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Effect of Different Sawdust on the Growth, Yield and Proximate Composition of Pleurotus Sajor-Caju.

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Abstract : *Pleurotus sajor-caju Cultivation on 5 different saw dust substrates such as- Mango tree(Mangifera indica,T_2),Mahagony tree (Swietenia mahagoni,T_3),jackfruit tree(Artocarpus heterophyllus,T_4),Teak tree(Tectona grandis,T_5)Rain Tree (Albizia saman, T_6) and mixture of all five tree sawdust (T_1) supplemented with 30% wheat bran and 1% lime as basal substrates were investigated. The effects of these saw dust substrates on comparative growth,yield performance and proximate composition of Pleurotus sajor-caju were analyzed.The highest mycelium running rate (0.77 cm/day) and the lowest time from primordial initiation to harvest (3.26days), were obtained in T_2. The highest time from stimulation to primordial initiation (4.33days) were found in T_4. The highest biological yield (276 g/packet), economic yield (269.40 g/packet), dry yield (26.56 g/packet), biological efficiency (82.34%), benefit cost ratio (5.22), the highest average number of primordia/packet (75.33), the highest average number of fruiting body/packet (61.33), the highest average weight of individual fruiting body (4.45 g) ,the highest amount protein content (27.44%) , the highest carbohydrate content (39.54%) , the highest amount of Nitrogen content (4.94%) the highest amount of iron (513.48 ppm) were obtained inT_2. Among all aspects, T_2 was found as a best substrate with BE (82.38 %) for the production of Plurotus sajor-caju.*

Keywords: *Growth, Sawdust, Spawn, Substrates, Pleurotus sajor-caju, Wheat bran, Yield*

I. Introduction

Mushroom is the fleshy, spore-bearing fruiting body of a fungus, typically produced above ground on soil or on its food source. Most mushroom-producing fungi are members of the genus *Pleurotus* under the class Basidiomycetes. *Pleurotus sajor-caju* is an edible mushroom having excellent flavor and taste. *Pleurotus* species are popular and widely cultivated throughout the world mostly in Asia and Europe owing to their simple and low cost production technology and higher biological efficiency [**1**]. Cultivation of *P. sajor-caju* mushroom has increased tremendously throughout the world because of their abilities to grow at a wide range of temperature and harvested all over the year. Mushrooms had long been used for medicinal and food purposes since decades. *Pleurotus* have broad adaptability with varied agro-climatic conditions **[2**]. Pleurotus have the ability to excrete hydrolyzing and oxidizing enzymes [**3**] which are capable of utilizing complex organic compounds that occurred agricultural wastes and industrial by-products [**4**]. It does not need any composting like button mushroom. *P. Sajor-caju* are commercially cultivated all over the year by using sawdust or rice straw as main substrate. Substrate plays an important role in the yield and nutrient content of oyster mushroom. The substrates on which mushroom spawn is grown, affects the mushroom production . Less nitrogen and more carbon containing substrate such as most organic matters containing cellulose, hemicellulose and lignin are preferable as mushroom substrate[**5**]. *Pleurotus sajor-caju* mushroom can grow on sawdust, wheat and paddy straw, banana leaves, sugarcane bagasse and leaves, wheat barn, rice husk etc. and their culture can be concentrated within a relatively small space *Pleurotus sajor-caju* requires a short growth time in comparison to other edible mushrooms [**6**]. The growth of different type of mushrooms show diverse growth and yield features for substrates. Availability of varied type of nutrient may indicate which typeof substrates is used [**7**]. Available sawdust of different trees or very low cost bearing substrates offers a potential source for mushroom cultivation in the tropics [**8**]. Mushroom cultivation is very beneficial for Bangladesh because with increasing population and conventional agricultural methods we cannot cope with the food problem, on the other hand sawdust and other materials are available here[**9**]. Edible mushrooms are recommended by the FAO as food, to meet protein requirement of developing countries, the large proportion of which depends mainly on cereals (World Bank, 2004). In general edible mushrooms are low in fat and calories, rich in vitamins B, D, K and sometimes vitamins A and C [**10**], contain more protein than any other food of plant origin and are also a good source of mineral nutrients [**11**]. Malnutrition is a problem in developing third world countries. Mushrooms with their flavor, texture, nutritional value and high productivity per unit area have been identified as an excellent food source to alleviate malnutrition in developing countries [**12**]. Oyster mushroom cultivation can play an important role in managing organic wastes whose disposal has become a problem [**13**]. These wastes can be recycled into food and environment may be less endangered by pollution [**14**]. Strengthening mushroom production sector could be essential in order to enable the rural economy its vibrancy and development,

increasing and diversifying business and employment opportunities in the rural areas, and providing income opportunities of small family farms.Apart from food value, its medicinal value for diabetics and in cancer therapy has been emphasized [**15**]. Many of mushrooms pose a range of metabolites of intense interest to pharmaceutical e.g. antitumour, antigenotoxic, antioxidant, anti-inflammatory, anti-hypertensive, antiplatelet-aggregating, antihyperglycaemic, antimicrobial, antiviral activities and food industries [**16**].

The present experiment was undertaken to evaluate influence of locally available substrates containing sawdust of different trees with wheat ban and 1% lime on growth and yield of *Pleurotus sajor-caju* mushroom. Those experiments were also to find the best sawdust among others as substrate for effective cultivation of *Pleurotus sajor-caju.*

II. Material And Methods

1.1. *Materials and Measurement:*

The experiment was conducted at the Biochemistry laboratory and Mushroom Culture House (MCH) of the Department of Biochemistry, Sher-e-Bangla Agricultural University, Dhaka **during the period from January to July 2014.** Fruiting body of oyster mushroom was collected from NAMDEC, Saver, Dhaka, Bangladesh. Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka. *Pleurotus sajor-caju* mushroom is characterized by the rapidity of the mycelial growth and high saprophytic colonization activity on cellulosic substrates. The sample was weighted by electric balance (KEY: JY-2003; China) and heated in a muffle furnace (Nebertherm: Mod-L9/11/c6; Germany).

2.2. Treatments of the experiments

Two different experiments with six treatments with five replications were conducted to achieve the desired objectives. The experiments were as follows:

Experiment 1: Effect of different sawdust substrates on yield contributing character of *Pleurotus sajor-caju* mushroom.

Treatments used:

T_1: Controlled(Mixture of sawdust) supplemented with 30% wheat bran and 1% lime
T_2: Mango(*Mangifera indica*) sawdust supplemented with 30% wheat bran and 1% lime
T_3: Mahogony (*Swietenia mahagony*) sawdust supplemented with 30% wheat bran and 1% lime
T_4: Jackfruit(*Artocarpus heterophyllus*) sawdust supplemented with 30% wheat bran and 1% lime
T_5: Teak tree(*Tectona grandis)* sawdust supplemented with 30% wheat bran and 1% lime
T_6:Rain tree(*Albizia saman*) sawdust supplemented with 30% wheat bran and 1% lime

Experiment 2: Effect of different sawdust substrates on proximate composition analysis of *Pleurotus sajor-caju* mushroom.

Treatments used:

T_1: Controlled(Mixture of sawdust) supplemented with 30% wheat bran and 1% lime
T_2: Mango(*Mangifera indica*) sawdust supplemented with 30% wheat bran and 1% lime
T_3: Mahogony (*Swietenia mahagony*) sawdust supplemented with 30% wheat bran and 1% lime
T_4: Jackfruit(*Artocarpus heterophyllus*) sawdust supplemented with 30% wheat bran and 1% lime
T_5: Teak tree(*Tectona grandis)* sawdust supplemented with 30% wheat bran and 1% lime
T_6:Rain tree(*Albizia saman*) sawdust supplemented with 30% wheat bran and 1% lime

2.3. *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$_2$ 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.

2.4. *Production of Oyster Mushroom (P. sajor-caju)*

2.4.1. *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 121ºC and 1.5 kg/cm2 and kept in slanting position for having maximum space for the organism in pure culture to proliferate.

2.4.2. Tissue culture

To obtain pure culture, a small piece of tissue was collected from the fruting body of *Pleurotus sajor-caju* mushroom and placed on the sterilized PDA medium under aseptic condition in a laminar air flow cabinet. It was then kept for 7-10 days in an incubator under 25^0C for sufficient mycelial growth. These pure culture were used for the entire experiment.

2.4.3. 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 [**17**]. Then it was mixed thoroughly with hands and maintained 55% moisture content by adding sufficient water. Then 200 gm of mixture was packed tightly 18*25 cm polypropylene (PP) bag. Each of the bags was prepared by using plastic neck and plugged the neck with cotton and covered with brown paper placing rubber band to hold it tightly in place. The packets were sterilized for 1 hour at 121^0C for 1 hours at 1.5 kg/cm^2 pressure in an autoclave and kept them for cooling. 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 20-22^0C for spawn run. The whole packet containing substrate became white due to fungal mycelia proliferation within 15-20 days and thus ready for spawning the substrate [**18**].

2.4.4. Preparation of substrates

Spawn packets using different sawdust, wheat bran, $CaCo_3$ in ratio 69:30:1 respectively and moisture should be maintained. The measured materials were taken in a plastic bowl and mixed thoroughly by hand and moisture was increased by adding water. Moisture was measured by using the moisture meter and adjusted the moisture content at 65%.

2.4.5. Preparation of spawn packets

The mixed substrates were filled into 10×12 inch polypropylene bag @ 500 g. The filled polypropylene bags were prepared by using plastic neck and plugged the neck with cotton and covered with brown paper placing rubber band to hold it tightly in place[**19,20**].

2.4.6.Inoculation and mycelium running in spawn packets

5 g mother spawn was inoculated into the packets in the laminar airflow cabinet and the packets were kept at 20-22^0C temperature until the packets become white with the mushroom mycelium. After completion of the mycelium running the rubber band, brown paper, cotton plug and plastic 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.

2.4.7. 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 mycelial 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 22^0C to 25^0C. The first primordia appeared 2-4 days after scribing depending upon the type of substrate. The harvesting time also varied depending upon the type of substrate [**19,20**].

2.4.8. Harvesting of mushrooms

Pleurotus sajor-caju mushrooms matured within 2-3 days after primordia initiation. The matured fruiting body was identified by curial margin of the cap, as described by [**21**]. Mushrooms were harvested by twisting to uproot from the base.

2.5. Data collection

Data were collected on the following parameters

Mycelial growth (%): Mycelial growth was counted by taking the full packet as a full unit and generally the data was taken at every two days intervals.

Mycelium running rate in spawn packet: Mycelium running rate (MRR) for each type of substrate was measured after the mycelium colony cross the shoulder of the packet. The linear length was measured at different places of packet using the following formula

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

Where, L= Average length of mycelium running (cm)
N= Number of days

Days required for completing mycelium running: Days required from inoculation to completion of mycelium running were recorded.

Time from stimulation to primordial initiation (days): Time required from stimulation to primordial initiation (days) were recorded.

Time from stimulation to primordial initiation to harvest (days): Time required from stimulation to primordial initiation to harvest (days) were recorded.

Average number of primordia per packet: Number of primordial per packet was recorded.

Average number of fruiting body per packet: Number of well-developed fruiting body was recorded. Dry and pinheaded fruiting bodies were discarded but tiny fruiting bodies were included in counting.

Average number of effective fruiting body per packet: Number of well-developed fruiting body was recorded. Tiny fruiting bodies were discarded from counting.

Average weight of individual fruiting body per packet: Average weight of individual fruiting body was calculated by dividing the total weight of fruiting body by the total number of fruiting body per packet.

Dimension of fruiting body (stipe and pileus): Diameter of pileus (cm), thickness of pileus (cm) and length of stripe (cm) of three randomly selected fruiting bodies was measured using a slide calipers

Biological yield: Biological yield per 500 g packet was measured 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 72^0C temperature for 24 hours and weighed again. The weight of blank envelop was subtracted from both the initial weight. The dry yield was calculated using the following formula (20).

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

Drying of mushrooms:The collected fruiting bodies of the mushroom were transferred to the laboratory. Then data were collected on different parameter. After collection of the data the fruiting bodies were dried in the sun separately as per treatment. In the time of drying the stipe and the pileus were separated for better drying.

Biological efficiency:Biological efficiency was determined by the following formula (**22**):

$$\text{Biological efficiency} = \frac{\text{Total biological weight of mushroom per packet (g)}}{\text{Total dry weight of substrate used per packet (g)}} \times 100$$

Benefit cost ratio: he benefit cost ratio for different low cost substrates were computed based on present market price of mushroom and cost of different inputs in the markets [**20**]

2.6.Proximate analysis of the mushrooms

2.6.1.Determination of Moisture: About 10-20 g of each sample were weighed into separated and weighed petridishes and dried in an oven at 100^0C to 105^0C till the weight of the petridishes with their contents was constant. The moisture content was expressed as percent of the fresh fruiting bodies.

$$\text{Moisture\%} = \frac{\text{Initial weight - Final weight}}{\text{weight of the sample}} \times 100$$

2.6.2.Determination of dry matter:The dry matter content of the mushroom sample was calculated by subtracting of the percent moisture of each sample from 100. The process was repeat 3-4 times for achieving constant weight of the sample used. The sample was grinded in a plant grinder fitted with a suitable screen.

2.6.3. ***Determination of total ash:*** One gram of the sample was weighed accurately into a crucible. The crucible was placed on a clay pipe triangle and heated first over a low flame till all the material was completely charred, followed by heating in a muffle furnace for about 5-6 hours at 600°C. It was then cooled in a desiccator and weighed. To ensure completion of ashing, the crucible was then heated in the muffle furnace for 1h, cooled and weighed. This was repeated till two consecutive weights were the same and the ash was almost white or grayish white in color. Then total ash was calculated as following equation:

Ash content (g/l00 g sample) = Wt of ash × 100/Wt of sample taken [**23**].

2.6.4. Determination of crude fiber: 10g of moisture and fat-free sample was taken in a beaker and 200 ml of boiling 0.255 N H_2SO_4 was added. The mixture was boiled for 30 minutes keeping the volume constant by the addition of water at frequent intervals. The mixture was then filtered through a Moslin cloth and the residue 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 minutes the mixture was filtered through a Moslin 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 (We) in an electric balance *(KEY: JY-2003; China).* The crucible was heated in a muffle furnace *(Nebertherm: Mod-L9/11/c6; Germany)* at 600°C for 5-6 hours, cooled and weighed again (Wa). The difference in the weights (We-Wa) represents the weight of crude fiber.

Therefore,

Crude fiber (g/l00 g sample) = [100-(moisture + fat)] x (We-Wa)/Wt. of sample [**23**].

2.6.5. Total carbohydrate estimation: The content of the available carbohydrate was determined by the following equation:

Carbohydrate (g/l00 g sample) = 100 - [(Moisture + Fat + Protein + Ash + Crude Fiber) g/100 g] [**23**].

2.6.6. Total Fat estimation: The dried sample (about 5g) was 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 hours. The ether extract was filtered into another weighted conical flask. The flask containing the original ether extract was washed 4 to 5 times with small quantities of ether and then 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 too 100°C, cooled in a desiccators and weighted [**23**]. The result was expressed as follows:

$$\text{Fat contents (g) per 100g of dried sample} = \frac{\text{Weight of ether extract x Percentage of dried sample}}{\text{weight of the dried sample taken}}$$

2.7. Determination of approximate composition of mineral content

2.7.1. Determination of protein :The Protein contents of the fruiting bodies of the mushrooms were determined by the standard Micro-kjeldhal procedure. According to this method total nitrogen contents of the samples were estimated and protein contents were finding out by multiplying by 6.25 to the total nitrogen values.

2.7.2. Determination of Ca, Mg, K, Fe, Zn and S

The sample was digested with nitric acid to release of Ca, Mg, K, Fe, Zn and S. Ca, Mg, Fe, Co, Mo, Se and Zn were determined by atomic absorption spectrophotometer, K was determined by flame photometry and P by spectrophotometer.

Calculations

For Ca, Mg, K, P

$$\text{mg per kg sample} = \frac{a \times 25000}{b \times c}$$

Where, a= mg/L Ca, Mg, K or P measured on atomic absorption spectrophotometer, flame photometer or spectrophotometer

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

c = g sample weighed into the digestion tube

If an additional dilution is made before the transfer to the 50 ml volumetric flask, the result is multiplied with the dilution factor. But the above elements were in trace. So addition of dilution was not to be performed.

For Fe, Zn, S

$$\text{mg per kg sample} = \frac{d \times 100}{c}$$

Zn and Fe measured on atomic absorption spectrophotometer

c = g sample weighed into the digestion tube

III. Results And Discussion

3.1. Effect of Different Saw Dust Substrates on the Growth and Yield

3. 1.1. Effect on mycelium growth

Effect of different sawdust substrates on mycelium running rate in spawn (cm): Mycelium running rate per day (MMR) for each type of substrates was measured after the mycelium colony crossed the shoulder of the packet. The linear length was measured at different places of packet. The highest running rate was observed in T_2 (0.77 cm) followed by T_3 (.70 cm) and the lowest mycelium running rate was observed in T_5 (0.59 cm) followed by T_4(0.62cm) as shown in Table 1. The present findings corroborates with the previous workers(Khan *et al.* 1991;.kalita et al. 2001) [**24**, **25**] reported that time taken for completion of spawn running may required to 17 days from 22 days by use of different substrates. Sarker (2004),[**9**] found that the mycelium running rate of oyster mushroom greatly influenced with the supplement of wheat barns in different levels. Bhuyan (2008), [**26**] also found similar result as found in the present experiment.

Effect of different sawdust substrates on time from stimulation to primordial initiation (Days): The highest time from stimulation to primordial initiation was observed in T_5 (7.62days) followed by T_4(7.33 days) , whereas lowest time from stimulation to primordial initiation was shown in T_2 (5.64 days) followed by T_3 (5.76 days) as shown in table 1. The result of present findings keeps in with the findings of previous scientists Gupta(1989),[**27**] found that the fruiting bodies appeared 12-15 days after the bags were removed.

Effect of different sawdust substrates on time from primordial initiation to harvest (Days): The lowest time from primordial initiation to harvest was in the treatment T_2 (3.26 days) followed by T_3 (3.33 days) and the highest time primordial initiation to harvest was observed in the treatment T_4 (4.33days) followed by T_1 (3.82 days).The result of present findings keeps in with the findings of previous scientists (Khan *et al.*2001, Royse,2002) [**24**,**28**] reported that after spwan running pinhead formation took 7-8 days and fruiting body formed after 3-5 days. Royse (2002) [**28**] found as the spwan rate increased the number of days to production decreased.

Table 1. Effect of sawdust substrates on mycelial growth of *Pleurotus sajor-caju*

Treatments	Mycelium running rate in spawn packets (cm)	Time from stimulation to primordia initiation (days)	Time from primordia initiation to harvest(days)
T_1	0.66 b	6.21b	3.82a
T_2	0.77a	5.64c	3.26c
T_3	0.70 a	5.76c	3.33b
T_4	0.62 b	7.33a	4.33a
T_5	0.59 c	7.62a	3.67a
T_6	0.64b	6.00a	3.58b
CV (%)	6.87%	0.72%	6.71%
LSD(0.05)	0.083	0.084	0.441

Means followed by same letter significantly different at 1% or 5% level of significance

3.1.2. Effect on yield contributing characters and yield

Effect of different sawdust substrates on average no. of primordia/packet: Statistically significant variation was found in terms of average number of primordia per packet of *Pleurotus sajor-caju* due to different sawdust used (Table 2).The highest average number of primordia per packet was observed from T_2 (75.33), which was followed by T_3(73.67), again the lowest average number of primordia per packet was found in T_5 (62.33) followed by T_6(65.67) .The result of the present study supported with the previous findings Dey (2006)[**29**] found that the number of primordia and the average yield of oyster mushroom give the lowest value with sawdust. Ahmed (1998) [**30**] reported significantly different number of primordia on different substrates. Bhuyan (2008) [**26**] found similar findings when he growing oyster mushroom on sawdust supplemented with different levels of cow dung.

Effect of different sawdust substrates on average number of fruiting body / packet: Statistically significant variation was found in terms of average number of fruiting body per packet of *Pleurotus sajor-caju* due to different sawdust used (Table 2).The highest average number of fruiting body per packet was recorded from T_2(61.33) followed by T_3 (59.67) and T_1(55.67). And the lowest average number of fruiting body per packet was observed in T_5(44.56) followed by T_4 (48.25).The result of the present findings keeps in with the findings of previous scientistsYoshida *et al.* (1993) [**31**] reported that the number of fruiting bodies was lower, but increased when the substrates was mixed with different supplements. Sarker (2004) [**9**] found that the number of fruiting body increased with the levels of supplement and continued up to a certain range and decline thereafter. Bhuyan (2008) [**24**] in a same type of experiment found similar results.

Effect of different sawdust substrates on average no. of effective fruting body/ packet: Statistically significant variation was found in terms of average number of effective fruiting body per packet of *Pleurotus sajor-caju* due to different sawdust used (Table 2).The highest average no of effective fruting body /packet was observed in the treatments T_2 (17.67) followed by T_3 (15.25) and the lowest average no of effective fruting body

/packet was observed in the treatments T_5 (11.65) followed by T_4(12.33). The findings of the present study matches with the study of Yoshida et al. (1993) [**31**] who reported that the number of effective fruting body were lowest,but increase when the subtrates was mixed with different supplements.

Effect of different sawdust substrates on average weight of individual fruiting body (g): Statistically significant variation was found in terms of average weight of individual fruiting body of *Pleurotus sajor-caju* due to different sawdust used (Table 2). The highest average weight of individual fruiting body was found from T_2 (4.45g), which was followed by T_1 (4.30g). On the other hand, the lowest average weight of individual fruiting body was found in T_5 (3.34g) which was followed by T_4 (3.46g). The findings of this experiment were also supported by Bhuyan (2008) [**24**] found comparatively higher weigh of individual fruiting body ranged from (4.02g to 7.01g), which may be due to environmental conditions or growing season.

Effect of different sawdust substrates on average length of stripe: The longest length of stipe was recorded from T_3 (2.69cm) followed by with T_2 (2.55cm), while the shortest length of stipe was found in T_5 (1.78 cm) followed by T_4(1.95cm). The findings of the present study matches with the study of Habib(2005) [**32**] and Sarkar *et al.*(2007)[**33**]. Both of two mentioned that the stripe length of *Pleorotus spp.* On different substrate varied from 1.93 cm to 2.97cm and diameter range from 0.74cm to 1.05cm.

Effect of different sawdust substrates on average thickness of pileus: Different sawdust showed statistically significant differences in terms of thickness of pileus. The average thickness of pileus in different treatment range from 0.09 to 0.70. All the treatments were statistically similar (Table 2). The highest thickness of pileus was found from T_2 (.81cm) followed by T_3 (.80cm) ,whereas the lowest thickness of pileus was recorded in T_5(0.64 cm) and T_4(.72cm). The findings of present study matches with the study of Habib(2005) [**32**]who found that the thickness of pileus ranged from 0.45cm to 0.70cm due to different substrates and Sarkar *et al.*(2007) **[33**] reported that the thickness of pileus ranged from 0.05cm to 0.80cm in case of oyster mushroom.

Table 2. Effect of different sawdust on yield attributes of *Pleurotus sajor caju*

Treatments	Average no. of primordial/packet	Average no. of Fruiting body/packet	Average no. of effective fruiting body/packet	Average weight of individual fruiting body	Average length of stripe	Average thickness of pileus
T_1	70.00 a	55.67b	14.77b	4.30ab	2.12b	0.79b
T_2	75.33 a	61.33a	17.67a	4.45a	2.55a	0.81a
T_3	73.67a	59.67a	15.25ab	3.87bc	2.69a	0.80a
T_4	68.33b	48.25c	12.33c	3.46de	1.95c	0.72b
T_5	62.33c	44.56d	11.65c	3.34e	1.78c	0.64c
T_6	65.67b	52.43b	13.60b	3.75cd	2.47b	0.74b
CV (%)	0.61%	0.52%	0.55%	1.44%	2.30%	6.41%
LSD(0.05)	0.763	0.517	0.142	0.099	0.094	0.087

Means followed by same letter significantly different at 1% or 5% level of significance

3.1.3. Effect of Different Sawdust Substrates on Biological Yield, Economic Yield (g), Dry Yield, Biological Efficiency, Benefit Cost Ratio

Effect of different sawdust substrates on biological yield: Biological yield of *Pleurotus sajor-caju* mushroom varied significantly due to different sawdust used under the present trial (Table 3). Different sawdust substrates had great effect on biological yield. The highest biological yield was recorded from T_2 (276.65 g), which was statistically similar with T_3 (272.55 g) followed by T_1 (268.15 g), while the lowest biological yield was recorded in T_5 (234.82 g) followed byT_4 (256.60g). The result of the present study found similar with the of previous studies Amin *et al.* (2007) [**10**] found the highest biological yield 247.3 g/packet for growing oyster mushrooms (*Pleurotus sajor-caju*).

Effect of different sawdust substrates on economic yield: Economic yield of *Pleurotus sajor-caju* grown on different sawdust showed statistically significant variation (Table 3). The highest economic yield was recorded from T_2 (269.40 g), followed by T_3 (264.80 g), whereas the lowest economic yield was observed in T_5 (228.15 g) which was followed by T_4 (248.15 g). The findings of this experiment also supported by the earlier findings of Amin *et al.* (2007) [**10**] found that the trend of economic yield corresponded with different supplements at different level. Payapanon *et al.* (1994) [**34**] mentioned that suitable amount of supplements added to sawdust medium maximized economic yield of oyster mushroom at optimum production cost.

Effect of different sawdust substrates on Dry yield: Different sawdust showed statistically significant variation in terms of dry yield of *Pleurotus sajor-caju* mushroom (Table 3). The highest dry yield was observed from T_2 (26.56 g), followed by T_3 (26.44 g) .On the other hand, the lowest dry yield was attained in T_5 (22.12 g) which was statistically similar with T_4 (22.46 g). The result of the present study was supported by the study of previous researcher Sarker *et al.* (2007) [**33**] who found the range of dry yield ranged from 4.28 to 29.98 g/packet of *Pleurotus* grown on different substrate. Kulsum *et al.* (2009) [**35**] found that the highest dry yield

was 21.27 g due to sawdust. Ahmed (1998)[**30**] observed that the diameter of pileus increased the quality and yield mushroom and highest dry yield from mango sawdust.

Effect of different sawdust substrates on Biological efficiency: Statistically significant variation was observed in terms of biological efficiency of *Pleurotus sajor-caju* mushroom due to different pasteurization method (Table 3). The highest biological efficiency was recorded from T_2 (82.34%), which was statistically similar with T_3 (81.55%) and followed by T_6 (75.45%) and T_1(74.44%), again the lowest biological efficiency was observed in T_5 (56.25%) which was statistically similar with T_4 (60.68%). Kalita *et al.* (1997) [**36**] observed biological efficiency for different substrates ranged from 35.2 to 60.9%. Obodai *et al.* (2003)[**37**] found biological efficiency (BE) followed a pattern and ranged from 61.0% to 80.0%.

Effect of different sawdust substrates on Benefit cost ratio: Different sawdust showed statistically significant variation in terms of benefit cost ratio of *Pleurotus sajor-caju* mushroom (Table 3). The highest benefit cost ratio was found from T_2(5.22), which was statistically similar with T_3 (5.15) and followed by T_1 (4.87) and T_6 (4.67). On the other hand, the lowest benefit cost ratio was recorded in T_5 (4.05) which was statistically similar with T_4 (4.33). The present findings found similar with the findings of previous research. Lim *et al.* (1997) [**38**] analyzed the cost and return of *Volvariella* and *Pleurotus* mushroom production and found the BCR of 8.9 and 5.1, respectively. Ahmed (1998)[**30**] also observed the benefit cost ratio of 7.32, 23.78 and 16.23 in case of *Pleurotus sajor-caju*.

Table 3. Effect of different sawdust on the yield of (*Pleurotus sajor-caju*)

Treatments	Biological yield(g)	Economic yield(g)	Dry yield (g)	Biological efficiency (%)	Benefit cost ratio
T_1	268.15 ab	262.55 b	26.06 b	74.44 b	4.87 b
T_2	276.65 a	269.40 a	26.56 a	82.34 a	5.22 a
T_3	272.55 a	264.80 a	26.44 a	81.55 a	5.15 a
T_4	256.60 c	248.90 c	24.46 c	60.68 c	4.33b c
T_5	234.82 d	228.15 d	22.12 c	56.25 c	4.05 c
T_6	265.28 b	258.34 b	25.55 b	75.45 b	4.67 b
CV (%)	0.03%	0.02%	0.20%	0.10%	1.32%
LSD (0.05)	0.163	0.097	0.091	0.133	0.113

Means followed by same letter significantly different at 1% or 5% level of significance

3.1.4. Relation between average number of fruiting body and economic yield (g)

The highest average number of fruiting body was recorded under treatment T_2 and that was 61.33 and highest economic yield was recorded under treatment T_2 and that was (269.4 g) respectively and the lowest average number of fruiting body was recorded under treatment T_5 and that was 44.56 followed by T_4 (48.25) lowest economic yield was under T_5 (228.15).

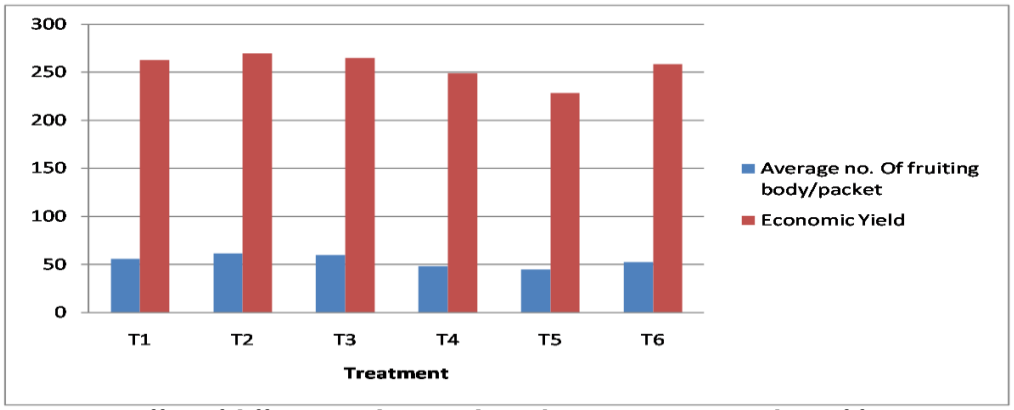

Fig 1. Effect of different sawdust on relation between average numbers of fruiting body/ packet and economic yield(g)

3.2. Experiment 2: Effect of different sawdust substrates on proximate analysis of Pleurotus sajor-caju

3.2.1 Effect on proximate composition of Pleurotus sajor-caju mushroom that produced in different treatment of this experiment.

Moisture content: Moisture content showed statistically significant variation in different treatment (Table 4). The highest moisture content was observed from T_5(89.55%), which was statistically similar to T_6(88.12%) and followed by (87.11%) T_1, while the lowest moisture content was found in T_2(85.23%) which was statistically similar with T_4(85.75%). The result of the present study found more or less similar with the study of previous

researchers Moni *et al.* (2004) [**2**] cultivated the oyster mushroom (*Pleurotus sajor-caju*) on different substrate and he found moisture content varied from 88.15 to 91.64%.

Dry matter: Different sawdust showed statistically significant variation in terms of dry matter content (Table 4). The lowest dry matter content was obtained from T_5 (11.45%), which was followed by T_6(12.88%), whereas the highest dry matter content was recorded in T_2 (14.77%) which was statistically similar with T_4 (14.65%). The result of the present study matches with the findings of previous one that reported by Kulsum *et al.* (2009) [**35**], they revealed that the dry matter percentage of the fruiting body was ranged from 9.40 to 9.98. Bhuyan (2008) [**26**] found no significant differences among the treatments when cow dung used as supplement. But in this study there was significant differences found among the treatments. This might be due to different levels of cultural practices.

Protein content: Different sawdust showed statistically significant variation in terms of protein content (Table 4). All the treatment contains a considerable amount of protein. The highest protein content was recorded from T_2 (27.44%), followed by T_3 (26.73%), while the lowest protein content observed in T_4 (25.75%) followed by T_1 (26.46%). The results of the present study was supported by the the findings of previous workers Chang *et al.* (1981)[**39**] reported that the fruiting bodies of mushrooms contained 26.6-34.1% crude protein. Moni *et al.* (2004) [**2**] cultivated the oyster mushroom (*Pleurotus sajor-caju*) and found that the percentage of crude protein varied from 18.46 to 27.78% respectively.

Lipid content: Significant difference was observed in terms of lipid content of *Pleurotus sajor-caju* mushroom due to different sawdust (Table 4). The highest lipid content was found from T_2 (4.67%), which was statistically similar to T_6 (4.25%) followed by T_3 (3.75%) , the lowest lipid content was recorded in T_5 (3.43%) followed by T_4(3.46%). The results of the present study was found more or less similar with the findings of Alam *et al.* (2007) [**10**] who reported 4.30 to 4.41% lipids in oyster mushroom grown on different substrates. Kulsum *et al.* (2009) [**35**] also found that lipid content was ranged from 3.44 to 5.43% due to sawdust supplemented with different levels of cowdung which is more or less similar to the present study.

Carbohydrate: Different amount of carbohydrate content was recorded under the present trial (Table 4). The highest carbohydrate was observed from T_5 (39.54%), followed by T_1 (38.54%), whereas the lowest carbohydrate content was observed in T_2 (37.16%) followed by T_6(37.77%). The findings of the present study does not match with the study of Chang *et al.* (1981)[**39**] reported that the fruiting bodies of mushrooms contained 40.30-50.7% carbohydrates. But it was supported by Alam et al(2007) [**10**] who found 39.82 to 42.83% of carbohydrates in *pleurotus spp.*

Crude fiber: Statistically significant variation was recorded in term of crude fiber content showed due to different sawdust (Table 4). The highest crude fiber was recorded from T_2 (23.28%), which was statistically similar with T_4 (23.22%). On the other hand, the lowest crude fiber content was found in T_5 (21.54%) which was statistically similar to T_6 (21.98%). The findings of the present study corroborate with the study Alam *et al.* (2007) [**10**] reported 22.87g/100g to 23.29g/100g of fiber in *Pleurotus spp.*

Ash: Statistically significant variation was recorded in term of ash content showed due to different sawdust (Table 4). The highest ash content was recorded from T_1 (8.64%), which was statistically similar to T_2 (8.13%).On the other hand, the lowest ash content was found in T_2(7.12%) followed by T_5 (7.55%). The findings of the present study was supported by the study of Kulsum *et al.* (2009) [**35**] who found that ash content was ranged from 6.58 to 8.41Alam *et al.* (2007) [**10**] reported 8.28 to 9.02% ash in *Pleurotus spp.*

Table 4. Effect of different sawdust on proximate nutrient composition of (*Pleurotus sajor-caju*)

Treatments	Moisture (%)	Dry matter (%)	Protein (%)	Lipid (%)	CHO (%)	Crud fiber (%)	Ash (%)
T_1	87.11 b	12.89 c	26.46ab	3.57c	38.58 b	22.67 a	8.64 a
T_2	85.23 c	14.77 a	27.44a	4.67a	37.16 d	23.28 a	7.12 d
T_3	86.34 b	13.66 b	26.73ab	3.75b	39.11 a	22.34 b	8.04 b
T_4	85.75 c	14.65 a	25.75b	3.46d	38.12 b	23.22 a	7.87 c
T_5	89.55 a	11.45d	26.53ab	3.43d	39.54 a	21.54b	7.55 c
T_6	88.12a	12.88 c	26.64ab	4.25ab	37.77 c	21.98 c	8.13 a
CV (%)	0.06%	0.35%	0.09%	1.46%	0.49%	0.50%	0.78%
LSD(0.05)	0.098	0.084	0.043	0.102	0.341	0.206	0.113

Means followed by same letter significantly different at 1% or 5% level of significance

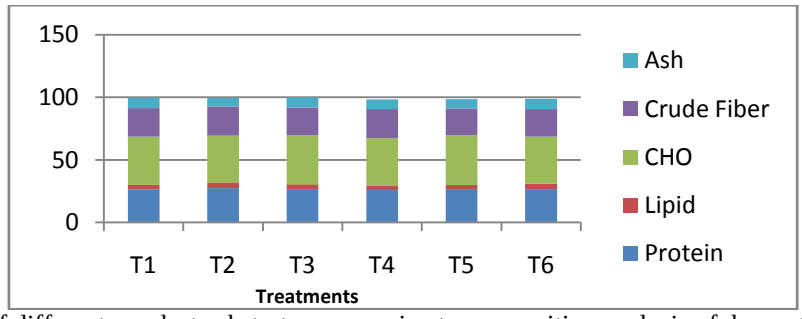

Fig. 2 . Effect of different sawdust substrates on proximate composition analysis of dry matter of *Pleurotus sajor-caju*

3.2.2 Effect on major mineral content

Effect on Nitrogen (N): Statistically significant variation was recorded in terms of Nitrogen content due to different sawdust used (Table 5). The highest amount of nitrogen content was recorded in T_2 (4.94%) which was followed by T_3 (4.78%), whereas the lowest in T_5 (4.04%) which was statistically similar with T_4 (4.63%). The findings of the present study matches with the study of Moni *et al.*(2004) [**2**] who analyzed for various nutritional parameters and found 4.22 to 5.59 % of nitrogen on dry matter basis in fruiting bodies of oyster mushroom.

Effect on Phosphorus (P): Statistically significant variation was recorded in terms of phosphorus content due to different sawdust used (Table 5). The highest amount of phosphorus content was recorded in T_2 (0.95%) which was followed by T_1 (.89%), whereas the lowest in T_5 (.72%) which was statistically similar with T_4 (.75%). The findings of the present study match with the study of Sarker et al. (2007) [**33**] who found 0.97% phosphorus in oyster mushroom grown on sawdust based substrates.

Effect on Potassium (K): Statistically significant variation was recorded in term of Potassium content showed due to different sawdust (Table 5). The highest amount of potassium was attained from T_2 (1.35%) which was statistically similar with T_1 (1.33%), the lowest phosphorus content was found in T_5(1.21%) followed by T_4(1.22%). The findings of the present study similar with the study of Chang et al. (1981) [39] who reported that the fruiting bodies of Pleurotus contained 1.432 to 1.88 mg/g of K on dry weight basis. Sarker et al. (2007) [**33**] also found 1.3% potassium in oyster mushroom grown on sawdust based substrates.

Effect on Calcium (Ca): statistically significant variation showed due to different sawdust used under the present trial (Table 5). The highest amount of calcium was observed from T_2(1.97%) which was followed by T_3 (1.94%), whereas the lowest calcium content was observed in T_5(1.77%) which was followed by T_1 (1.91%). Alam et al. (2007) [**10**] who found 22.15 to 33.7 mg/100 g calcium in different oyster mushroom varieties. Sarker et al. (2007) [**33**] also found 2400 ppm calcium in oyster mushroom grown on sawdust based substrates.

Effect on Magnesium (Mg): Variation was observed in terms of magnesium content due to different sawdust under the present trial (Table 5)The highest amount of magnesium was attained from T_2 (0.738%) which was followed by T_1 (0.727%) .On the other hand, the lowest magnesium content was found in T_4 (0.658%) which was followed by T_6 (0.673%). *Sarker et al.* (2004) [**9**] also found 0.21% magnesium in oyster mushroom grown on sawdust based substrates.

Effect on Iron (Fe): Iron content showed statistically significant variation due to use of different sawdust under the present trial (Table 5). The highest amount of iron was recorded from T_2 (513.48ppm) which was followed by T_1 (502.12ppm), whereas the lowest iron content was observed in T_5 (492.08 ppm) which was followed by T_4 (495.69 ppm) .The result of the present study found iron higher than the value found by Alam *et al.* (2007) [**10**] who found that iron content of different oyster mushroom varieties ranged from 33.45 to 43.2 mg/100g. Sarker *et al.*(2007) [**33**] found 92.09 ppm to 118.40 ppm iron in oyster mushroom grown on sawdust based substrates.

Effect on Zinc (Zn): Different sawdust showed statistically significant variation in terms of zinc content (Table 5). The highest amount of zinc was obtained from T_3 (16.32%) which was followed by T_2 (15.75%), whereas the lowest zinc content was recorded in T_5 (14.36%) which was followed by T_4 (14.49%). The results of the present study have the similarity with the study of Alam *et al.* (2007)[**10**] found from their earlier experiment that zinc content of different oyster mushroom ranged from 16 to 20.9%. Sarker *et al.* (2007) [**33**] found 30.92 ppm zinc in oyster mushroom grown on sawdust based substrates.

Sulphur (S): Statistically significant variation was recorded in terms of S content due to different sawdust substrates (Table 5). The highest S content was found in T_2(0.389%) which was statistically identical with

T_1(0.385%), whereas the lowest S content was recorded in T_5 (0.275%) treatment which was statistically similar with T_6 (0.323%). The findings of the present study were supported with the findings of Alam *et al.* (2007)[**10**] who recorded 0.238 to 0.321% of sulphur from their earlier study in oyster mushroom varieties.

Table 5. Effect of sawdust substrate on mineral contents of oyster mushroom (*Pleurotus sajor-caju*)

Treatment	N(%)	P(%)	K (%)	Ca(%)	Mg(%)	Fe(ppm)	Zn(%)	S (%)
T_1	4.69 bc	0.89 ab	1.33ab	1.91 b	0.727 a	502.12bc	15.64 a	0.385 ab
T_2	4.94 a	0.95 a	1.35a	1.97 a	0.738a	513.48 a	15.75 a	0.389 a
T_3	4.78 ab	0.86bc	1.28b	1.94 a	0.713 c	497.86c	16.32 a	0.328 bc
T_4	4.63c	0.75 d	1.22c	1.93 a	0.658bc	495.69d	14.49 b	0.365 b
T_5	4.04 d	0.72 d	1.21c	1.77a	0.721ab	492.08ab	14.36 c	0.275d
T_6	4.72 c	0.82c	1.36a	1.96 a	0.673 d	508.89 b	15.22 b	0.323 c
CV (%)	1.69%	4.91%	2.98%	2.14%	.45%	.16%	.28%	1.42%
LSD(0.05)	.142	0.074	0.070	0.074	0.006	1.488	0.078	0.009

Means followed by same letter significantly different at 1% or 5% level of significance

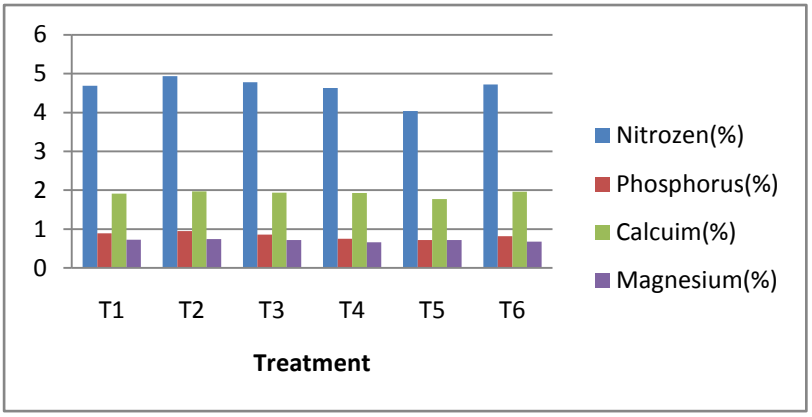

Fig. 3. Proximate composition analysis of dry matter of *Pleurotus sajor-caju*

IV. Conclusion

Pleurotus sajor-caju cultivation on different sawdust waste those generated in the saw mill presents a promising potential . Pleurotus sajor-caju Cultivation on 5 different saw dust substrates such as- Mango tree(Mangifera indica,**T_2**),Mahagony tree (Swietenia mahagoni,**T_3**),jackfruit tree(Artocarpus heterophyllus,**T_4**),Teak tree(Tectona grandis,**T_5**)Rain Tree (Albizia saman, **T_6**) and mixture of all five tree sawdust (**T_1**) supplemented with 30% wheat bran and 1% lime as basal substrates give better result than other substrates. Sawdust increase the yield of *P. sajor-caju and* sawdust substrate prove as better substrate compare to the previous research work. It make a new opportunity for rural people and offer economic incentives for agribusiness. Therefore, the mushroom cultivation may become one of the most profitable agribusiness that could produce food products from different substrates that are easily available and cheap in cost. Among all aspects, **T_2** was found as a best substrate with biological yield (276.65 g/packet) and BE (82.34%) followed by **T_3**, **T_1**, **T_6**, **T_4**, **T_5** for the production of mushroom.

V. Recommendations

In this experiment, T_2: Mango sawdust supplemented with 30% wheat bran and 1% lime performed better in respect of different growth, yield and nutrient composition and mineral content of *Plurotus sajor-caju*. Therefore, T_2: Mango sawdust supplemented with 30% wheat bran and 1% lime can be recommended for farmer level *Plurotus sajor-caju* mushroom cultivation.

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