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# Recycling of jute waste for edible mushroom production

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**Abstract**

Lignocellulosic jute waste products, viz. leaves, stick and caddis, generated in large quantities from jute cultivation and industry were used as separate substrates and in admixture with rice straw in a 1 : 1 ratio for the production of the edible mushroom *Pleurotus sajor-caju* (Fr.) Singer. While growth of mushroom mycelia was hindered on jute leaves, jute stick and caddis separately, and as mixed substrates with rice straw, were found to produce a good yield of the mushroom. The chemical and mineral analyses and neutral sugar composition of the mushroom fruit bodies are reported. It was found that the efficiency of jute wastes as substrates for the production of *P. sajor-caju* is better than other lignocellulosic substrates, such as sugarcane bagasse and paper wastes, but more or less similar to sorghum stalk and cotton wastes.

*Keywords:* Jute stick; Jute caddis; Rice straw; Lignocellulose substrate; *Pleurotus sajor-caju*; Chemical analysis

## 1. Introduction

Jute is an important industrial fibre which has diversified end uses from gunny bags to decorative products. India ranks first in the world's production of jute, with 2968.5 thousand tons of jute, kenaf and allied fibres (FAO, 1994). The area used for jute cultivation in India was 942 thousand hectares during 1994–1995, producing 1542 thousand tons of jute fibre (JMDC, 1994) and around 3.8 million tons of jute stick as by-product. The fibre is extracted by retting the jute plant stem in water, while the leaves and stick of the plant are obtained as agrowastes. During processing of the fibre in the mill, jute caddis, consisting of very short fibres, are dropped in large quantity (about 4%) as loom waste. Utilization of this large quantity of lignocellulosic biomass generated as waste from jute cultivation and industry has been a focus of research for workers in this field. Jute stick and caddis have been successfully utilized in pulp and paper manufacture (Ghosh et al., 1983), particle board industry (Das et al., 1987), biogas production (Banik et al., 1993), etc. Cultivation of the edible mushroom is another potential field of utilizing this lignocellulosic waste for which a variety of agricultural and forestry residues are already being used. In recent years, cultivation of the edible mushroom in India has increased many fold because of its nutritional value as a protein supplement to solve the protein-calorie malnutrition in developing countries facing population explosion. The easy availability and low cost of lignocellulosic biomass has made it an important substrate for mushroom production. The varied climatic conditions in different parts of India help in growing varieties of mushrooms without artificial temperature and humidity control.

Of all the edible varieties of mushrooms cultivated in India, the oyster mushroom (*Pleurotus* sp.) has found wide acceptance because of its easy cultivation and low cost of production. The best oyster mushroom in terms of productivity is *P. sajor-caju*, a very popular species in India. The present paper reports on the cultivation of *P. sajor-caju* using jute waste products, viz. leaves, stick and caddis, as substrate. Utilization of jute waste for edible mushroom cultivation would help in overcoming the protein malnutrition of a large population as well as control environmental pollution by converting wastes into proteinous food in addition to providing a supplementary income for the farmers and rural people.

## 2. Materials and methods

Dry leaves and sticks of jute plants (*Corchorus* sp.) were collected from the Central Research Institute for Jute and Allied Fibres, Barrackpore, West Bengal. Jute sticks were broken into small pieces (2.5 cm) in a disintegrator. Rice straw, a conventional substrate for mushroom production, was also chopped into small pieces (2.5 cm). Both jute stick and rice straw were soaked in boiled water overnight and then excess water was drained out. Jute leaves were soaked in water just before use. Jute caddis were collected from the jute mill, soaked in a 1% sodium hydroxide solution for 1 h and washed with water to remove alkali before use. Mushroom spawn of *P. sajor-caju* species was collected from the State Agricultural Department, West Bengal. Mushrooms were cultivated in nylon bags according to a standard technique (Fritshe, 1978). Nylon bags were each filled with 500 g of rice straw, jute leaves, jute stick and jute caddis as separate substrates. Mixed substrates were prepared by taking 500 g of a mixture of rice straw with jute leaves, jute stick and caddis separately in a 1 : 1 ratio in nylon bags. The spawn was placed in layers in the bags. The bags were then covered with a polyethene sheet. The polyethene sheet was removed as soon as the pinheads started appearing and water was sprinkled on alternate days until the mushroom fruit bodies were fully grown. Room temperature varied from 25°C to 30°C and relative humidity from 80–90%. The fresh weight of fruit bodies was measured in two harvests up to 40 days after spawning. The substrates, viz. rice straw, jute leaves, jute stick and caddis, were chemically analyzed for $\alpha$-cellulose, lignin and pentosan according to standard methods (TAPPI, 1971). Crude fat was estimated by extraction with ethanol-benzene (1 : 2, v/v) in a Soxhlet apparatus. Nitrogen was estimated by the Kjeldahl method. Ash values were determined by heating the sample at 550°C in a muffle furnace.

The mushroom fruit bodies, grown in different substrates, were also analyzed for their ash, crude fat, and nitrogen contents according to standard methods. The carbohydrate content was estimated by spectrophotometry using anthrone-sulphuric acid reagent. Efficiency of substrate was calculated as % yield of fresh mushroom on dry weight of substrate.

## 3. Results and discussion

The chemical compositions of rice straw, jute leaves, jute stick and caddis used as substrates in mushroom production are reported in Table 1. Jute leaves and stick were found to contain higher amounts of lignin than rice straw and jute caddis. $\alpha$-cellulose content was highest in caddis (54.2%) and considerably higher in rice straw (42.3%) and jute stick (40.8%) in comparison to that of jute leaves (20.5%). Jute stick and caddis are good sources of cellulose with high nitrogen and low ash contents in comparison to rice straw, while jute leaves contain less cellulose and more non-cellulosic matter. The yields of *P. sajor-caju* on rice straw, jute leaves, jute stick and caddis as separate substrates and also on the mixed substrates of rice straw with jute leaves, jute stick and caddis in a 1 : 1 ratio are reported in Table 2. It was found that jute leaves, unlike the leaves

Table 1
Chemical composition of different substrates

| Constituents | Rice straw | Jute leaf | Jute stick | Jute caddis |
|---|---|---|---|---|
| Ash | 10.9 | 8.8 | 1.3 | 2.4 |
| Fat and wax | 2.9 | 3.4 | 1.8 | 3.1 |
| Nitrogen | 0.6 | 2.4 | 2.0 | 1.4 |
| Lignin | 13.9 | 20.9 | 22.9 | 14.0 |
| Pentosan | 25.6 | 11.5 | 24.7 | 16.2 |
| $\alpha$-Cellulose | 42.3 | 20.5 | 40.8 | 54.2 |

Table 2
Yield of *P. sajor-caju* on different substrates

| Substrate | Spawn run period (days) Harvest | | No. of fructification Harvest | | Yield (g) | | | | Efficiency of substrate (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Harvest | | Total | Average | |
| | 1st | 2nd | 1st | 2nd | 1st | 2nd | | | |
| Rice Straw | 25 | 12 | 23 | 6 | 295 | 15 | 310 | 269 | 53.8 |
| | | | 21 | 5 | 216 | 13 | 228 | | |
| Jute leaves | 25 | – | – | – | – | – | – | – | |
| Jute stick | 25 | 4 | 23 | 32 | 95 | 32 | 127 | 112 | 44.8 |
| | | | 20 | 22 | 78 | 19 | 97 | | |
| Jute caddis | 22 | 10 | 25 | 7 | 220 | 58 | 278 | 273 | 54.6 |
| | | | 22 | 8 | 230 | 38 | 268 | | |
| Rice straw–jute leaves (1 : 1) | 22 | 11 | 18 | 6 | 190 | 4 | 194 | 176 | 35.2 |
| | | | 15 | 6 | 155 | 3 | 158 | | |
| Rice straw–jute stick (1 : 1) | 25 | 4 | 28 | 72 | 185 | 165 | 350 | 330 | 66.0 |
| | | | 23 | 56 | 170 | 140 | 310 | | |
| Rice straw–jute caddis (1 : 1) | 25 | 7 | 30 | 34 | 200 | 134 | 334 | 322 | 64.0 |
| | | | 28 | 38 | 189 | 121 | 310 | | |

Table 3
Chemical composition of *P. sajor-caju* grown on different substrates (values expressed on percent dry weight basis)

| Substrates | Moisture | Ash | Fat and wax | Crude protein ($N \times 6.25$) | Carbohydrate |
|---|---|---|---|---|---|
| Rice straw | 89.0 | 6.8 | 11.7 | 17.8 | 72.5 |
| Jute stick | 87.5 | 7.9 | 8.5 | 24.3 | 59.8 |
| Jute caddis | 88.0 | 8.8 | 5.3 | 31.6 | 38.0 |
| Rice straw and jute leaves (1 : 1) | 82.0 | 7.4 | 9.0 | 14.0 | 42.6 |
| Rice straw and jute stick (1 : 1) | 84.0 | 8.0 | 9.0 | 14.6 | 69.0 |
| Rice straw and jute caddis (1 : 1) | 87.5 | 9.3 | 8.4 | 27.8 | 41.3 |

Table 4
Mineral composition (g/100 g dry weight) of *P. sajor-caju* grown on different substrates

| Substrate | Ca | Na | K | Fe | Cu | Zn |
|---|---|---|---|---|---|---|
| Rice straw | 0.025 | 0.186 | 3.110 | 0.016 | 0.006 | 0.011 |
| Jute stick | 0.023 | 0.821 | 2.101 | 0.004 | 0.001 | 0.006 |
| Jute caddis | 0.036 | 0.331 | 3.072 | 0.009 | 0.001 | 0.009 |
| Rice straw and jute leaves | 0.033 | 0.139 | 3.290 | 0.015 | 0.007 | 0.017 |
| Rice straw and jute stick | 0.012 | 0.351 | 3.372 | 0.002 | 0.001 | 0.005 |
| Rice straw and jute caddis | 0.024 | 0.216 | 4.499 | 0.011 | 0.002 | 0.007 |

of banana, sugarcane, etc. producing good mushroom yields, are not a suitable substrate. The fast decomposition of the jute leaves might be the reason for hindering the growth of mushroom mycelia. The mushroom yield is decreased when grown on rice straw–jute leaves (1 : 1 ratio) in comparison to its yield on rice straw alone. The mushroom yield is quite satisfactory on jute stick and caddis and in their mixture with rice straw. The chemical and mineral compositions of mushroom fruit bodies grown on different substrates are shown in Tables 3 and 4. The chemical composition indicates that the fruit bodies are quite rich in protein. The mineral contents show slightly higher values for some elements grown on mixed substrate. The results of the analysis indicate that the mushroom *P. sajor-caju* can be grown in good yield on jute stick and caddies alone, while mixed substrates of rice straw with jute stick or caddis show better yields, as indicated by efficiency of substrate in Table 2. The growth of mycelia is, however, hindered on jute leaves. A number of workers studied the conversion of various plant wastes, including some industrial crop wastes, into the edible mushroom. Balasubrahmaniyan (1988) used willow dust, a waste comprising short fibres, leaf beats, seed hulls, etc. from cotton seed mills and obtained 600 g of *P. sajor-caju* mushroom per kg of willow dust in 25 days. Nallathanubi and Marimuthu (1993) employed paddy straw, sorghum stalk, cotton stalk, perthenium stem, bagasse, coir pith, sawdust and paper waste as substrates for the production of mushroom varieties. The efficiency of the substrates indicates that jute wastes are better substrates for growing *P. sajor-caju* in comparison to other lignocellulosics, such as perthenium stem, sugarcane bagasse and paper waste, but are more or less similar to sorghum stalk and cotton wastes.

## 4. Conclusion

Lignocellulosic jute waste products, viz. leaves, stick and caddis, generated in huge quantities from jute cultivation and industry were used as substrates for the production of the oyster mushroom (*P. sajor-caju*). Jute stick and caddis, like various other lignocellulosic substrates, were found to produce the mushroom in good yield, either alone or in admixture with rice straw in a 1 : 1 ratio. Jute leaves, however, did not show any growth of mushroom mycelia, probably due to fast decomposition. The chemical analysis of mushroom fruit bodies indicated similar characteristics of fruit bodies grown on other conventional substrates. Growing of the oyster mushroom is an ideal income, generating activity for rural people in jute-growing areas because of its dependence on cheap raw materials (jute wastes, straws, etc.), simple technology and low initial investment.

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