Low quality jute bark, after treatment with a fungal culture of *Penicillium corylophilum*, showed improvement in fibre quality viz. strength and fineness and enhanced processability of the yarn at mill level. Conventional potato dextrose broth (PDB) was used for large-scale production of the fungus for application on barky jute at the jute mill. But, the process has several limitations like non-uniform growth of fungus and high cost for labour and energy inputs as well as for substrate. To overcome the limitations, the fungus was produced using rice husk, a cheap agro-residue, as substrate. Rice husk as substrate provided good and uniform growth of fungus, which sustained for at least 90 days. The fungus produced on rice husk has been used successfully for processing of low quality jute fibre in jute mills. There was overall improvement in spinning parameter due to application of the culture.

**Keywords**: *Penicillium corylophilum*, rice husk, solid state fermentation, jute processing, mill trial

**Introduction**

Jute is the principal commercial crop of eastern India and Bangladesh. Jute fibre is present in the bark of the plant *Corchorus capsularis* and *C. olitorius* attached to the epidermal tissues by pectin and other gummy materials. The fibre is extracted from the stem by microbial retting, which determines the quality of jute fibre. Improper retting leads to production of low quality fibre, which does not fetch good market price and also its processability is unsatisfactory. To overcome improper retting, a fungal culture, which involves treatment of barky jute with the fungus, *Penicillium corylophilum*, has been developed for softening of barky jute. The fungus proved very effective in improving the quality of poorly retted jute by reducing the pectin and hemicellulosic component without affecting the cellulosic component of the fibre and also in substantially softening barky jute. Physico-chemical nature of barky jute treated with *P. corylophilum* was also studied. The fungus performed well at farmers level too. The fungus produces good amount of the enzyme pectinase, which aids in removing the bark present on the fibre (unpublished work). Due to the good properties of the fungus in improving the quality of jute, trials were conducted for large-scale softening of jute at the mill by treating fibre with the fungal culture.

Potato dextrose broth (PDB) medium had conventionally been used for production of *P. corylophilum* biomass for large-scale trials, but the process had several limitations like non-uniformity of fungal growth, requirement of large number of trays for industrial production of fungal culture and high labour involvement in the production process.

In this study, rice husk was used as a substrate for production of the fungus, *P. corylophilum* by solid-state fermentation (SSF), which produces more fungus than liquid state fermentation (LSF). SSF, in comparison to LSF, offers superior volumetric productivity, use of simpler machinery and inexpensive substrate, simpler downstream processing, less wastewater output and less energy requirements.

Rice husk, an agro waste, is cheap and abundantly available in India. Production of rice in India in the year 2000-2001 was 88.25 million tonnes. Rice husk, a major part of the rice crop, is wasted or is largely under utilized. However, many researchers have tried to use rice husk for energy, ceiling boards and ruminant feed. In the present study, large-scale production of fungus *P. corylophilum* was done at the Howrah Jute Mill, Kolkata by SSF using rice husk as substrate. Subsequently, jute fibre was processed and the effect of the fungal culture on yarn spinning and quality parameters were investigated.
Materials and Methods

Microorganism

The fungus *P. corylophilum* was isolated from decomposing jute fibre at the Institute and was identified at the Division of Mycology and Plant Pathology, IARI, New Delhi, India, and is being maintained on potato dextrose agar slants.

Potato Dextrose Broth

Potatoes (500g) were cut, boiled in distilled water (2 l) and filtered through muslin cloth. The volume of extracted liquid was made up to 4 l, dextrose (20 g) was added to it and mixed thoroughly. The liquid extract was then poured in a sterilized galvanized steel tray (84 × 54 × 2.54 cm) and inoculated with 50 ml suspension of *P. corylophilum* isolated from decomposing jute fibre. The medium was incubated at 30°C for 4 days. This medium is used for the industrial production of fungus.

Solid State Fermentation (SSF)

In two separate experiments, 1 kg each of rice husk and wheat bran was autoclaved at 20lb pressure for 1 hr and spread in galvanized steel trays (84 × 56 × 2.54 cm). The fungal culture suspension (50 ml) grown on PDB was sprayed on them, thoroughly mixed and spread into 1-1.25 cm thickness. Viable cell count was taken after four days of growth.

Effect of Chemicals on Growth

Rice husk and wheat bran, 10g each, were taken in 250 ml EM flask, to which 12ml water was added and autoclaved at 20 lb pressure for 20 min. To rice husk and wheat bran, chemicals (dextrose, ammonium dihydrogen orthophosphate, sodium chloride) and yeast extract were added to assess whether these compounds act as growth enhancers.

Repeated Use of Rice Husk as Substrate

The same rice husk was repeatedly used as substrate for growth of fungus *P. corylophilum*. After each round of growth, the husk was properly washed, autoclaved and reinoculated with the fungus. After each stage, a viable cell count was taken and total sugar present was estimated by anthrone reagent.

Viable Cell Count

The moldy rice husk was kept in polythene packets at room temperature and the colony forming units (CFU) were determined by serial dilution plate technique, at an interval of 15 days, to check the viability of the fungal culture.

Measurement of Cell Biomass

For measuring cell biomass, moldy rice husk was thoroughly washed with distilled water till the husk was free from fungus. The washings were filtered through a weighed Whatman filter paper no.1. The paper containing residue was oven dried at 70°C till a constant weight was observed. The cell biomass was calculated gravimetrically from the difference in initial and final weights of the filter paper.

Mill Trial

For large-scale trials, rice husk (1 kg) was autoclaved at 20 lb pressure for 1 hr and spread on galvanized steel trays. Fungal culture suspension (50 ml) grown on PDB was sprayed on them. After 4 days of growth, the moldy rice husk was soaked in water, at the rate of 1 kg rice husk in 3 l of tap water. After about 30 min of soaking, the green suspension, which contained extracellular enzymes and the fungal spores, were sieved through a piece of cloth to remove rice husk and a clear suspension of the fungal culture was obtained. The fungal culture thus obtained was applied on jute fibre along with oil emulsion during passage of the fibre through the softener machine.

To assess the efficiency of the fungal culture as a jute processing aid, two sets of experiments were conducted in a jute mill. Two identical batches of jute were processed in similar spinning systems to produce jute hessian warp yarn. The only difference between the two sets was that in one case the fungal culture was incorporated in the batching oil emulsion, that was applied to the fibres before stacking them in a pile for 24 hrs while for the other set, no fungal culture was used. For spinning of jute into yarns of about 8 lb/spyndle (278 tex), normal mill practices were followed in both the cases comprising application of jute batching oil emulsion (JBO), stacking in piles for 24 hrs, three stages of drawing and finally spinning on a ‘apron-draft’ spinning frame. Trials, which were conducted continuously for 10 days, involved processing of 20 tonnes of jute each day for both the sets. During spinning, snap studies were carried out to determine the end breaks per min at the spinning frame. Breaking strength (kg) and linear density (tex) of the spun yarns were determined following standard methods. Quality ratio of the yarns were derived from breaking strength and linear density values as follows:

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\text{Quality ratio} = \frac{\text{Breaking strength (lb)}}{\text{Grist (lb/spyndle)}} \times 100
\]
Doff weight was measured for 50 spools of each of the yarn samples and the average value has been presented. End breakage rate was determined by studying the same for 72hrs on 3 spinning frames ($110 \times 3 = 330$ spindles) for each of the samples with and without the fungal culture. Moisture content (%) of yarn was measured using an electronic moisture meter on yarn packages and the average of 50 readings has been reported.

**Results and Discussion**

The results of comparative growth of the fungus *P. corylophilum* on the three growth media show that the best growth of fungus was observed on rice husk followed by wheat bran and PDB (Table 1). Besides supporting growth, rice husk and wheat bran were cheaper substrates when compared to PDB. These agro-wastes were convenient to handle for large-scale use and labour and energy requirements are low. Rice husk, however, performed better than wheat bran as growth medium with longer durability of the culture at $30^\circ C$ (Fig. 1). The CFU/ml remained constant for a month, after which there was a sharp decline in the cell count. However, there were viable cells till 90 days after which the study was abandoned due to contamination by *Aspergillus* species and actinomycetes. Additional chemical or nutrient did not enhance the growth of fungus (Table 2). In the light of the above observation, rice husk was chosen as medium for large-scale production of the fungal culture and its application at mill level during jute processing.

Cell count and cell biomass decreased with repeated use of rice husk as substrate (Table 3). The amount of sugar in the extracted liquid also decreased with repeated use of rice husk. At the third stage, $153 \times 10^{10}$ fungal cells per ml were satisfactory for treatment of jute. Thus, the same husk could be used at least three times repeatedly without any adverse effect on production of fungal culture.

Comparing jute processing with and without fungal culture (Table 4), there was improvement in processability of the fibre as well as in the quality of the yarn produced on incorporation of the fungal culture in the jute batching oil emulsion. The end breakage rate in the spinning frame was reduced from 1.24/min to 0.90/min for 100 spindles on incorporation of fungal culture. This indicated efficient softening of jute during piling due to higher microbial activity, which led to more efficient carding action thereby generating lesser number of short fibres and improved filamentation of the meshy structure of jute during the carding process. Besides,
the fungal treated yarn showed higher moisture retention, which appears to influence the spinning performance of jute favourably. Cumulative effects of these factors were apparently responsible for production of yarn of superior breaking strength and quality ratio. The yarn exhibited significantly lower variation in breaking strength values. Thus, on incorporation of the fungal culture, *P. corylophilum* in the batching oil emulsion before piling of jute, a more uniform yarn of improved strength characteristics was produced at a marginally higher rate of production as indicated by doff weight.

**Conclusion**

The fungus, *P. corylophilum* helped in increasing the processability of jute and also enhanced its quality. Rice husk proved to be a good substrate for the large-scale production of fungus. No extra chemical nutrients were required to support the growth of the fungus on rice husk. The husk could also be recycled for production of fungus with good yield. Thus, it can be said that rice husk can successfully replace PDB as substrate for industrial production of *P. corylophilum* for improvement of quality and processability of jute.

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**References**