Enterolobium Cyclocarpum (Jacq.) Griseb.-A Versatile Biomass Producer for Production of Quality Paper

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ABSTRACT: Pulp and papermaking characteristics alongwith total biomass yield of a fast growing tree species - Enterolobium cyclocarpum have been evaluated. The fibre length of 1mm and low lignin content of 20% accompanied by other normal characteristics have been highlighted for its favourable use as hardwood in pulp and papermaking. Pulping by chemical sulphate process requires 15% of active alkali with an unbleached pulp yield of 50.5% and kappa no. of 15.5. Bleaching by CEH sequence shows pulp yield of 43.4% and brightness of 81.2%. The strength properties are discussed vis-a-vis quality of paper.

Introduction

The acute population pressures and low per capita availability of paper, coupled with the substantial pressures on land to produce paper grade pulp in addition to food, fuel and fodder, the situation is becoming a grave concern to the paper industry in the country. On account of demographic pressures the demand for conventional raw materials has out-stripped the natural regeneration so much so that a constant vigil has been made to find alternative sources[1-6]. As the conventional species are comparatively slow growers and the degraded land further slows down their normal growth-rate, several new indigenous and exotic short rotation fast-growing tree species like Australian Eucalyptus (Eucalyptus spp.), Poplars (Populus spp.), Subabul or Kubabool (Leucaena leucocephala), Agasti (Sesbania grandiflora), Siris (Albizia lebbeck), Gumhari (Gmelina arborea), Silver oak (Grevillea robusta) etc. have recently been studied and their pulp and paper making characteristics evaluated[4-8].

Enterolobium cyclocarpum, a Jamaican N_2 fixing leguminous tree has been found to be extremely fast-growing, reaching 2m. of height and 8 cm. of girth within first six months of planting. At the end of 4th year it is found to attain on an average 12m. in height and 75 cm. at dbh. Thereafter the vertical growth slows down but the girth increase gets the momentum till it reaches 15 years of age. A 4-year fully grown plantation when harvested has been found to yield about 120 m. tonnes of fresh wood with 40% moisture per hectare in 1m. X 1m. spacing. The superiority of this species is its rapid growth, nitrogen fixing ability, coppicing capability, good fuel value (4, 400 K cal/kg), low density and low lignin content.

Results and Discussion

The bulk density and basic density values of the wood are found to be 125 and 300 kg/m^3, respectively, which are much lower than other hardwoods. The basic density of hardwoods[9] acceptable for pulp and papermaking is in the range of 250 to 650 kg/m^3. The wood is highly porous and access of alkali into such porous mass becomes easier than in hardwood possessing higher density values. Consequently, the pulping characteristics of this wood are bound to be appreciable.

The average fibre length and width are 0.98 mm and 30.36 μ respectively which are on the higher sides (Table 5). In eucalyptus[10] the fibre length and width are 0.7-0.8 mm and 20-25 μ, respectively.

According to the proximate analysis (Table 1), it has high holocellulose (80.3%) and low lignin (20.6%) content. Cold and hot water solubility, 1% NaOH solubility and alcohol-benzene extractive values are in the same range as for other hardwoods[11]. The ash content of Enterolobium is 1.5%, while pentosan content is 17.5%.

It requires relatively low active alkali (15%) for removal of lignin and extractives to achieve the unbleached yield of 50.5% and kappa on. of 15.5 (Table 2).

The unbleached pulp was bleached by using CEH

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Table -1

Proximate Chemical Analysis Results

Property	%
1. Cold water solubility	6.8
2. Hot water solubility	8.7
3. 1% NaOH solubility	19.3
4. Alcohol-benzene solubility	2.5
5. Acid insoluble lignin	20.6
6. Holo-cellulose	80.3
7. Pentosan	17.5
8. Ash content	1.5

Table -2

Pulping Characteristics

Property		Results
1. Active alkali charge (as Na_2O)	(%)	15.0
2. Sulphidity of white liquor	(%)	18±1
3. Bath ratio		1:2.7
4. H factor		1380
5. Cooking schedule		
Time to temperature	(Min.)	120
Time at temperature	(Min.)	90
6. Cooking temperature	(^{0}C)	165
7. Screened unbleached yield	(%)	47.2
8. Rejects	(%)	3.3
9. Total unbleached pulp yield	(%)	50.3
10. Kappa no.		15.5

sequence. During bleaching, the pulp required Cl_2 dose of 5.6% to attain the brightness of 81.2%. Viscosity and bleached yield are found to be 7.2 cp and 43.2% which are quite attractive. At initial 20°SR and 40°SR freeness levels, the fibre classification result shows maximum fibres retained in -30, +50 mesh fractions (Table 3 & 4).

Table -3

Bleaching Characteristics

Property		Results
1. Kappa no.		15.5
2. CHLORINATION:		
a. Chlorine added	(%)	3.6
b. Chlorine consumed	(%)	3.6
3. ALKALI EXTRACTION:		
a. Alkali added	(%)	1.8
b. Final pH		9.5
4. HYPO-STAGE:		
a. Hypo (available chlorine) added	(%)	2.0
b. Chlorine consumed	(%)	1.9
c. Buffer added	(%)	0.4
d. Final pH		8.0
5. Total chlorine added	(%)	5.6
6. Total chlorine consumed	(%)	5.5
7. Shrinkage	(%)	8.1
8. Brightness	(% El)	81.2
9. Viscosity	cp (0.5m, CED)	7.2
10. Bleached pulp yeild	(%)	43.4

Conditions of bleaching	Chlorination	Extraction	Hypo-stage
1. Retention time, hrs.	0.75	1.5	2.5
2. Consistency, %	3	10	10
3. Temperature, ^{0}C	Ambient	55	40

Table -4

Bauer McNett Fibre Classificaiton

	Fibre retained, %	
Mesh size, No.	Initial (20°SR)	40°SR
+ 16,	9.5	2.9
- 16, + 30,	16.7	3.4
- 30, + 50,	47.2	46.3
- 50, + 100,	15.9	25.9
- 100,	10.7	21.5

Table -5

Fibre Morphological Characteristics

Fibre length, mm	
Maximum	1.34
Minimum	0.23
Average	0.98
Fibre width, micron	30.36

Strength properties of bleached pulp at initial, 30° and 40°SR are shown in Table 6. The bulk value is found to decrease from 1.55 to 1.27 cc/g at 40°SR. The increase in burst factor to 39.3 at 40°SR from 22.3 at initial stage is quite normal. The tear factor decreases with increases in beating while the breaking length and double fold values have improved on beating to 40°SR. Breaking length of 6690 m and zero span braking length value of 11,830 m are properties which indicate superiority of this hardwood over

Table -6

STRENGTH PROPERTIES OF BLEACHED PULP AT DIFFERENT °SR LEVELS

Particulars	(Initial)	20°SR	30°SR	40°SR
1. Bulk	cc/g	1.55	1.38	1.27
2. Burst factor	-	22.3	37.0	39.3
3. Tear factor	-	45.4	43.2	37.2
4. Breaking length	m	4262	5520	6690
5. Double fold	no.	9	20	40
6. Zero span breaking length	m	-	11830	-

other hardwoods.

Experiments have been conducted by blending the wood with bamboo for production of quality paper; compositions of Bamboo: Enterolobium, 80:20, 75:25, 70:30 were prepared. The active alkali for cooking the three compositions was 17%. The unbleached pulp yield (Table 7) with the first two compositions was 49.8% while with the third composition, it came down to 45.8%, the corresponding kappa number being 19.5 and 17.4 respectively. The results show that high unbleached pulp yield can be obtained [12] in the mixed pulp.

Table -7

PULPING CHARACTERISTICS OF MIXTURES OF BAMBOO AND ENTEROLOBIUM CYCLOCARPUM

Property		Bamboo: Enterolobium (80:20)	Bamboo: Enterolobium (75:25)	Bamboo: Enterolobium 70:30)
1.Active alkali charges	%	17.0	17.0	17.0
2. Sulphidity of white liquor	%	18±1	18±1	18±1
3. Bath ratio	-	1:2.7	1:2.7	1:2.7
4. H factor	-	1380	1380	1380
5. Cooking Schedule:				
Time to temperature	min.	120	120	120
Time at temperature	min.	90	90	90
6. Cooking temperature	°C	165	165	165
7. Screened unbleached yield	%	48.6	48.4	44.8
8. Rejects	%	1.2	1.3	1.8
9. Total unbleached yields	%	49.8	49.7	45.8
10. Kappa No.	-	19.6	19.2	17.4

From the results of bleaching (Table 8) characteristics, it can be seen that total Cl_2 consumption in the three compositions are 8.1, 7.6 and 6.6%, respectively with brightness values 80.5 to 81.5%. Thus, barring aside the yield, composition having 30% of Enterolobium is also quite suitable for production of quality paper. The viscosity values of 8.7, 8.1 and 7.8 cp for the three compositions are fairly good. The bleached pulp yield for the first two compositions are 43.2 and 43.8 while for Enterolobium rich composition, it is 40.3%.

The strength properties of hand sheets made with the above three compositions at initial (18,16, 16°SR), 30°SR and 40°SR freeness levels are shown in Table 9. The bulk values at 40°SR marginally reduce from 1.44 to 1.38 cc/g on increasing Enterolobium cyclocarpum from 20 to 30% in the mixture.

The strength properties are found to improve as

Table -8

BLEACHING CHARACTERISTICS OF UNBLEACHED PULPS OF BAMBOO AND MIXTURE OF E. CYCLOCARPUM

Property		Bamboo: Enterolobium (80:20)	Bamboo: Enterolobium (75:25)	Bamboo: Enterolobium (70:30)
1.Kapp a no.		19.6	19.2	17.4
2. CHLORINATION:				
a. Chlorine added	%	5.75	5.75	5.0
b. Chlorine consumed	%	5.75	5.61	4.7
c. Final pH	-	1.9	1.8	1.8
3. ALKALI EXTRACTION				
a. Alkali added	%	2.0	2.0	1.8
b. Final pH	-	10.5	10.5	10.0
4. HYPO-STAGE				
a. Hypo (as available Cl_2) added	%	2.5	2.0	2.0
b. Chlorine consumed	%	2.32	1.98	1.9
c. Buffer added (as NaOH)	%	0.5	0.4	0.4
d. Final pH	-	8.5	8.0	8.2
5. Total Cl_2 added	%	8.25	7.75	7.0
6. Total Cl_2 consumed	%	8.07	7.59	6.6
7. Shrinkage	%	11.0	9.55	8.3
8. Brightness, % El		81.5	80.5	81.0
9. Viscosity (0.5 m CED)	c^D	8.7	8.1	7.8
10. Bleached pulp yield	%	43.25	43.8	40.3

Table -9

STRENGTH PROPERTIES OF MIXED BAMBOO AND ENTEROLOBIUM CYCLOCARPUM BLEACHED PULP AT DIFFERENT FREENESS LEVELS

	(80:20)			(75:25)			(70:30)		
Property	18°SR	30°SR	40°SR	16°SR	30°SR	40°SR	16°SR	30°SR	40°SR
1. Bulk cc/g	2.07	1.53	1.44	2.08	1.53	1.41	2.11	1.52	1.38
2. Burst factor -	8.6	26.0	29.6	8.9	26.7	29.9	9.6	30.5	35.7
3. Tear factor -	65.7	29.7	27.1	50.2	33.7	30.9	58.3	40.6	32.9
4. Breaking length m	2295	4950	5640	2300	5400	6055	2400	5700	6650
5. Double fold no.	2	5	6	2	6	9	3	12	24
6. Zero span breaking length m -	-	8280	-	-	9150	-	-	10700	-

Enterolobium cyclocarpum percentage increased; the burst and tear factor increase from 29.6 and 27.1 to 35.7 and 32.9 respectively at Bamboo: Enterolobium cyclocarpum of 80:20 and 70:30. The breaking length value increased by 1000 m when Enterolobium cyclocarpum content increased from 20 to 30% in the mixture; the double fold no. increased from 6 to 24. The zero span breaking length value is also enhanced by 2500 m in the third composition.

It is seen that bamboo could be replaced with minimum 30% Enterolobium cyclocarpum wood. In view of non-

availability of bamboo, use of higher percentage of hardwood (causing replacement of bamboo) is of paramount economical interest in paper industry. The bamboo; hardwood mix composition of 80:20 can be changed to 70:30 without effecting the strength properties.

Conclusion

Enterolobium cyclocarpum can impart better yield, optical and strength properties. Enterolobium cyclocarpum wood can be mixed upto a minimum of 30% with bamboo to produce quality paper.

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