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RAW MATERIALS FOR PULP AND PAPER INDUSTRY

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Communication between man and man is a must for the development of the world of yesterday, today and tomorrow. Speech supplemented by written of printed records plays an important role in communication of thoughts from one generation to the another. Paper though of comparatively recent origin has undoubtedly been the principal medium for such records and communications. Paper consumption at any time is an indication of the socio-economic development of the country and hence its civilization.

The basic raw material for the production of pulp and paper is the cellulose in the form of fibres. Cellulose fibres is the main constituent of nearly evey plant life. There are however numerous factors which limit the

actual selection of the raw material for the large scale paper manufacture, Some of the salient points to be considered are as under :

1. The plant must be plentiful.
2. Continuity of supply of the plant must be assured.
3. The logging and extraction of the material to the mill site must be easy to carry out at economic level.
4. The location of the material should be in the proximity of the mill so that the lead is minimum.
5. Other industries should not compete for the use of this plant.
6. The material should be cheap.
7. It should not deteriorate during storage.
8. The amount of the fibre that can be economically extracted from the plant should be high.
9. The fibre must be of suitable size and character for making particular type of paper. Taking the above factor into consideration different raw materials have played an important role in the development of the paper industry in this country depending on its demand. Broadly the raw materials are as under :-
   (i) Rag era (1420-1870)
   (ii) Grass era (1870-1925)
   (iii) Bamboo era (1925 ....)
   (iv) Wood and Agriculture residues era. (1964 ....)

The changing of Pattern of fibreous raw materials by Pulp and Paper Industry since 1924 is detailed in Table-1.

see page 11

Rags

Rags are even used today to a limited extend due to its limited availability for making speciality papers as it has high inherent strength.

Grasses

Sabai grass has been one of the main fibrous raw materials in India and has been used to the extent of 25 percent of the total fibrous raw material requirement in India. Extraction of single species of grass is uneconomical as grasses occur mostly in mixture in large tracts of lands. Utilisation of the mixture of grasses for the production of writing and printing papers will not only give a perspective economic value to a large tract of land hitherto considered unproductive but will also meet the demand for more resources for pulp and paper. Mixtures of grasses growing in the large scale mechanized plantation of forests can also be available to the paper industry.

Bamboo

It was in 1909 that Sir R. S. Pearson, Forest Economist F. R. I. Dehradun made an extensive survey of some of the Principal Bamboo areas in India & Burma and published his findings in 1913. In 1910 Shri W. Raitt started experimenting with the pulping of bamboo and developed fractional methods of pulping by Soda and Sulphate process. These results were confirmed by Pilot Plant trials carried out at F. R. I. in 1925. These surveys and researches served to place at the disposal of the industry a raw material which was available in plentiful supplies, almost in perpetuaty and on which therefore the growth and development of the industry could depend at that time. Bamboo forms a rich belt of vegetation upto 4,000 m altitude. Their distribution is quite dense in W. Ghats, Bengal, Sikkim, Arunachal Pradesh and Andamans. The Total number of species in India both wild and cultivated by seeds or offsets are 140 and the principal genera are *Arundinaria, Bambusa, Dendrocalamus, Cephalo Stachym, Melocanna* and *Ochlandrii.* The paper industry uses mainly *D. strictus and Bambusa arundinacea.* At present about 2 million tonnes is used by the industry. More of Bamboo could perhaps be made available for the paper industry by

(1) increased production of bamboo by scientific management,
(2) making more bamboo areas accessible and
(3) creation of new bamboo plantations on all suitable barren lands not utilized for any other better purpose.

Chemical composition of some important species of bamboos and pulps alongwith chemicals used in pulping, Kappa No. and Pulp yields are recorded in table II. While fibre characteristics and strength properties of both unbeaten and beaten pulps are recorded in table III & IV respectively. On scrutiny and analysis of the results recorded in tables it is seen that :

1. Lignin content of different species varies within a narrow limit of (24 + 3%) and pentosan varies with in a narrow limit of (19.5 + 3.5%). It is possible that these differences are due to variations within and between clums and age and other factors like locality etc.
2. The unbleached Yield of pulp from nine species varies within a narrow limit of 52 + 3%. These variations may be due to the variations in the culms in case of *Bamboosa Vulgaris, Bamboosa polymorpha* and *Malocanna baciferra* the yield was about 44%. The reason for this low yield in these species is not clearly understood but it requires confirmation if this is due to lower specific gravity.
3. A variation in the fibre length, diameter and luman width are pointing that these may be due to heterogenous nature of these materials. It is also observed that paranchyma proportion varies within a narrow limit of 21.5 + 4.5%.
4. The strength properties and their improvements on beating is not related to the fibre dimensions, but it may be said that the thinner walled fibres often give higher strength value than the thicker walled ones.

Hardwoods

As the availability of bamboo for further expansion of paper industry would alone be not adequate so the attention was diverted to hard woods which are either occuring in our forest or are being raised in plantations. Total forest area in India is nearly 6,99,300 Sq. Kms. and is broadly classified as under :

Temperature	Tropical
Coinfers 3%	Evergreen 12%
Broad leaved 4%	Deciduous 80%
	Others 10%
Total 7%	Total 93%

As the conifers are occuring at high altitudes and rugged terrains, the extraction and transportation cost to the mill site will be very high and hence their utilization is not possible except in limited cases for making speciality papers.

The above classification shows that bulk of our forests are deciduous hardwoods. Using these & forests resources will not only help in attaining the increased productio but will also help in the improvement of our forests.

A large number of species of woods may occur in one and the same forest and may not yeild a particular species in sufficient quantity for economic expoloitation so possibilities of using mixed hardwoods for the production of sulphate pulps suitable for wrapping and writing & printing papers were investigated with encouraging results. The annual growth rate is 0.5 m^3. per hectare in case of natural forests while in case of plantation it may vary from 3.0 to 7.0 m^3 per hectare. As the mortality of the mono culture plantations is high steps may be taken to raise suitable mix cultures in the various industrial catchment areas detailed in App. I. Above 40% of the raw materials used by the big mills is hardwoods these days.

In table V to X the results of the investigations carried out on the laboratory as well as on the pilot plant for the production of wrapping papers and writing in printing paper from hardwoods both individual and mixed hardwoods are detailed.

Work done on Production of Wrapping Paper

The optimum studies of pulping and strength properties of pulp prepared from hardwoods for production of wrapping papers are recorded in Table V.

It is clear that the yield of the pulp varies from 38% to 65 % with most of the species having a yield of over 50% as compred to bamboo where the yield at about 40%. On the basis of physical strength properties these would be classified as under.

Very Good : Breaking length over 9000 metres and burst factor over 60.

(i) Eucalyptus grandis

(ii) Gerugepinnata

(iii) Protica serratum

(iv) Eucalyptus globulus

(v) Trema orientalis.

Good : Breaking length between 6000–9000 metres and burst factor between 45–60.

(i) Anthocephlus chinensis (A. cadamba)
(ii) Eucalyptus hybrid (Mysore gum)
(iii) Acacia decurrena
(iv) Eucalyptus torelliana
(v) Terminalia coriacea
(vi) Casuarina Equisetifolia
(vii) Oydrcur semecareifoli
(viii) Quercus dilatata
(ix) Quercus incana
(x) Hevea brasilianisis.

Fair : Breaking length below 6000 metres and burst factor below 45 :

(1) Xylia xylocarpa
(2) anogessus latifolia
(3) Moringa oleifera
(4) Pterocarpus marsupium
(5) Bischofia javanica
(6) Acacia auriculseformis.

Pilot Plants results are recorded in table VI, The yields obtained on the laboratory scale. As expected the strength properties of paper made on paper machine were less than that of the laboratory handsheets. The classification of wood tasted on both laboratory and pilot plant is not significant altered from the classification based only on laboratory results.

The possibility of using mixtures of hardwoods for the producton of sulphate pulps for wrapping papers is amply proved by the results recorded in Table VII. Although on the Forest Research Institute pilot plant the papers were made from a furnish containing 100 percent mixed hardwood pulps, it may perhaps be necessary on fat running commercial machines to add some portion of bamboo or other long fibred pulp.

Writing & Printing Papers

Systematic work on the utilisation of several species of hardwoods for production of sulphate pulp for writing and printing papers has been undertaken during the past sixteen years and the results are recorded in table VIII and it shows that in all cases the yields are higher except Erythrnie suberrose (31.6%) and Helicteres isora (34.2%) than bamboo (35.6%). The pulping and bleaching conditions are similar to bamboo. The tearing strength, as already discussed, is lower than bamboo because of the shorter to fibre length. For running on higher speed paper machines it may be necessary to mix bamboo or other long fibred pulp in a small proportion of about 20% or so. Hardwoods have in general higher tensile strength and burst factor than bamboo, the exceptions being Acacia aurifuliformia, Erythrine suberosa, Ailanthus altissima. Mallotus philippensis, Mangifera indica and Melia azadarach. On a consideration of yields and strength properties the forty woods tested can be grouped as follows :-

Very good (over 48% yield and over 6000 breaking length)

(i) Alibizzia lebbek,
(ii) Acacia decurrens
(iii) Albizzia
(iv) Broussonetia papyifera
(vii) Dalbergia sisoo
(vi) Acacia mearnsi
(vii) Anthocephalus cadamba
(viii) Eucalyptus globbulus
(ix) Eucalyptus grandis
(x) Lannea coromandelica
(xi) Moringa pterygosperma
(xii) Ochroma lagopus
(xiii)Pterooymbium tinctorium
(xiv) Trema orientalis.

Good (Over 45% yield and over 5000 m breaking length)

1. Ailanthus altissima
2. Acacia mearnsi
3. Boswellia serrata
4. Casuarina equisetifolia
5. Kydia calycina
6. Populus ciliata
7. Symingtonia populnea.

Fair (Over 39% yield and over 4800 m. breaking length).

1. Ailanthus excelsa
2. Alnus nepalensis,
3. Bischofia javanica
4. Cassia siamea
5. Eucalyptus citriodora
6. Eucalyptus hybrid(Mysore gum)
7. Eucalyptus robusta
8. Gmelina arborea
9. Morus alba,
10. Sterculia alata.

Poor (Under 39%) yield or under 4800 m breaking length)

1. Acacia auriculiformis
2. Cleistanthus collinus
3. Erythrine suberosa
4. Eupatorium odoratus
5. Helicateres isora
6. Lagerstroemia parviflora
7. Mallotus Philippensis
8. Manfifera indica
9. Melia azedarach.

Sixteen of the 40 species tested on a laboratory scale were also tested on a pilot plant scale. The yields obtained on a pilot plant scale were similar to the laboratory results, but the strength of the papers made on the paper machine was less than that of the laboratory hand sheets. The strength was however of acceptable standard for ordinary writing and printing papers. Although on the pilot plant, papers were made in many cases from furnish containing 100% hardwood pulp, it may be necessary on a fast running commercial machine to add some proportion of bamboo or other long fibred pulp. The results are recorded in Table IX. The classification of woods tested on both laboratory and pilot plant scale is a not significantly altered from the classification based only on laboratory results.

Pulping of Mixture of Hardwoods

Although several individuals species of hardwoods have been found suitable for production of paper pulp but the results could not be implemented by the paper industry as in no single area are sufficient quantities of single species found. In tropical forests a large number of species of hardwoods occur in one and the same forest. Although several States have started experimental plantations of hardwoods, the areas of these plantations have not yet attained sufficient size to be suitable for commercial exploitation by the paper industry. Therefore, if hardwoods are to be used immediately in India for production of paper pulp, a process for pulping mixture of hardoods will have to be used.

The results of pilot plant experiments on the manufacture of writing and printing papers from the mixtures of hardwoods are given in 'X' which show that writing and printing papers can be mad in satisfactory yields and strength properties from mixtures of hardwoods. Although on the Pilot Plant the papers were made from a furnish containing 100 percent mixed hardwood pulp, it may perhaps be necessary on fast running commercial machines to add some proportion of bamboo or other long fibred pulp.

Mixture of bamboo and mixed hardwoods

Mixture of bamboo and mixed hardwoods are similar to bamboo. As the pulping conditions of hardwoods are similar to those of bamboo and it will be expensive to have a separate streams for bamboo and hardwoods, the feasibility of pulping them together was investigated with encouraging results on the laboratory as well as pilot plant seek. The investigations revealed that as the percentage of hardwoods was increased, the breaking length improved and burst factor improved slightly and this with further increase falls. Tiar factor and double folds decrease with the increase in the amount of hardwoods. The formation is improved with the increase in proportion of hardwoods through the press picking starts due to high percentage of vessels in the hardwoods, when a mixture of bamboo and mixed hards in the proportion of 50:50 is pulped bleached by conventional method the strength properties of hand sheets are as under :-

	Mixture of bamboo & mixed hard woods	100% of bamboo
Breaking length (Meters)	5090	5580
Burst Factor	35.0	34.8
Tear Factor	88.3	123.0

Agricultural residues

India is an agricultural country and its economy depends on agriculture. The main crops are wheat, rice, sugar cane, cotton, tobacoo and other cereals. The general problems in their utilization are the bulkness and seasonal availability resulting in storage problems and fire hazards during syorage. The recovery of the chemicals is not economically viable due to the presence of high sellacious ash in the straws and bagasse. Total availability of straws is estimated as 70 million tons out of which only one half is for farm and non farm uses. The availability of Bagasse is about 2 million tons. Researches carried out have established the feasibility of making various grades of pulp, paper and boards. These meterials are the main fibrous raw materials in the case of small scale sector except that Tamil Nadu Newsprint is using bagasse to a considerable extent. Advantages of these endeavours have been as under :-

1. More income for our farmers to strengthen rural economy.
2. Less dependance on our very inadequate forest resources
3. Wider dispersal of the industry
4. Potential for more employment
5. Lower gestation period
6. Less capital cost per tonne out put.

The main disadvantage of setting up of these small mills has been lower capacity utilization.

It may be concluded that at present all most all the available raw materials are being used by the industry. The break-up of the raw materials used are approximately as under :-

Bamboo	55%
Hardwoods	25%
Agriculture residues	5%
Grasses & others	15%

The national commission of Agriculture has well observed that unless and untill pulp and paper industry and forestry are linked together substantial and balanced growth of these sectors cannot be achieved.

For the development of the industry it is essential that the raw materials resources should be planned and made available on a sustained basis at reasonable prices by raising suitable industrial plantations of suitable pulp

woods such as eucalyptus, tropical pines and mixed plantations in collaboration with the industry, state forest departments and industrial finance institutions. The cost of raw materials available at mill site should be linked directly in the prevailing paper prices as it forms about 65% of the cost of paper produced. New technologies like thermo-mechanica, Chimo-mechanical etc. should be adopted so that the available resources of the raw materials yields higher percentage of pulp. For ordinary writing and printing papers 30% these pulps should be used.

List of Industrial Catchments

1. Jhalum
2. Chinab
3. Jamuna (H. P.)
4. Jamuna (U. P.)
5. Kulu Valley
6. Y. P. Eucalyptus
7. Bastor (M. P.)
8. Bilaspur (M. P.)
9. Chandrapur and Bhandara (Maharashtra)
10. Nepa Mills (M.P. and Maharashtra)
11. East Godavari and Khammam District (A.P.)
12. Krishna (A. P.)
13. Mahboobnagar (A.P.)
14. North Karnataka (West Coast Paper Mills)
15. Central Karnataka (Mysore Paper Mills)
16. South Karnataka (Mandyo Paper Mills)
17. South West Tamil Nadu (Stshassyoo Paper Mills and South India Viscose)
18. North Kerala (Gwalior Rayon)
19. Central and South Kerala
20. News Print Project and Punalur Paper Mills (Kerala)
21. South Bihar
22. Koraput District (Orissa)
23. North Bengal
24. Nowgong (Assam)
25. Cachar (Assam)
26. North Cachar (Assam)
27. Tripura
28. Manipur
29. Mizoram
30. Nagaland
31. Arunachal Pradesh

TABLE I

	1924-25	1936-37	1952-53	1958-59	1967-68
Bamboo	5,830	57,840	2,86,000	4,50,000	8,00,000
Sabai grass & other grasses	26,160	34,550	50,000	50,000	70,000
Wood Pulp imported	7,979	20,976	3,600	30,000	30,000
Waste Paper	8,506	5,908	24,500	25,000	40,000
Rags Hemp etc.	—	8,568	24,500	25,000	15,000
Bagasse	—	—		20,000	40,000
Mixed hardwoods	—	—	—	—	1,50,000
Salai Woods	—	—	—	—	45,000
Straw and other materials	—	—	—	—	10,000

TABLE II

Alkali consumption, Kappa No., and unbleached Pulp yield and chemical composition of Bamboos and Pulps

Sl. No.	Species	Caustic Soda used in%	Kappa number	Pulp yield in %		Chemical composition in %			
				Unscre-ened	Scre-ened	Lignin in Bamboo	Lignin in pulp	Pentosan in Bamboo	Pentosan in pulp
1.	Bambusa Arundinacea	21	27.4	52.1	51.7	24.2	3.1	20.8	16.2
2.	Bambusa Nutans	20	24.3	54.7	54.5	21.7	2.8	20.0	16.8
3.	Bambusa Polymorpha	20	27.2	44.4	43.4	24.7	3.0	18.5	17.0
4.	Bambusa Tulda	21	28.2	54.8	54.4	23.1	4.7	18.1	11.3
5.	Bambusa Vulgaris	22	24.3	44.4	43.8	22.9	3.6	21.0	17.6
6.	Cephalostachyum Pergracil	20	28.2	54.5	52.8	24.9	4.3	18.4	15.9
7.	Dondrocalamus Hamiltonii	19	27.4	56.6	54.2	22.4	3.7	16.9	16.1
8.	Dendrocalamus Longispathus	20	25.2	48.9	48.4	25.0	3.9	18.6	15.8
9.	Dendrocalamus Strictus	22	28.0	51.0	50.9	26.0	3.0	23.2	15.3
10.	Melocanna Baccifera	25	25.0	43.9	43.8	27.0	4.1	19.6	15.5
11.	Oxytenanthera nigrociata	23	27.9	52.0	51.8	22.6	3.8	16.2	16.7
12.	Thyrsostachys , Olivery	22	27.2	48.9	47.0	20.9	3.0	18.5	17

TABLE III

Variation of Fibre Characteristics of bamboo species

Sl. No.	Species	Fibre* Length mm.	Fibre* Diameter	Luman* diameter	Paren chyma%
1.	Bambusa Arundinacea	2.24	16.34	4.93	21.7
2.	Bambusa Nutans	2.40	15.55	3.91	20.6
3.	Bambusa Polymorpha	2.53	16.11	4.94	22.4
4.	Bambusa Tulda	2.10	15.43	5.59	18.4
5.	Bambusa Vulgaris	2.02	15.06	5.62	20.0
6.	Cephalostachyum Pergracil	2.20	16.25	4.07	18.3
7.	Dondrocalamus Hamiltonii	2.40	13.98	3.40	26.6
8.	Dendrocalamus Longispathus	2.70	15.02	3.39	17.5
9.	Dendrocalamus Strictus	2.45	14.51	2.33	21.2
10.	Melocanna Baccifera	2.78	15.60	3.55	19.5
11.	Oxytenanthera nigrociata	2.43	15.96	3.31	18.7
12.	Thyrsostachys Olivery	2.31	15.72	3.67	19.5

* Only mean values have been given

TABLE IV

Mean values of unbeaten and beaten in valley beater strength properties pertaining to each of the 12 bamboo species alongwith the critical difference between the mean values

Sl. No.	Caustic Species	Unbeaten			Beaten		
		Breaking length meters	Burst factor	Tear factor	Breaking length meters	Burst factor	Tear factor
1.	Bambusa Arundinacea	2240	8.0	54.5	6750	41.3	122.9
2.	Bambusa Nutans	1430	4.9	39.2	7560	42.8	166.9
3.	Bambusa Polymorpha	1990	8.0	76.4	6320	51.3	218.7
4.	Bambusa Tulda	1060	5.2	49.0	7460	50.0	181.2
5.	Bambusa Vulgaris	2070	9.1	88.2	7260	50.9	134.9
6.	Cephalostachyum Pergracil	1730	5.1	36.1	7550	47.3	149.8

7.	Dondrocalamus Hamiltonii	2620	10.2	133.9	8320	53.3	194.7
8.	Dendrocalamus Longispathus	1450	4.2	70.1	7360	52.0	164.7
9.	Dendrocalamus Strictus	1440	4.9	48.5	6470	44.7	190.4
10.	Melocanna Baccifera	820	2.9	32.0	5480	40.0	210.7
11.	Oxytenanthera nigrociata	1580	7.0	31.7	6730	49.0	168.0
12.	Thyrsostachys Olivery	1160	2.5	52.6	5800	48.4	164.1
Critical difference between two mean values		90	0.9	3.9	260	2.1	6.9

TABLE - V

Pulping conditions, yield and strength properties of hardwood pulps for wrapping papers

Sl. No.	Name of species	Pulping Conditions & yield			
		Total Chemicals*	*Sulphidity**	*Temperature*	*Time*
		%	%		hrs.
1.	Acacia auriculaeformis	24	25	162	4.0
2.	Anthocenphalus Ghinensis (A. Cadamba)	20	25	153	4.0
3.	Acacia decurrans	14	25	153	5.0
4.	Anogeissus latifolia	14	25	162	6.0
5.	Bischofia Javanica	29	25	170	4.0
6.	Causuarina equisetifolia	18	25	153	6.5
7.	Eucalyptus globulus	12	25	153	5.0
8.	Eucalyptus grandis	18	25	162	3.0
9.	Eucalyptus hybrid (Mysore gum)	18	25	162	4.0
10.	Eucalyptus tore-	18	25	162	4.0
11.	Garuga pinnata	14	25	153	4.0

	Strtength Properties			Reference
Yield* %	Breaking length metres	Surat factor -	tear factor -	
67.4	4700	27.8	59.0	Indian forestar, No.1.51-55 (1966)
52.2	7750	54.0	103.1	Paper Salesman 17, No. 7, 61 (152)
63.3	8890	45.7	84.5	Indian Forestar, 80 No.2, 116-125 (1955)
39.0	6110	36.1	78.5	Indian Forestar, 96, No. 9, 691-696 (1970)
48.0	5440	47.5	76.0	Indian Pulps & Paper,19, 19, No. 12 (1965)
54.0	7920	47.6	115.0	Indian Forestar,96, No. 11 830-840 (1970)
62.7	10062	62.2	140.0	Indian Foresta No.10 514-521 (155)
53.0	13410	87.0	83.0	Indian Forest, No. 6, (1967)
505.	6050	68.3	99.0	Indian Pulp & 5, No. 3 (1968)
47.0	7560	55.0	126.0	Indian Forestar, 96, No. 7 (1970)
47.0	12100	80.0	66.6	Indian Forestar,96, No.8, 691-696 (1970)

contd.....

1	2	3	4	5	6
12.	Hevea brasilensis	20	25	170	4.0
13.	Moringa elaifera	12	25	162	2.0
14.	Pterocarpus marsupium	14	25	153	4.0
15.	Protium serratum	14	25	153	4.0
16.	Quercus same-carpifolia	14	25	153	4.0
17.	Quercus dilata	14	25	153	4.0
18.	Quercus dilincana	14	25	153	4.0
19.	Terms orientalis	12	33.3	153	4.5
20.	Terminalia ceriacea	14	25	153	4.0
21.	Xylia xylocarpa	14	25	162	4.0

7	8	9	10	11
41.5	7819	46.6	66.6	Indian Pulp & Paper, 24, No. 3, (1969)
56.8	5900	39.0	70.6	Indian Pulp & Paper, 24, No. 3, (1969)
47.5	5310	38.2	186.0	Indian Forester, 96, No. 6, 691-696 (1970)
48.9	11600	68.0	96.0	Indian Forester, 96 No. 6, 691-696 (1970)
54.0	6380	50.6	100.0	Proceedings of the Symposium on Utilisation
56.3	6050	46.6	90.0	of Hardwoods for Pulp
55.6	6050	48.3	91.6	& Paper, forest Research Institute, Dehradun, p. 86-92 (136).
66.2	9170	59.1	93.0	Indian Forester, 80, No.8, 453-465 (1954)
54.2	8333	50.7	100.0	Indian Forester, 96 No. 9, 691-696 (1970)
38.1	6960	43.2	141.4	Indian Forester, 96 No. 6, 691-696 (1970).

TABLE - VI

Pilot Plant trials of hardwood for wrapping paper

Sl. No.	Name of Species	Pulping Conditions & Yield			
		Total Chemicals	Sulphidity	Temperature	Time
		%	%	C	hrs
1.	Acacia decurrens	14	25	153	5.0
2.	Eucalyptus grandis	18	28	153	4.0
3.	Eucalyptus globulus	16	25	153	5.0
4.	Eucalyptus hybrid (Mysore gum)	18	25	162	3.0
5.	Trema Orientales	12	33.3	169	4.5

Strength Properties					
Yield*	Breaking length		burst factor		Test Factor
%	metres		—		—
	R.D.	C.D.		R.D.	C.D.
65.3	6760	3250	24.6	60.9	67.0
47.8	5000	3780	25.0	61.8	70.0
57.9	6810	3710	28.0	81.8	81.3
52.7	7150	4440	49.6	67.7	72.5
53.4	7420	3370	23.1	52.6	62.0

TABLE - VII

Pilot Plant Digestion and Strength Properties of Wrapping Papers from Mixture of Hardwoods

Sl. No.	Composition	Digestion Conditions and yield				
		Total Chemical %	Sulphi-dites %	Tempera-ture °C	Time hr	Yields %
1.	2.	3.	4.	5.	6.	7
1.	60% al and 3 parts each of Terminalia Chebula (harra), chieichera else (kusum), Ougeinia oojeineni (sandan), Terminalia alata Varnepalenis (sain) Tectona grandis(teak)	24	23	153	4.6	43.1
2.	Anogeissuslatifolia (axle wood), Dio pyro melanoxylon (econy) oymida febrifuga(rohini), Cleistanthus collinu (karade) Adina cordilolia (Haldu), Garuga pinnata (Garuga) Mitragyna parviflora (Kain) Terminalia crenulata (laurel) Xylia xylocarpa (irul)*	20	25	162	6.0	41.8
3.	Acer pictum (maple) Prunus cornuta (cherry) Celtis australi (haokberry) Pieris Ovalifolia Aesculus indica (horse chestnutt) Corylus colurna (nazal) Populus ciliata (poplar)	14	25	153	6.0	40.7
4.	Xylia xylocarpa, Anogiessu latifelia, Terminalia cariacea, pterocarpus arsupium Garuga pinnata Protium serratum	14	25	153	6.0	47 2
5.	Querous semecarpifolia	14	25	153	4.0	49.0

Strength properties					Reference
Breaking length Met.	Burst factor	Tear factor			
M.D.	C.D.		M.D.	C.D.	
8.	9.	10.	11.	12.	13.
5240	4870	23.0	88.5	97.5	Indian Forester, 90, No. 11, 755-757 (1954)
4580	3400	18.7	69.0	72.8	Indian Forester, 96, No. 1, 64-71 (1970)
6440	4030	27.7	63.0	75.0	Indian Forester, 96 No. 4 328-331 (1970)
8040	5480	40.0	73.0	80.0	Indian Forester, 96 No. 9, 691-696 (1970)
5860	4160	30.0	50.0	54.0	Indian Forester,96, No. 3, 258-262 (1970)

* % Expressed over-dry raw material.

TABLE - VIII

Sulphate Digestion and Strength properties of Standard Sheets from Hardwoods tested only of Laboratory Scale

Sl. No.	Name of Species	Despatch Conditions & yield			
		Total Chemicals*	NaoH Na2s	Material liquor	Digestion temperature
		%			^{0}C
1.	Acacia ouriou	20	3:1	1:4	152
2.	Acacia decurrens (oreum wettle)	24	2:1	1:4	143
3.	Acacia mearnsi (Black green Wettle)	22	2:1	1:4	142
4.	Ailanthus altississ (Tree of heaven)	20	3:1	1:3.5	162
5.	Ailanthus excelss (marukh)	18	3:1	1:5	162
6.	Albizzie chanesis (siran)	24	3:1	1:5.5	153
7.	Albizzie lebbek (kokka)	24	2:1	1:4	153
8.	Albizzia procers (white siris)	24	2:1	1:4	142
9.	Alnus mepelensis (slder)	23	3:1	1:5.5	162
10.	Anthocophalus Kadam)	20	3:1	1:4	179
11.	Biachafia javanica (bishss wood)	20	3:1	1:4	170
12.	Boswellia serrata (saioi)	22.2	2:1	1:5	162
13.	Broussonetia papyrifera (paper sulberry)	24	2:1	1:5.5	153

Digestion period	Bleach pulp yield*	Bleach Consum tion*	Breaking length	Tear factor	Burst factor	Bright-ness
hours	%	%	mts.			
4	41.2	11.2	4550	64	27	73
6	63.0	6.3	6980	56.2	35.6	—
6	57.5	6.6	6610	81.0	41.9	—
6	66.0	10.0	5150	82	27.8	73
6	39.4	8.2	5890	70	36	67
6	51.4	9.0	9610	92.9	62.8	61
6	50.0	5.6	6950	92	50	70
6	55.3	6.3	5700	85	43	72
4	43.3	9.6	5980	83	41	71
4	48.2	12.0	8060	99.8	45.6	77
4	41.0	9.9	5900	83	46	73
6.0	45.4	7.6	6070	65.3	37.7	—
6	48.1	8.7	9010	81.8	48.2	—

contd .....

1	2	3	4	5	6
14.	Cassia siassa	22	4:1	1:4	153
15.	Casuarina equisstifalia (casuarina)	16	3:1	4:3.5	162
16.	Cleistanthus collinus	20	3:1	1:4	162
17.	Oalhegia sisoo (sisoo)	20	3:1	1:4	153
18.	Erythrino suboran (dauldhak)	20	3:1	1:5	170
19.	Eucalyptus citriodora	26	2:1	1:4	142
20.	Eucalyptus globuios (blue gun)	22	3:1	1:3	153
21.	Eucalyptus grandis	20	3:1	1:4	162
22.	Eucalyptus hibrid (Myrosre gum)	20	3:1	1:4	162
23.	Eucalyptus robusta	20	3:1	1:4	160
24.	Eupstorium odartum (Essamlota)	22	2:1	1:5	162
25.	Gaolina artherna (gamari)	27	3:1	1:4	163
26.	Palicters isora (maror phal)	22	2:1	1:4	153
27.	Kydia calycina (pula)	20	3:1	1:4	162
28.	Lageratromia parviflora	20	3:1	1:4	162
29.	Lannea coromandel-ica (Jhigan)	20.4	3:1	1:4.5	153
30.	Mallotus philipoen-sis(Kamla)	22	3:1	1:4	178
31.	Manifra indica (mango)	22	2:1	1:4	162
32.	Malia azadrrach (persian lilac)	18	3:1	1:4	162

7	8	9	10	11	12	13
4	41.0	9.5	5750	103	40	78
6	50.3	12.7	5750	103	40	78
4	36.3	14.2	6880	195.2	41.8	70
4	52.7	15.0	6140	106	39.1	68
4	31.6	17.8	4280	85.5	16.9	—
6	42.0	13.8	5000	68.0	40	64
6	52.8	8.3	7340	85.3	47.5	72
4	50.0	14.0	8920	66.6	60.0	76
4	41.5	9.1	4840	63.6	34.2	75
4	42.7	7.2	5500	103.5	46.2	68
6	37.0	13.5	8520	69.9	40.7	63
4.5	39.8	9.2	5970	66.5	38.0	70
6	34.2	7.3	5710	64.9	33.7	—
4	47.6	18.9	5210	88.6	74.5	68
4	41.8	12.6	4260	68.0	24.0	65
6	51.3	8.9	6670	72.6	47.4	—
4	37.8	14.5	4860	67	30	69
4	42.0	6.3	3690	43	20	70
3	47.5	6.4	3730	40.3	25.0	70

Contd.....

1	2	3	4	5	6
33.	Moringa pterygos-perna(drumstick)	20	-	-	162
34.	Porous alba (Mulberry)	20	3:1	1:4	162
35.	Dherssa lagopoo (pales)	21	3:1	1:4	162
36.	Populue Cillars (Poplar)	22	3:1	1:4	153
37.	Pterocymbium tihotorium (Papita)	24	2:1	1:4	153
38.	Sterculia alata (Lathok)	22	2:1	1:3.5	162
39.	Symingtonia populnea (Pioli)	18	3:1	1:4	162
40.	Terms orientalis (qutel)	22	3:1	1:4	170

7	8	9	10	11	12	13
2	52.0	11.1	6380	72.0	—	68
6	42.2	8.7	4880	64.1	38.2	60
6	51.2	14.5	9680	70.9	80.3	68
6	52.1	7.5	5930	65	33	76
6	48.0	4.7	8530	104	40.0	—
6	39.4	11.4	8470	90.4	50.0	69
4.25	46.1	9.3	5010	107	37	69
4	36.6	9.5	5580	123	34.8	77

TABLE - IX

Pilot plant Digestions & Strength Properties of Paper from Hardwoods

Sl. No.	Name of Species	Digestion Conditions & yield				
		Total Chemicals	NaOH: Na2S	Material liquor	Digestion Temp.	Digestion Period
		%			°C	hrs.
1.	2.	3.	4.	5.	6.	7.
1.	Acacia decurrens (green wattle)	24	2:1	1:4	153	6
2.	Acacia mearnei	34	2:1	1:4	162 for 2 hrs. and 153 for remaining period.	6
3.	Albizzia chinensis	22	2:1	1:5	162	6
		14.4	2:1	1:4	162 for 2 hrs. & 153 for remaining period	4
4.	Boswellia serrata (Salai)	24.4	2:1	1:4.4	162	6
5.	Broussonetia-papyfera (paper mulberry)	25	2:1	1:5.8	162	6
6.	Cleostenthus cellinus.	20	3:1	1:4	162	4
7.	Dalbergia sissoo (sisaso)	20	3:1	1:4	152	4
8.	Eucalyptus globulus	23	3:1	1:3	153	6
9.	Eucalyptus grandis	20	3:1	1:4	162	4

Strength properties of paper							Remarks
Bleach pulp yield	Bleach consumption		Breaking length	Tear factor		Burst factor	Composition of furnish
%	%	M.D. Mtr.	C.D. Mtr.	M.D.	C.D.		
8.	9.	10.	11.	12.	13.	14.	15
53.0	6.2	3730	2200	64.8	66.3	19.4	70% W 30 %B
54.3	6.2	4160	2070	52.4	58.6	115.6	70% W 30%B
49.0	9.2	6400	3380	63.4	66.6	29.9	100% W
49.2	15.7	3240	2080	62.5	76.7	17.8	100% W
40.1	11.3	3580	1880	51.1	58.1	13.5	75% W 25%W
48.6	8.8	4750	420	41.4	43.9	19.5	100% W
37.0	9.7	4400	2660	53.5	60.1	15.5	100% W
43.4	16.6	4780	2790	73.0	72.7	19.6	85 % W 15% B
66.0	10.1	5270	2990	61.1	64.1	18.0	imported pulp 100 % W
47.3	12.1	3810	2770	33.3	38.3	22.4	100% W

contd .....

1	2	3	4	5	6	7
10.	Eucalyptus hybrid (Mysore gum)	20	3:1	1:4	162	4
11.	Kydia Calycina (pula)	20	3:1	1:4	162	4
12.	Morous alba (mulberry)	20	3:1	1:4	162	6
13.	Populus ciliata (Popolar)	22	3:1	1:4	163	6
14.	Petrocymbium tinotorium	24	2:1	1:4.1	153	6
15.	Dendrocalamus strictus	22	2:1	1:4.8	153	6

8	9	10	11	12	13	14	15
37.7	8.7	4260	2900	48.6	52.2	16.8	100% W
49.2	15.7	3240	2080	62.5	76.7	17.8	100% W
41.2	11.8	5350	2730	58.4	73.8	25.7	80% W 20% B imported Pulp
50.0	6.8	4640	3980	46.8	52.5	22.5	100% W
47.2	7.0	4740	2260	56.8	65.5	22.6	100% W
49.8	11.4	5190	2370	58.0	64.2	26.4	60% W 40% B

* The % is expressed on the basis of the oven-dry basis raw material. As standard bleaching powder containing 35% available chlori.

TABLE - X

Pilot plant Digestions and Strength Properties of Paper Made wholly from Mixture of hardwoods

	Digestion Conditions and yield				
	Total Chemicals %	NaOH2: Na2S	Material liquor	Digestion temperature °C	Digestion period hrs.
1. 80 % shares robusts and 4% each of Terminalia chebulia, Schleichera Gugeiuia oojeinanals, Terminalis tomontosa & tectona grandis.	24	3:1	1:4	153	4½
2. Equal proportion of Macarange denticulate, Macaranga oeltato, Trena orientalis, Callicarpa arbores, Codrela toona Garuga pinnata, Litssa polyanthe Albizzis stipulsts, Albizzia procera, Tetramelss nudiflors, shorea assnica & Dipterocarpus macrocarpus.	20	—	—	170	4
3. Mixed in proportion of reported occurrence Anogoinsus latifolis, Disspyron oslanoxylon, Soymida fabrifuge, Dalbergia latifolis, Cleistanthus cellinus, Adina cordifolia, Lagerstromia parviflora, Garuga pinnata Mitranyna parviflora, Garuga pinnata Madhuca latifolia, Grewia tiliasfolia, Terminalia tommentos and Xylia xylocarpa.	20	3	1:4	162	4

Unbleached pulp yield	Bleach pulp yield	Bleach consumption as d2 on pulp	Strength properties of paper: Breaking length M.D. mtr.	Breaking length C.D. mtr.	Tear factor M.D.	Tear factor C.D.	Burst factor
40.1	—	12	3350	2470	39.6	38.4	12.1
40.3	38.0	6.3	5270	3570	43.0	47.0	21.9
48.7	32.6	14.8	1930	2350	61.2	66.7	19.9