Paulownia Fortunei - A New Fibre Source for Pulp And Paper

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ABSTRACT

***Paulownia fortunei** is a fast growing tree species; native to china and belongs to the family Scruphulariacea. It is a promissing tree species for plantation as pulp wood. The proximate chemical analysis, pulping, papermaking and fibre characteristics of Paulownia fortunei is discussed in the paper and its comparison with Dendrocalamus strictus, Eucalyptus tereticornis and Populus deltoides are also discussed.*

The proximate chemical analysis of P. fortunei reveals that holocellulose content is 69.56% whereas in E. tereticornis it is 70.10%, in P. deltoides 75.10% and D.strictus 62.20%. The lignin content is 28.0% and it is found little higher than other two pulpwoods and bamboo. The average fibre length of P. fortunei is 1.42 mm, which is more than P.deltoides but lesser than E. tereticornis and D.strictus. The average fibre diameter of P. fortunei is 0.030 mm. which is more than other species from which its comparison is discussed. Kraft pulping with 14% total chemicals as Na_2O, P. fortunei gave 51.0% pulp yield and kappa number 25.00. On comparison with E. tereticornis and P.deltoides under same chemical charge and cooking conditions the pulp yield obtained in case of E. tereticornis is 49.63% and for P.deltoides is 54.60% The kappa numbers obtained (32.7-46.6) were much higher as compared to P.fortunei.

The tensile index, burst index and tear index of P. fortunei were 106.12 Nm/g, 6.47 $kPam^2/g$ and 2.67 mNm^2/g respectively. It was observed that physical strength properties of unbleached pulp from P.fortunei compares well with the other three most widely used raw materials for pulp manufacture viz. D. strictus, E. tereticornis and P.deltoides.

INTRODUCTION

Paulownia, a genus of fast growing timber trees is native to china and belongs to family Scruphulariacea. It is a deciduous tree. Under normal growing conditions, productive Paulownia can give an annual increment of 3-4 cm in DBH and 0.04-0.05 m^3 in timber volume production. In better sites an annual increment of 8-9 cm in DBH and 0.2 m^3 in volume production is achieved. In China Paulownia

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Table-1

Data on outstanding Paulownia performers (P. fortunei) in India

Location	Latitude	Longitude	Age (Years)	GBH (cm)	Height (m)
Itanagar (Ar P)	27°08'N	93°40'E	3.5	70	13.1
Chessa (Ar P)	27°18'N	94°16'E	3.5	99	12.1
Dehradun (UP)	30°19'N	78°04'E	5.0	95	19.5
Dehradun (UP)	30°19'N	78°04'E	1.5	40	11.0
Dehradun (UP)	30°19'N	78°04'E	2.0	55	10.0
Allahabad (UP)	25°28'N	81°54'E	2.0	33	10.0
Allahabad (UP)	25°28'N	81°54'E	1.0	--	7.0
Kanpur (UP)	26°28'N	80°24'E	4.9	66	14.9
Kanpur (UP)	26°28'N	80°24'E	4.0	66	18.6
Roorkee (UP)	20°52'N	77°53'E	1.5	35	11.0
Gaja (UP)	--	--	3.5	35	8.8
Gaja (UP)	--	--	4.9	37	9.4
Gajiabad (UP)	--	--	3.0	76	10.2
Kukrail (UP)	--	--	2.0	34	14.3
Ludhiana (Pb)	--	--	0.7	18	6.4
Hoshiapur (Pb)	--	--	0.7	11	1.9
Rohtak (HR)			2.1	69	7.2
Dehradun (UP) (Coppice)	30° 19'N	78° 04'E	2.5 yrs shoot 4.5 yrs root	96	15.0

grows in plains and hills upto 2400 metre altitude. Old Paulownia trees are existing near the old metropol buildings in Shimla and Bangalore. First systemic introduction trial of Paulownia using P. Fortunei was established during June, 1993 at the Forest research Institute, DehraDun. Since then, it has ben planted on trial basis to screen productive and adaptive genetic materials in many States. Paulownia germplasm presently planted in the country includess clones/ species of P. Fortunei, P. tomentosa, P fargesii, P.elongatta and P. Kawakamii. Most of these species are highly productive and are increasingly grown on commercial basis in many countries. The data on outstanding Paulownia formunei in India has been given in table 1[1].

Paulownia wood is suitable for many uses. It is light, strong, rot resistance, odourless and dries easily. Specific gravity of 2 years old Paulownia grown at Forest Research Institute was found between 0.229 to 0.332 in comparison to 0.26-0.33 of mature Paulownia wood in China. Being a light coloured, low specific gravity and fast growing Paulownia can be considered as a promising plantation grown pulp wood. Keeping this in view the pulping and paper making properties of P. fortunei have been evaluated and discussed in the present paper so that it can be exploited for pulp and paper manufacture when available in large scale.

EXPERIMENTAL

RAW MATERIAL PREPARATION

Paulownia fortunei logs were chipped in a pilot

plant four knife Waterous chipper and chips were screened in Waterous chip screen to get a uniform chips size about 2-3 cm long, 2-2.5cm wide and 4-5 mm thick. The chips were air dried and stored in plastic bags. Before pulping the oven dry weight of the wood chips were determined as per standard methods.

PROXIMATE CHEMICAL ANALYSIS

Alcohol-bebzene extractives of wood meal (40-60 mesh) was determined as per standard method. Klason lignin was determined according to TAPPI test method T222 om-88. Holocellulose content was determined by using acid chlorite method described by Browning[2]. Pentosan was determined according to TAPPI test method (T 223 - O 5-78).

DETERMINATION OF FIBER CHARACTERISTICS

For determining fibre dimensions radial chips from each rings were macerated in nitric acid and potassium chlorite at room temperature as per method described else where by Singh etal[3]. The macerated material was thoroughly washed with distilled water several times to remove the traces of nitric acid and then stained with saffranin.

The fibres were mounted in glycerine and fibre length was determined under the microscope at a magnification of X100. Fiber diameter and lumen width were determined by same microscope at a magnification of about X 400 at the maximum point in each fibre. 30 readings were taken from macerated material from each ring. From the above observations wall thickness was calculated.

PULPING

The wood sample of Paulownia fortunei was delignified using kraft process in a "hatto" air heated multi digester, equipped with six auto claves of 2.5 liters capacity. The digester is equipped with two temperature sensors. One is intended for sensing the temperature of the heating chamber. The second sensor is inserted into one of the autoclave for accurate measurement of autoclave temperature. There are two digital panel meters to indicate the temperature. The heating device was set as per the cooking condition given below for the wood samples during pulping.

PULPING CONDITIONS

Total active alkali as Na_2O	:	14%, 16%
Sulphidity	:	25%
Material to liquor ratio	:	1:3
Cooking schedule		
From Room temp. to 165°C	:	90 minutes
At 165°C	:	90 minutes

After the cooking cycle is over, the pulps were washed screened and pulp yield and Kappa number were determined using TAPPI test method T-235-OS-76.

ANALYSIS OF PULP

All the pulp samples were beaten separately in a Lampen mill under standard condition to 250±25ml CSF. Hand sheets 60±2g/m² were prepared as per ISO standard (R-187).

The physical strength properties of the standard handsheets were determined according to ISO standard (DP 5269). The optical properties were determined by Elrepho Data color-2000.

Table-2

Proximate chemical analysis

Particulars	P. fortunei	D. strictus	E. tereticornis	P. deltoides
Alcohol-Benzene solubility (%)	3.05	3.32	2.80	2.01
Klason Lignin (%)	28.0	25.80	25.52	24.00
Holocellulose (%)	69.56	62.20	70.10	75.12
Pentosan (%)	15.08	18.10	16.00	15.4

RESULTS AND DISCUSSION

PROXIMATE CHEMICAL ANALYSIS OF P.FORTUNEI AND ITS COMPARISON WITH E. TERETICORNIS, P.DELTOIDS AND D. STRICTUS

The table-2 indicates the data on proximate chemical analysis of P. fortunei and its comparison with three conventional species viz. D. strictus, E. tereticornis and P. deltoides. The alcohol -benzene solubility in P. fortunei was 3.05% as compared to 3.32%, 2.80% and 2.01% for D. strictus, E. tereticornis and P. deltoides respectively. The lignin content in P. fortunei was 28.0% which is little higher than D. strictus (25.8%) followed by E. tereticornis (25.52%) and P deltoides (24.0%). The holocellulose content in P. fortunei was 69.56% as compared to 62.20% 70.10% and 75.12% for D. strictus, E. tereticornis and P.deltoides respectively. The pentosan contents was 15.08% in P. fortunei whereas in D. strictus, E. tereticornis and P. deltoides it was 18.10%, 16.0% and 15.4% respectively.

FIBRE CHARACTERISTICS OF P. FORTUNEI AND ITS COMPARISON WITH E. TERETICORNIS, P. DELTOIDES AND D. STRICTUS

The table 3 shows that average fiber length of P. fortunei is 1.420 mm. It is comparatively higher than P.deltoides (0.952mm) but much lesser than D. strictus (3.250mm) and E. tereticornis (1.650mm).

It could be seen from table 3 that the average fibre diameter of P. fortunei is 0.030 mm, which is higher than the other three species as mentioned in table 3 taken for comparison.

KRAFT PULPING CHARACTERISTICS OF P.FORTUNEI AND ITS COMPARISION WITH OTHER PULP WOOD AND BAMBOO

It could be seen from table 4 that at 14% total

Table-3

Fibre Characteristics of P. fortunei and its comparison with E. tereticornis, P. deltoides and D. strictus

Particulars		P. fortunei	D. strictus	E. tereticornis	P. deltoides
Fiber length (mm)	Min.	0.600	1.000	0.700	0.480
	Avg.	1.420	3.250	1.650	0.952
	Max.	1.720	5.500	3.920	1.520
Fiber diameter (mm)	Min.	0.025	0.013	0.007	0.015
	Avg.	0.030	0.012	0.013	0.024
	Max.	0.040	0.020	0.02	0.033

Table-4

Pulping Characteristics

Particulars	P. fortunei		D. strictus	E. tereticornis		P. deltoides	
Total Chemical as Na_2O (%)	14	16	14	14	16	14	16
Screened pulp yield (%)	51.00	44.54	50.9	49.63	48.32	54.60	54.02
Rejects (%)	2.62	0.66	4.0	1.20	0.03	0.40	0.25
Kappa number	25.00	23.0	36.3	32.71	24.6	46.60	28.50

chemicals as Na_2O, P. fortunei gave 51.0% puip yield and kappa number 25.00 On comparison at same chemical charge and condition of pulping E. tereticornis gave pulp yeild of 49.63% and P. deltoids 54.60% and kappa number 32.71 and 46.60. The pulp yield in case of D. strictus is 50.09% and gave kappa number 36.3. Further the data in table 4 revealed that when the pulp from P. fortunei was prepared with 16% chemical charge the pulp yield and kappa number was 44.54% and 23.00 as compared with E. tereticornis and P. deltoids the pulp yield were 48.32% and 54.02% respectively and kappa number were 24.6 and 28.50 respectively.

THE PAPER MAKING PROPERTIES OF UNBLEACHED PULPS

The table 5 showed the tensile, tear and burst indices of pulps prepared from P. fortunei at 14 and 16% active alkali as Na_2O. The results were compared with D. strictus, E. tereticornis and P. deltoides. It could be seen from table 5 that the pulp prepared from 14% active alkali the tensile, tear and burst indices were 106.12 Nm^2/g, 2.67 mNm/g and 6.47 $kPam^2/g$ respectively in case of P. fortunei while on comparing with D. strictus, E. tereticornis and P. deltoides the tensile, tear and burst indices were 64.70 Nm/g, 19.04 mNm^2/g, 4.77 $kPam^2/g$, 78.0 Nm/g, 7.80 mNm^2/g, 6.25 $kPam^2/g$, 116.03 Nm/g, 6.89 mNm^2/g and 10.09 $kPam^2/g$ respectively. It is observed that pulp prepared from P.fortunei at 14% active alkali gave lower tear index as compared to E. tereticornis, P. deltoides and D. strictus. This is attributed due to higher fibre length of these two species as compared to P.fortunei whereas tensile index is comparable with P.deltoides and much higher with D.strictus and E. tereticornis. The burst index is comparable with E. tereticornis and higher than D. strictus and much lower than P. deltoides. Further it is observed that pulps prepared with 16% active alkali the tensile tear and burst indices were 99.84 Nm/g, 2.49 mNm^2/g and 5.50 kPam/g for P. fortunei. Similar trends were observed in tensile, burst and tear indices in case of pulps prepared with 14% active alkali.

Bleaching studies and it characteristics etc. shall be published in second part of the study.

CONCLUSION

It could be seen that physical strength properties of P. fortunei compares well with the other three most widely used raw material for the pulp manufacture viz. D. strictus, E. tereticornis and P. deltoids. So from the investigation carried out it is concluded that P. fortunei is a promising pulp wood for the manufacture of pulp and paper.

Table-5

Strength properties of unbleached pulp

Active Alkali as Na_2O	Particulars	P. fortunei	D. strictus	E. tereticornis	P. deltoides
14%	Tensile index (Nm/g)	106.12	64.70	78.00	116.03
	Tear index (mNm^2/g)	2.67	19.04	7.80	6.89
	Burst index ($kPam^2/g$)	6.47	4.77	6.25	10.09
16%	Tensile index (Nm/g)	99.84	-	63.0	117.45
	Tear index (mNm^2/g)	2.49	-	8.40	6.63
	Burst index ($kPam^2/g$)	5.50	-	4.30	8.37

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