Pulping of jute stick by a combination of microbial and chemical process

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INTRODUCTION

Partial delignification of jute stick chips is possible by a microbial process using the basidiomycetes *Phanerochaete chrysosporium* (Bhattacharyya, *et al.*, 1987). The ultimate purpose of delignification of the sticks is making hand made paper sheets in the rural sector where the jute sticks are available in abundance as a waste. In an attempt to prepare hand-made sheets from microbially treated sticks, it was however, observed that though the chips became soft and flexible after incubation, the cohesion between particles was not sufficient to hold them together and the sheets were very brittle with little srrength. From a comparison of scanning electron microphotographs of the microbial and chemical pulps (Bhattacharyya & Basak, 1988) it was evident that in the former, though the cementing material between the ultimate cells which mainly consisted of lignin was effectively degraded and decomposed, separation of fibre structure was poor even after beating; in the chemical pulp, on the contrary, swelling was much more pronounced and this appeared to result in better macerisation on beating. In view of the above, a combination of microbial and mild chemical process was tried-chemical treatment preceeding microbial incubation and vice-versa with an overall objective of developing for the rural sector of the country a cheap process of pulping jute sticks, which would require smaller amounts of chemicals and power than the chemical process conventionally followed.

METHODS

Jute Stick :

Sticks of Tossa jute (*Corchorous olitorius*, Linn, Variety JRO 632) obtained after retting of green plants were collected from a local source. The sticks were manually broken to small chips (2-3 cm long and 1-1.5mm wide) and air-dried to a moisture content 10%.

Fungus :

Phanerochaete chrysosporium, Burds (ME 446, ATCC 35540) was obtained from Centre for Forest Mycology Research, Forest Products Laboratory, US Dept. of Agriculture, Madison Wisconsin. It was maintained at 40°C on 2% malt-agar slopes (Kirk, *et. al.*, 1978)

The cultural conditions followed were as described in our previous paper (Bhattacharyya, *et al.*, 1987). The nutrients used were glucose, yeast extract and Dox's solution.

Chemical Pulping :

The chips were treated with 5% NaOH (liquor ratio 1:20) for 48 h at 30°± 1°C in an open vat, squeezed, washed with water until free from alkali and refined in a disc refiner (Sprout Waldron Co. USA) The resultant pulp in certain cases was further treated with 10% NaOH for 48 h by the same method and refined. (Ghosh *et. al.*, 1983).

Preparation of hand-made paper sheets :

The pulp was beaten in valley beater (A. B. Lorentz & Wettre Stockholm, Sweden) and sheets of 60 G.S.M and 20cm dia. were made in a sheet-making machine (Universal Engineering Corporation, Saharanpur, U. P., India according to the design of British

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Papermakers' Association, London model SCA, SCAN-C26) Calendering of the sheets was done by putting the sheets between two aluminium plates in hot press at 70°C under a pressure of 0.35 Kg/Cm² for 10 min.

Physical Testing of Paper sheets :

Breaking length was measured in a Tensile Strength Tester as per TAPPI (1971) method and expressed in metre. Burst factor was determined in a Bursting Strength Tester (SCAN-P-24 model) by the TAPPI Standard (1971).

Chemicals

All the chemicals used for preparing growth media of the fungus were of BDH 'Analar' grade. Caustic Soda used for the pulping process was of Laboratory Reagent grade; S.D. Chemicals Calcutta, India.

RESULTS AND DISCUSSION

The results are presented in Tables 1 & 2. From Table 1, it is seen that it is very difficult to prepare sheets from the jute stick pulp made by the microbial

TABLE—I

Physical Properties of Paper Sheets of Jute Stick Pulp made by Microbial process followed by Chemical Treatment

Sl. No.	Pulping Treatment*	Physical properties of sheets			
		With Calendering		Without Calendering	
		Breaking length (metre)	Burst factor	Breaking length (metre)	Burst factor
I.	Control (Jute stick chips incubated with nutrients only for 6 days)	Paper sheets could not be made			
II.	Jute stick chips incubated with nutrients and fungus for 6 days.	Paper sheets made were very brittle			
III.	Jute stick chips treated with 5% alkali for 48 h.	2882	8	2191	2
IV.	Jute stick chips treated with 5% alkali for 48 h. then 10% alkali for 48 h.	3790	17.5	3600	12.8
V.	Combination of II and III	2833	12.5	2667	6.0
VI.	Combination of II and IV	6396	20.3	4050	14.8

* For details of pulping treatment see text.

TABLE–2

Physical properties of Paper Sheets of Jute Stick Pulp made by Chemical Process followed by Microbial Incubation.

Period of Incubtion (Days)	Physical properties of sheets	
	Breaking length (metre)	Burst Factor
3	3218	24
4	3653	32
5	2201	25

All the sheete were calendered. Chemical Pulping was done by treating with 5% alkali.

process by incubating with the fungus for 6 days. However, when the microbial process is followed by a chemical one the resultant pulp gives very good paper sheets in general compared to that obtained by the corresponding chemical process alone in respect of physical properties viz. burst factor and breaking length. In case of treatment No. V, however, the marginal drop in breaking length for calendered sheets may be ignored and taken as an isolated case. Two steps of alkali treatment (5% and then 10%) always give better sheets than one step (5%) treatment and when there is prior microbial treatment there is further improvement in properties. From the result there is every reason to presume that the microbial treatment degrades the lignin component partially and at least some of these degraded fractions remain in insoluble form. The subsequent chemical process helps in hydrolysing the degraded lignin completely to soluble fragments and the pulp becomes suitable for making paper sheets. The effectiveness of the pulping process is better in two step alkali treatment than in one step as the extent of the hydrolysis is obviously higher in the former case. Calendering helps in increasing cohesion between particles and as such calendered sheets gave better properties.

In the reverse process of combination viz. treatment with 5% alkali proceeding microbial incubation it was observed that microbial growth was far better than that in the previous process of combination. Pulping was completed even in 4 days of incubation and paper sheets made was satisfactory in respect of physical properties. Prior chemical treatment might have removed the waxy substances from the sticks and made it swelled and porous besides degrading lignin component partially. Some essential nutrients for the subsequent fungal growth might have also been released in the process. This was evidenced from a separate experiment where the different nutrients essentially used (viz. Dox's Soln., yeast extract and glucose) for the fungal growth were omitted by a process of permutation and combination. It was observed that one can safely dispense with glucose while yeast extract is indispensable for the fungal growth suggesting that B-Vitamins are very essential for growth and lignolytic activity of the fungus on jute sticks. As sugars were released in the chemical process there was no necessity of adding sugar as starter.

Thus, though it is very difficult to prepare paper sheets from the pulp made by a microbial process using the specific basidiomycetes *P. chrysosporium*, a combination of the microbial process with a milder chemical treatment than it is required in the conventional chemical process yields pulp suitables for making hand made paper sheets using very simple appliances. The consumption of chemicals and power will obviously be lower in the combined process. The sequence of combination may be two ways-microbial incubation proceeding chemical treatment and vice-versa and the combination is more effective in the latter in respect of time of operation as well as extent of reduction in consumption of chemicals.

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REFERENCES :

Bhattacharyya, S.K., Banerjee, S.K., Basak, M.K., Day, A & Debsarkar, N.L. (1987). Pulping of jute sticks by a microbial method. *Biological Wastes*. **19**, 233-236.

Bhattacharyya, S.K. & Basak, M.K. (1988). *Annual Report, Jute Technological Research Laboratories* Calcutta.

Ghosh, I.N., Roy, A.K. & Sanyal, A.K. (1983). Mixed pulping of jute stick and jute root cuttings. *Indian Pulp & Paper*, **37**, 17-20.

Kirk, T.K., Schultz, E. Comnors, W.J., Lorenz, L.F. & Zeikus, J.G. (1978). Influence of culture parameters on lignin metabolism by *Phanerochaete chryso porium Arch. Microbiol.* **117**, 227-85.

TAPPI (1971) *Standard and suggested methods*. Technical Association of the Pulp and Paper Industries, New York.