Characteristics of Packaging Papers From Commonly Used Cellulose Raw Materials in Indian Paper Industry

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Bamboo, pine, eucalyptus, kenaf, baggasse rice straw, gunny rags. and kraft waste paper are the raw materials studied in the present investigation. Indian market kraft papers are compared with European fluting medium and American linerboard and fluting medium.

Paper as a packaging material is contrasted with plastics and wood.

Introduction :

Packaging papers occupy an important place in industrial economy. The rate of consumption of packaging papers in a country parallels its rate of industrial development. In 1972–74, the production of packaging papers/boards was around 325,000 tonnes, constituting roughly 40% of the total production of paper and board in the country. The planning commission estimates on the demand of Industrial papers (kraft and brown wrappers, paper–boards and others) towards the end of fifth, sixth and seventh five year plans are: 587,000 tonnes (1978-79), 840,000 tonnes (1983-84) and 1250,000 tonnes (1988–89) respectively.

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Paper based materials account for over 45% of all the packaging materials. Packaging industry uses paper/board in the form of (a) Bags (b) wrappers (c) Sealing tapes (d) Boxes (e) Drums and tubes and (f) Cushioning materials. For example, paper based products are employed in packaging (i) milk and milk products (ii) preserved fruits and vegetables (iii) biscuits (iv) tea and coffee (v) pharmaceuticals (vi) rubber and rubber goods (vii) textiles (viii) paint and varnishes (ix) batteries (x) bicycle and automobile spares (xi) defence stores, to name a few applications. Light weight, easy disposability (for lamination, printing, etc.) non–reactivity towards the material packed, cheap cost, ease of packing and transport are some of the factors governing the increased use of paper based products for packaging[1]

Fibrous Raw Materials

Wood (soft-wood and hardwood) bamboo, straw (wheat and rice), rags and cotton linters, bagasse and secondary fibre (recycled or waste paper) are among the predominantly used cellulosic raw materials in the manufacture of packaging papers. Due to differences in fiber morphology, composition and distribution of cellulose, hemicellulose and lignin in the cell wall and depending on the pulping process, etc., pulps of different characteristics result from different fibrous raw materials.

Bamboo, rice straw, pine, eucalyptus, gunny rags, bagasse, kenaf and kraft waste paper are studied in the present

investigation. The cooking details and pulp yields are listed in Table 1. The cooking parameters are so chosen as to yield pulps suitable for kraft papers, viz corrugating medium and liner board.

Table 2 gives the strength properties of pulps at 250 ml CSF (60 gsm handsheets). Pine kraft pulp shows the highest overall strength : breaking length 7.80 Km, burst factor 56.9, tear factor 201 and double folds (MIT) 428. It is interesting to note that kraft pulp of kenaf (*Hibiscus sabdariffa*) gave the highest breaking length (8.57 KM.) and double folds (654) recorded in the present study, but the tear factor at 80 is much lower than the corresponding values for pine (TF 201) and bamboo kraft pulps (TF 103). Rice straw pulps exhibited the lowest over-all strength, followed by whole bagasse soda pulp; the strengths of these pulps could be improved, however, on further delignification but at the cost of drop in yield.

Table 3 records the strength properties of pulps at 450 ml CSF for 120 gsm handsheets, the freeness and gram weight so chosen as to correspond to the the manufacturing conditions of liner board and corrugating medium in actual practice. The phenomenon noticed in Table 2 for 60 gsm handsheets at 250 ml CSF is confirmed in Table 3. It can be seen from the strength data listed in the various tables that gunny rag

Table 1
Cooking Conditions for Various Cellulosic Raw Materials :

Raw Materials.		Bamboo			Rice Straw		Pine	Eucalyptus		Gunny rags.	Whole bagasse.	Whole Kenaf.	Kraft waste paper
PROCESS		Kraft	NSSC	Green Liq.	Soda Cook	Lime Cook	Kraft	NSSC	Green Liq.	Soda Cook	Soda Cook	Kraft Cook	—
1. Cooking Chemical On OD Material,	%	17.0 as TAA Na_2O	20.0 as Na_2SO_3	24.0 as TTA Na_2O	6.0 as NaOH	6.0 as CaO	20.0 as TAA Na_2O	25.0 as Na_2SO_3	25.0 as TTA Na_2O	4.00 as NaOH	6.0 as NaOH	14.0 as TAA Na_2O	—
2. Time to Max. Temp,	Min.	180	60	90	30	30	180	60	90	30	30	45	—
3. Time at Max. Temp,	Min.	90	300	120	120	120	90	300	120	120	180	90	—
4. Max. Temp,	°C.	155	160	165	140	140	170	140	165	170	140	165	—
5. Bath Ratio, (Chips to Liquor)		1:2.5	1:2.5	1:2.5	1:5	1:5	1:2.5	1:2.5	1:2.5	1:5	1:5	1:5	
6. Unscreened Yield on OD Raw Material	%	50.2	62.0	50.8	68.2	83.2	46.0	70.4	57.4	52.5	77.0	55.3	
7. Refined Yield on OD Material	%	—	60.3	—	56.4	75.2	—	64.8	53.1	50.6	71.7	—	
8. Screened Yield on OD Material	%	49.3	59.1	50.4	56.4	75.2	44.5	63.6	52.8	50.2	59.7	48.2	
9. Permanganate Number of Unbleached Pulp,		22.0	24.0	31.5	15.0	20.7	23.0	34.8	28.5	32.2	31.8	16.5	21.6
10. Kappa Number of Unbleached Pulp,		34.9	42.0	74.0	22.7	31.8	31.8	39.0	84.8	58.2	78.2	24.3	30.5
11. Ash	%	1.6	3.0	2.2	13.9	15.8	0.6	1.1	2.3	1.8	1.6	2.8	4.6

NOTE : For bamboo and Pine Kraft Cooks, Cooking Schedule is 45 Min, to 105°C, 45 Min. at 105°C, 90 Min to Max. temp. and 90 Min. at Max. temp.

Table 2
Strength Evaluation (Valley Beater) of Unbleached Pulps from Different Cellulose Raw Materials (60 gsm Handsheets)

Raw Material	Bamboo			Rice Straw		Pine	Eucalyptus		Gunny rags	Whole bagasse	Whole Kenaf	Kraft waste paper
Process	Kraft	NSSC	Green Liq.	Soda Cook	Lime Cook	Kraft	NSSC	Green Liq.	Soda Cook	Soda Cook	Kraft Cook	—
Initial Freeness ml CSF	670	690	705	400	500	670	590	520	670	450	600	500
Final Freeness ml CSF	250	250	250	150	150	300	250	250	250	2 0	250	250
Beating Time, Min.	58	63	62	25	38	60	35	37	59	16	23	19
Breaking Length, KM	76.60	6.66	5.54	2.46	2.40	7.80	6.95	7.77	5.71	2.76	8 57	3 47
Burst Factor, Mullen	42.2	45.1	50.1	25.6	19 6	56.9	40.2	44.6	53.9	22.0	52.3	25.8
Tear Factor, ELM	103	152	193	70.5	69.5	201	72 4	57.1	78.6	48	80	88.5
Double Folds, MIT	172	86	213	3	4	428	59	183	631	9	634	12
Sheet Density, g/cc.	0.60	0.62	0.55	0.62	0.58	0.66	0.67	0.65	0.55	0 62	0.74	0.57
Fiber classification of unbeaten pulps (Clark)												
+20 Mesh %	38.8	34.9	40.1	4.7	25.0	70.8	12.2	5.1	65.3	5.7	26.8	38.0
—20+50 Mesh %	19.7	17.5	16.8	20.8	14.9	12.7	28.8	33.2	12.8	27.2	32.8	17.0
—50+65 Mesh6 %	7.0	8.0	6.8	12.9	8.4	4.0	22.6	26.6	4.8	16.9	15.4	8 5
—65+125 Mesh 6%	4.5	4.0	5.6	11.0	7.3	2.2	18.4	14 2	2.4	19.4	8.2	4.6
—125 Mesh %	30.0	36.1	30.7	50.6	44.4	10.3	18.0	20.9	14.7	30.8	16.8	31.9

Table 3
Strength Properties for Different Cellulosic Raw Materials (120 GSM Handsheets) at 450 ML CSF.

Raw Material	Bamboo	Eucalyptus	Pine	Whole Kenaf	Rice Straw	Whole bagasse.	Gunny rags	Kraft waste paper.
Process	**Kraft**	**NSSC**	**Kraft**	**Kraft**	**Soda**	**Soda**	**Soda**	—
Initial Freeness, ML CSF	670	590	670	600	450	450	670	500
Final Freeness, ML CSF	450	450	450	450	450	450	450	450
Beating Time, Min.	30	15	25	5	0	0	30	4
Breaking Length KM.	6.49	5.82	7.81	8.36	2.75	3.73	4.54	2.97
Burst Factor, Mullen.	45.1	38.4	56.4	47.7	18.8	18 3	34.4	21.8
Tear Factor, Elm.	159	75.6	223	102	811	62	115	96
Double Folds, MIT.	220	3	732	540	3	2	42	9
Sheet Density	0.61	0.64	0.68	0.68	0.47	0.57	0.50	0.60
CMT (Concora) Kgs.	30.2	33.5	30.0	33.0	16.5	22.0	26.5	17.5
Stiffness (Kenley) gms. (of 120 gsm; 250 ML CSF handsheets)	4.65	5.10	7.9	4.15	3.9	5.1	8.5	4.9

pulp will add strength to the furnish, when mixed with weaker straw, bagasse or kraft waste paper pulp Medium quality corrugating medium/wrapping papers can be manufactured from such pulp furnishes. In the present study, new gunny rags are used. In actual practice, once or twice used gunny rags are cooked in the mills for the obvious reason of economy.

The concora crush results (CMT) in Table 3 are for type A flute at a temperature of 360°F. (1/2" x 6" strip). The highest CMT value is recorded for eucalyptus N.S.S.C. pulp. CMT values for the various pulps at 450 ml. CSF are: 3[illegible].2 Kgs. for bamboo kraft; 21.5 Kgs. for bamboo N.S.S.C. and 27.5 Kgs for bamboo green liquor, 16.5 Kgs. for rice straw soda and 11.7 Kgs for rice straw lime, 30 Kgs. for pine Kraft, 33.5 Kgs. for eucalyptus N.S.S.C. and 22.0 Kgs. for bagasse soda, 33.0 Kgs. for kenaf kraft, 24.2 kgs. for eucalyptus green liquor, 26.5 Kgs. for gunny soda and 17.5 Kgs. for kraft waste.

In the range of 700 ml to 250 ml CSF, CMT value increases with refining, however, on further refining to 100 ml CSF, the value has either remained constant or fallen. For bamboo green liquor pulp, for instance, CMT values at 705 ml CSF, 450 ml CSF and 100 ml CSF are 41.1 Kgs., 31.5 Kgs. and 31.0 Kgs. respectively. The stiffness values listed in Table 3 (for 120 GSM handsheets at 250 ml CSF) show that lime cooked straw gives the stiffest sheet, which explains perhaps the utilisation of straw board in various packaging applications.

Green liquor cooks are being increasingly practised abroad on hard woods in place of traditional N.S.S.C cooks, owing to water pollution problems with N.S.S.C spent liquors, especially where cross recovery (with kraft black liquor) is not done. In the present study, the concora results for eucalyptus and bamboo N.S.S.C. and green liquor cooks seem contradictory. Eucalyptus N.S.S.C. pulp has given a higher CMT value of 33.5 Kgs as against 24.2 Kgs. for eucalyptus green liquor pulp. In case of bamboo, the N.S.S.C. pulp has yielded, however, a CMT value of 21.5 kgs. as against 27.5 Kgs. for green liquor pulp. A detailed investigation of N.S.S.C. and green liquor cooks will provide the final answer on the relative merits of each process for a particular raw material.

It may be mentioned that green liquor pulping of pine is being studied abroad for the manufacture of linerboard. The results obtained so far suggest that higher cooking chemical and lime are needed to produce pulps at somwhat of a higher yield and close to the present day linerboard grade pulps in paper making characteristics. The advantage of not going in for causticization and lime mud reburning is a positive feature of green liquor pulping, especially at the present level of fuel oil prices. Attempts are also made to use as high a precentage of green liquor hardwood pulps as possible in linerboard furnishes to conserve long fibred softwood species.

Market Papers

Strength properties of Indian Kraft papers and European fluting medium are listed in Table 4. It can be seen that the strength properties of most Indian kraft papers compare favourably with European fluting medium. The strength properties of kraft papers from straw and waste paper are predictably lower than those manufactured from virgin bamboo or wood pulps.

It is perhaps meaningful to leave corrugating medium manufacture to smaller paper mills. With the addition of long fibred gunny, rag or market bamboo pulp, the mini paper mill should be in a position to supply fluting medium of requisite quality.

Although neutral sulphite semi-chemical pulp gives fluting medium of the best quality, it is not possible at the present time to go in for this process in our country due to spent liquor recovery and water pollution problems.

Table 5 lists the specifications of some standard grades of corrugating medium and linerboard in United States The burst factors (mullen) of Indian kraft papers are somewhat lower than those of American linerboard grades of the same basis weight. This is

Table 4
Strength Prope ties of Some Indian & Foregin Kraft Papers

Properties	Paper Mills No. 1 70% Bamboo 30% Hard-wood	No. 2 90% Reed-Bamboo 80% Hard-wood	No. 3 50% Gunny 50% Straw	No. 4 100% Waste Paper	No. 5 70% Waste Paper 30% Gunny	No. 6 75% Hard-wood 25% Soft-wood	No 7 100% Bamboo	European Fluting Medium NSSC	100% Waste Paper	100% Straw
Basis Weight, gsm	140	122.5	100.5	108	148	91	80	115	122	125
Caliper, Microns	230	180	180	205	275	140	150	216	233	218
Bulk, cc/g	1.64	1.46	2 3	1.9	1.88	1.53	1.87	1.88	1.91	1.74
Breaking length, km										
MD	4.97	5.45	3.0	3.64	3.47	4 32	4.37	7.10	4.90	3.50
CD	3.67	3 31	1.55	2.00	3.06	2.99	2.43	2.50	2.40	2.00
Avg	4.32	4.38	2.29	2.82	3 27	3.65	3 50	4 80	3.60	2.75
Burst factor, Mullen	22.1	29.2	12.6	13.2	18.0	23.2	22.8	32 2	27.8	21.6
Tear factor, Elmendorf										
MD	128 5	153 3	90.0	94.6	85.1	118	114	56	88	57
CD	145.1	161.5	102	112	93.3	143	131	77	95	67
Avg	137.1	157.4	96	103	89.2	130	122	66,5	91.5	62
Double folds, MIT										
MD	57	225	6	12	—	68	52	—	—	—
CD	52	190	5	8	—	40	17	—	—	—
Avg	54	208	6	10	—	54	34	—	—	—

Table 5
Characteristics of American Corrugating Medium and Linerboard

Basis Weight gsm	Caliper inches	Burst Mullen, psi(g)	Concora psi(g)
125	0.009–0.0095	70	42
161	0.0105–0.0120	80	55
178	0.0125	—	60
185	0.0118	95	—
205	0.0119	105	—

Table 6
Some Characteristics of Normal Packaging Materials

Materials	**Modulus of elasticity, Kg./m²**	**Density, Kg./m³**	**Range of thickness mm**	**Range of basis weight g/m²**
Woods				
Plywood (Coniferous)	$(30–60).10^7$	575–595	4–12	—
Plywood (Birch)	$(65–75).10^7$	640–650	4–12	—
Boards				
Hardboard	45.10^7	900–950	2.0–6.4	—
Multilayer board	$(14–35).10^7$	650–800	—	200–600
Particle board	(35.17^7)	650	8–25	—
Pasted board	$(30–90).10^7$	625–800	—	300–2000
Corrugated board	$(3–36).10^7$	150–300	—	350–1500
Plastics				
Polyethylene (Low Density)	2.10^7	920	0.2–10	—
(,,) (High Density)	12.10^7	960	0.2–10	—
Polystyrene (Impact)	26.10^7	1050	0.2–3	—
(,,) (Normal)	36.10^7	1050	0.2–3	—
Poly Vinyl Chloride	26.10^7	1400	0.2–4	—
Polypropylene	$12.5.10^7$	900	0.2–4	—
Metals				
Constructional Steel	2.10^{10}	7860	0.2–10	—
Tin Plate	2.10^{10}	7860	0.28–0.38	—
Aluminium Plate	7.10^9	2690	0.20–6.0	—
Aluminium Alloys	7.10^9	2690	0.20–0.40	—
Glass	7.10^9	2650	0.8–0.8	—

possibly due to differences in fibre used and the pulping process employed. Intensive efforts should be focussed on bamboo and other local raw materials to produce stronger pulps with improvements in pulping process and equipment. At the same time, research activities should be stepped up to develop packaging machinery and techniques to profitably utilise papers from local fibrous materials in various packaging applications.

High Strength Kraft Papers.

As is well known, it is difficult to manufacture from bamboo pulp (relatively short fibre compared to short wood pulps and having over 30% fines) high strength sack kraft papers. Pine and fir grown in Himalays yield stronger kraft pulps than could be obtained from bamboo, but not quite close to those of continental or North American softwood pulps used for multi-wall sacks.

One way to manufacture high strength kraft paper will be to fractionate pulp into long fibered and short fibered fractions, It may be noted here that Black-Clawson's Celler-sizer, operating on pressurised fractionation principle, is stated[3] to have been successfully employed in fractionating high yield virgin pulp and waste paper pulp to yield long fibred stock for liner board and short fibered stock for corrugating medium. This technique might prove useful in upgrading bamboo pulp and refining the long fibred stock with additives like gums, starch, carboxy-methyl-cellulose, sodium silicate, etc. to further improve on sheet strength.

Papers made from short fibered raw materials, especially non-woody fibers, have low tensile energy absorption (TEA) values due to the lower tensile and stretch values compared to sheets from wood pulps. It is found the TEA value, not just tensile or strech, controls the utility of a sheet for multi-wall sack papers. Clupak Inc. made use of the principle of mechanical compaction[2] of the sheet to increase the machine direction stretch around four to seven times as great as the stretch of the uncompacted paper, thereby increasing the TEA value by over 300%. The technique in brier is as follows: The moist web of paper, while, still in plastic form, is subjected to the recoil action of an endless elastic surface, a rubber belt or blanket. Judicious application of Clupak technique will upgrade short fibered pulps like straw, baggasse, etc. in addition to the relatively longer fibered bamboo for use in high strength kraft papers for packaging cement, sugar and other products.

It is necessary to know whether a sustained and reasonable market exists for high strength kraft papers-sack kraft or multi-wall sack It is worth considering Clupak technique of sheet compaction or Black Clawson's celler-sizer fiber classification, if kraft papers resulting from these techniques could be sold at attractive prices in the market, since the investment for equipment as well as operating costs are high to produce extensible kraft papers.

Stifness Considerations of Packaging Materials :

All packages should perform two essential functions :

(a) to protect the contents and (b) to isolate the contents from effects originating from the outside or inside of the package. The protective function requires stiffness to withstand handling. The insulation function can be satisfied by barrier properties obtained with the addition of plastics or aluminium foil or wax coating, etc.

The minimum amount of packaging material is normally determined by stiffness requirement, with the exception of brittle materials such as glass. Table 6. lists some important characteristics or the commonly used packaging materials[4]. Specific stiffness of packaging material can be determined by the relationship $:S = \frac{E_{h^3}}{12}$ where S is specific stiffness, h is thickness of the packaging material and E is modulus or elasticity,. With the knowledge of price/unit weight of packaging material, its density and elastic moduls, it can be shown that the finished packages of multi-layer board and corrgated fiber board have the lowest price per unit volume

in practically the whole range of volumes for rigid packages[5]

Paper versus plastics and wood.

Plastics are homogeneous, uniform packaging materials that impart barrier characteristics like resistance to watervapour, etc. to packages. Poor adaptablity to graphic arts such as printing, difficulty to recycle from the solid waste disposal view point as well as high cost are the main deterrents in the increased use of plastics for packaging. Due to four-fold increase in fuel oil prices in the last two years, the competetive position of plastics worsened vis-a-vis paper in the packaging field. This situation may change in 1980 when India is supposed to become self-sufficient in oil.

In view of the higher excise duty on packaging papers at Rs. 1200/-ton presently, wood has staged a come-back as a packaging material in certain applications, especially in Northern India where it is available at relatively cheaper prices. It is hoped this will be a passing phase; otherwise fiber resoures which can be better put to use in pulping will be wasted in not so useful applications. Also, wooden packages will be heavier, inconvenient and the packing and transport costs higher than in paper hased packages. Furthermore, many countries do not accept wooden packages as these are prone to insect attack, etc. Constituting health hazards.

It looks right now that paper by itself or paper in combination with coatings, plastics, aluminium, foil, etc. that will continue to be the predominant packaging material in the next ten years to come.

Tests for packaging papers:

IS 1397-1967 lists specifications for kraft papers 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 linerboard, CLT (Concora liner test) and stiffness values are very important, in addition to burst. Indian standards should be revised to include these important tests.

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