Bleachable Grade Pulp from Tropical Hardwoods from Andhra Pradesh

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SUMMARY

Authors have tested 29 species of Tropical Hardwoods growing in Andhra Pradesh forests for their suitability as pulp wood. Out of these 29 species, 20 species were reported earlier (1,2) and 9 species have been reported here.

Acacia auriculiformis, Albizia lebbeck (Siris), *Gliricidia meculata, Pongamai pinnata* (Karanj), *Prosopis juliflora* (Tumma) both old and young, *Schleichera oleosa* / S. *itrijuga* (Pusku, Kusum), *Sesbania grandiflora* (Dhaincha), young *Tectono grandis* (Teak) and *Xylia xylocarpa* (Bojja) were tested.

Out of these nine species, *Albizia lebbeck, Sesbania grandiflora, Prosopis juliflora* (young) and *Acacia auriculiformis* were found quite suitable for making bleachable grade pulp by Kraft Process. Their alkali demand varies between 14–16% as TAA and their strength properties are fairly satisfactory. By the Method of Grading developed by the same Laboratory (3) these woods find their place in I Group, i.e. very good suitability.

Young Teak wood has added advantage of being used without debarking, but for this purpose, the wood must be from fresh plantations, 4–8 years old which have thin smooth bark. Such wood can be available from teak plantation trimmings.

Pongamia pinnata, Schleichera trijuga were found next best in pulping for bleachable grade pulp. They have slightly higher alkali demand and comparatively lower strength proporties.

Old *Prosopis juliflora,* although was also found useful, falling in II group of Grading, yet, it occupied the lowest position in that category. With its hard, thick, cracked bark and deep coloured heartwood, and hard in chipping , it does not make a favourable wood for bleachable grade pulp.

Gliricidia meculata and *Xylia xylocarpa* were found unsuitable for making bleachable grade pulp as their allkali demand was fairly high, pulp was hard and not easily bleachable. Their pulp world produce shives and low brightness by conventional CEHH system of bleaching.

INTRODUCTION

Some time back (1,2), 20 species of tropical hardwoods found in Andhra Pradesh have been reported for their pulping properties by Sulphate process of cooking. To identify the suitability of hardwoods for making bleachable grade pulp, a method of grading was also postulated (3). As an extension of same work, further 9 species of tropical hardwoods found in Andhra Pradesh forests have been tested and are reported here. Out of these 9 species, 7 species, viz. *Albizia lebbeck* (Siries), *Sesbania grandiflora* (Dhaincha), *Prosopis juliflora* (young), *Acacia auriculiformis,* Young *Teak Wood, Pongamia pinnata* and *Schleichera trijuga* have been found suitable for making bleachable grade pulp. The other two species viz. *Gliricidia meculata, Xylia xylocarpa* were found unsuitable for this purpose, as their pulp was found very difficult to bleach and hard in cooking. Old *Prosopis juliflora* was found just on the border of Group II and Group III, i.e. it cannot be depended upon for its suitability for making bleachable grade pulp.

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EXPERIMENTAL

1. Logs of wood samples were debarked and

chipped. Size of chips in each case was maintained as for as possible below 1,1/2". To have uniformity in bulk density data of chips, chips taken for this purpose were dried at 105°C (+20) to constant weight. Physical appearance of each wood, its bark and bulk density data were given in Table—l.

Fibre dimensions and fibre composition of unbleached and bleached pulps for each species were determined as given in Table—ll. below. Fibre classification was carried out in the L & W Fibre Classifier having horizontal sieve disc.

2. Cooking tests were carried out to match the cooking conditions followed in the plant with bamboo. To find out the change of pulping behaviour with different systems of cooking, in some cases two or more systems were adopted as indicated below. In most of the cases, cooking conditions were maintained same.

3. In case with Test Cooks No.1 (b), 2 (b, d) 3 (a) and 9, cooking was carried out by impregnation method, i.e. 4-stage steaming process as given below with a total cooking cycle of 4 hours.

(a) from room temp. to ..(30 psi)	— 1 hour
(b) at ....°C (30 psi)	— 1 hour
(c) from ....°C (30 psi) to 168°C (98 to 100 psi)	— 1 hour
(d) at 168°C (98–100 psi)	— 1 hour
	4 hours

Average sulphidity in white liquor was maintained around 16% and dilution ratio 1:2.5. Cooks were performed in open steam heated rotary digester of 200 Lit. capacity.

4. Test Cooks Nos. 1 (a), 2 (a) c), 4, 6 (a, b) and 8 were carried out by two stage steaming system or straight cooking method, i.e. raising steam pressure from atmosphere to 98–100 psi in two hours in first stage and maintaining at 98–100 psi for 2 hrs. in second stage of cooking.

5. In case of Test Cooks 5 (a, b), 7 (b), total cooking cycle was 4 hrs. consisting 1 hour in first stage (i.e. from atmosphere pressure to 98–100 psi) and 3 hours in second stage (i.e. at 98–100 psi).

6. In Cooks Nos. 3 (b), 5 (c, d) and 7 (a) were two stage cooking cycle, consisting 2 hrs. in first stage, 2.1/2 hours in second stage, 2 hours in first stage, 3 hours in second stage, 1 hr. in first stage, 2 hours in second stage, respectively.

7. T.A.A. and T.E.A. taken in each case, conditions of cooking, with properties of resulting unbleached pulp are given in Table—III.

8. Bleaching tests were carried out as indicated in Table—IV. Conditions of bleaching followed in each case are given against each test cook no. with quality of bleached pulp and its yield.

9. Standard hand sheets of unbleached and bleached pulps from each test were made as per Tappi Standard and their strength properties were determined after conditioning at 65% humidity and at 20°C. These values have been given in Table—V.

OBSERVATIONS AND DISCUSSIONS

1. *Albizia lebbeck* (Siris), young trees of *Prosopis juliflora* (upto 3 years age), young teakwood, *Acacia auriculiformis* and *Sesbania grandiflora* were found quite suitable for bleached pulp production with easy pulpability by conventional Kraft cooking system. These woods behave normally in chipping and mostly contained light coloured bark and sap wood.

Except *Sesbania grandiflora,* which is fairly light, B.D. being 170 kg/m³ (b.d.wt.), other species were fairly weighty, having B.D. 242.6–256.7 Kg/m³ (on b.d. basis). B.D. of young teak wood was also low (190 Kg/m³).

2.(a) *Albizia lebbeck,* on 2 stage cooking with 16% T..As Na_2O gave fairly soft pulp of P. No. 14.4 and Kappa No. 23.4, with 50.42% unbleached yield (on b.d. chip weight). Rejection was fairly low, being 3.1%. Impregnation method of cooking under similar conditions gave slightly harder pulp with practically double rejection and lower yield by nearly 1%. Lower alkali (14% Na_2O) proved inadequate to give good quality pulp (Table—III Sl. No.2a and b).

(b) On bleaching by CEHH system, bleached pulp of fairly high brightness of 81° GE was produced with total consumption 8.0% Cl_2 and 4% NaOH in extraction and buffing. Bleached pulp yield came to 40.2% on b.d. wt. of chips (Table—VI, Seria INo. 2 (a).

2-stage cooked pulp behaved better in bleaching than the 4-stage (Impregnation Method) cooked pulp (Table—IV, S.No. 2 b).

(c) In strength properties, *Albizia lebbeck,* cooked with 16% TAA as Na_2O by Impregnation method (Table—V, Sl. No. 2 (b), showed higher values than those of bld. pulp from two-stage cooking (Sl. No. 2a). In general, strength properties of both bleached and unbleached pulp were fairly high.

(d) Fibre classification also showed the percentage of fibre retained on 60 mesh was nearly 91.2% (unbleached) and 77% (bleached) (Table—II, Sl. No.2), comparing very well with bamboo pulp. Slanderness ratio was also fairly high being 67%.

3.(a) *Sesbania grandiflora* is something between soft wood and hardwoods. It is fairly light in weight. Crop of 2–3 years age contains fairly thin smooth light coloured bark and hence its debarking prior to cooking is not necessary. Older plants some time develop thick cracked bark, which if not removed causes specks in pulp.

(b) It is a bulky material and hence pulp yield per digester charger (from stationary digesters) will fall as compared to that from bamboo. This fall in yield may be around 27% taking the average Bulk density of bamboo around 232 kg/m³ (b.d. weight).

(c) *Sesbania grandiflora* is easily pulpable and its alkali demand is low (Table—III, Sl.No.7a and b). With 12% TAA as Na_2O, an easily bleachable pulp of Kappa No. 35–36 could be produced with an unbleached yield of 47–48% (on b.d. wt. of chips). This pulp consumed 11% total Cl_2 by CEHH system of bleaching (Table—IV, Sl.No.7a and b) to give a bright pulp of 80° GE and bleached yield of 39.7% (on b.d. wt. of chips).

(d) Although *Sesbania* pulp on bleaching showed +60 mesh fibre content, only 26% and fairly high fines contents passing 80 mesh to be 30% (Table —II, Sl. No. 7). yet the strength properties of both unbleached and bleached pulps were fairly high (Table—V, Sl.No.7a and b). With D.F. endurance being above 143, breaking length exceeded 7000 meters and B.F. around 40.

4. (a) *Prosopis juliflora* of 3 years and lower age very much behaved as soft wood in its pulping properties. With 15% Na_2O as TAA (Table—III Sl. No. 5b), a fairly soft pulp of Kappa No 28 could be produced. Rejection was a bit higher, being 4.3%. With 17% Na_2O as TAA, Kappa No. of resulting pulp (Sl. No. 5a) was 24.2. Unbleached pulp yield was 48.27%. This pulp consumed 6% total Cl_2 in CEHH system of bleaching (Table—IV, Sl. No. 5a) to give bleached pulp yield of 41.8% (on b.d. chips weight), with a fairly good brightness of 77.5° GE.

(b) *Prosopis juliflora* (young) pulp was found weak in strength properties (Table—V, Sl. No. 5a) giving breaking length below 5000 M and Double Fold number below 45.

(c) Fibre classification tests also (Table—II, Sl. No. 5a) showed short-fibre diminance in its pulp having more than 72% fibre passing through 60 mesh.

5. (a) *Acacia auriculiformis* was found to be a good wood giving easily pulpable and bleachable pulp (Table—II, Sl. No.1) with more than 65% fibre retained on 60 mesh. With 16% TAA as Na_2O, bleachable grade pulp of Kappa Number 26.9 could be made, with an unbleached yield of 47–48% (on b.d. wt. of chips) Table—III, Sl. No. 1) four-stage (Impregnation) cooking produced slightly harder pulp.

(b) With 8–9% total Cl_2 consumption, a fairly good bright pulp of 77–78° GE, could be produced with 37–38% bleached pulp yield (on b.d. weight of chips).

(c) Both unbleached and bleached pulps of *Acacia auriculiformis* showed fairly good strength properiies (Table—V, Sl. No. 1 a and b). Unbleached pulp possessed breaking length around 7000 M, D.F. 52–55, and B.F. 40–44 whereas bleached pulp showed slightly lower figures.

6. (a) Young Teak wood logs and trimmings from new plantations were found to possess fairly satisfactory pulping properties. Since the bark is thin and light coloured, the logs could be pulped without debarking. With 16% TAA as Na_2O, an easily bleachable pulp of Kappa No. 35.6 could be made giving unbleached yield of 43.7% (on b.d. wt. of chips). With 8.8% total chlorine consumption, bleached pulp of 79° GE brightness was produced giving bleached pulp yield of 37.8% (on b.d. wt. of chips) (Table—IV, Sl. No. 8).

(b) Strength properties of young Teak wood were found to be low, B.L. around 5000 M, D.F. being 10–20 and B.F. around 26–28 (Table—V, Sl. No. 8).

7. (a) *Pongmia pinnata* (Karanj) showed comparatively inferior pulping properties. With 16% TAA as Na_2O, a bleachable grade pulp of 33.3 Kappa No. and 45% unbleached pulp yield (on b.d. wt. of chips) (Table — III, Sl. No.4) could be made. Rejection was found to be appreciably high (5.35%).

(b) Bleach consumption of Unbleached *Pongamia pinnata* pulp was also found to be high, i.e. 15.8% (Table—IV, Sl. No.4), with bleached pulp yield of 36% (on b. d. wt. of chips).

(c) Strength properties of both unbleached and bleached pulps from *Pongamia pinnata* were found to be comparatively poorer (Table—V, Sl. No. 4), having B.L. below 5000M, D.F. around 50 and B.F. around 30.

8. (a) *Schleichera trijuga* (Pusku or Kusum) was found to possess higher alkali demand to produce bleachable grade pulp. With 18% TAA as Na_2O, bleachable grade pulp of 36.3 Kappa No. was produced, giving unbleached pulp yield of 48.8% (Table—III, Sl. No. 6). With 16% TAA, rejections as well as Kappa No. were found to be high.

(b) *Schleichera trijuga* pulp of Kappa No. 36.3 comsumed 13% total chlorine by CEHH system (Table —VI to yield 42.7% bleached pulp (on b.d. wt. of chips) and 79° GE brightness.

Bleached pulp Viscosity was found comparatively low, being only 4.8 Cp (with 0.5% C.E.D.).

(c) *Schleichera trijuga* pulps, both unbleached and bleached showed comparatively lower strength properties (Table—V Sl. No. 5b).

9. (a) *Prosopis juliflora* of older than 3 years age, which possessed thick cracked bark and dark heart wood (Table—I , Sl. No. 5b), was found difficult

TABLE — I

PHYSICAL QUALITIES OF WOODS TESTED

Sl. No.	Botanical name of wood	Local Name	Appearance and bark characteristics	Chipping quality	Bulk density of debarked wood (chips) Kgs/M³ (B.D. basis)
1.	*Acacia auriculiformis*	—	Light coloured wood with light brown heart wood portion and thin bark.	Normal chipping	256.7
2.	*Albizia lebbeck*	Siris	Whole body of log one colour. Light ash coloured thin bark, smooth in structure and soft.	Easy chipping	212.6
3.	*Gliricidia meculata*	—	Thin bark wood, central portion is dark brownish.	Easy chipping	256.0
4.	*Pongamia pinnata*	Karanj	Light yellow coloured wood with thin, smooth ash coloured bark.	Easy chipping	231.0
5.	(*a*) *Prosopis juliflora* (Young)	Tumma	Thin bark with light colour. Heart portion is light brown.	Easy chipping.	247.0
	(*b*) *Prosopis juliflora* (old)	Tumma	Thick bark with dark colour central portion is dark brownish, heart portion covered by light brown colour.	Hard chipping	324.0
6.	*Schleichera trijuga*	Pusku or Kusum	Whole log of light brown colour with thick cracked bark.	Easy chipping	272.5
7.	*Sesbania grandiflora*	Dhaincha	Thin dull white bark of younger crop. Thick brownish white bark of old plants.	Easy chipping	170.0
8.	*Tactona grandis* (young)	Teak	Thin bark havng no heart wood; throughout the log is light brown.	Easy cippng	190.0
9.	*Xylia xylocarpa*	Bojja	Light brown coloured heart wood.	Easy chipping	288.0

TABLE—II

FIBRE CHARACTERISTICS OF HARDWOODS TESTED

Sl. No.	Name of Hardwood		Fibre Classification			
			% Fibre +40 mesh	% Fibre —40 +60 mesh	% Fibre —60 + 80 mesh	% Fibre —80 mesh
1	2		3	4	5	6
1.	*Acacia auriculiformis*	(*a*) Unbld.	28.0	39.6	13.7	18.7
		(*b*) Bld.	23.0	52.3	8.7	16.0
		Fibre Dimension :		Max.	Ave.	Min.
		Length (mm)		0.99	0.795	0.6
		Diameter (Microns)		18.0	15.3	12.1
		Slanderness Ratio			**51.9**	
2.	*Albizia lebbeck*	(*a*) Unbld.	43.0	48.2	9.2	19.0
		(*b*) Bld	26.0	51.2	6.8	16.0
		Fibre Dimension :		Max.	Ave.	Min.
		Length (mm)		1.42	1.05	0.62
		Diameter (Microns)		22.45	15.64	9.0
		Slandernes Ratio			**67.1**	

1	2	3	4	5	6	7
3.	*Gliricidia meculata*	(*a*) Unbld.	16.6	47.8	7.0	28.6
		(*b*) Bld.	—	—	—	—
		Fibre Dimension :		Max.	Ave.	Min.
		Length (mm)		1.085	0.883	0.543
		Diameter (Microns)		24.4	18.68	10.6
		Slanderness Ratio			**41.8**	
4.	*Pongamia pinnata*	(*a*) Unbld.	52.2	8.2	16.6	23.0
		(*b*) Bld.	52.3	20.2	11.2	16.4
		Fibre Dimension :		Max.	Ave.	Min.
		Length (mm)		1.53	1.29	1.08
		Diameter (Microns)		27.6	15.0	9.0
		Slanderness Ratio			**86.0**	
5. (*a*)	*Prosopis juliflora* (young)	(*a*) Unbld.	22.4	5.6	35.1	36.9
		(*b*) Bld.	25.45	5.24	32.68	36.63
		Fibre Dimension :		Max.	Ave.	Min.
		Length (mm)		1.5	0.81	0.67
		Diameter (Microns)		11.4	12.6	9.0
		Slanderness Ratio			**64.2**	
(*b*)	*Prosopis juliflora* (Old)	(*a*) Unbld.	23.4	6.8	34.4	35.4
		(*b*) Bld.	32.52	6.6	27.42	33.46
		Fibre Dimension :		Max.	Ave.	Min.
		Length (mm)		1.61	0.82	0.70
		Diameter (Mcrons)		15.2	12.63	9.1
		Slanderness Ratio			**64.0**	
6.	*Schleichera trijuga*	(*a*) Unbld.	51.3	16.9	18.8	13.2
		(*b*)Bld.	52.8	21.2	16.8	9.2
		Fibre Dimension :		Max.	Ave.	Min.
		Length (mm)		0.96	0.87	
		Diameter (Microns)	1.65	21.5	16.6	9.0
		Slanderness Ratio			**58.0**	
7.	*Sesbania grandiflora*	(*a*) Unbld.	48.8	27.4	8.2	15.6
		(*b*) Bld.	8.0	18.0	43.6	30.4
		Fibre Dimension :		Max.	Ave.	Min.
		Length (mm)		2.17	1.23	0.6
		Diameter (Microns)		30.6	20.5	9.0
		Slanderness Ratio			**60.0**	
8.	*Tactona grandis* (Teak) (Young)	(*a*) Unbld.	40.4	42.4	9.2	18.4
		(*b*) Bld.	33.4	48.6	9.4	8.6
		Fibre Dimension :		Max.	Min.	Ave.
		Length (mm)		1.5	0.98	0.6
		Diameter (microns)		32.2	18.4	13.8
		Slanderness Ratio			**53.2**	
9.	*Xylia xylocarpa*	(*a*) Unbld.	50.6	15.7	6.8	26.9
		(*b*) Bld.	39.2	19.1	11.4	30.3
		Fibre Dimension :		Max.	Ave.	Min.
		Length (mm)		1.0	0.89	0.62
		Diameter (Microns)		24.8	18.7	11.7
		Slanderness Ratio			**42.3**	

TABLE — III

COOKING CONDITIONS ADOPTED FOR HARD WOODS

Sl. No.	Test Cook No.	Name of Hardwood	Alkali taken TAA % as Na_2O	Total effective alkali T.E.A.% as Na_2O	BLACK LIQUOR °TW	Temp. °C	Residual Alkali Na_2O gpl	P. No.	Kappa Number	Unbld. yield % (on b.d. wt. of chips)	Rejects %	Viscosity in Cp at 20° C 0.5% CED	Copper Number
1		2	3	4	5	6	7	8	9	10	11	12	13
1.	a)	Acacia auriculiformis (Two stage)	16.0	13.44	7.0	87.0	10.8	17.7	26.9	47.4	2.05	11.3	0.83
	b)	**Acacia auriculiformis** (Four Stage)	16.0	13.46	10.0	82.0	10.5	18.6	32.3	48.3	1.89	10.8	0.48
2.	a)	**Albizia lebbeck** (Two Stage)	16.0	13.48	10.2	83.0	10.5	14.4	23.4	50.42	3.1	18.5	0.78
	b)	**Albizia lebbeck** (Four stage)	16.0	13.43	9.0	82.0	11.2	16.5	27.3	49.6	5.83	18.2	0.69
	c)	**Albizia lebbeck** (Two stage)	14.0	12.04	9.5	78.0	10.9	17.0	28.9	48.3	7.8	19.2	0.63
	d)	**Albizia lebbeck** (Four stage)	14.0	12.0	8.5	81.0	10.1	19.0	38.4	47.8	8.3	18.3	0.70
3.	a)	**Gliricidia meculata** (Four stage)	16.0	14.5	12.5	78.5	10.54	32.2	70.4	50.0	6.2	—	1.68
	b)	**Gliricidia meculata** (Two stage)	18.0	16.5	11.75	84.0	10.85	31.2	58.8	48.9	4.35	—	1.78
4.		**Pongamia pinnata** (Two stage)	16.0	14.2	12.0	79.0	10.2	18.8	33.3	45.0	5.35	24.71	0.44
5.	a)	**Prosopis juliflora** (young) (Two stage 5 hrs. cook)	17.0	15.73	8.25	85.0	12.4	15.0	24.2	48.27	1.45	17.64	0.29
	b)	**Prosopis juliflora** (young) (Two stage)	15.0	13.85	5.0	84.0	9.3	16.82	28.1	46.50	4.3	15.84	0.30
	c)	**Prosopis juliflora** (o/d) (Two stage)	10.0	9.18	4.5	88.0	7.75	Very difficult in cooking, further tests abandoned.					
	d)	**Prosopis juliflora** (old) (wastage)	15.0	13.82	7.5	85.0	7.75	24.4	41.6	48.92	5.75	—	0.52
6.	a)	**Schleichera trijuga** (Two Stage)	16.0	14.4	12.0	85.0	9.3	19.0	43.0	39.6	14.03	10.5	0.84
	b)	**Schleichera trijuga** (Two stage)	18.0	16.3	8.0	90.0	11.80	18.0	36.3	48.8	3.0	15.4	1.08
7.	a)	**Sesbania grandiflora** (Two Stage) (3 hours cooking)	12.0	11.02	8.0	87.0	12.4	24.9	35.1	47.0	2.5	9.52	1.02
	b)	**Sesbania grandiflora** (Two stage) (4 hours cooking)	12.0	11.04	6.0	87.0	9.6	25.1	36.2	48.0	1.5	24.27	0.7
8.		**Tactona grandis**-Teak (Young) (Two stage)	16.0	13.40	9.0	83.0	10.2	17.2	35.6	43.7	0.93	20.4	0.38
9.		**Xylia xylocarpa** (Four stage)	16.0	14.4	7.5	80.0	12.4	33.0	70.46	50.13	3.9	5.2	1.52

TABLE—IV

CONDITIONS OF BLEACHING ADOPTED FOR HARDWOODS

Sl. Test Cook No.	Name of Hardwood	Bleaching Stage	Chlorine consumed %	Total Retention time (minutes)	pH maintained	% NaOH taken for extraction (on b.d. wt. of pulp)	Brightness achieved °GE	Bleached yield (on b.d. wt. of chips) %	Viscosity in Cp at 20° C (0.5% CED)	Copper Number
1	2	3	4	5	6	7	8	9	10	11
1.	(*a*) **Acacia auriculiformis** (TAA 16% Two Stage Cooking)	*a*) Chlorination	5.0	30	2.5	—				
		b) Extraction	—	60	11.0	2.5				
		c) I-Hypo	2.5	180	9.5–10.0	1.0				
		d) II-Hypo	0.53	180	9.0–9.5	0.5	78.0	37.6	12.2	0.36
			8.03	450		4.0				
	(*b*) **Acacia auriculiformis** (TAA 16% Four Stage Cooking)	*a*) Chlorination	5.6	30	2.3	—				
		b) Extraction	—	60	11.0	2.5				
		c) I-Hypo	2.8	180	9.5–10.0	1.0				
		d) II-Hypo	0.75	180	9–9.5	0.5	77.5	38.1	11.6	0.38
			9.15	450		4.0				
2.	(*a*) **Albizia lebbeck** (TAA 16% Two Stage Cooking)	*a*) Chlorination	5.0	30	2.3	–				
		b) Extraction	–	60	11.0	2.5				
		c) I-Hypo	2.1	180	9.5–10.0	1.0				
		d) II-Hypo	0.9	180	9–9.5	0.5	81.0	40.2	7.3	1.6
			8.0	450		4.0				
	(*b*) **Albizia lebbeck** (TAA 16 % Four stage cooking)	*a*) Chlorination	5.0	30	2.5	—				
		b) Extraction	—	60	11.0	2.5				
		c) I-Hypo	2.0	180	9.5-10.0	0.9				
		d) II-Hypo	1.3	180	9–9.5	0.5	82.0	40.7	6.7	2.34
			8.3	450		3.9				
	(*c*) **Albizia lebbeck** (TAA 14% Two Stage Cooking)	*a*) Chlorination	5.21	30	2.3	—				
		b) Extraction	—	60	11.0	2.5				
		c) I-Hypo	3.9	180	9.5–10.0	0.9				
		d) II-Hypo	1.4	180	9–9.5	0.3	78.0	39.6	4.9	2.7
			10.51	450		3.7				
	(*d*) **Albizia lebbeck** (TAA 14% Four Stage Cooking)	*a*) Chlorination	5.2	30	2.5	—				
		b) Extraction	—	60	11.0	2.5				
		c) I-Hypo	4.0	180	9.5–10.0	0.8				
		d) II-Hypo	2.0	180	9–9.5	0.7	81.5	38.2	5.8	2.24
			11.2	450		4.2				
3.	**Gliricidia meculata**		Difficult to bleach.							
4.	**Pongamia pinnata**	*a*) Chlorination	7.8	30	2.3	—				
		b) Extraction	—	60	11.0	2.5				
		c) I-Hypo	4.98	180	9.5–10.0	0.5				
		d) II-Hypo	3.0	45	9–9.5	0.5	76.0	36.0	12.73	0.704
			15.8	315		3.5				
5.	(*a*) **Prosopis juliflora** (Young) (17% TAA)	*a*) Chlorination	4.87	30	2.5	—				
		b) Extraction	—	60	11.0	2.5				
		c) I-Hypo	1.06	180	10–10.5	0.7				
		d) II-Hypo	0.1	180	10–10.5	0.25	77.5	41.8	6.84	0.33
			6.03	450		3.45				
	(b) **Prosopis juliflora** (old) (15% TAA)	*a*) Chlorination	4.99	30	2.5	—				
		b) Extraction	—	60	11.0	2.5				
		c) I-Hypo	1.91	180	10–10.5	0.5				
		d) II-Hypo	0.67	180	10–10.5	0.30				
			7.57	450		3.05	76.0	39.5	7.6	0.17
	(c) **Prosopis juliflora** (old)	*a*) Chlorination	8.32	30	2.5	—				
		b) Extraction	—	60	11.0	2.5				
		c) I–Hypo	2.75	180	10–10.5	0.15	75.0	42.1	4.83	0.97
			11.07	20		2.65				
6.	**Schleichera trijuga**	*a*) Chlorination	8.0	30	2.5	—				
		b) Extraction	—	60	10–10.5	2.5				
		c) I–Hypo	5.0	180	8.5–9.0	0.5	79.0	42.7	4.8	1.0
			13.0	270		3.0				
7.	(a)**Sesbania grandiflora** (3 hrs. cooking)	*a*) Chlorination	8.7	30	2.5	—				
		b) Extraction	—	60	11.0	3.5				
		c) I–Hypo	2.2	180	10–10.5	0.2				
		d) II–Hypo	1.7	180	9–9.5	0.1	80.0	39.7	6.29	1.5
			11.6	450		3.8				
	(b) **Sesbania grandiflora** (4 hours cooking)	*a*) Chlorination	8.0	30	2.5	—				
		b) Extraction	—	60	11.0	3.5				
		c) I–Hypo	2.05	180	10–10.5	0.2				
		d) II–Hypo	0.95	180	9–9.5	0.1	76.0	40.3	7.2	0.35
			11.0	450		3.8				
8.	**Tactona grandis** Teak (Young)	*a*) Chlorination	5.2	30	2.5	—				
		b) Extraction	—	60	11.0	2.5				
		c) I–Hypo	2.5	180	9.5–10.5	1.0				
		d) II–Hypo	1.1	180	10–10.5	0.4	79.0	37.8	7.2	1.4
			8.8	450		3.9				
9.	**Xylia xyiocarpa**	*a*) Chlorination	8.0	30	2.5	—				
		b) Extraction	—	60	10.0	2.5				
		c) I–Hypo	5.4	180	9–10.0	1.0				
		d) II–Hypo	Not consumed	180	9–10.0	0.5	52.0	37.2	5.4	0.59
			13.4	450		4.0				

TABLE — V

STRENGTH PROPERTIES OF HARDWOODS PULP.

Serial Test Cook No.	Name of the wood	Quality of pulp	Substance gms/cm^2	Caliper mm	Burst Factor	Tear Factor	Breaking Length (Meters)	Folding Endurance (Double folds
	2	3	4	5	6	7	8	9
1	a) **Acacia auriculiformis** (TAA 16% Two Stage Cooking)	a) Unbld	62.0	0.1	44.2	56.7	7602	55
		b) Bld.	65.0	0.1	35.4	39.4	5538	31
	b) **Acacia auriculiformis** (TAA 16% Four Stage Cooking)	a) Unbld.	61.0	0.09	40.0	52.4	7268	52
		b) Bld.	60.0	0.08	32.5	38.4	5448	32
2	a) **Albizia lebbeck** (TAA 16% Two Stage Cooking)	a) Unbld.	60.0	0.08	50.0	56.0	7444	161
		b) Bld	63.0	0.08	33.0	35.5	6397	45
	b) **Albizia lebbeck** (TAA 16% Four Stage Cooking)	a) Unbld.	64.0	0.09	49.2	53.7	7635	224
		b) Bld.	63.0	0.08	43.4	38.1	6790	34
	c) **Albizia lebbeck** (TAA 14% Two Stage Cooking)	a) Unbld.	60.0	0.08	46.6	53.3	7066	112
		b) Bld.	59.0	0.07	17.0	19.8	5310	18
	d) **Albizia lebbeck** (TAA 14% Four Stage Cooking)	a) Unbld.	61.0	0.08	41.0	55.0	7000	98
		b) Bld.	62.0	0.08	30.0	18.2	5558	12
3	a) **Gliricidia meculata** (TAA 16% Four Stage Cooking)	a) Unbld.	66.0	0.14	22.7	38.2	4081	4
	b) **Gliricidia meculata** (TAA 18% Two Stage Cooking)	b) Unbld.	65.0	0.12	25.4	26.9	4416	5
4	**Pongamia pinnata** (TAA 16% Two Stage Cooking)	a) Unbld.	64.0	0.09	31.0	50.0	4480	51
		b) Bld	60.0	0.08	30.0	46.0	4555	34
5.	a) **Prosopis juliflora** (Young) (TAA 17% Two Stage 5 hrs.)	a) Unbld.	67.0	0.09	25.4	47.8	4378	41
		b) Bld.	61.0	0.085	29.2	36.7	4743	41
	b) **Prosopis juliflora** (Young) (TAA 15% Two Stage 5 hrs.)	a) Unbld.	60.0	0.105	33.7	42.5	5066	58
		b) Bld.	65.0	0.09	26.2	44.3	4062	63
	c) **Prosopis juliflora** (old) (TAA 15% Two Stage 4 hours)	a) Unbld.	63.0	0.12	20.9	55.9	3761	21
		b) Bld.	61.0	0.10	23.0	36.7	4262	10
6	a) **Schleichera trijuga** (TAA 16% Two Stage Cooking)	a) Unbld.	63.0	0.14	23.8	54.0	4867	15
	b) **Schleichera trijuga** (TAA 18% Two Stage Cooking)	a) Unbld.	62.0	0.13	22.6	51.6	4527	10
		b) Bld.	64.0	0.10	20.3	45.3	4580	12
7	a) **Sesbania grandiflora** (TAA 12% Two Stage 3 hours)	a) Unbld.	63.0	0.10	40.3	45.7	7386	183
		b) Bld.	68.0	0.095	39.1	38.8	9255	143
	b) **Sesbania grandiflora** (TAA 12% 2 Stage 4 hrs.)	a) Unbld.	67.0	0.12	44.8	47.8	6966	332
		b) Bld.	65.0	0.1	36.3	36.9	6810	153
8	**Tactona grandis** Teak (Young) (TAA 16% 2 Stage Cooking)	a) Unbld.	57.0	0.09	28.1	56.1	5555	20
		b) Bld.	60.0	0.08	26.7	31.0	5000	10
9	**Xylia xylocarpa** (TAA 16% Four Stage Cooking)	a) Unbld.	65.0	0.12	16.3	54.1	4861	5
		b) Bld.	64.0	0.085	25.0	29.0	4166	16

Note—1. In Column 2, % TAA indicated in brackets shows the alkali used in cooking as given in Table—III.

2. During bleaching tests, temperature in Chlorination and Hypo was maintained at room temperature (around 28°–30°C) and in Extraction with NaOH, temperature was kept around 70–75°C.

3. In all the bleaching tests, chlorination was at the rate of 60–65% of total chlorine demand.

TABLE — VI

PULPING AND PAPER MAKING CHARACTERISTICS OF A RAW MATERIAL FOR CHEMICAL PULP.

No	Variants Suitability Factors	Grade 1 Norms	(100) points	Grade II Norms	(50) points	Grade III Norms	(25) points	Grade IV Norms	(12.5) points
					Gradients				
1.	Chipping quality	Normal	100	Slightly hard	50	Hard	25	Too hard	12.5
2.	Bulk Density (Kg/M^3)	200(±30) & above	100	170-150	50	150–120	25	120	12.5
3.	Alkali demand (as Na_2O) TAA % on B.D. chips	160 and less	100	18.0 & above	50	20	25	22	12.5
4.	Knots Rejects (% on chips)	1.0 and less	100	1–2	50	2–4	25	4	12.5
5.	Permanganate Number	18 (±2) or less	100	18–22	50	20-30	25	30	12.5
6.	% Yield on B.D. chips								
	a) Unbleached	44.0 or more	50	42 (±2)	25	37(±3)	12.5	30 (±3)	6.25
	b) Bleached	40.0 or more	50	37 (±2)	25	30(±4)	12.5	25	6.25
7.	Bleachability of pulp	Easy (78° GE)	100	Slightly difficult (73°GE±3)	50	Bleachable with difficulty (68°GE±3)	25	Partially bleachable (with shives)	12.5
8.	Fibre characteristics :								
	a) Fibre classification								
	i) +0 mesh —%	40 or more	25	25–40	12.5	15–25	6.25	15	3.1
	ii) —80 mesh —%	30 or less	25	30–35	12.5	35–40	6.25	40	3.1
	b) Slanderness ratio L/D	100 and above	50	50–100	25	30–50	12.5	30	6.3
9.	Strength properties (Unbld.)								
	a) Breaking length (m)	5000 and above	25	4500–3500	12.5	2000–3500	6	2000	3.1
	b) Burst factor	25 and above	25	20–25	12.5	15–20	6	2000	3.1
	c) No. of double folds	25 and above	25	20–25	12.5	10–20	6	10	3.1
	d) % Stretch	25 and above	25	1.5–2.5	12.5	1–1.5	6	1.0	3.1

Note:—1. All data to be taken on bone-dry (B.D.) basis.

2. Testing standards followed as per Tappi specifications.
3. In CEH system of bleaching, chlorination to make with 60–70% of total chlorine demand by gas chlorine and rest by calcium hypochlorite bleach liquor.
4. In fibre-classification, data are taken on B.D. wt. of unbld., screened unbeaten pulp.
5. In TAA demand, expected sulfidity in cooking liquid is to be kept around 20%.

TABLE — VII

PULPING CHARACTERISTICS OF SOME HARD WOODS.

Sl No	Name of Wood	Chipping quality		Bulk density	Alkali demand on	Knots rejects %	Permanganate	% yield on b.d.wt.chips		Bleachability	Fibre classification		Slanderness	Strength properties of Unbleached sheets.			
		Very Hard/	Normal	Kg/M³ (on b.d. wt. of chips)	b.d. wt of chips (TAA % as Na_2O)	on b.d. wt. of chips	Number	Unbld.	Bld.	of pulp CEHH/ CEH	+40 mesh %	—80 mesh %	ratio	B.L. m.	B.F.	No. of D.F.	Stretch %
1.	**Acacia auriculiformis**		X	256.7	16.0	2.0	17.7	47.4	37.6	Easy	28.0	18.7	51.9	7602	44.2	55	3.0
2.	**Albizia lebbeck (Siris)**		X	242.6	16.0	3.1	14.4	50.4	40.2	Easy	33.0	19.0	67.1	7444	50.0	161	—
3.	**Gliricidia meculata**		X	256.0	18.0	4.3	31.2	48.9	—	Very difficult	16.6	28.6	41.8	4416	25.0	5	2.0
4.	**Pongamia pinnata** (Amla)		X	231.0	16.0	5.35	18.8	45.0	36.0	Easy	52.8	16.4	86.0	4480	31.0	51	1.8
5.	**Prosopis juliflora**																
	a) Young		X	247.0	17.0	4.3	17.0	48.0	41.0	Easy	22.4	36.9	64.2	5066	33.0	58	3.56
	b) Old	X	X	324.0	15.0	1.5	24.4	48.0	29.0	Very Difficult	22.0	35.0	64.0	3761	20.0	21	3.2
6.	**Schleichera trijuga**		X	272.5	18.0	3.0	18.0	48.8	42.7	Easy	51.3	13.2	58.0	4567	22.6	10	2.2
7.	**Sesbania grandiflora**		X	170.0	12.0	1.5	25.1	48.0	40.3	Easy	48.8	8.2	60.0	6966	44.8	33	2.8
8.	**Tectona grandis** Teak (Young)		X	190.0	16.0	0.9	17.2	43.7	32.7	Easy	18.8	30.2	—	5555	28.1	20	—
9.	**Xylia xylocarpa**		X	288.0	16.0	3.9	33.0	50.1	37.6	Difficult	50.6	26.9	42.3	4961	16.3	5	1.4

to cook (Table—III, Sl. No. 5 c & d). With 15% TAA as Na_2O, pulp produced possessed Kappa No. of 41.6 and rejection was fairly high.

(b) Bleach consumption of old *Prosopis juliflora* pulp was about 11% when brightness of the bleached pulp could not go beyond 75° GE (Table—IV. Sl. No 5c). Viscosity of bleached pulp was found to be low, being only 4.83 Cp (with 0.5% CED).

(c) Strength properties of this pulp were found appreciably low (Table —V, Sl. No. 5c) having B.L. below 4300 M. and B.F. below 23.

10. (a) *Gliricidia meculata* could not be cooked to bleachable grade pulp with even 18% TAA as Na_2O when Kappa No. of the pulp produced was 58.8 and rejects above 4%. This pulp did not respond well to CEHH system of bleaching and could not be bleached (Table—IV, Sl. No.3).

(b) Unbleached pulp showed weak strength properties (Table—V, Sl. No. 3a, b).

11. *Xylia xylocarpa* (Bojja) also was found unsuitable for making bleachable grade pulp by Kraft process of cooking (Table—III, Sl. No. 9, Table—IV Sl. No. 9). Its alkali demand was also high and strength properties poor (Table V, Sl. No. 10).

TABLE—VIII

SUITABILITY OF RAW MATERIALS FOR PULPING

Name of Raw Materials		Total number of points achieved (as per suitability factor)
GRADE I	(Above 700 points)	
2	**Albizia lebbeck**	762.5
7	**Sesbania grandiflora**	750.0
5	(*a*) **Prosopis juliflora** (young)	719.0
1	**Acacia auriculiformis**	712.5
8	**Tactona grandis** (Teak—Young)	707.0
GRADE II	(700 to 500 points)	
4	**Pongamia pinnata**	687.5
6	**Schleichera trijuga**	653.0
5	(*b*) **Prosopis juliflora** (Old)	506.0
GRADE III	(500 to 350 points)	
3	**Gliricidia meculata**	390.6
9	**Xylia xylocarpa**	362.2
GRADE IV	(Below 350 points) NIL	

higher alkali demand with poorer pulp strength properties (Table—VII, Sl. No. 4 and 6). Obviously according to our Method of Grading these woods were evaluated as II gr. wood for making bleachable grade pulp.

3. Old *Prosopis juliflora,* above 3–3.1/2 years age was found not very good wood for making bleachable grade pulp. Although in our Method of Grading, this occupied lowest place in Group II, yet its fluctuating quality containing dark thick cracked bark, deep coloured heart wood and very short fibre (Table—VII Sl. No. 5 b) having only 22% retained on 40 mesh, proves undependable in normal consumption. With large portion of deep coloured heart wood, the bleaching of its pulp have been found very difficult by the conventional CEHH system.

4. (a) *Gliricidia meculata* and *Xylia xylocarpa* were found very inferior woods and unfit for making bleachable grade pulps. Their alkali demand was found higher, harder in chipping and difficult to bleach (Table—VII, Sl. No.3 and 9).

CONCLUSIONS

With the help of the Tentative Grading Method for Hardwoods (3), when applied to above mentioned observations, as detailed in Table—VI and Table VII, we could draw following conclusions about the suitability of hardwood species discussed in this paper.

1. (a) *Albizia lebbeck, Sesbania grandiflora,* young *Prosopis juliflora* plants and *Acacia auriculiformis* are fairly good woods which with 15% Na_2O as T.A.A. (and average 16% sulphidity) produce easily bleachable grade pulp. Pulp yield from these woods comes around 47–48% (on b.d. wt. of chips) of unbleached pulp and 36–40% of bleached pulp.

(b) Strength properties of *Acacia auriculiformis, Albizia lebbeck* and *Sesbania grandiflora* pulps are fairly good comparing well with bamboo.

Fibre content retained on 60 mesh is also fairly satisfactory for these pulps which is generally above 60% except in case of *Prosopis juliflora* whose fibre in general is very short being only below 30% retained on 60 mesh.

(c) Young Teak wood (*Tactona grandis*) gave fairly satisfactory pulping properties and low alkali demand (Table—VII, Sl. No. 8) of 16% Na_2O as TAA. But its fibre was found comparatively very short and strength properties also comparatively lower.

2. *Pongamia pinnata* and *Schleichera trijuga* showed

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