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PULPING SUITABILITY OF VARIOUS FIBROUS RAW MATERIALS OF WEST PAKISTAN

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Abstract. Investigations have been carried out into the pulping suitability of various fibrous raw materials of West Pakistan with a view to establishing alternate raw material sources for pulp and paper making. These studies include their chemical analysis, pulping procedures and the physical testing of the pulps formed, together with their availability and possible use. It is concluded that a number of fibrous raw materials posses suitable qualities for pulp making and can not only serve as stand-by materials for the presently used raw materials but can also help the future growth of the industry in the country.

Paper and board play such an important role in the present-day economic development that their consumption is taken as an index of a country's progress and prosperity. The per capita consumption in West Pakistan is estimated at 3.5 lb as against 480 lb in U.S.A, 140 lb in Japan and 92 lb in U.K. This figure, however, must rise with the development of industry and trade, improvements in the media of information and education and a rise in the standard of living. The fourth five-year plan, therefore, envisages creation of additional capacity and further additional capacity may have to be created during the fifth plan.

The development of paper and board industry in Pakistan has been steady, although the rate of development has been very slow. The country had no mill for making pulp, paper and board at the time of independence but now has the capacity to meet its present requirements of duplex board, chip board, writing and printing papers and certain packing and wrapping papers. However, papers like kraft, tissue, cigarette and specialities are still being imported and total imports during 1969–70 alone were close to 26,000 tons.[1]

The main reason for the slow growth of this industry in the country has been the non-availability of suitable fibrous raw materials. The country is poor in forest resources and the wood forests in the northern regions (i.e. Dir, Swat and Kaghan valleys) are largely inaccessible.[2] The paper and board industry, therefore, depends mostly on agricultural wastes and the raw materials commonly in use are: wheat straw, sugarcane bagasse, kahi grass and cotton linters. Wood pulps are entirely of imported origin and are used together with the local pulps to get the desired strength properties in the paper and board manufactured. Table 1 lists paper and board mills of West Pakistan.

A thorough investigation was carried out on the various fibrous raw materials available in West Pakistan with a view to establishing alternate raw material sources for pulp and paper production. Those showing some promise of use were then subjected to comprehensive laboratory studies to ascertain their pulping suitability.

All the raw materials were tested in mature and fresh form only, except the following: (i) sugarcane bagasse, tested in depithed form, (ii) kenaf, tested in various stages of growth; matures at flowering stage.

Experimental Techniques and Results*

Experimental studies on a fibrous raw material consisted of the following:

Chemical Analysis. Chemical analysis yields some direct information about the suitabilities of a raw material. Samples for chemical analysis were first crushed in the laboratory dry disintegrator and screened through a cloth gauze. The screened, fine powder was then tested for the following contents of a raw material, using Tappi[4] standard methods as mentioned below:

Chemical test	*Tappi standard no.*
α-Cellulose	T230 os-61
Ether-soluble matter	T5m—59
Alcohol–benzene-soluble matter	T6m—59
Lignin	T13m—54
Pentosans	T19m—50

Moisture contents were determined by placing the sample in an oven at 100–105°C till constant weight. The residue after ignition at 775±25°C for 3–4 hr was taken as a measure of ash content. The test results obtained are given in Table 2.

Pulping Suitability. The pulping suitability of a raw material was established by following the process of paper making in the laboratory pilot-plant and testing the hand sheets formed for their strength properties.

Non-wood raw materials were cut with a blade or knife into suitable lengths of 2–3 in and washed with water to remove adhering dirt and sand. Woods were debarked and cut into 1 in chip size. The prepared raw material was then cooked in an electrically heated laboratory digester, having a capacity of 1.5 kg of oven-dried material. Mixing of raw material with chemicals and its feeding into the digester was carried out manually.

*All experimental results have been rounded off to the first place of decimal

Neutral sulphite, sulphate and soda cooking processes were used for these studies and the working details are given in Table 3.

The cooked material was thoroughly washed in a simple washing pan, using tap-water, till no traces of chemicals were retained in the washings. The cooked mass was then transferred to a wet disintegrator to ensure defibration and to form a homogeneous mass, free from bundles and knots. Disintegration was carried out for 30-60 sec depending upon the nature of the raw material. The disintegrated pulp was then subjected to screening process, using a slotted screen of 0.15 mm slot width to obtain 'true fibres'. The oversize was rejected and the screened pulp was subjected to refining in the laboratory refiner till a beating degree of 45°SR was obtained. Consistency during screening was maintained at 1–1.5% and during refining at 3–3.5%. Screening process also provided an estimate of cooked or screened yield. (Table 4).

Paper sheets having substance of 70–80 g/m² were then formed on the laboratory sheet former, pressed in a hydraulic sheet press at a pressure of 5–7 kg/cm² and dried at 60–70°C.

The dried hand sheets were then tested for their physical and strength properties in accordance with Tappi[4] standard methods (Table 5). The different factors were calculated as below:

$$\text{Burst factor} = \frac{\text{Bursting strength (kg/cm}^2) \times 1000}{\text{Substance (g/m}^2)}$$

TABLE 1. PAPER AND BOARD MILLS OF WEST PAKISTAN.*

Province	Name of industry	Location	Main raw materials	Scope of production: Paper	Scope of production: Board	Capacity (ton/yr): Paper	Capacity (ton/yr): Board
Punjab	Packages Limited	Lahore	Wheat straw, cotton linters and waste paper	Brown kraft, cartridge, printing, poster, super-calender, tetra base, imitation art, tissue, white offset, envelope and buff papers.	Duplex, kraft lined, plyboard, coated board, grey board, file board and card board.	7,000	17,000
	Sethi Straw Board Mills	Gujranwala	Wheat straw, rice straw and waste paper	—	Straw board, chipboard, paper board, grey board and kraft lined board	—	12,000
	Mandiali Paper Mills	Sheikhu-pura	Wheat straw	Printing and wrapping papers	—	3,000	—
	Lasani Straw Board Mills	Gujranwala	Wheat straw and waste paper.	—	Straw board	—	2,100
	Mehr Straw Board (Aziz Industrial Corporation)	,,	,,	—	Grey board	—	1,500
	Ghulam Qadir Straw Board Mills	,,	Wheat straw	—	Straw board	—	900
Sind	Allied Paper Industries Ltd	Gharo	Wheat straw and cotton linters	Printing, writing, creamlaid and duplicating papers	—	4,000	—
	Dawn Paper and Board Mills	Hyderabad	Wheat straw and waste paper	—	Straw board, chipboard, paper board and greyboard	—	2,500
	Central Cardboard Industries	Karachi	Wheat straw and waste paper	—	card board	—	2,250
	Dadabhoy Paper Mills Ltd	,,	Wheat straw, waste paper and jute waste	Kraft, wrapping papers	—	3,000	—
	Pakistan Security Printing Corporation	,,	Rags, cotton linters	Bank note and security papers	—	1,400	—
N.W.F.P.	Pakistan Paper Corporation Ltd	Charsadda	Sugarcane bagasse	Manila, writing, printing and duplicating papers	—	30,000	—
	Adamjee Paper and Board Mills	Amangarh	Wheat straw, kahi grass and cotton linters	Air mail paper including blue aerogramme, bond, writing, printing, manifold, offset, imitation art and cigarette papers	Duplex, grey board, coated board, file board and card board	5,000	18,000

*The information is obtained partly through ref.[3]

$$\text{Breaking length (m)} = \frac{\text{Tensile strength/1.5 cm strip (lb)} \times 100000}{\text{Substance (g/m}^2) \times 1.5 \times 2.2}$$

$$\text{Tear factor} = \frac{\text{Tearing strength (g)} \times 100}{\text{Substance (g/m}^2)}$$

$$\text{Bulk (cm}^3\text{/g)} = \frac{\text{Caliper (mm)} \times 1000}{\text{Substance (g/m}^2)}$$

Discussion

As the raw materials studied fall into two broad categories, namely: non-wood raw materials, i.e. nos. 1–14 (Table 2) and woods, i.e. nos. 15–18 (Table 2) these are discussed separately.

Non-Wood Raw Materials. It is seen from Table 2 that α-cellulose content, which is a rough measure of normal cellulose for chemical wood pulps, is generally of the same order for the new raw materials tested as for sugarcane bagasse, and kahi, except gorkha and dhaman which have low α-cellulose content and kenaf which has values approaching those of coniferous and deciduous woods.[5,6]

The lignin content of gorkha and chari is similar to that of sugarcane bagasse. These values are about 75% those for soft woods and about equal to those

TABLE 2. CHEMICAL ANALYSIS(%).*

Raw material	α-Cellulose	Ether-soluble	Alcohol/benzene-soluble	Lignin	Pento-sans	Mois-ture	Ash
Raw Materials in Use							
1. Wheat straw (*Triticum vulgare*)	43.2	—	—	16.9	19.2	10.0	7.5
2. Rice straw (*Oryza sativa*)	48.8	—	7.2	13.0	20.0	7.8	9.5
3. Sugarcane bagasse (*Saccharum officinarum*)	35.1	—	0.9	21.0	23.1	6.8	1.7
4. Kahi (*Phragmites karka*)	35.4	—	8.9	17.0	24.4	14.2	2.5
5. Cotton linter (*Gossypium hirsutium*)	87.4 (total)	1.0	—	3.2	3.2	8.0	4.0
Raw Materials not in Use							
6. Rhodes grass (*Chloris gayana*)	34.1	6.5	7.4	10.2	19.9	9.8	8.3
7. Gunj-gumaz (*Panicum antidotale*)	30.6	2.7	3.8	10.7	20.6	8.3	10.1
8. Ghorkha (*Lasiurus hirsutus*)	21.6	9.9	1.0	21.3	21.0	9.1	6.4
9. Pampi (*Eragrostis megastachya*)	35.9	1.0	1.1	13.5	19.6	10.9	12.8
10. Chari (*Sorghum almum*)	37.0	5.2	4.2	21.7	20.0	9.0	5.2
11. Dhaman (*Cenchrus setigerus*)	21.0	3.1	5.4	11.5	19.7	9.3	22.8
12. Kenaf (*Hibiscus cannabinus*)							
(i) Preflowering	48.7	—	—	16.2	22.2	75.5	4.2
(ii) Flowering	48.0	—	—	16.2	21.9	71.5	3.5
(iii) After flowering	—	—	—	—	—	75.0	—
13. Nara (*Arundo donax*)	—	—	—	—	—	50.0	3.5
14. Australian grass (*Diplachine fusca*)	—	—	—	—	—	—	—
15. Pine (*Pinus wallichiana*)	48.8	—	12.4	25.1	13.4	56.9	0.8
16. Poplar (*Populus euphratica*)	50.0	—	3.2	24.2	17.3	14.0	0.4
17. Spruce (*Picea morinda*)	57.6	—	2.9	30.0	7.9	33.5	0.6
18. Paper mulberry (*Brousonetia papyrifera*)	35.9	—	—	17.5	19.6	11.0	1.0

*All results, except moisture content, are given on oven-dried fibre basis.

for hard woods. Other non-wood raw materials tested have lower still lignin content. On the other hand, the pentosan content of all non-wood raw materials tested is higher than that of woods.

Nara and various qualities of kenaf have too high a moisture content. This may result in rapid and extensive fibre deterioration in storage and may also exert unfavourable economic problems during transportation and feeding.[7] Ash content of all the non-wood raw materials tested is many times in excess of most hard and soft woods,[5] both because of higher percentages of mineral salts present in them and because of silica particles imbedded into the plant fibres. Very high ash content as for dhaman, pampi and gunj-gumaz cannot only affect the physical properties of pulp and its bleaching and cooking requirements,[6] it can also be harmful for the production equipment.

A direct comparison of the pulps obtained from various raw materials is not always possible because of the inter-relation of their strength properties namely: breaking length, burst factor and tear factor. However, Tables 4 and 5 give a fairly good indication of the pulping suitability of various new raw materials tested. It is seen that kenaf yields the best results as the pulps obtained at various stages of its growth have excellent screened yield, strength properties and bulk. The screened yields are low for rhodes grass, gunj-gumaz and chari, although their strength properties are equivalent to those of wheat straw and they possess a better bulk, which points to their possible use as substitute of waste paper and semi-chemical pulps for improved bulk.

Australian grass has strength properties approaching those of wheat straw but a lesser screened yield, whereas pampi and dhaman have strength properties similar to kahi and rice straw but inferior to wheat straw. Their yield is also fairly low, but their improved bulk offers possibilities of their use as substitute of kahi and rice straw.

Ghorkha and nara both have very inferior strength properties and may not be of much interest, except that ghorkha has a very good bulk.

Woods. It is seen from Table 2 that the chemical analysis of pine and spruce is similar to that reported for soft woods and that of poplar and paper mulberry is similar to that reported for hard woods.[5,6] These wood species were subjected to both neutral sulphite and sulphate cooking processes and details of the

TABLE 3. DETAILS OF COOKING PROCESSES.

Raw material	Na_2SO_3 (%)	Na_2CO_3 (%)	Cooking temp (max) (°C)	Time for max temp attainment (min)	Cooking time (hr)	Press (kg/cm²)	Liq-fibre ratio
Neutral Sulphite Process							
Wheat straw	17	5.6	160	60	3.0	6.5/7.5	2.5:1
Rice straw	12	2.5	170	45	3.5	,,	6:1
Sugarcane bagasse	14	2.8	165/170	30	,,	,,	4:1
Kahi	12	2.5	170	45	,,	,,	6:1
Rhodes grass, Gunj-gumaz, Ghorkha, Pampi, Chari, Dhaman	13	3.0	165/170	45	3.5	,,	5:1
Kenaf	18	3.5	170	,,	2.0	,,	7:1
Nara	16	4.0	160	,,	3.0	,,	7:1
Paper mulberry	18	3.5	150	,,	4.0	6–7	3:1
Sulphate Process	Sulphidity (%)	Effective alkali (%) (expressed as Na_2O)					
Pine, Poplar, Spruce	18	13	165/170	—	3.0	6.5/7.5	3:1
Soda Process	Active alkali (%) (expressed as Na_2O)						
Cotton linter	9.5	—	145	60	4.5	4/5	4:1
Australian grass	8.9	—	160	45	3.5	6/7	4:1

suitable process for each are given in Table 3. Screened yields for these are slightly lower (Table 4) than the figures reported in the literature for soft and hard woods[5,6,13] for respective cooking processes. The strength properties (Table 5), are substantially better than those of non-wood raw materials and conform to the figures normally reported in the literature.[6] The physical properties of some imported wood pulps are given in Table 6 for comparison.

Experiments have also been carried out on Pakistani pine, popular and paper mulberry at the Laboratories of M/s. Escher Wyss, GmbH, Germany, using relatively low-cooking temperatures and too short cooking times and employing both neutral sulphite and sulphate cooking processes.[14] The results show yields about twice as much as those indicated in Table 4 but, for obvious reasons, the strength properties are lower than those reported in Table 5.

A raw material can only be suitable for commercial exploitation when its chemical and physical characteristics are supplemented by abundant supplies. The present situation is detailed in Table 7.

Conclusions

The new raw materials tested possess characteristics encouraging enough to warrant their commercial exploitation. Of special interest in the non-wood raw materials is kenaf, as it promises to replace imported kraft pulps in unbleached form and imported sulphate pulps when bleached. A proper planning of its cultivation and pulping may rid the country largely of the need of imported long fibre pulps. Encouraging results are also given by rhodes grass, gunj-gumaz, chari, Australian grass and, to some extent, by pampi and dhaman.

The variety of soft and hard woods available in Pakistan, although at present subject to various difficulties of procurement, can also serve as a potential source of pulp and paper making. In planning the pulp production through local wood sources, however, it should be remembered that, at sometime in the process of industrialization, urban and other requirements for wood will begin to put heavy and increasing demands on the forest. Therefore, in preliminary and long range planning of projects, it is well to envisage integrated operations such as now exist[16] quite widely in the northern hemisphere.

In the initial stages of endeavouring to locate new sources of pulp and paper raw materials, it appears advisable that attention should be centered primarily on a few potential sources and locations that are most favourably suited. If operations tend to be over ambitious, too widespread and diversified, there may be discouraging failures. Each case should be examined on its own merits and the drawing of economic conclusions from general cost data avoided.

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Table 4. Pulping Yields(%).*

Raw Material	Crude yield	Screened yield	Rejects
Wheat straw	50.0	48.4	1.2
Rice straw	35.0	31.3	3.0
Sugarcane bagasse	51.0	49.3	1.8
Kahi	66.5	54.5	10.4
Cotton linter	—	92.0	—
Rhodes grass	43.5	38.0	4.0
Gunj-gumaz	43.0	41.5	1.8
Ghorkha	47.0	33.3	13.7
Pampi	43.8	37.5	2.0
Chari	42.6	38.5	1.5
Dhaman	46.8	39.0	3.5
Kenaf			
Preflowering	48.8	45.3	3.5
Flowering	48.6	43.5	4.1
After flowering	56.0	49.8	4.5
Nara	60.7	—	—
Australian grass	46.0	38.0	8.0
Pine	—	43.9	—
Poplar	—	40.2	—
Spruce	—	33.3	—
Paper mulberry	—	37.5	—

*Estimation of 'rejects' is subject to experimental errors during screening, as it has not been determined by difference method. All yields are given on oven - dried fibre basis.

Table 5. Physical Properties.

Raw Material	Original beating degree (°SR)	Burst factor	Tear factor	Breaking length (m)	Brig-htness (%)	Bulk (cm^3/g)
Wheat straw	24	28·1	35·6	5670	40·0	1·5
Rice straw	27	20·3	36·6	4190	39·0	1·9
Sugarcane bagasse	17	44·0	43·3	7200	32·0	1·4
Kahi	—	18·9	49·5	4210	32·5	1·7
Cotton linter	—	16·4	120·5	2620	38·0	2·4
Rhodes grass	29	33·3	34·5	6240	54·5	1·8
Gunj-gumaz	32	31·7	40·6	5610	50·5	2·0
Ghorkha	30	15·2	25·0	3250	57·5	2·4
Pampi	34	26·4	41·4	4803	55·5	1·9
Chari	32	34·0	39·0	5750	53·0	1·8
Dhaman	26	27·9	34·6	4985	54·5	1·9
Kenaf						
Preflowering	—	42·3	80·8	7600	54·5	2·6
Flowering	—	36·2	64·3	6850	37·0	1·8
After flowering	—	35·3	81·8	7625	43.0	1·4
Nara	—	18·7	18·7	4500	—	—
Australian grass	—	27·9	36·7	5750	34·5	1·9
Pine	10	53·5	100·0	6200	—	—
Poplar	16	60·2	53·7	7725	—	—
Spruce	14	61·8	105·0	5770	—	—
Paper mulberry	—	33·5	42·3	5940	—	2·1

Table 6. Properties of Some Imported Wood Pulps.

Pulp	Origin	°SR	Burst factor	Tear factor	Breaking length (m)
Bleached sulphite	Sweden	45	49·2	79·2	7850
Bleached sulphate	Canada	45	71·5	98·0	10200
Unbleached hard wood kraft	America	45	(i) 33·0	67·0	6800
			(ii) 68·2	109·0	10262
			(iii) 82·5	104·0	12250

TABLE 7. SUITABILITY OF RAW MATERIALS STUDIED.

Raw material	Availability	Cultivation conditions	Possible use	Other comments
Wheat straw	Is a byproduct of wheat crop. Total quantity available is around 8 million ton/yr	Wheat crop is ready by April/ May. The plant attains a height of 4–5 ft.	Wheat straw is being used locally for making various qualities of paper and board either by itself or together with waste paper, cotton linters and imported wood pulps (vide Table 1). A substantial part is used as cattle feed or is wasted.	Coarse straw pulps for the manufacture of corrugating paper have been produced in U.S.A. for many years, using wheat straw. Fine straw pulps suitable for use in fine papers have been produced in Holland, France, Germany, Italy, Belgium and other European countries.[1,5]
Rice straw	Is a byproduct of rice crop. Total quantity available is around 2 million ton/yr.[1,8]	Rice crop is ready by Oct/ Nov. The plant attains a height of 4-5 ft.	Is used very sparingly together with wheat straw.	Suffers from high silica content and the pulping calls for a deashing more than delignification.[5] High silica content is also harmful to the production equipment because of its abrasive action.
Sugarcane bagasse	Available as a by-product of sugar mills. Total quantity is estimated at 0·8 million ton/yr	Sugarcane matures by Nov/ December and the plant attains a height of up to 15 ft.	Pakistan Paper Corporation is the only local paper mill using it at present. With better depithing facilities, the use can become more wide spread. Some sugar mills use it as fuel. Is also being used for the manufacture of insulating board.	Bagasse has been used extensively for the production of coarse insulating board and it has also been used in the manufacture of fine paper. It is easier to pulp and requires less chemicals for pulping than hard woods.[5] It can, however, be used only in depithed or partially depithed form.
Kahi	About 50,000 ton/ yr are available.	Grows wild along river banks and attains a height of 8 ft. Matures during March/April.	Kahi is the main raw material of Adamji Paper and Board Mills and has also been used successfully at Packages Ltd.	Kahi grass has shown a special promise as a substitute of waste paper or semi chemical wood pulp for improvements in the bulk of paper board.
Cotton linters (2nd cut)	Is available as a byproduct from cotton mills. Total availability is estimated at 13,000 ton/yr	The cotton crop matures in Sept/Oct.	Is used mainly together with other pulps to get the desired strength on wet presses of machine and to improve the tear of paper and board.	Much of the pulp made from cotton linters (2nd cut) is being used for the manufacture of rayon, as elsewhere in world, and the annual requirement is around 20,000 ton. Paper and board mills are, therefore, obliged to use 1st cut or mill run linters.
Rhodes grass	Is presently used as fodder. Can be grown in any quantity in the fields.	Grows to a height of 3 ft and matures in Sept/Oct.	It can be used as a substitute of commonly used local raw materials.	The grass shows a good combination of strength properties and bulk and possesses a brightness better than all local raw materials. Yield is comparatively low.
Gunj-gumaz	Available at Mianwali, Jehlum, Gujrat and Campbelpur.	Grows wild in the deserts and attains a height of 8 ft. Matures in September.	Same as above.	Same as above.
Ghorkha	Available at Mianwali, D.G. Khan, Muzaffargarh	Grows in all desert areas of West Pakistan and attains a height of 5 ft. Matures in October.	Its good bulk points out the possibility of its use as a filler.	The grass has very poor strength properties and may only be used in combination with stronger pulps.
Pampi	Available at Sanghar, Mirpur Khas, Quetta, Multan, Lahore and Sialkot.	Has been recently introduced in West Pakistan and attains a height of 4–5 ft.	May be used as a good substitute of kahi and rice straw.	Has comparatively low yield.
Chari	Is presently used as fodder. Can be grown in any quantity in the fields.	Grows to a height of 7–8 ft. Matures in Sept/Oct.	It can be used as a substitute of local raw materials of common use.	The grass has low yield but very favourable strength properties and a good bulk compared to wheat straw.
Dhaman	Salt range areas.	Grows wild and attains a height of 4 ft. Matures in October.	May be used as a substitute of kahi and rice straw.	Has comparatively low yield.

(Continued)

(Table 7 continued)

Raw material	Availability	Cultivation conditions	Possible use	Other comments
Kenaf	Is not being cultivated regularly in West Pakistan. Was grown on experimental level by Packages Ltd. and Ayub Agricultural Research Centre, Lyallpur. Is grown selectively by farmers for making ropes and hedges etc.	Flowers in rainy season and matures in October / November. Requires good soil, though not much water.	Preliminary trials in America have shown that kenaf pulps perform equally to most soft wood pulps and are superior to most hard wood pulps.[9] It may also be used as a blending material to improve lower quality pulps.	Kenaf is an outstanding new fibrous raw material which has attracted attention all over the world and is being experimented on in Cuba, Ecuador, Egypt, England, Guatemala, Haiti, Honduras, Pakistan, Peru, Republic of Panama, South Africa, Spain, U.S.A. and other countries of the world.[10] It can, however, be used only in the depithed form.
Nara	Available at Muzaffargarh, Jacobabad, Mianwali, Larkana, Sialkot, Lahore.[11]	Grows wild along rivers and on marshy lands. Belongs probably to bamboo family.	Suffers from poor strength properties.	Is reportedly being used in India for the manufacture of paper and board.[11] Can be used only in depithed form.
Australian grass	Lahore, Gujranwala, Hafizabad, Thatta, Kullor Kote Lake.	Grows on saline land and is recommended for salinity control by agriculturists and botanists.	Can be used as a substitute of local raw materials.	Has strength properties approaching those of wheat straw. Yield is low. Vast areas of West Pakistan are saline. The cultivation of this grass can serve the dual purpose of controlling salinity and of providing a suitable pulp making raw material.
Pine and spruce (soft woods)	The availability, estimated together with fur and kail is as follows[15] (i) timber standing on trees - 2000 million ft^3. (ii) annual cut - 6·5 million ft^3.	Grows in the following forest areas: Murree hills, Hazara Dist., Swat, Dir, Chitral, Azad Kashmir.	The good tearing strength of these pulps makes these suitable for the production of liner and sack paper, even without the addition of imported kraft pulps.[14]	The pulp obtained from pine using sulphate process, can be beaten very easily and the strength properties reach their maximum at 20–23 °SR. The strength properties are only 10% lower than those of comparable European kraft pulps.
Poplar nd paper mulberry (hard woods)	Neither of the two species is available in abundance at present.	Poplar is being grown at Changa Manga on experimental basis. Paper mulberry is grown at Kundian and annual output is estimated[15] at 30,000 ft^3.	Because of the relatively high brightness and bulk of these woods, they can be used both as filler for boards and for semichemical pulp for fluting. Further improvement in properties can be achieved by slight variations in the yield. There are also possibilities of their use for newsprint paper.[14]	Pulping of Pakistani poplar and paper mulberry using neutral sulphite process was found more difficult than it is with comparable European beach and poplar woods, and an additional 10–15% of thermal and chemical energy is required. The strength properties of semi chemical pulps obtained are consistantly lower than those of Italian poplar.[14]

University, New Campus, Lahore, for assistance with the botanical names of the raw materials tested.

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