Development of biological pulping processes for non-woody plants

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SUMMARY
Atmospheric refining of untreated and fungal (Ceriporiopsis subvermispora) treated jute and kenaf bast was studied for the production of mechanical pulp. Determination of energy consumption at each stage of refining under various freeness levels was made. Steam explosion prior to refining of untreated and fungal treated jute and kenaf bast was also included in the investigation. The strength and optical properties of the mechanical and biomechanical pulps were determined. The investigation showed that considerable energy savings and enhancement in strength properties could be realized by the application of fungal pretreatment.

INTRODUCTION
Global concerns for preservation of forests and elimination of pollution from pulping and papermaking processes has led us to explore alternate fibrous resources other than wood and new environmentally benign pulping and bleaching processes for papermaking without sacrificing quality. Various alternate fibrous resources such as non-woody plants and agricultural residues are already in use in many countries and considerable research efforts have been undertaken to produce pulps by conventional and non-conventional approaches. Biological approaches using various fungal strains and enzymes for pulping and bleaching of wood has received wide-spread attention in the past decade, however, very scant attention has been given to non-woody plants; which in general have lower lignin content, different morphological features, higher yield of fibrous raw material per acre, and require less drastic conditions for pulping compared to wood. It is therefore imperative to evaluate this potential fibrous resource.

The world-wide potential availability of non-woody material is estimated to be 2.3 billion BD metric tons per annum (1). A search for new fiber crops by the U.S. Department of Agriculture in the 1960's and 70's identified kenaf (Hibiscus cannabinus) as a promising alternative fibrous raw material for papermaking (2). Jute (Corchorus capsularis) has been traditionally a major source of textile fibers and specialty papers. A major decline in jute exports from developing countries has accelerated research to diversify jute utilization for value added products.
The effect of fungi, especially white-rot fungi, on wood was systematically studied by Campbell in the 1930’s (3). The advantage of using fungal treatment prior to mechanical refining of wood with beneficial results has been proven in more recent studies (4,5). Very scant information is available on the use of fungal treatment prior to mechanical pulping of non-woody plants and is practically non-existent in the case of kenaf and jute bast. Therefore studies on the atmospheric refiner mechanical pulping (RMP) and bio-refiner mechanical pulping (BRMP) of kenaf and jute bast were initiated to evaluate alternate environmentally benign pulping processes. Effect of steam explosion of untreated and fungal treated bast materials prior to refining was also studied.

MATERIALS AND METHODS

Refining
Cut bast strands of kenaf and jute were refined under atmospheric pressure in a 12” Sprout Waldron single disc refiner. Two stage refining was carried out. Mechanical and biomechanical pulps were obtained at various freeness levels and energy consumption was measured at each stage of refining.

Steam Explosion Pulping
Steam explosion pulping of untreated and fungal treated bast strands was carried out in 1 litre stainless steel pressure digester with steam jacket at 190 degree centigrade for 4 minutes prior to refining.

Fungal Treatment
*Ceriporiopsis subvermispora* (Fil.) was selected for this study because of its greater lignin selectivity (6). The inoculum and medium preparation are described in our previous paper (7).

Pulp Testing
Tappi standards were employed for the evaluation of all the pulps after removing the latency by standard method.

Scanning Electron Microscopy
Samples of inoculated and noninoculated bast strands were scanned using Hitachi 450 scanning electron microscope.

RESULTS AND DISCUSSION

Figures 1 and 2 show the reduction in energy consumption for biomechanical pulps (BMP) compared to refiner mechanical pulp (RMP) for jute and kenaf bast. Exploded untreated (ERMP) and fungal treated (EBRMP) samples followed by refining further reduced the energy consumption by 8-10%. The strength properties viz, tensile, burst and tear were enhanced by biological treatment and steam explosion of untreated and fungal treated samples improved the strength properties further. The same trend was observed for both kenaf and jute. Figure 3 shows tensile strength of the kenaf pulps at two freeness levels. The steam explosion process reduced the brightness levels considerably (Figure 4). Scanning electron micrographs of biopulps reveal separation of bundles of fibers containing cells of varying thickness (Figure 5). Fun gal pretreatment appears to modify cell wall and middle lamella which results in considerable energy saving during refining. It was also observed that pulps obtained from fungal treated bast strands at lower CSF levels were easier to drain compared to untreated samples and had sufficiently high opacity values. Single stage alkaline hydrogen peroxide bleaching of a refiner mechanical pulp of jute at 150 ml CSF increased the brightness from 35% to 70%, whereas bleaching of a jute biopulp at the same CSF level resulted in brightness increase from 31% to 57% under identical conditions of bleaching.
REFERENCES
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