Evaluation of some non-conventional raw materials for producing high brightness pulps

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ABSTRACT

Kraft pulping studies of non-conventional raw materials like gunny cutting, jute fibre and cotton linter was carried out to produce suitable quality of unbleached pulps for bleaching them under D C/E.P/H/D sequence to get pulp brightness over 85% P.V. unbleached pulp yield was highest in cotton linter followed by jute fibre, sisal fibre and gunny cuttings. The brightness achieved under D.C/E.P/HD sequence with gunny cutting, sisal, jute fibre and cotton linter was 83.5%, 92 0%, 86.0% and 86.5% respectively as compared to mill bamboo pulp bleached to the brightness of 89.0% under the same bleaching sequence. Brightness of gunny cutting pulp could not be increased more than 83 5% P.V even after increasing the bleach chemicals The bleached pulp yield was highest in cotton linter (72 8%) followed by jute fibre (60.13%), sisal (58.0%) and gunny cutting (47.15%). The bleach consumption in mill bamboo pulp and jute fibre was higher than gunny cutting, sisal and was lowest in cotton linter. The viscosity of all the non-conventional bleached pulps and mill bamboo bleached pulp was satisfactory. Sisal has higher breaking length, burst factor but tear factor was higher in cotton linter as compared to other non-conventional bleached pulps and mill bamboo pulp. Sisal and jute fibre bleached pulps are more suitable for development of speciality paper of high brightness and physical strength properties as compared to other non-conventional bleached pulps and mill bamboo bleached pulp.

Introduction :

With growth of population, the increase in literacy, the growing trend of professionalism in work force and greater economic activities of society, the consumption of different varieties of paper and paper product would rise in our country. The development council for paper and allied products has estimated that the demand for paper in India by 2000 A.D. is likely to be two times the production in 1987 and per capita consumption of paper will rise from 2 kg in 1987 to 4.5 kg in 2000 A.D. By this time demand of paper, paper boards and newsprint is expected to be 31.68 and 9.44 lakh tonnes respectively[1].

In view of limited availability of bamboo and its high cost of plantation and low annual yield, the existing bamboo forest in our country will not be able to meet the entire requirement of cellulosic materials for pulp and paper industry. The industry's annual consumption of bamboo is 1.7 million tonnes, but demand is expected to increase 4 million tons within the next 10 years. Even if the large mills change their pulp furnish consumption from 60% bamboo and 40% hard woods to 70% hard woods and 30% bamboo, the shortfall of pulp wood and bamboo is expected to be 5.5 million tons at the end of this decade[2].

The industry is gearing itself to use more and more bagasse, kenaf, wheat straw, rice straw, hessian cutting and waste paper etc. Straw, bagasse and bamboo are leading fibres being used from quality stand point, but many other non wood plant fibres are being used for speciality pulps. Pulp production in many countries is

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based on 100% non wood fibres and some 25 countries depend on non-wood plant fibres for more than 50% of pulp production, with China and India being the leaders[3]. Non conventional raw materials selected for kraft pulping studies are gunny cutting, sisal, jute fibre and cotton linter. Besides these non conventional raw materials mill bamboo unbleached pulp was also taken for comparison and its bleachability.

Experimental :

Autoclave ,digestion :

Manually chopped non conventional raw materials were digested by sulphate process in an electrically heated digester having indirect forced liquor circulation arrangement Pulp yield, pulp characteristics and black liquor analysis for different parameters was carried out according to Tappi Standards. Results are tabulated in table 1.0.

Refining of pulp :

Hard cook pulps were passed through Sprout Waldron disc refiner at a consistency of 6-8% and clearance between the refiner plates (D-2 A-501) was kept 127 microns.

Fibre classification :

Fibre classification of unbleached pulp was carried out in a Bauer Monett classifier and results are reported in table 1-1. For comparison mill bamboo pulp was also taken for fibre classification.

Beating characteristics and physical strength properties

Beating of unbleached sulphate pulp was carried out in a P F I. mill at 10% consistency to arrive at 45° SR freeness. Hand sheets were prepared and tested for physical strength properties as per Tappi Standards. The findings are reported in table 1.2.

Bleaching :

Non-conventional unbleached pulps were bleached under DC/EP/H/D sequence to get more than 85% P.V. brightness. Bleaching conditions and results are given in table 1.3.

Fibre morphology :

Two hundred measurements of fibre length and fibre diameter were carried out under a Projectina Projection microscope to arrive at an average value. The Findings are given in table 1 4.

Fibre classification of bleached pulp :

Fibre classification of bleached pulps is tabulated in table 1 5.

Beating and physical strength properties of bleached pulps :

All the non-conventional bleached pulps were beaten at 45° SR freeness. Standards sheets were prepared and tested for physical strength properties. Results are given in table 1.6.

Discussion :

Bulk density :

Bulk density (Kg/m^3) of gunny cutting, jute fibre cotton linter and sisal fibre are 172 0, 136.0, 120 0 and 98 5 respectively and are in decreasing order.

Kraft pulping :

Bath ratio in the digestion of all the four non-conventional raw materials was kept high because of low bulk density. In cotton linter and gunny cutting bath ratio was kept higher than other two raw materials as absorption of water was more and it facilitated liquor circulation properly,

Gunny cutting needs higher alkali (15%) than sisal (13-14%) cotton linter (10-12%) and jute fibre (14%) for producing pulp of kappa No. 15-17 for gunny cutting and sisal fiber, 22.3 for jute fiber and 5-5.2 for cotton linter. The unbleached pulp yield was highest in cotton linter (76 9%) followed by jute fibre (63.1%), sisal fibre (61.5-63 0%) and gunny cutting (50.7-52 0%).

Gunny cutting and cotton linter black liquors have calorific value lower than other two black liquors but silica content showed a reverse trend. Other parameters of black liquor analysis are reported in Table-1.

TABLE—1.0

Kraft Cooking of Non Conventional Raw Materials

S. No.	Particulars	Digestion No.	Gunny cutting 1	2	Sisal fiber 3	4	Jute fibre 5	Cotton linter 6	7
1	Moisture, %		7.4	7.4	8.3	8 3	7.6	5.6	5.6
2	Sulphidity, %		16.0	16.0	16.0	16 0	16.0	16.0	16.0
3	Bath ratio		1:8	1:7	1:6	1:6	1:6	1:10	1:9
4	Alkali % as Na_2O		15.0	15.0	13.0	14.0	14.0	12.0	10.0
5	**Cooking schedule (mts)**								
	(i) Upto 150°C		120	120	120	120	120	120	120
	(ii) At 150 °C		180	210	180	180	180	180	180
	(iii) Total time (hrs)		5.0	5.5	5.0	5.0	5.0	5.0	5.0
6	Unbleached pulp yield, % on O D raw material.		52.0	50.7	63 0	61.5	63.1	76.9	80.0
7	Kappa No.		16.8	15.0	16.6	15.1	22.3	5.2	5.0
8	**Black Liquor Analysis**								
	(i) pH		10.9	10 8	10.8	10.9	10 7	10.8	10 7
	(ii) R.A.A as Na_2O g/L		9.3	8.8	9 3	11.0	10.8	7.7	6 2
	(iii)°TW at 60°C		4.5	7.0	5.5	7.0	9 0	3 5	3.0
	(iv) Total solids, %		6.4	8 4	7.5	9.0	9 0	3 8	3 5
	(v) Inorganics, %		35.0	36.5	31 9	33 0	34.3	39 4	37 5
	(vi) Organics, %		65.0	63.5	68.1	68 0	65.7	60 6	42.5
	(vii) Silica, % on O.D. total solid		0 63	0.52	0.37	0.33	0 37	0.80	0.70
	(viii) Calorific Value, Cal/gram		—	2664	2988	—	2940	2513	—

TABLE—1.1

Bauer Mcnett Classification of Unbleached Pulps

S No	Mesh size	RETENTION,% Bamboo mill pulp	Gunny cutting No. 2	Sisal fibre No 3	Jute fibre No. 5	Cotton linter No. 6
1	+ 40	62.87	97.40	98 06	95.80	93 45
2	+ 70	9.50	1.36	1.39	2.30	2.74
3	+ 100	2.84	0.62	0.31	0.75	1.92
4	+ 140	1.89	0.46	0.04	0 55	1.75
5	— 140	22.90	0.16	0 20	0.60	0.14
6	Total	100.00	100.00	100.00	100.00	100.00

Fibre classification :

Fibre classification of unbleached pulps in a Bauer Mcnett classifier confirms over 93% fibres were retained on + 40 mesh whereas in mill bamboo pulps for comparison it was on lower side(62.87%).This confirms these non-conventional raw materials produce long fibres pulp. Further fines in bamboo pulp is higher than other non-conventional raw material pulps (Table–1.1).

Beating and physical strength properties of unbleached pulp.

Beating revolutions in gunny cutting, sisal fibre and jute fibre is nearly same indicating same energy requirement to arrive at 45°SR freeness but was higher than mill bamboo pulp. Physical strength properties of sisal unbleached pulp is superior to remaining three unbleached pulps but cotton linter has inferior strength properties to mill bamboo pulp (Table 1.2).Unbleached cotton linter has highest unbleached pulp brightness 44.5-45.5% P.V followed by jute fibre (44 0% P V) sisal (41.0% P.V) gunny cutting (36.37% P.V) and mill bamboo pulp (21.0% P.V).

Bleaching of Pulps :

Mill bamboo and non-conventional unbleached pulps were bleached under DC/E P/H/D sequence in order to get pulp brightness more than 85% P V brightness with minimum pulp degradation. It was discovered in many laboratories [4-8] that treating unbleached pulp sequentially with chlorine dioxide and then with chlorine, without washing between these two treatment gave even lower kappa No in the extraction stage and higher brightness after chlorine dioxide stages hence chlorine to the tune of 10% was replaced by chlorine dioxide in the sequentional bleaching. To get higher pulp viscosity, brightness and minimum pulp degradation hydrogen peroxide in the alkali extraction stage and sulphamic acid in the hypochlorite stage of bleaching were added as per the dosages and bleaching conditions (Table 1.3).

In non-conventional raw materials, bleach consumption was higher in jute fibres followed by gunny cutting, sisal and cotton linter as expected due to higher kappa No. Shrinkage in jute fibre and cotton linter bleached pulps was 4. 7%, 5.3% respectively and was lower than gunny cutting (7.0%) and sisal (8 0%). The pulp brightness and viscosity were 92% and 10.6 Cps respectively in sisal bleached pulp and was higher than other non-conventional bleached pulps. Brightness in gunny cutting pulp could not be improved more than 83–84% P.V even after increasing dosage of bleaching chemicals. Mill bamboo pulp requires higher bleach consumption and results higher pulp shrinkage as compared to non-conventional raw materials (Table 1.3).

Fibre morphology :

The average L/D ratio in sisal bleached pulp is higher than other non-conventional pulps giving an idea of better strength properties than other non-conventional and bamboo fibrous pulps (Table 1.4).

Fibre classification of bleached pulps :

Fibre classification of all the non-conventional bleached pulps confirm over 87.0% fibres were retained on+40 mesh and was higher than mill bamboo bleached pulp. Fines content in non-conventional bleached pulps is lower than bamboo pulp (Table 1.5).

Physical strength properties of bleached pulps :

Amongst the non-conventional bleached pulps sisal has higher breaking length, burst factor but tear factor was higher in cotton linter pulp. Sisal and jute fibre bleached pulps are more suitable for development of speciality paper than gunny cutting and cotton linter. Bamboo pulp has inferior strength properties than sisal, gunny cutting, jute fibre but was superior to cotton linter except its tear factor (Table 1.6).

Conclusions :

Kraft pulping studies of gunny cutting, sisal, jute fibre and cotton linter for producing high brightness pulps (over 85% P.V) indicate that sisal and jute fibre bleached pulps are more suitable for development of speciality paper of high brightness and physical strength properties as compared to other non-conventional bleached pulps and mill bamboo bleached pulp. Desired high pulp brightness from gunny cutting could not be achieved under D.C./E.P/H/D sequence but bamboo pulp and cotton linter pulps were suitable for the same.

TABLE—1.2

Unbleached Pulp Strength Properties of Non-Conventional Raw Materials.

S. No.	Particulars	Bamboo mill pulp	Digestion No.	Gunny Cutting 1	Gunny Cutting 2	Sisal fibre 3	Sisal fibre 4	Jute fibre 5	Cotton linter 6	Cotton linter 7
1	Initial freeness °SR	—		7	7	8	7	7	6	6
2	Final freeness °SR	45		45	45	45	45	45	45	45
3	No. of beating revolution in P.F. mill.	13000		15,300	14,000	15,300	14,000	13,500	12,000	13,000
4	Bulk, cc/gram	1.41		1.67	1.58	1.58	1.46	1.62	1.73	1.76
5	Breaking length (meters)	5759		6781	6438	8040	7840	7030	4350	5093
6	Burst factor	51.6		66.6	59.6	78.6	75.7	50.3	33.0	36.2
7	Tear factor	101.6		154.3	150.9	146.0	140.0	126.5	173.0	183.0
8	Doublefold	302		582	677	1335	1028	1000	640	572
9	Tensile Index, mN/g	56.46		66.48	63.12	78.82	76.86	68.92	42.65	49.93
10	Burst Index, KPa.m²/g	5.06		6.53	5.84	7.70	7.42	4.93	3.26	3.55
11	Tear Index mN.m²/g	9.96		15.13	14.79	14.31	13.72	12.40	16.96	17.94
12	Brightness of pulp % P.V.	21.0		36.0	37.0	41.0	41.0	44.0	44.5	45.5
13	Ash, %	1.2		1.36	1.32	1.03	1.02	1.39	1.05	1.12

Table 1 3

Bleaching of Bamboo and Non-Conventional Pulps

S No.	Particulars	Bamboo pulp	Gunny cutting	Sisal fibre	Jute fibre	Cotton linter
	Digestion No.	—	2	3	5	6
	Kappa No.	25.0	15.0	16.6	22,3	5.2
1.	**D/C Stage :**					
	1 Chlorine dioxide added, % as available chlorine	0.6	0.54	0.50	0.55	0.14
	2 Chlorine added % as available chlorine	0.6	4.0	4.0	5.5	1.4
	3 Chlorine consumed %	6.46	4.33	4.35	5.85	1 38
	4 End pH	1.4	1.5	1.8	1.7	2.3
2.	**EP-Stage :**					
	1 Alkali applied % as NaOH	2.0	2.0	2.0	2.0	1.0
	2 Hydrogen peroxide applied, %	0.3	0.3	0.3	0.3	0 2
	3 End pH	9.2	10.0	9.5	9.5	10.0
3.	**Hypochlorite stage :**					
	1 Hypo applied, % as available chlorine	2.5	2.0	2.0	2.0	1.5
	2 Buffer added, % as NaOH	0.7	0.6	0.6	0.6	0.6
	3 Sulfamic acid added, %	0.1	0.1	0.1	0.1	0.1
	4 End pH	8.2	8.3	8.4	8.2	8.2

Table 1.3 (Contd)

S. No.	Particulars	Bamboo pulp	Gunny cutting No. 2	Sisal fibre No. 3	Jute fibre No. 5	Cotton Linter No. 6
4.	**Chlorine dioxide stage**					
	1 Chlorine dioxide added % as available chlorine.	1.5	1.5	1.0	1.5	1.0
	2 Chlorine dioxide consumed as chlorine, %	1.42	1.47	0.97	1.45	0.97
	3 End pH	4.5	4.4	4.6	4.2	5.0
5.	**Final Results**					
	1 Total chlorine applied, %	10.6	8.04	7.50	9.55	4.04
	2 Total chlorine consumed, %	10.38	7.80	7.32	9.30	3 89
	3 Shrinkage pulp, %	12 0	7.0	8.0	4.7	5.3
	4 Bleached pulp yield, % on O.D. raw material.	—	47.15	58.0	60.13	72.8
	5 Brightness of pulp, % P.V.	89.0	83.5	92.0	86.0	86.5
	6 Viscosity (0 5%, CED) CPs	9.0	10.8	10.6	8 6	—
	7 P C. No.	2.10	2.73	0.79	1.09	1 67
	8 Ash %	0.8	0 6	0.6	1.0	0.9

CONSTANT BLEACHING CONDITIONS

Stage	D/C	E P.	H.	D.
Consistency, %	3.0	10.0	10.0	10.0
Temperature' °C	Room	55+1	40	70
Time, Hrs	0.75	1.0	2.0	2.5

Table 1.4
Fibre Morphology of Non–Conventional Bleached ulps

S. No.	Particulars	Bamboo pulp	Gunny cutting	Sisal fibre	Jute fibre	Cotton linter
1.	**Fibre length (m m)**					
	1 Minimum	1.20	1 60	1.50	1.40	1 20
	2 Maximum	4.40	3.60	6.40	6.00	4.80
	3 Average	2.03	2 13	3.37	2.75	3.54
2.	**Fibre diameter (m.m.)**					
	1 Minimum	0.010	0.005	0.010	0.007	0.010
	2 Maximum	0.037	0.060	0 027	0.038	0 042
	3 Average	0.019	0.020	0.020	0.031	0.026
3.	**Slenderness ratio**	106.8	106.5	168.5	88.7	136.2

Table 1.5
Bauer Mcnett Classification of Bleaching Pulps

S. No.	Mesh size	RETENTION %				
		Bamboo pulp	Gunny cutting No. 2	Sisal fibre No. 3	Jute fibre No. 3	Cotton linter No 6
1	+ 40	60.87	92.31	90.76	87.50	87 32
2	+ 70	8.58	2.43	2.00	3.10	4.09
3	+ 100	4.85	0.81	1.20	2 10	2 31
4	+ 140	0.89	0.44	0.60	1.90	1.27
5	— 140	24 81	4.01	5 44	5.40	5.01
6	Total	100 00	100.00	100.00	100 00	100.00

Table 1.6
Physical Strength Properties of Bleached Bamboo and Non-Conventional Raw Material Pulps

S. No.	Particulars	Bamboo pulp	Gunny cutting No. 2	Sisal No. 3	Jute fibre No. 5	Cotton linter No. 6
1.	Final freeness °SR o. beaten pulp	45	45	45	45	45
2	No. of beating revolution in P. F. I. mill.	9,500	10,500	11,500	11,500	9,000
3.	Bulk cc/gram	1.30	1.44	1.40	1.50	1.49
4	Breaking length, meters	5528	6021	7640	6847	4650
5	Burst factor	45.0	50.7	70.6	48 3	33.6
6.	Tear factor	77.9	124.3	126.0	105 5	125.6
7.	Double fold	192	278	680	350	192
8.	Tensile Index, m, N/g	54.20	59.03	74.90	67.13	45.59
9.	Burst Index, K.Pa. m^2/g	4.41	4.97	6 92	4 73	3.29
10.	Tear Index mN. m^2/g	7.63	12.19	12.35	30.34	12.31

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