Indian Fibrous Raw Materials for Packaging Papers - A Comparative Study

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SUMMARY

Bamboo, pine, eucalyptus, bagasse, straw, hessian and kraft waste are among the most commonly used cellulosic fibrous raw materials in Indian Paper Industry in the manufacture of packaging papers.

Pulp strengths of the above raw materials are compared at various freeness levels in the present study. Stiffness and concora crush values of pulps from Indian non-wood fibers, hitherto unavailable, are reported in the paper.

The strength properties of some typical packaging papers manufactured from non-wood fibers in large and small scale Indian Paper Mills are also given.

INTRODUCTION

Bamboo forests, which are fast getting depleted will not be alone able to provide the necessary quantities of cellulosic raw material to meet the future demand for cultural and packaging papers. Indian Paper Industry will of necessity have to turn to other fibrous resources and use a higher percentage of short fibered raw materials like hardwoods, rice and wheat straw, bagasse and other raw materials like kenaf, jute sticks, etc. in addition to recycling larger quantities of waste paper. In fact, some medium sized paper plants in the country have already started taking steps to cultivate kenaf to augment their sources of fiber supply.

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TABLE—I

PROXIMATE ANALYSIS AND DIMENSIONS OF COMMON USED CELLULOSIC RAW MATERIALS IN INDIAN PAPER INDUSTRY

Sl. No.	Particulars		Bamboo	Pine	Kenaf	Eucalyptus	Whole Bagasse	Rice Straw	Hessian
PROXIMATE ANALYSIS :									
1.	Ash	%	3.0	0.3	2.5	0.5	4.5	15.0	1.2
2.	Hot water solubility	%	5.5	3.5	8.5	8.7	8.0	13.0	5.8
3.	1% NaOH solubility	%	24.0	16.0	26.0	25.0	36.0	48.5	19.0
4.	Lignin	%	25.0	27.0	18.0	23.0	18.0	12.0	11.5
5.	Pentosans	%	15.0	9.0	19.0	20.0	29.0	23.0	18.0 (Hemicellulose)
6.	Alpha cellulose	%	40.0	42.0	40.0	44.0	36.0	32.0	56.0
FIBER DIMENSIONS :									
1.	Fiber length	mm	2.7	3.6	2.2	1.2	1.5	1.1	2.4
2	Fiber width	mm	0.015	0.040	0.014	0.024	0.017	0.010	0.018

The objective of the present investigation is to make a detailed study of the strength potential of pulps of the commonly used fibrous raw materials in Indian Pulp Mills. For instance, there is practically no information in literature on the stiffness and concora crush characteristics of pulps from non-wood fibers, although these properties are very important from packaging viewpoint.

EXPERIMENTAL WORK

Bamboo, pine, kenaf, eucalyptus, whole bagasse, rice straw and hessian are the raw materials chosen in the present study. The proximate analysis and fiber dimensions of the above raw materials are given in Table—I. The cooking conditions for the various raw materials in differing cooking processes are given in Table—II.

The chemical properties of the pulps are determined in accordance with Tappi Standards T 203, 212, 222, 223, 230 & 244. The pulps are beaten in Valley beater as per Tappi Standard T 200 and the strength properties determined in accordance with Tappi Standard T 220.

DISCUSSION OF RESULTS

PROXIMATE ANALYSIS & FIBER DIMENSIONS

As can be seen from Table-I, bamboo is intermediate between pine and eucalyptus in fiber length and chemical composition. Whole bagasse without depithing and rice straw have the lowest alpha cellulose contents and the highest ash contents. Fiber length to diameter ratio is the highest for bamboo at 180:1 and the lowest for eucalyptus at 50:1, with pine having a ratio of 90:1. The high length to diameter ratio in bamboo fibers makes them stiff, which possibly accounts for bulkier papers from bamboo pulps than from wood pulps.

NON-WOOD FIBER PULPS FROM DIFFERENT COOKING PROCESSES

Table—II lists the cooking conditions for the various raw materials in the present study. Bamboo and eucalyptus are cooked by kraft, green liquor and neutral sulphite semi-chemical processes. Due to lack of cross- recovery facilities in Indian Paper Mills and for reasons of pollution. NSSC cooking process does not hold much promise in the Indian context, although the best pulps for corrugating medium can be manufactured at about ten per cent higher yield in bamboo and euclayptus NSSC cooking processes than in kraft pulping. Details of NSSC pulping of bamboo and eucalyptus are reported elsewhere (1) and not included in the present paper. Unlike NSSC process, green liquor cooking can be easily adapted to the conventional kraft process. Besides, it will dispense with the causticisation and lime sludge reburning operations of the regular kraft process. Desilicated green liquor could be advantageously used for cooking bamboo to manufacture high yield

TABLE—II

COOKING CONDITIONS FOR DIFFERENT CELLULOSIC RAW MATERIALS IN THE PRESENT STUDY AND THE CHEMICAL PROPERTIES OF THE RESULTING PULPS

Sl. No.	Particulars	Bamboo Kraft	Bamboo Green Liquor	Pine Kraft	Whole Kenaf Kraft	Eucalyptus Kraft	Eucalyptus Green Liquor	Whole Bagasse Soda	Rice Straw Soda	Hessian Soda
1.	Chemicals on OD raw materials, %	16.5 TAA as Na_2O	24.0 TTA as Na_2O	20.0 TAA as Na_2O	16.0 TAA as Na_2O	16.0 TAA as Na_2O	25.0 TTA as Na_2O	12.0 as NaOH	12.0 as NaOH	12.0 as NaOH
2.	Bath ratio (Solid: Liquor)	1:2.5	1:2.5	1:2.5	1:5	1:2.5	1:2.5	1:5	1:5	1:5
3.	Time to max temperature, Min	180	90	150	150	180	90	60	45	75
4.	Time at max temperature, Min	90	120	120	90	90	120	180	145	120
5.	Maximum temperature, °C	160	165	170	165	165	165	150	140	170
6.	Refined yield,* %	—	—	—	—	—	53.1	46.2	43.0	55.6
7.	Rejects,* %	2.0	2.4	1.7	2.4	1.0	0.3	4.2	—	—
8.	Screened yield,* %	49.6	50.4	43.5	49.4	44.1	52.8	42.0	43.0	53.6
9.	Kappa Number	35.2	57.5	33.4	19.6	24.0	58.2	34.1	18.5	58.0
CHEMICAL PROPERTIES OF UNBLEACHED PULP										
1.	Ash, %	1.7	2.6	1.1	1.2	2.3	2.8	4.5	13.8	1.0
2.	Lignin, %	5.9	9.5	5.5	4.0	5.7	9.9	5.8	3.7	8.8
3.	Pentosans, %	12.2	13.3	7.0	15.0	14.3	16.6	20.0	15.6	7.0
4.	Alpha cellulose, %	75.5	72.5	81.5	79.0	72.5	70.0	64.7	64.2	75.0
5.	Viscosity (0.5% CED), cps	15.2	14.0	16.5	27.6	11.5	14.0	7.2	6.2	13.2
6.	1% NaOH solubility, %	6.0	6.1	7.5	11.0	8.0	9.5	8.0	8.2	8.5

Note : —TAA — Total Active Alkali
TTA — Total Titrable Alkali
* Percentage on O.D. raw material.

TABLE—III

STRENGTH EVALUATION (VALLEY BEATER) AND FIBER CLASSIFICATION OF UNBLEACHED PULPS

Sl. No.	Particulars	Bamboo Kraft		Bamboo Green Liquor		Pine Kraft		Kenaf Kraft		Eucalyptus Kraft		Eucalyptus Green Liquor		Whole Bagasse (Soda)		Rice Straw (Soda)		Hessian (Soda)	
		a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
1.	Initial freeness, ml (CSF)	700	700	705	705	730	730	650	650	500	500	520	520	350	400	400	400	650	650
2.	Final freeness, ml (CSF)	450	240	450	250	450	250	450	250	450	250	450	250	350	250	350	250	450	250
3.	Breaking length, (km)	5.34	6.30	4.72	6.10	5.09	6.63	6.56	7.86	4.68	6.75	4.82	6.61	3.38	4.24	3.75	4.42	4.06	3.12
4.	Burst Index, (kPa)(m)/g	374	4.56	3.84	4.45	3.78	4.67	4.64	5.46	3.18	4.88	3.25	4.76	1.56	2.55	2.35	2.70	3.30	4.04
5.	Burst factor, (Mullen)	39.1	46.5	39.2	45.4	38.5	47.6	47.3	55.7	32.4	49.8	33.1	38.5	19.0	26.0	24.0	27.5	23.7	41.2
6.	Tear Strength (mN)	931	707	795	638	990	821	641	506	613	518	589	511	324	296	283	259	984	836
7.	Tear factor (Elmendorf)	158	120	135	108	168	139	109	86	104	88	100	86.7	55	50.2	48	44	164	142
8.	Double folds (MIT)	244	330	85	280	315	495	709	1242	11	443	19	367	3	17	20	31	150	970
9.	Bulk, (cm^3/g)	1.88	1.6	2.05	1.72	1.32	1.24	1.6	1.32	1.72	1.47	1.75	1.48	1.71	1.31	1.96	1.66	2.08	1.82
	FIBER CLASSIFICATION OF UNBEATEN PULP (CLARK)																		
	+ 20 mesh %	26.5		40.1		60.8		26.8		11.5		7.1		8.7		10.8		60.4	
	— 20 + 50 mesh %	31.5		16.8		12.7		32.8		42.1		39.2		26.2		22.8		11.3	
	— 50 + 65 mesh %	8.0		6.8		6.0		15.4		20.4		26.5		16.7		14.3		8.0	
	— 65 +125 mesh %	5.8		5.6		4.3		8.2		5.5		6.3		13.3		11.0		7.5	
	—125 mesh %	28.2		30.7		16.2		16.8		20.5		20.9		35.1		41.1		12.5	

Note : —The above strength properties are determined on 60 gsm handsheets as per Tappi Standard T 220 os–71.

pulps for corrugating medium. Desilication of green liquor is essential, as otherwise there will be a continuous buildup of silica in the cooking system when regenerated green liquor is used for cooking bamboo in a closed cycle.

In the present study, bamboo green liquor and kraft cooks have given pulps around 50% yield, although the kappa number of the green liquor pulp is 57.5 as against 35.2 for the kraft pulp. The lignin content in the green liquor pulp is 9.5%, compared to 5.9% in the kraft pulp. In eucalyptus, however, the green liquor cook has given 8.7% higher yield than in kraft cook. The lignin contents of the eucalyptus green liquor and kraft pulps are 9.9% and 5.7% respectively. Under the cooking conditions used in the present study for bamboo and eucalyptus in green liquor pulping, hemi-celluloses are preferentially retained in the latter cook relative to lignin, than in the former cook. A series of green liquor cooks will have to be conducted on bamboo with variation in cooking time, temperature and chemical (total titrable alkali) to determine the optimum conditions for a higher pulp yield than in the kraft process.

Pine kraft pulp has the highest alpha cellulose content at 81.5% and rice straw soda pulp the lowest at 64.2%. As is well known, pressure cook of rice straw produces a pulp with high ash content (13.8%). The viscosity of kenaf (Hibiscus sabdarifia) kraft pulp is the highest at 27.6 cps (0.5% CED), where as rice straw soda pulp has the lowest viscosity at 6.2 cps.

FIBER CLASSIFICATION OF PULPS

The fiber classification (Clark) results of unbeaten pulps are given in Table—III.

The long fibered fraction (retention on 65 mesh) of the various pulps is 66% for bamboo kraft, 63.7% for bamboo green liquor, 79.5% for pine kraft, 75.0% for kenaf kraft, 74.0% for eucalyptus kraft, 72.9% for eucalyptus green liquor, 51.6% for whole bagasse soda, 47.9% for rice straw soda and 79.7% for hessian soda. The fines fraction (passing through 125 mesh) is the lowest in hessian soda pulp at 10.2% and the highest in rice straw soda pulp at 41.1.

PULP STRENGTHS

Breaking length, burst, tear and double folds at two different levels of freeness (of interest in commercial manufacture of packaging papers) are given in Table—III. Flutting (corrugating) medium is normally manufactured at a stock freeness of around 450 ml (CSF) and kraft liner around 250 ml (CSF). Pulp strength results are expressed in old units as well as new SI units.

Kenaf kraft pulp has the highest breaking length in the range of 150-600 ml (CSF), followed by bamboo kraft, hessian soda, rice straw soda and whole bagasse soda. The lower breaking length in whole bagasse soda pulp than in rice straw soda pulp is possibly because of the presence of pith in the former pulp.

In the freeness range studied, hessian soda pulp has the highest tear factor, followed by bamboo kraft, kenaf kraft, whole bagasse soda and rice straw soda pulps. The tear factor at 250 ml (CSF) for the various pulps is 12 for bamboo kraft, 108 for bamboo green liquor, 139 for pine kraft, 85 for kenaf kraft, 88 for eucalyptus kraft, 86.7 for eucalyptus green liquor, 50.2 for whole bagasse soda, 44 for rice straw soda and 142 for hessian soda (Table—III).

Although hessian soda pulp has a higher tear factor than bamboo kraft pulp at any freeness level in the present study, bamboo has a higher tear factor at a given burst factor in the range of 30-45 burst factor. In papermaking it is more important to have a high tear factor at a given burst factor than having either a high tear factor or burst factor individually.

The maximum burst factor developed by rice straw soda pulp is 30, whereas it is 26.5 for whole bagasse soda pulp. Rice straw soda pulp has a tear factor of 35 at the maximum burst factor of 30 and whole bagasse soda pulp has a tear factor or 45 at the maximum burst factor of 26.5. It is thus clear that packaging papers manufactures from 100% rice straw or whole bagasse pulps will have poor tear and burst strengths.

Among the non-wood pulps studied in the present investigation, in the range of 30-40 burst factor, hessian soda pulp gives the bulkiest sheets followed by bamboo kraft and kenaf kraft pulps. As for whole bagasse soda and rice straw soda pulps in the range of 20-25 burst factor, the latter has a much higher bulk than does the former at a given burst factor.

STIFFNESS AND CONCORA CRUSH RESULTS

Stiffness (Taber) values of different pulps are given in Table—IV at two different freeness levels. Hessian soda pulp has the highest stiffness at 250 ml (CSF), whereas rice straw soda pulp has the lowest stiffness at the same freeness. In fact, rice straw pulp from lime cook has higher stiffness than does rice straw soda pulp. The results in Table IV show that stiffness drops with freeness except for rice straw soda pulp, where the stiffness value has increased from 16.3 at 350 ml (CSF) to 20.3 at 150 ml (CSF).

Table-V gives the results of concora crush for the various pulps at 450 ml (CSF). The concora crush test results (CMT) are on 120 gsm handsheets for type A flute at a temperature of 360°F (1/2" x 6" strip). At 450 ml (CSF), the highest CMT value is

323.7 Newtons for kenaf kraft pulp and the lowest CMT value is 161.8 Newtons for rice straw soda pulp.

In the freeness range of 200-500 ml (CSF), eucalyptus green liquor pulp has a higher CMT value than the bamboo green liquor pulp. CMT value increases on refining for bamboo green liquor pulp. In case of eucalyptus green liquor pulp, CMT value passes through a maximum at 250 ml (CSF) and then falls. It is worthwhile studying the effect of freeness on CMT value for bamboo kraft, kenaf kraft, hessian soda, bagasse soda and rice straw soda pulps.

TABLE—IV

STIFFNESS (TABER) VALUES OF DIFFERENT PULPS (120 GSM HANDSHEETS)

Sl. No.	Nature of Pulp	Pulp Freeness ml (CSF)	Stiffness mN (milli-newtons)
1.	Bamboo Kraft	450	38.6
		250	22.3
2.	Bamboo Green Liquor	450	35.5
		250	31.5
3.	Bamboo NSSC	450	49.7
		250	44.7
4.	Pine Kraft	450	28.4
		300	22.9
5.	Kenaf Kraft	450	22.8
		250	17.3
6.	Eucalyptus Kraft	450	32.9
		250	24.4
7.	Eucalyptus Green Liquor	450	29.0
		250	22.6
8.	Eucalyptus NSSC	450	41.6
		250	22.3
9.	Whole Bagasse Soda	450	22.3
		250	20.3
10.	Rice Straw Soda	350	16.3
		150	20.3
11.	Rice Straw Lime	450	19.3
		150	17.3
12.	Hessian Soda	250	60.0
13.	Kraft Waste Paper	450	26.4
		250	25.4

COMMERCIAL PACKAGING PAPERS

Tabe-VI gives the strength properties of commercial kraft papers for both large and small Indian Paper Mills. The small paper mills account for about fifteen percent of the total paper production in the country. Large paper mills produce paper from virgin pulp. The small paper mills, however, use agricultural residues, hessian and waste paper. The packaging papers produced by the large mills are superior in quality, as can be seen from the strength results listed in Table—VI. The highest strength results are obtained for paper from mill No. 2 using reed pulp. The packaging papers produced by the small paper mills are used for fluting, while the kraft papers manufactured by the interested mills are used for liner.

India does not at present produce high strength kraft paper. Stronger kraft papers could be manufacturetd from fractionating bamboo pulp, refining

TABLE—V

CONCORA CRUSH VALUES OF UNBLEACHED PULPS (120 GSM HANDSHEETS)

Sl. No.	Nature of Pulp	Pulp Freeness ml (CSF)	CMT Newtons (N)
1.	Bamboo Kraft	450	296.2
2.	Bamboo Green Liquor	705	40.2
		450	269.8
		250	309.0
		150	304.1
3.	Bamboo NSSC	450	211.0
4.	Pine Kraft	450	296.2
5.	Kenaf Kraft	450	323.7
6.	Eucalyptus Green Liquor	520	230.5
		450	237.4
		250	348.2
		100	220.7
7.	Eucalyptus NSSC	450	328.6
8.	Whole Bagasse Soda	450	215.8
9.	Rice Straw Soda	450	161.6
10.	Rice Straw Lime	350	114.8
11.	Hessian Soda	450	260.0
12.	Kraft Waste Paper	450	171.7

TABLE—VI

STRENGTH PROPERTIES OF PACKAGING PAPERS FROM SOME INDIAN PAPER MILLS

Sl. No.	Particulars		No. 1 70% Bamboo 30% Hard Wood	No. 2 90% Reeds 10% Hard Wood	No. 3 50% Hessian 50% Rice Straw	No. 4 100% Waste Paper	No. 5 70% Waste Paper 30% Hessian	No. 6 75% Hardwood 25% Softwood	No. 7 100% Bamboo
1.	Basic Weight, (g/m²)		140	122.5	100.5	108	118	91	80
2.	Caliper, (mm)		0.23	0.18	0.18	0.21	0.28	0.15	0.15
3.	Bulk, (cm³/g)		1.64	1.46	1.8	1.9	1.9	1.53	1:87
4.	Breaking Length, (km)	MD	4.97	5.45	3.00	3.64	3.47	4.32	4.57
		CD	3.67	3.31	1.55	2.00	3.06	2.99	2.43
5.	Burst Index, (kPa)(m)/g		2.17	2.86	1.23	1.29	1.76	2.28	2.24
6.	(Burst factor), (Mullen)		22.1	29.2	12.6	13.2	18.0	23.2	22.8
7.	Tear Strength, (mN)	MD	1177	1228	592	668	824	702	597
		CD	1329	1294	670	791	903	851	685
8.	(Tear factor), (Elemendorf)	MD	85.66	102.2	60	63.1	56.7	78.7	76
		CD	96.73	107.7	68	74.7	62.2	95.3	87.3
9.	Double folds, (MIT)	MD	57	225	6	12	—	68	52
		CD	52	190	5	8	—	40	17
10.	Stiffness, (mN)	MD	18.8	22.3	23.3	10.9	23.8	4.6	19.3
		CD	9.84	7.7	9.13	6.5	32.5	7.7	7.9
11.	Stiffness, (TABER (TABER) UNITS)	MD	9.25	11.0	11.5	5.4	11.75	2.25	9.5
		CD	4.95	3.8	4.5	3.2	16.0	3.8	3.9

separately the longer fibered fraction and then adding internal bonding agents such as starch, guar gum, carboxy methyl cellulose (2).

The lower tensile energy absorption values of papers from non-wood fibers prohibits their use for multi-wall sacks. Pilot plant tests by Clupack, Inc. on Central Pulp Mills bamboo kraft pulp have, however given promising results (3).

Thus for non-wood fibers have the potential to be used for the highest strength packaging papers.

INDIAN STANDARDS FOR PACKAGING PAPERS

IS 1397-1967 lists specifications for kraft paper of grade I and II in regard to burst factor, breaking length, pH, cobb sizing and moisture content. For corrugating medium, CMT is more important than burst (mullen). Similarly, for liner-board, CLT (Concora liner test) and stiffness values are very important, in addition to burst. Indian standard should be revised to include these important tests.

It is heartening to note that ISI are bringing out a separate standard for kraft liner and corrugating medium.

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