EVALUATIN OF NALITA WOOD (*Trema orientalis*) AS SOURCE OF FIBER FOR PARERMAKING

M. Sarwar Jahan[1] · Sung Phil Mun[2]

1) Pulp and Paper Research Division, BCSIR Laboratories, Bangladesh

2) Division of Forest Science, Chonbuk National University, Korea

ABSTRACT

Nalita wood (*Trema orientalis*) is one of the fastest growing woods in the world. It may be a viable species for pulpwood. The physical, chemical and morphological properties of Nalita were studied. The total lignin, pentosan and holocellulose content in Nalita wood were 24.7%, 22% and 81.2%, respectively. Its fiber length was about 0.92 mm, which are comparable to *Acacia mangium*. Nitrobenzene oxidation of Nalita wood meal indicated that the guaciayl and syringyl unit were the major constituent of Nalita lignin. Nalita produced 50% pulp yield at Kappa number 21 in soda-anthraquinone process. The strength properties of Nalita pulp were comparable to other tropical hardwood pulp. At 40。 SR, the breaking length, burst index, tear index and total energy absorption were 6000 m, 3.5 kPa · m^2/g and 7.0 mN · m^2/g and 75 J/m^2, respectively.

INTRODUCTION

The demand of raw materials for papermaking is continuously increasing as a result of the increase in paper consumption. Nonwood or fast growing tree may overcome the shortage of fibrous raw materials for pulping. *Acacia mangium* and

Eucalyptus camadonesis are most promising fast growing wood in the environment of Bangladesh. From a forestry point of view, growth performance is one of the most important criteria for species selection. Recent literature (1) showed that Nalita wood is one of the fastest growing woods in the world. It was also reported elsewhere as the fastest growing tree (2). Local name of *T. orientalis* is Nalita. The fastest growth of Nalita occurs in warm, moist areas with consistent temperatures. Nalita is widely distributed through a range of altitudes in higher rainfall areas. It prefers sites on well-drained, exposed soils (3). Nalita is also a nitrogen-fixing tree. Bangladesh environment favors *T. orientalis* for its good growth. Several researchers demonstrated that genetic makeup could influence fiber characteristics of the fiber (4). It is widely reported in the literature that significant variation in physical and chemical compositions among the species. However, the success of any reforestation programs would certainly depend on the quality of wood produced.

In this investigation an effort has been made to characterize morphological and chemical properties of Nalita wood as well as pulping it by soda-anthraquinone process has also been done.

EXPERIMENTAL

Material

The 3-year old Nalita tree used in this study was collected from the Dhaka region of Bangladesh. These trees were debarked and chipped to 1 x1 x 2 cm size. The wood chips were ground in a Wiley mill and 40-60 mesh sizes was used for chemical analysis.

Physical, morphological properties

For the measurements of fiber length, 1 g of wood sample was macerated in a solution containing 1:1 HNO_3 and $KClO_3$. A drop of macerated sample was taken in a slide glass and fiber length was measured under a profile projector (Nikon V-12, Japan). The fiber diameter was measured in an image analyzer (Bummi Universe, Korea).

Chemical analysis

The extractive (T204 om88), Klason lignin (T211 om83), acid soluble lignin (UM 250), pentosan (T 223) and ash content (T211 os76) were determined in accordance with Tappi Test Methods.

Holocellulose was determined by treating extractive free wood meal with $NaClO_2$ solution. The pH of the solution was maintained at 4 by adding CH_3COOH-CH_3COONa buffer.

Alkaline nitrobenzene oxidation of Nalita wood was carried out according to Mun's modified method (Mun and Wi 1991). GC analysis was conducted using a gas chromotograph Shimatzu GC 17A (Japan) equipped with CBP1 capillary column (0.25 mm x 25 m). Conditions used were as follows: column temperature was programmed to increase from 150 to 270℃ at the rate of 5 ℃/min; injection and detection temperature were 220 and 270℃, respectively; column flow was rate 1 ml/min and split ratio 20.

Pulping

Pulping was carried out in a 20-L capacity batch cylindrical reactor heated by means of electrical resistance and was rotated by a motor. The normal charge was 1 kg of moisture free Nalita chip. The following parameters were maintained:

- The alkali concentration was 17% as Na_2O on o.d. Nalita wood.
- The cooking temperature was constant at 170℃
- The cooking time was 2 h at the maximum temperature.
- The liquor ratio was 5.
- Anthraquinone charge was 0.1% AQ (on o.d. Nalita wood).

After digestion the pulp was washed till free from residual chemicals and screened by flat vibratory screener (Yasuda, Japan). The pulp yield and screen reject were determined as percentage of oven-dry raw materials. The kappa number of the pulps was determined according to Tappi Test Methods (T 236).

Evaluation of pulps

Nalita pulp was beaten in a Valley beater to different freeness (。SR) and hand sheets of about 60 gm/m^2 were made in a Rapid Kothen Sheet Making Machine according to German Standard Methods number 106. The sheets were tested for tensile, total energy absorption (T 494 om-96), burst (T 403 om-97) and tear strength (T 414 om-98) according to TAPPI Standard Test Methods.

RESULTS AND DISCUSSION

Growth rate and physical properties

Figure 1 shows the average growth rate in height and diameter at barest height (DBH) at a few month intervals.

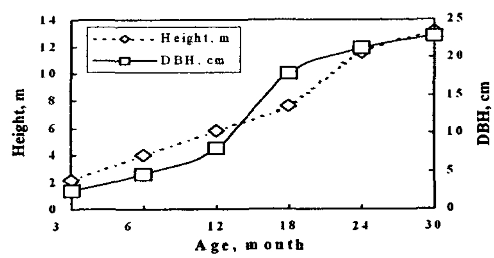

Fig. 1. Growth rate of Nalita tree.

The growth of this tree was exceptionally high, therefore, rate was measured after a few month interval. Fig. 1 indicates that the average DBH increased to 21.3 cm at the age of 24 months after that the rate was level off. The average DBH and height of 4-year old *Acacia mangium* were approximately 24.1 cm and 8 m, respectively (5). The average height of tree increased to 13.11 m at 30 months. *Eucaliptus amplifolia* produced 12.8 m height and 17 cm DBH in 53 months in Florida (6). The clone, Capitol Lake was a native clone of *Poplus trichocarpa* had DBH, 8.7 cm and height 15.2 m at the 9 years old. Generally, trees whose rotation time is about 15 years are considered fast growing wood. Therefore, it is seen that Nalita is one of the fastest-growing tree.

Table 1 shows the chemical and morphological properties of Nalia wood. Fiber length is of special importance to the pulp and paper industry, and for this reason extensive literature exists concerning its variation within and among tree. The average fiber length of Nalita wood was 0.925 mm as shown in Table 1. Sahri *et al* (7) showed that large and medium diameter trees have longer fibers than the small diameter. Kennedy and Smith noted (8) that fiber length is longer in better sites. Fast-grown sprout had shorter fibers than slow grown. The fiber length range was almost similar to *Acacia mangium* and other tropical hardwood (9). Quality of writing and printing paper grades require a blend of long fiber from softwood and short fiber from hardwood. The short fibers provide surface that are smooth and receptive to fast and clear application of ink. Therefore, Nalita pulp could be used as in the manufacture writing and printing paper. The fiber wall thickness was about 2.43 μm, which was comparable to maple (10). Nalita is the fastest growing wood. Therefore, it contains high proportion of springwood. The cell wall of springwood is relatively thin than summerwood.

Nalita wood had lignin content to 24.4%. This was similar to poplar clone (11) and higher than that of aspen (9) and lower than *Acacia mangium* (9). The cold water, hot water, 1% alkali and alcohol-benzene extract were 3.5%, 5.1%, 21.9% and 1.9%, respectively. The alcohol-benzene solubility of Nalita wood was similar to aspen and 1% alkali solubility similar to poplar clone. The α-cellulose and pentosan in Nalita were 49.8% and 22%, respectively. The pentosan and α-cellulose value were almost similar to hybrid poplar (12).

Table 1. Chemical characteristic of Nalita wood

Cold water solubility, %	3.5
Hot water solubility, %	5.1
1% alkali solubility, %	21.9
Alcohol-benzene extract, %	1.9
Lignin, %	24.4
Pentosan, %	23.4
α-cellulose, %	49.7
Ash, %	0.96
Fiber length, mm	0.925
Fiber diameter, ㎛	23.9
Fiber wall thickness, ㎛	2.43

Table 2 shows the yield of alkaline nitrobenzene oxidation products obtained from the Nalita wood. From the Table it is seen that the predominant product was identified to be syring- aldehyde (S), which comprised 20% of lignin. It was resulted from the degradation of noncondensed syringyl unit. Vanillin (V) appeared as the second major degradation products resulted from the noncondensed guaiacyl unit. The relative ratio of S to V was 1.6. The results appeared to be in general agreement with the range of S to V ratios obtained from hardwood lignin (13).
Soda-anthraquinone pulping of Nalita wood was done at a constant condition. The results are shown in Table 3. At 17% active alkali in 2-h cooking screened pulp yield of Nalita was 48.9%, at the same time reject and kappa number were 1.1 and 21, respectively.

Table 2. Nitrobenzene oxidation products of Nalita wood

Aldehyde, %			S/V
P	V	S	
1.6	11.9	19.8	1.6

P: *p*-hydroxy benzaldehyde, V: vanillin, S: syringaldehyde.

Figures 2, 3 present the strength properties of Nalita pulp cooked at different freeness. Beating improved the strength properties of Nalita pulp. Initial stage of beating increasedstrength properties rapidly, further increase of beating increase of strength properties slowly. Tear index was increased rapidly with increasing beating followed by decrease with further beating. At 20。 SR, tear strength of Nalita was 7.8 mN · m^2/g. Pulp strength is best presented by plot tear strength versus tensile strength as shown in Figure 4. With tensile index in the range of 50 N · m/g, Nalita pulp sheets highest tear index about 7 mN · m^2/g. This suggests that pulp of Nalita wood should be beaten to obtain about 50 N · m/g to get maximum tear and tensile ratio.

Fig. 2. Tensile strength and Total energy absorption development with beating.

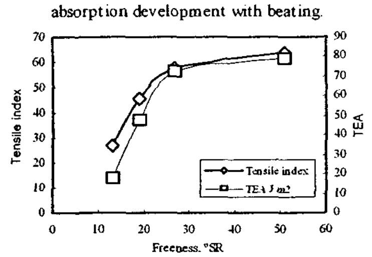

Fig. 3. Burst index and tear index development with beating.

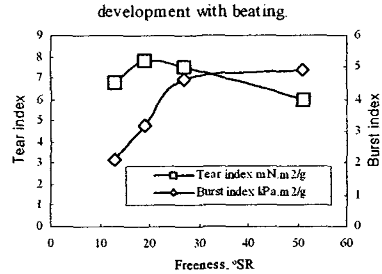

Fig. 4. The relationship between tensile and tear strength.

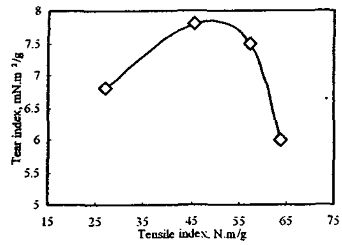

Table 3. shows the comparison of 3-year old soda-AQ Nalita pulp and kraft bamboo pulp (14), which are the major fibrous raw materials in Bangladesh. Pulp yield was higher and kappa number lower than bamboo. The breaking length was higher but tear index of Nalita wood pulp was lower as compared to bamboo pulp.

Table 3. Properties of Nalita pulp in soda- AQ process.

	Nalita	Bamboo
Screened pulp yield, %	48.9	-
Reject,%	1.1	-
Total pulp yield, %	50.0	45.9
Kappa number	21	24.6
Breaking length*, m	6,000	5,511
Burst index*,kPa · m²/g	3.5	4.9
Tear index*, mN · m²/g	7.0	18.1

* At 40。 SR

CONCLUSIONS

The following conclusions may be drawn from this investigation:

- The chemical and morphological characteristics of Nalita wood were almost similar to tropical hardwood.

- Nalita wood lignin mainly composed of syringyl (S) and guacyal unit (V). The ratio of S/V was 1.6
- Nalita wood produced pulp yield of about 50% at kappa number 21, which were better than bamboo pulp.
- The strength properties of soda-AQ Nalita wood pulp were other tropical hardwood and bamboo.

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