

Suitability of Whole Jute Plants Over Other Conventionally Used Non-Woody Raw Materials for Paper And Newsprint

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ABSTRACT

Jute is an annual plant widely cultivated in eastern and central part of the India. The main user of the jute plant in the country are gunny bag industries, using only the bast portion (25% of the whole plant) for the gunny bags, leaving behind the jute sticks as the waste. Due to then growing demand of the synthetic bags the gunny bags industry is facing hard time. Lot of efforts are going on for the alternate uses of jute fibers mainly in textile and handicraft. Jute bast fiber is already used by paper industry for the specialty grade paper but in very little quantity. The efforts have been made to utilize whole jute for paper and newsprint.

Bleachable grade kraft pulp was produced by 17% Na₂O. Pulps showed good bleaching response and could easily be bleached to around 83% ISO brightness by CEH bleaching. A comparison of the pulp with other non-woody raw materials i.e bagasse and bamboo showed much more superior strength properties except higher tear strength in bamboo pulp.

A partial replacement of chlorine (20%) with chlorine dioxide, the pulp could be bleached to 88% ISO level. This high brightness pulp can be used as a reinforcing pulp for certain grade of papers to replace bamboo and soft wood pulp to some extent.

Unbleached Semi chemical pulp produced by using 15% NaOH can also be used as reinforcing pulp of waste paper for producing unbleached kraft paper.

Whole jute APMP showed suitable strength and optical properties for newsprint.

INTRODUCTION

Raw Material Situation

Fast depletion of the natural forest in the country has resulted acute shortage of forest based raw materials for the paper and newsprint industry. Because of the short supply of wood and bamboo, the agricultural residues have gained importance. Wheat straw, rice straw and other grasses are being used since long but the bagasse is gaining importance day by day. Wheat straw, being regular cattle feed, not available in plenty. Rice straw is not suitable for large and medium paper mills because it poses problems in recovery unit due to high silica (6-24%). Bagasse

is a raw material for both types of mill i.e. with and without recovery unit. It also give little difficulties in handling, depithing and storage. Pulp produced showed poor drainage, opacity and strength properties.

Jute is seasonal agricultural produce of tropical countries with abandoned rainfall. India, Bangladesh, Malaysia, Thailand etc. are the principal jute producer countries. India contributes about 2/5 of the total world jute production. Main jute producing states

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Table-1			
Physical Data and Proximate Analysis of Whole Jute and Other Raw Materials			
Particulars	Whole Jute	Bagasse	Bamboo
Ash	1.20	1.80	3.3
Silica	0.24	1.5	1.8
Solubility in :			
Hot water	3.7	4.0	6.0
Alc-Benzene	2.4	2.8	3.2
N/10, NaOH	28.5	23.5	30.3
Holocellulose	75.3	62.1	69.0
Klasson Lignin	23.2	23.4	25.7
Results expressed as % on B.D. raw materials and corrected for ash.			

in India are Assam, Bihar, Orissa and West Bengal. West Bengal contributes to a maximum. On maturity, jute plant grows to a height of 1.5-2.5 Mts., having an average yield of around 1.6 Mt/hac. In India. At present 8.5 Lac hectares of land is under jute cultivation in the country (1).

Most useful portion of the jute plant is the bast fiber. It contributes about 1/3rd of the whole jute plant and rest is the core material, called jute sticks. It is a waste, being used in boilers or thrown as a waste.

Studies Carried Out at CPPRI

1. Utilization of whole jute plants for craft pulping followed by CEH bleaching to compare the suitability of the pulp with other nonwoody raw materials pulps ie bagasses and bamboo.
2. Bleaching of whole jute pulp to high brightness (88% ISO for superior grade products and also to replace imported soft wood pulp.)
3. Production of semichemical pulp to use as reinforcing pulp for waste paper and poor quality agro residues pulp, for the production of kraft paper.
4. Suitability of whole jute high yield pulp for newsprint.

EXPERIMENTAL

Raw Material Preparation

Whole jute plants from West Bengal region were taken for laboratory studies. Air dried sample was chopped to 2-3 cm length strips with the bast intact. After attaining uniform moisture the strips were taken

for proximate chemical analysis and pulping etc.

Pulping

Kraft pulping experiments were carried out in a rotatory digester to produce bleachable grade pulp. Pulp was washed, screened and evaluated for yield and kappa number. Soda semichemical pulp was produced similarly except by using lower temperature and cooking chemical dose. High yield CMP was produced by APMP.

Bleaching

Pulp was bleached by CEH bleaching sequence upto 83% ISO brightness. Partial replacement of chlorine (20%) with chlorine dioxide followed by other bleaching sequences. pulp could be bleached to 88% ISO brightness level.

Pulp Evaluation

Pulps were processed in a PFI mill and hand sheets were prepared. Physical strength and optical properties were determined as per the standard procedures detailed in laboratory manual (2).

RESULTS AND DISCUSSIONS

Whole Jute as Raw Material

Table-1 indicates the result of proximate chemical analysis of whole jute, bagasse and bamboo. Whole jute contains holocellulose (75.3%) as compared to bagasse (69%), bamboo (62.1%). Like in bagasse the lignin content in whole jute is slightly less (23.2%) as against bamboo (25.7%). Whole jute contains less silica (0.2%) compared to bagasse (1.5%) and bamboo (1.8%). This low silica content is a good indication for efficient working of chemical recovery system.

Table-2			
Pulping data of Whole Jute and other Widely Used Raw Materials			
Particulars	Whole Jute	Bagasse	Bamboo
Cooking chemical Na ₂ O%	17	13	17
Unscreened pulp yield %	50.2	62.2	43.4
Screen rejects %	Nil	1.4	Nil
Kappa number of unbleached pulp	21.2	16	22.1
Black liquor analysis :			
pH :	10.7	10.6	11.0
Total solids % w/w	15.0	11.8	20.9
RAA as Na ₂ O g/l (at 200 g/l total solids)	3.9	2.5	10.7
Constant Conditions:			
	Bamboo	Bagasse	Whole Jute
Raw material filled in each bomb, gm	400	200	200
Raw material to liquor	1:3	1:5	1:4
Sulphidity of cooking liquor	20/25	20	20
Cooking Schedule:			
Time to raise temp to 100°C, Min =	30		
Time to raise temp 100°C to 168°C =	100		
Cooking time at 168°C, min	90		

Suitability of Whole Jute Bleached Pulp over other Non woody Raw material Pulp

Table-2 indicates the result of pulping of whole jute, bagasse and bamboo. By using 17% chemical

Table-3			
CEH Bleaching of Whole Jute and Other Raw Materials Chemical Pulp			
Particulars	Whole Jute	Bagasse	Bamboo
Unbleached Pulp kappa:	21.2	16	22.1
Bleaching sequence:	CEH	CEH	CEHH
Chlorination stage:			
Cl ₂ app/consume, %	5.0/4.9	3.5/3.3	5.5/5.0
Alkali Extr. stage:			
Sod. Hydroxide, % (End pH above 10.5)	2.0	2.0	2.5
Hypochlorite stage:			
Ca-hypochl. appl./con. as avail. chlorine %			
I stage	1.0/1.0	2.0/1.9	1.5/1.36
II stage	-	-	0.5/0.4
Total buffer used as NaOH, %	0.2	0.5	0.6
Bleached pulp Brightness, % ISO	77.0	77.8	79.2
Opacity, %	81	76	84
Viscosity, Cm ³ /g	630	360	582
Yield loss in bleaching %	4.8	6.2	5.8

Table-4																								
Bleaching of Whole Jute Chemical Pulp to High Brightness																								
Unbleached pulp kappa : 21.2																								
Unbleached pulp brightness, % ISO : 22.6																								
Unbleached pulp viscosity cm³/g : 992																								
Bleaching sequence:	CEH			CED			D/CEoH			D/CEoD			D/CEoPD											
Chlorination stage:																								
ClO ₂ as available																								
Chlorine applied, %	-			-			1.0			1.0			1.0											
Cl ₂ app/consume, %	5/4.9			5/4.9			4/3.7			4/3.7			4/3.7											
Alkali Extr. stage:																								
Sod. Hydr, % (End pH above 10.5)	2.0			2.0			2.0			2.0			2.0											
Oxygen pressure Kg/cm ²	-			-			2.0			2.0			2.0											
H ₂ O ₂ , %	-			-			-			-			0.3											
Brightness, %ISO (after extraction stage)	40.8			40.8			55.3			55.3			62.1											
Hypo/Dioxide appl.																								
as avail. chlo. %	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3									
Bleached pulp	77.7			83.2			64.0			88.1			88.3			87			86			88.1		
Brightness, % ISO	81.9			55.2			70.1			88.4			84.5			88			86.9					

as Na₂O, a reject free pulp of kappa 21.2 with 50.2% yield was produced. Though it consumes same chemical as bamboo but yield (50.2%) is quite higher than bamboo (43.4%).

ISO brightness by CEH sequence without much degradation. Whole jute bleached pulp showed higher intrinsic viscosity compared to bagasse pulp.

Table-3 indicates the result of conventional CEH/CEHH bleaching of whole jute pulp is very good like that of bagasse. Pulp could be bleached to 83%

Table-4 indicates the result of chlorine dioxide substitution in the chlorination stage and in the final stage of bleaching. Partial replacement of chlorine (20%) with chlorine dioxide in the chlorination stage

Table-5								
Physical Strength Properties of Bleached Pulp of Whole Jute, Bagasse and Bamboo								
Particulars	PFI (rev)	Freeness ml C.S.F.	Drainage time, Sec	Apparent Density g/cm ³	Burst Index KPam ² /g	Tensile Index Nm/g	Tear Index mNm ² /g	Fold Kohler Molin (log)
Whole Jute	500	330	12.09	0.73	5.10	82.5	9.20	2.58
	1500	200	23.90	0.79	6.00	89.0	7.20	2.74
	2000	176	24.10	0.84	5.90	87.0	7.25	2.71
Bagasse	0	525	4.8	0.75	1.90	39.0	5.60	1.28
	250	300	8.0	0.78	3.05	51.0	5.30	1.62
	500	235	11.8	0.81	3.50	51.5	5.25	1.91
Bamboo	0	715	3.3	0.56	0.75	20.0	11.2	0.85
	2000	605	3.5	0.62	2.50	39.5	20.3	1.85
	4000	490	3.9	0.63	3.45	49.5	16.8	2.52
	6000	355	5.0	0.68	4.30	55.5	15.4	3.02
	8000	240	7.0	0.69	4.70	60.5	14.2	3.15

Particulars	PFI (rev)	Freeness ml C.S.F.	Burst Index KPam ² /g	Tensile Index Nm/g	Tear Index mNm ² /g	Fold Kohler Molin (log)
Whole Jute	500	330	5.10	82.5	9.20	2.58
Bagasse	250	300	3.05	51.0	5.30	1.62
Bamboo	6000	355	4.30	55.5	15.4	3.02

Pulp Type	Freeness ml C.S.F.	D.Time (s)	Burst Index KPam ² /g	Tensile Index Nm/g	Tear Index mNm ² /g
Whole Jute:	375	8.37	3.2	46.0	10.2
Bagasse:					
Waste Paper					
50 : 25 : 25					

followed by EoH, EoD and EopD could result around 88% ISO brightness. Bleaching response of chlorine dioxide in final bleaching stage is quite poor compared to hypochlorite. Conventional CEH bleaching and D/C EoD bleaching showed better response compared to that CED and D/C EoD respectively.

Use of hydrogen peroxide in extraction stage appears to be encouraging just after extraction but its impact is negligible in achieving overall brightness gain at the end of the final stage of the

bleaching.

Table-5 shows the physical strength properties of the bleached pulps of whole jute, bagasse and bamboo at different stages of beating. It is quite evident that all the properties like tensile, tear, burst and tear/tensile ratio of the whole jute pulp are higher than that of bagasse pulp at all the stages of beating. A comparison of physical strength properties at freeness around 300ml CSF as indicated in Table-6, showed very good strength properties of whole jute pulp compared to bagasse and bamboo except the higher tear in case of bamboo. The beating energy

Particulars	Data
Freeness, ml C.S.F.	175
Burst Index, KPam ² /g	2.1
Tensile Index, Nm/g	48
Fold kohler molin log	0.90
Tear Index mNm ² /g	4.2
Porosity Bendesten	100
Brightness % ISO	62
Opacity, %	98.4

	% of Whole Jute	Cost/ton (Rs.)	Value/ton of Whole Jute (Rs.)
Bast portion, valuable fibre of the plant (suitable for gunny bags industry).	25	7500	1875
Jute sticks, waste of	75	300	225

required for whole jute pulp is quite low compared to bamboo pulp.

All the above informations indicate that whole jute is a good raw material for making pulp superior than bagasse. For most grades of paper, there is no necessity for blending long fiber bamboo and imported soft wood pulp. More over whole jute high brightness pulp can be utilized as a reinforcing pulp to replace imported softwood pulp for other hard wood and bagasse pulps for certain grade of paper production.

Whole Jute Semichemical Pulp as a Reinforcing Pulp for Unbleached Kraft Paper

Suitable grade semichemical pulp was produced from whole jute by using 15% NaOH as pulping chemical. Pulp produced showed very good strength properties and can be used as a reinforcing pulp for bagasse and other pulps. A blend of 50% whole jute semichemical pulp with 25% bagasse pulp and 25% waste paper could produce a kraft paper of very good tear and bursting strength as evident from Table-7.

Suitability of Whole Jute CMP for Newsprint

An APMP produced from whole jute showed very good physical strength and optical properties as indicated in Table-8. Pulps appear to be suitable for the production of newsprint without the blending of chemical pulp component.

Economics and Scopes for Jute Cultivators

Table-9 indicates the cost evaluation of whole jute plant per ton B.D.. On the basis of this table, one can assume that the farmers are earning around Rs. 2000 per ton of the kraft (B.D.) after lot of labour inputs for separating the bast fiber. If farmers sell their whole jute plants to paper industry at around same price, they can earn better in addition to the wider scope for the promotion of jute plantation.

CONCLUSIONS

1. Whole jute plant has an advantage that it does not require any pretreatment step as depithing as in bagasse.

2. Whole jute plant contains higher holocellulose compared to bagasse and bamboo. Like in bagasse, lignin content in whole jute is somewhat lower than in bamboo. Like wood the whole jute contain less silica which is a positive indication for efficient working of chemical recovery unit.
3. Using 17% Na₂O at 168°C for 90 minutes, bleachable grade pulp of kappa 22 and yield 50%, with the very good bleaching response could be produced. Pulp could be bleached to 83% ISO brightness by CEH bleaching sequence.
4. Pulp could be bleached to 88% ISO brightness level by substituting 20% chlorine with chlorine dioxide in chlorination stage. However the chlorine dioxide bleaching response in final stage of bleaching is not encouraging.
5. Physical strength properties of bleached chemical pulp of whole jute are superior than bagasse and bamboo pulps, except higher tear in case of bamboo. Beating energy for whole jute pulp is quite low compared to bamboo pulp.
6. Whole jute soda semichemical pulp can be used as reinforcing pulp for unbleached kraft paper production from waste paper and agro residue pulp.
7. Whole jute APMP pulp is suitable for newsprint without blending chemical pulp.

REFERENCES

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