thoroughly with hands and maintained 55% moisture content by adding sufficient water. Then 200 g of mixture was packed tightly 18 × 25 cm polypropylene bags. Each of the bags was prepared by using bamboo neck and plugged the neck with cotton and covered with brown paper placing rubber band to hold it tightly in place. Then inoculums from pure culture were placed aseptically to the mother spawn packets. The packets after inoculation were again plugged with cotton and were kept at 20-22 °C for spawn ran.

The whole packet containing substrate became white due to fungal mycelia proliferation within 15-20 days and thus ready for spawning the substrate.

**Preparation of Spawn Packets:** Spawn packets using different sawdust (individual five trees as T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub> and mixture of trees as T<sub>1</sub>), wheat bran and CaCO<sub>3</sub> in ratio 69:30:1 respectively. The mixed substrates were filled into 10 × 12 inch polypropylene bag. The spawn packets preparation, sterilization, inoculation and incubation were done using the method described by Sarker *et.al.* (2007)<sup>25</sup>. The weight of each spawn packet was 500 g. Moisture was measured by using the moisture meter and adjusted the moisture content at 65%. Therefore the packets were sterilized about 1h and then these were kept for cooling. After cooling, 5 g mother spawn were inoculated into the packets in the laminar air flow cabinet and were kept at 20-22 °C temperature until the packets become white with the mushroom mycelium. After completion of the mycelium running the rubber band, brown paper, cotton plug and bamboo neck of the mouth of spawn packet were removed and the mouth was wrapped tightly with rubber band. Then these spawn packets were transferred to the culture house.

**Cultivation of Spawn Packet:** Two ends, opposite to each other of the upper position of plastic bag were cut in “D” shape with a blade and opened by removing the plastic sheet after which the opened surface of substrate was scraped slightly with a tea spoon for removing the thin whitish mycelia layer. Then the spawn packets were soaked in water for 15 minutes and invested to remove excess water for another 15 minutes. The packets of each type were placed separately on the floor of culture room and covered with newspaper. The moisture of the culture room was maintained 80-85% relative humidity by spraying water 3 times a day. The light around 300-500 lux and ventilation of culture house was maintained uniformly. The temperature of culture house was maintained 22-25 °C. The first primordial appeared 3-5 days after scribing depending upon the type of substrate. The harvesting time also varied depending upon the type of substrate.

**Harvesting of Mushroom:** Oyster mushrooms matured within 2-3 days after primordial initiation. The matured fruiting body was identified by cural margin of the cap, as described by Sarker *et.al.* (2007)<sup>25</sup>. Mushrooms were harvested by twisting to uproot from the base. Mushrooms were harvested 3 times from a packet. After completing

the first harvest again the packets were scraped at the place where “D” shaped cut had been done and were soaked in a bucket for five minutes and then placed in the culture house and water was sprayed regularly. The primordial appeared 9-10 days after first harvest and 7-8 days after second harvest. Water spraying was continued until the mushrooms were ready to be harvested. Then the harvested mushroom samples were subjected to growth, yield, proximate and mineral content analysis.

### Growth and Yield Performance Analysis

**Mycelial Growth (%):** Full packet as a full unit was fixed to determine the mycelial growth. The mycelial growth was counted and generally the data was taken at every two days intervals.

**Mycelium Running Rate in Spawn Packet (cm):** After the mycelium colony cross the shoulder of the packet the mycelium running rate for each type of substrate was measured. The linear length was determined at different places of packets described by Sarker *et al.* (2007)<sup>25</sup>.

$$\text{MRR} = \frac{L}{N} \text{ cm/day}$$

Where, L = Average length of mycelium running for different places (cm) and  
N = Number of days

**Days Required for Completing Mycelium Running:** The required days from inoculation to completion of mycelium running were measured.

**Average Number of Fruiting Body/Packet:** Well-developed fruiting body number was recorded. Dry and pinheaded fruiting bodies were discarded but tiny fruiting bodies were included in counting.

**Average Weight of Individual Fruiting Body/Packet:** Average weight of individual fruiting body was estimated by the ratio of total weight of fruiting body per packet to the total number of fruiting body per packet.

**Biological Yield (g):** Biological yield per 500 g packet was estimated by weighing the whole cluster of fruiting body without removing the lower hard and dirty portion.

**Economic Yield:** Economic yield per 500 g packet was recorded by weighing all the fruiting bodies in a packet after removing the lower hard and dirty portion.

**Dry Yield:** About 50 g of randomly selected mushroom sample was taken in a paper envelop and was weighed correctly. The mushroom was oven dried at 72 °C temperature for 24 hours and weighed again. The weight of blank envelop was

subtracted from both the weight. The dry yield was calculated using the formula described by Sarker *et al.* (2007)<sup>25</sup>.

$$\text{Dry Yield (g/500g packet)} = \frac{\text{Economic yield} \times \text{Oven dry weight of sample (g)}}{\text{Fresh weight of sample (g)}}$$

**Biological Efficiency:** Biological efficiency was determined by the formula described by Ahmed *et al.* (2013)<sup>34</sup>.

$$\text{Biological Efficiency} = \frac{\text{Total biological weight (g)}}{\text{Total weight substrate used (g)}} \times 100.$$

**Cost Benefit Ratio:** The benefit to cost ratios for different low cost substrate were computed based on present market price of mushroom and cost of different inputs in the markets<sup>25</sup>.

### Proximate Analysis

Mushrooms grown from the spawn were collected from each packet separately and all the wastes and dusts were removed from the fruiting body. Thereafter, they were ready to analyze.

**Estimation of Moisture:** About 10-20 g of the material of each sample were weighed separately and then the samples were dried in an oven at 105 °C with pre-weighed petri-dishes till the weight of the petri-dishes with their contents were constant. The moisture content was expressed by percent and evaluated by the formula described by Sarker *et al.*, (2007) and Raghuramulu *et al.*, (2003)<sup>25, 26</sup>.

**Estimation Dry Matter:** A clean container (dish or beaker) was placed in an oven at 105 °C overnight. The container was weighted followed by cooling in a desiccator. The samples were kept into the container and the samples were weighted. The container was placed in the oven at 105 °C for 24 h again. The container was allowed to cool in a desiccator and was weighted. Again, the container was placed in the oven at 105 °C for 2 h. It was cooled in a desiccator and weighted again. Repeat drying, cooling and weighing was continued until the weight becomes constant. Then the percentage of dry matter content of the sample was evaluated by the formula found elsewhere<sup>25, 26</sup>.

$$\text{Moisture (\%)} = \frac{\text{Initial Wt.} - \text{Final Wt.}}{\text{Original weight of sample}} \times 100$$

$$\text{Dry Matter (\%)} = \frac{\text{Wt. of oven dried sample}}{\text{Original weight of sample}} \times 100$$

**Estimation of Crude Fiber:** 10 grams of moisture and fat-free sample was taken in a beaker and was added 200 ml of boiling 0.255 N

H<sub>2</sub>SO<sub>4</sub>. The mixture was boiled for 30 min to keep the volume constant by the addition of water at frequent intervals. The mixture was then filtered through a muslin cloth and the residue was washed with hot water till free from acid. The material was then transferred to the same beaker and 200 ml of boiling 0.313 N NaOH was added. After boiling for 30 min (keeping the volume constant as before) the mixture was filtered through a muslin cloth and the residue was washed with hot water till free from alkali followed by washing with some alcohol and ether. It was then transferred to a crucible, dried overnight at 80-100 °C and weighed. The crucible was heated in a muffle furnace at 600 °C for 5-6 h, cooled and weighed again. The difference of those two mentioned weights represents the weight of crude fiber and percentage was calculated by the formula found in the literature<sup>26, 27</sup>.

$$\text{Crude Fiber (\%)} = \frac{\text{Dry weight after digestion}(W_d) - \text{Weight of ash}(W_a)}{\text{weight of moisture and fat-free fat-free sample}} \times 100$$

**Estimation of Lipid:** Fat was estimated by crude ether extraction of the dry materials. The dried samples (about 5 g) were weighted into a conical flask and plugged with fat free cotton. The flask was then placed in an electric shaker and extracted with anhydrous ether for about 16 h. The ether extract was filtered into another weighed conical flask. The flask containing the original ether extract was washed 4 to 5 times with small quantities of ether and the washings were also transferred to the filter paper. The ether in the conical flask was then removed by evaporation, and the flask with the residual was dried in an oven at 80 °C to 100 °C, cooled in a desiccators and weighted as well as percentage of lipid was determined by the formula found elsewhere<sup>26</sup>.

$$\text{Fat Contents (g) per 100g of Dried Sample} = \frac{\text{Weight of Ether Extract} \times \text{Percentage of Dried Sample}}{\text{Weight of Dried Sample Taken}}$$

### Estimation of Total Carbohydrate:

Carbohydrate content was determined and expressed by percentage by the formula found in the literature<sup>26, 28</sup>.

$$\text{Carbohydrate (g/100g sample)} = 100 - [(\text{Moisture} + \text{Fat} + \text{Protein} + \text{Ash} + \text{Crude Fiber}) \text{ g/100g}]$$

**Estimation of Total Ash:** Ash content of the samples was determined by heating the pre dried samples in a muffle furnace for about 5-6 h at 600 °C until stable weight is gained and white or grayish white color is obtained. Percentage of ash also calculated by the formula found elsewhere<sup>26</sup>.

$$\text{Ash content (g/100g sample)} = \frac{\text{Wt of ash} \times 100}{\text{Wt of sample taken}}$$

**Estimation of Crude Protein:** Sample was dried and grinded using a mortar and pestle to analyze crude protein content. James (1995), Chang & Buswell (2003) described the Kjeldahl method in which the nitrogen content was first determined and then multiplied with 6.25 to obtain the protein content of the sample<sup>29, 30</sup>. Then the percentages of protein were calculated by using the formula.

$$\text{Crude Protein (\%)} = \% \text{ N} \times 6.25$$

**Mineral Content Estimation:** Total nitrogen was determined by a micro Kjeldahl apparatus in the traditional method and calculated using the following formula.

$$\% \text{ N in the supplied fiber sample} = \frac{(a \times M_{\text{HCl}} - b \times M_{\text{NaOH}}) \times 1.401}{c}$$

Where,

a = Volume of HCl in mL measured into the conical flask in the distill H<sub>2</sub>O (usually 20 mL)

b = Volume of NaOH in ml used for titration of the content in the conical flask

c = Weight of powdered sample in gm used for the analysis

M<sub>HCl</sub> = Molarity of the HCl measured into the conical flask

M<sub>NaOH</sub> = Molarity of the NaOH used for titration

The samples were digested with nitric acid to release of Ca, Mg, K, Fe, and P. Ca, Mg and Fe were determined by atomic absorption spectrophotometer, K was determined by flame photometry, and P was determined by spectrophotometer using the formula found in the literature<sup>31</sup>.

Fe, Mo, Zn, Co and Se contents were also measured by atomic absorption spectrometer (AAS) directly in the undiluted filtrate by using the formula found in the literature<sup>31</sup>.

$$\text{For Ca, Mg, K and P mg per kg sample} = \frac{a \times 25000}{b \times c}$$

Where,

a = Ca, Mg, K or P measured in a scale of mg/L on atomic absorption spectrometer/flame photometer.

b = Volume of diluted filtrate in ml transferred into the 50 ml volumetric flask for determination of Ca, Mg, K and P

c = Weight of sample in gm taken into the digestion tube

$$\text{For Fe, Mo, Zn, Co and Se mg per kg sample} = \frac{d \times 100}{c}$$

Where, d = Fe measured in a scale of mg/L on atomic absorption spectrophotometer

c = g sample weighed into the digestion tub

### Statistical Data Analysis

Microsoft Office Excel 2013 was used to analyze various parameters by following standard statistical method by considering, 5 treatments with 3 replications and 1 spawn packets in each replication. The collected data were analyzed for partitioning the total variance using computer operated MSTAT-C programme. The data for the characters considered in the present experiments were statistically analyzed by the Complete Randomized Design (CRD) and Randomized Complete Block Design (RCBD) method. The analysis of variance was conducted and means were compared following least significant difference (LSD) test at 1% and 5% level of probability for interpretation of results were the formula found in the literature<sup>32</sup>.

## RESULTS AND DISCUSSION

### Growth Characters of Oyster Mushroom

Mycelium running rate, time required to complete mycelium running, time in stimulation to primordia initiation, average number of primordia per packet, average number of fruiting body per packet and average weight of individual fruiting body of white oyster mushroom showed statistically significant variation due to different sawdust (Table 1). The highest mycelium running rate (0.76 cm) was observed in T<sub>5</sub> (Mahogany sawdust) which was statistically similar (0.75 cm and 0.70 cm) to T<sub>1</sub> (Mango sawdust) and T<sub>6</sub> (Mixture of all sawdust), respectively and closely followed (0.68 cm) by T<sub>3</sub> (Segun sawdust), while the lowest mycelium running rate (0.63 cm) was found in T<sub>4</sub> (Gamari sawdust) which was statistically similar (0.64 cm) to T<sub>2</sub> (Raintree sawdust). Khan *et al.* (1991) reported that sawdust amended with different organic supplement like wheat chaff, wheat bran, paddy straw, cotton waste etc. provided suitable condition for spawn running<sup>33</sup>. Bhuyan (2008) also found similar result as found in the present experiment<sup>34</sup>. The maximum time required to complete mycelium running (19.20 days) was observed in T<sub>2</sub> which was statistically similar (19.00 days and 18.60 days) with T<sub>4</sub> and T<sub>6</sub>, respectively, whereas the minimum time required to complete mycelium

running (18.20 days) was found in T<sub>1</sub> which was statistically similar (18.40 days) to T<sub>3</sub> and T<sub>5</sub>. The result of the present finding was found similar with Amin *et al.* (2007); Khan *et al.* (2008); Gupta (1989)<sup>7, 17, 35</sup>. The maximum time in stimulation to primordia initiation (4.00 days) was observed in T<sub>4</sub> which was statistically similar (3.60 days and 3.40 days) to T<sub>2</sub>, T<sub>3</sub> and T<sub>6</sub>, respectively, whereas the minimum time (2.60 days) was found in T<sub>5</sub> which was statistically similar (2.80 days) to T<sub>1</sub>. The result of the present finding was found similar with Amin *et al.* (2007); Khan *et al.* (2001) and Gupta (1989)<sup>7, 17, 35</sup>. Sarker (2004) observed that duration in primordia initiation of oyster mushroom was significantly lower as compared to control *i.e.* no supplement was used<sup>36</sup>. The highest average number of primordia per packet (75.20) was observed in T<sub>5</sub> which was statistically similar (73.60 and 71.20) to T<sub>1</sub> and T<sub>3</sub> respectively, while the lowest average number of primordia per packet (65.80) was found in T<sub>2</sub> and T<sub>4</sub> which was statistically similar (69.60) to T<sub>6</sub>. Dey (2006) found that the number of primordia and the average yield of oyster mushroom give the lowest value with sawdust<sup>37</sup>. The highest average number of fruiting body per packet (57.20) was observed in T<sub>5</sub> which was statistically similar (54.00) to T<sub>1</sub> and closely followed (51.60) by T<sub>3</sub>, whereas the lowest average number of fruiting body per packet (47.00) was found in T<sub>2</sub> which was statistically similar (48.00 and 50.60) to T<sub>4</sub> and T<sub>6</sub>. This variation might be due to variation among the sawdust. The result of the present study found similar with the previous findings of Bhuyan (2008), Sarker (2004) and Yoshida *et al.* (1993)<sup>38, 36, 34</sup>. Yoshida *et al.* (1993) reported that the number of fruiting bodies was lower, but increased when the substrates was mixed with different supplements<sup>38</sup>. The highest average weight of fruiting body (4.45 g) was observed in T<sub>5</sub> which was statistically similar (4.42 g) to T<sub>1</sub> and closely followed (4.21 g) by T<sub>6</sub>, while the lowest average weight of individual fruiting body (3.76 g) was found in T<sub>4</sub> which was statistically similar (3.87 g) to T<sub>2</sub>. The findings of this experiment were also supported by the findings of Sarker *et al.* (2007a) and Bhuyan (2008)<sup>39, 34</sup>. Sarker (2004) found significant increase in weigh of fruiting body in gram per sporocarps over control in spawn packet containing different supplement in compared with sawdust alone<sup>36</sup>. Bhuyan (2008) found comparatively higher weight of individual fruiting body ranged in (5.02 g to 7.01 g)<sup>34</sup>.

**Table 1. Effect of different sawdust on growth and yield contributing characters of white oyster mushroom (*Pleurotus ostreatus*)**

Treatments	Mycelium running rate in spawn packets (cm)	Time required to complete mycelium running	Time in stimulation to primordia initiation	Average number of primordia per packet	Average number of fruiting body per packet	Average weight of individual fruiting body (g)
T <sub>1</sub>	0.75 a	18.20 c	2.80 bc	73.60 ab	54.00 ab	4.42 a
T <sub>2</sub>	0.64 c	19.20 a	3.60 a	65.80 c	47.00d	3.87 cd
T <sub>3</sub>	0.68 bc	18.40 bc	3.40 ab	71.20 ab	51.60 bc	4.03 c
T <sub>4</sub>	0.63 c	19.00 ab	4.00 a	65.80 c	48.00 cd	3.75 d
T <sub>5</sub>	0.76 a	18.40 bc	2.60 c	75.20 a	57.20 a	4.45 a
T <sub>6</sub>	0.70 ab	18.60 abc	3.40 ab	69.60 bc	50.60bcd	4.21 b
LSD (0.05)	0.058	0.608	0.630	3.894	4.016	0.165
CV(%)	6.55	7.69	4.64	4.25	5.99	3.04

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

### Yield Contributing Characters and Yield of Oyster Mushroom

Statistically significant variation was recorded in terms of length and diameter of stipe and pileus, thickness of pileus, biological, economic and dry yield, biological efficiency and benefit to cost ratio for different sawdust (Table 2). The highest length of stipe (2.69 cm) was observed in T<sub>1</sub> which was statistically similar (2.63 cm) to T<sub>5</sub> and closely followed (2.46 cm and 2.40 cm) by T<sub>6</sub> and T<sub>3</sub>, respectively, while the lowest length of stipe (2.13 cm) was found in T<sub>4</sub> which was statistically similar (2.20 cm) to T<sub>2</sub>. Ahmed (1998) reported significant effects of various substrates on length of stalk<sup>40</sup>. Habib (2005) found that the length of stipe of oyster mushroom on different substrates varied in 1.93 cm to 2.97 cm<sup>41</sup>. The highest diameter of stipe (1.15 cm) was observed in T<sub>5</sub> which was statistically similar (1.14 cm) to T<sub>1</sub> and closely followed (1.08 cm) by T<sub>3</sub>, whereas the lowest diameter of stipe (1.01 cm) was found in T<sub>4</sub> which was statistically similar (1.02 cm) to T<sub>2</sub>. Habib (2005) found that stipe of oyster mushroom on different substrates varied in 0.74 cm to 1.05 cm<sup>41</sup>. The highest diameter of pileus (6.88 cm) was observed in T<sub>5</sub> which was statistically similar (6.83 cm) to T<sub>1</sub> and closely followed (6.70 cm) by T<sub>6</sub>, while the lowest diameter of pileus (6.37 cm) was found in T<sub>4</sub> which was statistically similar (6.42 cm) to T<sub>2</sub>. Ahmed (1998) reported significant effects of various substrates on diameter of pileus<sup>40</sup>. He also found that lower diameter of pileus produced the lowest yield and concluded that the diameter of pileus increased the quality and yield of mushroom and highest dry yield in mango sawdust. The highest thickness of pileus (0.80 cm) was observed in T<sub>1</sub> which was statistically similar (0.82 cm) to T<sub>5</sub> and closely followed (0.75 cm and 0.73 cm) by T<sub>6</sub> and T<sub>3</sub>,

while the lowest thickness of pileus (0.68 cm) was found in T<sub>4</sub> which was statistically similar (0.69 cm) to T<sub>2</sub>. Habib (2005) found that thickness of the pileus ranged in 0.45 cm to 0.70 cm due to different substrates<sup>41</sup>. The highest biological yield (227.68 g) was observed in T<sub>5</sub> which was statistically similar (227.03 g, 226.97 g and 219.51 g) to T<sub>1</sub>, T<sub>6</sub> and T<sub>3</sub> and closely followed (212.24 g) by T<sub>2</sub>, while the lowest biological yield (204.78 g) was found in T<sub>4</sub> which was statistically similar (212.24 g) to T<sub>2</sub>. Dhoke *et al.* (2001) found significant effect of different agro-wastes on yield of oyster mushroom<sup>42</sup>. Baysal *et al.* (2003) found the highest yield of oyster mushroom with the substrate composed of 20% rice husk in weight basis<sup>16</sup>. The highest economic yield (207.58 g) was observed in T<sub>5</sub> which was statistically similar (206.42 g and 199.55 g) to T<sub>1</sub> and T<sub>6</sub> and closely followed (194.98 g) by T<sub>3</sub>, while the lowest biological yield (181.96 g) was found in T<sub>4</sub> which was statistically similar (189.40 g) to T<sub>2</sub>. Sarker (2004) found appreciable variations in economic yield also observed at different levels of supplements under different substrate-supplement combinations<sup>36</sup>. The highest dry yield (18.88 g) was observed in T<sub>5</sub> which was statistically similar (18.85 g, 18.07 g and 17.93 g) to T<sub>1</sub>, T<sub>6</sub> and T<sub>3</sub>, respectively, while the lowest dry yield (17.26 g) was found in T<sub>4</sub> which was statistically similar (17.51g) to T<sub>2</sub>. Sarker *et al.* (2007a) who found the range of dry yield ranged in 4.28 to 29.98 g/packet of *Pleurotus ostreatus* grown on different substrate<sup>39</sup>. Kulsum *et al.* (2009) found that the highest dry yield was 21.27 g due to sawdust<sup>43</sup>. The highest biological efficiency (84.08%) was observed in T<sub>5</sub> which was statistically similar (83.86%, 83.44% and 82.86%) to T<sub>1</sub>, T<sub>6</sub> and T<sub>3</sub>, respectively and closely followed (80.72%) by T<sub>2</sub>, while the lowest biological yield (78.30%) was

found in T<sub>4</sub>. Kalita *et al.* (1997)<sup>44</sup> observed biological efficiency for different substrates ranged in 35.2 to 60.9%. Obodai *et al.* (2003)<sup>45</sup> found biological efficiency (BE) followed a pattern and ranged in 61.0% to 80.0%. Shen and Royse (2001) found supplements combined with basal ingredient results better mushroom quality as well as Biological efficiency<sup>46</sup>. The highest benefit cost ratio (BCR) (4.25) was observed in T<sub>5</sub> which was

statistically similar (4.18) to T<sub>1</sub> and closely followed (3.93) by T<sub>6</sub>, whereas the lowest BCR (3.62) was found in T<sub>4</sub> which was statistically similar (3.71) to T<sub>2</sub>. The present findings found similar with the findings of previous research. Lim *et al.* (1997) analyzed the cost and return of *Volvariella* and *Pleurotus* mushroom production and found the BCR of 8.9 and 5.1, respectively<sup>47</sup>.

**Table 2. Effect of different sawdust on the dimension of fruiting body, yield, biological efficiency and benefit cost ratio of white oyster mushroom (*Pleurotus ostreatus*)**

Treatments	Length of stipe (cm)	Diameter of stipe (cm)	Diameter of pileus (cm)	Thickness of pileus (cm)	Biological yield (g)	Economic yield (g)	Dry yield (g)	Biological efficiency (%)	Benefit cost Ratio
T <sub>1</sub>	2.69 a	1.14 a	6.83 a	0.80 a	227.03 a	206.42 ab	18.85 a	83.86 a	4.18 ab
T <sub>2</sub>	2.20 c	1.02 c	6.42 cd	0.69 cd	212.24 bc	189.40 cd	17.51 b	80.72 bc	3.71 cd
T <sub>3</sub>	2.40 b	1.08 b	6.53 c	0.73 bc	219.51 ab	194.98 bc	17.93 ab	82.86 ab	3.76 cd
T <sub>4</sub>	2.13 c	1.01 c	6.37 d	0.68 d	204.78 c	181.96 d	17.26 b	78.30 c	3.62 d
T <sub>5</sub>	2.63 a	1.15 a	6.88 a	0.82 a	227.68 a	207.58 a	18.88 a	84.08 a	4.25 a
T <sub>6</sub>	2.46 b	1.09 b	6.70 b	0.75 b	226.97 a	199.55 abc	18.07 ab	83.44 a	3.93 bc
LSD <sub>(0.05)</sub>	0.154	0.041	0.124	0.413	11.84	10.91	1.148	2.502	0.286
CV(%)	4.96	3.55	1.41	5.18	4.13	4.25	4.87	2.33	5.61

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

### Proximate Composition of Oyster Mushroom

Statistically significant variation was recorded in terms of moisture, dry matter, protein, lipid, ash, carbohydrate and crude fiber content of mushroom for different sawdust (Table 3). The highest moisture content (87.77%) was observed in T<sub>4</sub> which was statistically similar (87.01%) to T<sub>2</sub> and closely followed (86.49% and 86.64%) by T<sub>6</sub> and T<sub>3</sub>, respectively, while the lowest moisture content (85.84%) was found in T<sub>5</sub>. The result of the present study found more or less similar with the study of previous researchers (Alam *et al.*, Moni *et al.*, 2004; 2007 and Rahman, 1994)<sup>1, 48, 49</sup>. Moni *et al.* (2004) cultivated the oyster mushroom (*Pleurotus sajor-caju*) on paddy straw, banana leaves, sugarcane baggase, water hyacinth, betel nut husk and he found moisture content varied in 88.15 to 91.64%<sup>48</sup>. The highest dry matter content (14.16%) was observed in T<sub>5</sub> which was statistically similar (13.51% and 13.36%) to T<sub>6</sub>, T<sub>1</sub> and T<sub>3</sub>, respectively, whereas the lowest dry matter content (12.23%) was found in T<sub>4</sub> which was statistically similar (12.99%) to T<sub>2</sub>. The result of the present study matches with the findings of previous one that reported by Kulsum *et al.* (2009) revealed that the dry matter percentage of the fruiting body was ranged in 9.40 to 9.98 due to sawdust supplemented with different levels of cow dung<sup>43</sup>. The highest protein content (24.97%) was

observed in T<sub>5</sub> which was statistically similar (24.83% and 24.50%) to T<sub>1</sub> and T<sub>6</sub>, respectively and closely followed (24.37%) by T<sub>3</sub>, while the lowest protein content (24.12%) was found in T<sub>4</sub> which was statistically similar (24.17%) to T<sub>2</sub>. Chang *et al.* (1981) reported that the fruiting bodies of mushrooms contained 26.6-34.1% crude protein<sup>50</sup>. The highest lipid content (6.15%) was observed in T<sub>5</sub> which was statistically similar (6.10% and 6.03%) to T<sub>1</sub> and T<sub>6</sub>, respectively and closely followed (5.94%) by T<sub>3</sub>, while the lowest lipid content (5.72%) was found in T<sub>4</sub> which was closely followed (5.89%) to T<sub>2</sub>. The results of the present study was found more or less similar with the findings of Alam *et al.* (2007) who reported 4.30 to 4.41% lipids in oyster mushroom grown on different substrates<sup>1</sup>. Kulsum *et al.* (2009) also found that lipid content was ranged in 3.44 to 5.43% due to sawdust supplemented with different levels of cow dung which is more or less similar to the present study<sup>43</sup>. The highest ash content (13.35%) was observed in T<sub>5</sub> which was statistically similar (13.28%, 13.24% and 13.11%) to T<sub>1</sub>, T<sub>6</sub> and T<sub>3</sub>, respectively, whereas the lowest ash content (12.81%) was found in T<sub>4</sub> which was statistically similar (13.03%) to T<sub>2</sub>. The findings of the present study was differed by the findings of Kulsum *et al.* (2009) who found that ash content was ranged in 6.58 to 8.41% due to sawdust supplemented with different levels of cow dung<sup>43</sup>.

The highest carbohydrate content (44.02%) was observed in T<sub>4</sub> which was closely followed (43.32%) by T<sub>2</sub>, while the lowest carbohydrate content (41.52%) was found in T<sub>5</sub> which was statistically similar (41.89% and 42.20%) to T<sub>1</sub> and T<sub>6</sub>, respectively. The findings of the present study are supported by the study of Kulsum *et al.* (2009) who found that carbohydrate content was ranged in 32.85 to 56.38% due to sawdust supplemented

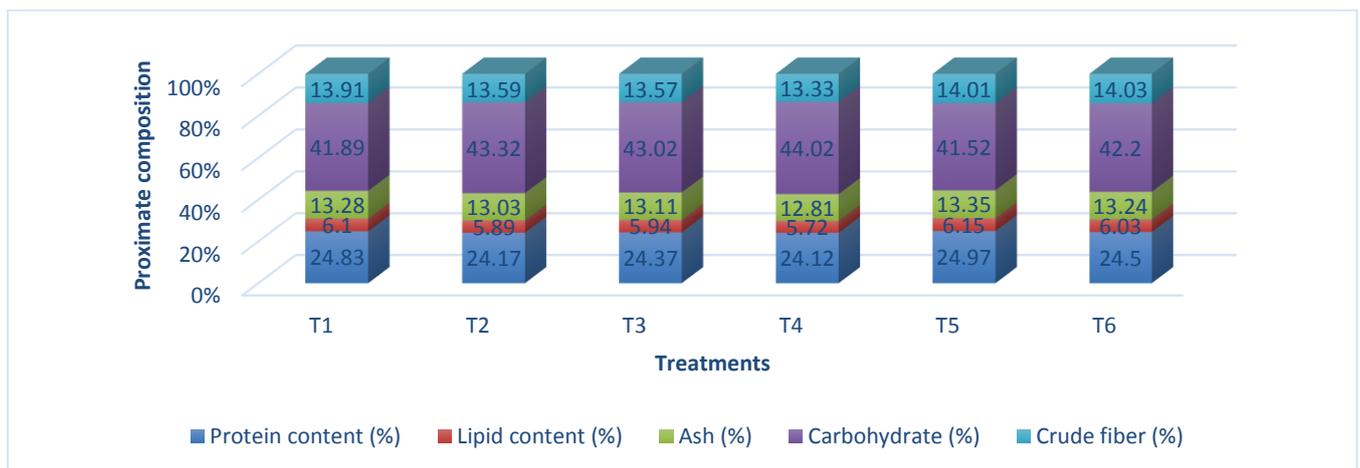
with different levels of cow dung<sup>43</sup>. The highest crude fiber content (14.03%) was observed in T<sub>6</sub> and T<sub>5</sub> which was statistically similar (14.01%, 13.91%, 13.59% and 13.57%) to T<sub>5</sub>, T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub>, respectively, whereas the lowest crude fiber content (13.33%) was found in T<sub>4</sub>. The findings of the present study differ with the study Alam *et al.* (2007) and they reported 22.87 g/100 g to 23.29 g/100 g of fiber in *Pleurotus spp*<sup>1</sup>.

**Table 3. Effect of different sawdust on proximate nutrient composition of white oyster mushroom (*Pleurotus ostreatus*)**

Treatments	Moisture (%)	Dry matter (%)	Protein content (%)	Lipid content (%)	Ash (%)	Carbohydrate (%)	Crude fiber (%)
T <sub>1</sub>	86.64 bc	13.36 ab	24.83 ab	6.10 ab	13.28 a	41.89 c	13.91 ab
T <sub>2</sub>	87.01 ab	12.99 bc	24.17 c	5.89 c	13.03bc	43.32 b	13.59 ab
T <sub>3</sub>	86.64 bc	13.36 ab	24.37 bc	5.94 bc	13.11ab	43.02 b	13.57 ab
T <sub>4</sub>	87.77 a	12.23 c	24.12 c	5.72 d	12.81 c	44.02 a	13.33 b
T <sub>5</sub>	85.84 c	14.16 a	24.97 a	6.15 a	13.35 a	41.52 c	14.01 a
T <sub>6</sub>	86.49 bc	13.51 ab	24.50 abc	6.03 abc	13.24ab	42.20 c	14.03 a
LSD (0.05)	0.772	0.772	0.469	0.160	0.226	0.697	0.569
CV(%)	2.68	4.46	1.47	2.08	2.13	1.42	1.84

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Different sawdust substrates and wheat bran had an effect on the approximate composition of *Pleurotus ostreatus* which was shown in Fig. 1.



**Fig. 1:** Effect of sawdust substrates with wheat bran on the proximate composition analysis of dry matter of *Pleurotus ostreatus*

**Mineral Content of Oyster Mushroom**

Statistically significant variation was recorded in terms of nitrogen, phosphorus, potassium, calcium, magnesium, iron, sulphur and zinc content of mushroom for different sawdust (Table 4). The highest nitrogen content (4.00%) was observed in T<sub>5</sub> which was statistically similar (3.97% and 3.92%) by T<sub>1</sub> and T<sub>6</sub>, respectively, while the lowest nitrogen content (3.86%) was found in T<sub>4</sub> which was statistically similar (3.87%) to T<sub>2</sub>. The highest phosphorus content (0.89%) was observed in T<sub>5</sub> which was statistically similar (0.87% and 0.86%) by T<sub>1</sub> and T<sub>6</sub>, respectively, while the lowest phosphorus content (0.74%) was found in T<sub>4</sub> which was statistically similar (0.78%) to T<sub>2</sub>.

The findings of the present study differ with the study of Sarker *et al.* (2007a) who found 0.97% phosphorus in oyster mushroom grown on sawdust based substrates. Kulsum *et al.* (2009) was found that phosphorus content ranged in 0.84 to 0.92% due to sawdust supplemented with different levels of cow dung<sup>43</sup>. The highest potassium content (1.35%) was observed in T<sub>5</sub> which was statistically similar (1.33% and 1.32%) by T<sub>1</sub> and T<sub>6</sub>, respectively, while the lowest potassium content (1.24%) was found in T<sub>2</sub> which was statistically similar (1.25%) to T<sub>4</sub>. The findings of the present study similar with the study of Chang *et al.* (1981) who reported that the fruiting bodies of *Pleurotus* contained 1.432 to 1.88 mg/g of K on dry weight

basis<sup>50</sup>. Sarker *et al.* (2007a) also found 1.3% potassium in oyster mushroom grown on sawdust based substrates<sup>39</sup>. The highest calcium content (17.33 mg/100 g) was observed in T<sub>6</sub> which was statistically similar (17.25, 16.91, 16.16 and 16.15 mg/100 g) by T<sub>1</sub>, T<sub>5</sub>, T<sub>2</sub> and T<sub>3</sub>, respectively, while the lowest calcium content (15.72 mg/100 g) was found in T<sub>4</sub>. Alam *et al.* (2007) who found 22.15 to 33.7 mg/100 g calcium in different oyster mushroom varieties<sup>1</sup>. Sarker *et al.* (2007b) also found 2400 ppm calcium in oyster mushroom grown on sawdust based substrates<sup>51</sup>. The highest magnesium content (14.50 mg/100 g) was observed in T<sub>5</sub> which was statistically similar (14.39, 14.28 and 14.04 mg/100 g) by T<sub>1</sub>, T<sub>6</sub> and T<sub>3</sub>, respectively, while the lowest magnesium content (13.35 mg/100 g) was found in T<sub>4</sub>. Sarker (2004) also found 0.21% magnesium in oyster mushroom grown on sawdust based substrates<sup>36</sup>. The highest iron content (47.46 mg/100 g) was observed in T<sub>1</sub> which was statistically similar (47.14 and 46.90 mg/100 g) by T<sub>5</sub> and T<sub>6</sub>, respectively, while the lowest iron content (44.89 mg/100 g) was found in T<sub>4</sub>. The result of the

present study found iron higher than the value found by Alam *et al.* (2007) who found that iron content of different oyster mushroom varieties ranged in 33.45 to 43.2 ppm<sup>1</sup>. The highest sulphur content (0.274 mg/100 g) was observed in T<sub>5</sub> which was statistically similar (0.273, 0.266 and 0.263 mg/100 g) by T<sub>1</sub>, T<sub>3</sub> and T<sub>6</sub>, respectively, while the lowest sulphur content (0.251 mg/100 g) was found in T<sub>4</sub> which was statistically similar (0.256 mg/100 g) to T<sub>2</sub>. The findings of the present study were supported with the findings of Alam *et al.* (2007) who recorded 0.238 to 0.321% of sulphur in their earlier study in oyster mushroom varieties<sup>1</sup>. The highest zinc content (15.81 mg/100 g) was observed in T<sub>5</sub> which was statistically similar (15.69, 15.36, 15.34 and 15.19 mg/100 g) by T<sub>1</sub>, T<sub>6</sub>, T<sub>3</sub> and T<sub>2</sub>, respectively, while the lowest zinc content (15.00 mg/100 g) was found in T<sub>4</sub>. The results of the present study have the similarity with the study of Alam *et al.* (2007) found in their earlier experiment that zinc content of different oyster mushroom ranged in 16 to 20.9%<sup>1</sup>. Sarker *et al.* (2007a) found 30.92 ppm zinc in oyster mushroom grown on sawdust based substrates<sup>39</sup>.

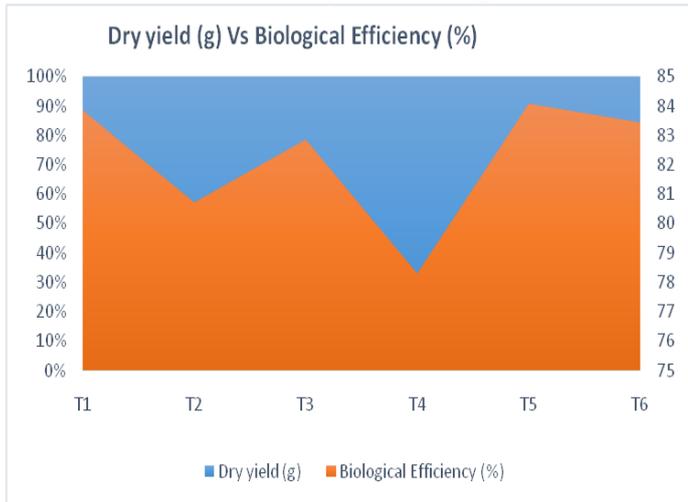
**Table 4. Effect of different pasteurization method on the on mineral contents of pink oyster mushroom (*Pleurotus ostreatus*)**

Treatments	N (%)	P (%)	K (%)	Ca (mg/100 g)	Mn (mg/100 g)	Fe (mg/100 g)	S (mg/100 g)	Zn (mg/100 g)
T <sub>1</sub>	3.97 ab	0.87 ab	1.33 a	17.25 a	14.39 ab	47.46 a	0.273 a	15.69 ab
T <sub>2</sub>	3.87 c	0.78 c	1.24 c	16.16 ab	13.90 b	45.39 bc	0.256 bc	15.19 ab
T <sub>3</sub>	3.90 bc	0.83 b	1.30 ab	16.15 ab	14.04 ab	45.95 b	0.266 ab	15.34 ab
T <sub>4</sub>	3.86 c	0.74 c	1.25 bc	15.72 b	13.35 c	44.89 c	0.251 c	15.00 b
T <sub>5</sub>	4.00 a	0.89 a	1.35 a	16.91 ab	14.50 a	47.14 a	0.274 a	15.81 a
T <sub>6</sub>	3.92 abc	0.86 ab	1.32 a	17.33 a	14.28 ab	46.90 a	0.263 abc	15.36 ab
LSD (0.05)	0.075	0.413	0.058	1.222	0.517	0.806	0.013	0.719
CV(%)	4.15	4.42	3.84	5.64	2.82	1.33	4.37	3.58

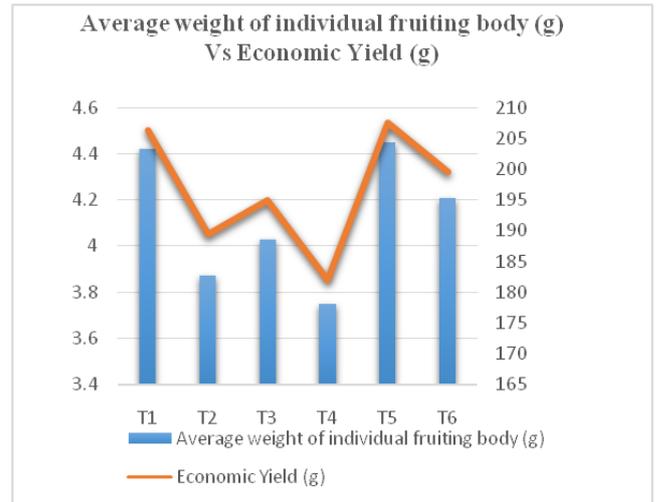
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

**CORRELATION STUDY**

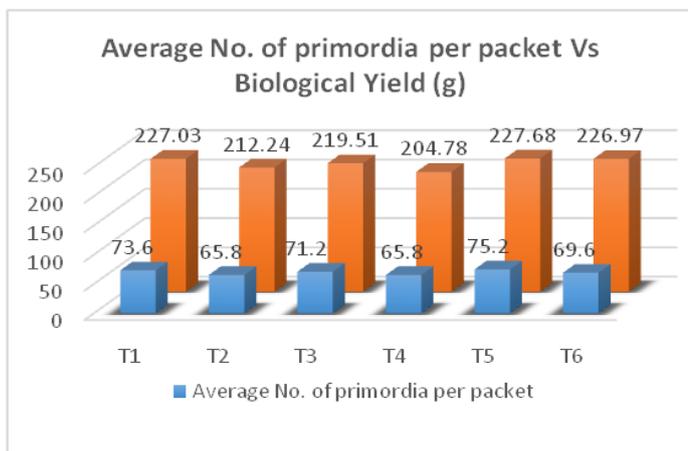
Different correlation study curve are given bellow.



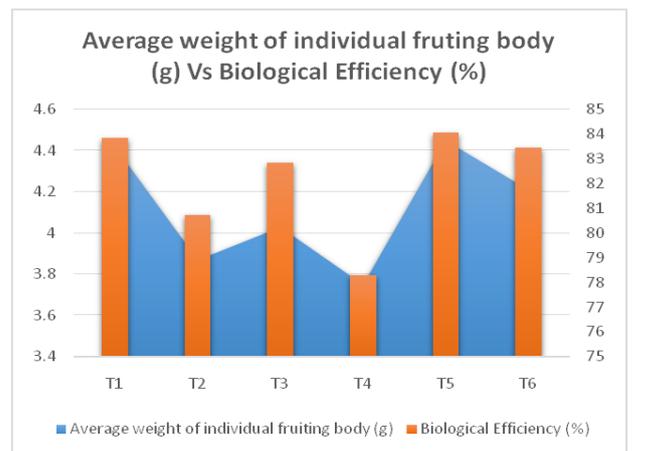
**Fig. 2:** Effect of different sawdust on relationship between dry yields with biological efficiency



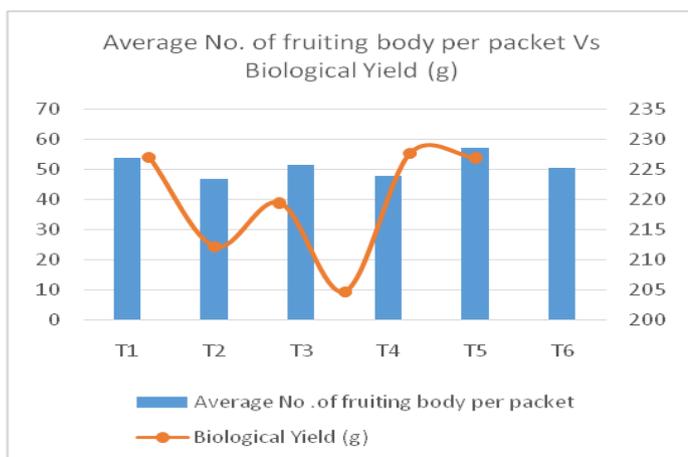
**Fig. 3:** Effect of different sawdust on relationship between average weights of individual fruiting body with economical yield



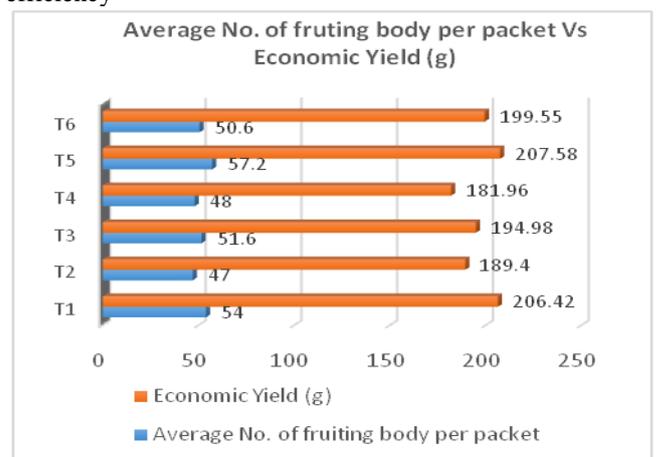
**Fig. 4:** Effect of different sawdust on relationship between average numbers of primordial per packet with biological yield



**Fig. 5:** Effect of different sawdust on relationship between average weights of individual fruiting body with biological efficiency



**Fig. 6:** Effect of different sawdust on relationship between average numbers of fruiting body per packet with biological yield



**Fig. 7:** Effect of different sawdust on relationship between average numbers of fruiting body per packet with economic yield

## CONCLUSION

Effect of different sawdust substrates on the growth, yield and proximate composition of *Pleurotus ostreatus* was observed. It may offer economic incentives for agribusiness to examine these residues as valuable resources and develop new enterprises to use them to produce nutritious mushroom products. Therefore, the mushroom cultivation may become one of the most profitable agribusiness that could produce food products from different substrates and help to dispose them in an environment friendly manner. Among the sawdust T<sub>5</sub> (Mahogany sawdust) performed significantly better on growth, yield, nutrient and mineral content of white oyster mushroom compare to the other sawdust used in this study.

## ACKNOWLEDGEMENT

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