Pulping and Paper Making Characteristics of Kenaf

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ABSTRACT

Kenaf (Hibiscus cannabinus) is a herbaceous non-wood, most promising plant fibre source for pulp and papermaking with longer fibres than other non-wood plants. The kenaf stalk consists of two distinctive regions: the outer bark and an inner woody core. The outer bark contains long bast fibres while the inner or woody core portion contains short fibres. This paper presents the results of research efforts made to characterise the fibres of kenaf bark and stalk and their pulping and bleaching characteristics for papermaking (sulphate/ sode in case of bark and chemi-refiner-mechanical-pulp in case of whole stalk). Results reveal that the core fibre is shorter but has thinner cell walls and wider lumen. On the other hand, the bast fibre is longer with thicker cell walls and narrow lumen and therefore exhibits higher tear index. Bleached pulps from soda and sulphate pulping behave similarly under identical conditions.

INTRODUCTION

In recent years 'Kenaf" (Hibiscus cannabinus and H. sabdiriffa) have shown great potential for pulp and paper manufacture in developing countries where the conventional fibre resources are gradually depleting. A review of kenaf pulping work (1-8) reveals that there is tremendous amount of interest in kenaf as paper making pulp. In some countries kenaf has already been used in paper industry. In India, it is mainly grown in Bihar, Assam, Orissa, Andhra Pradesh, Madhya Pradesh and Tamil Nadu. The growth rate of the plant is 15 to 25 tonnes of dry plant per hectare. This renewable non-wood resource certainly holds the most promising mterial with much long fibres than other non-wood plants for pulp and paper industries.

It is believed that instead of concentrating entirely on the whole plant, efforts should be devoted to separating the few dissimilar components of kenaf, namely the bark and the core stalk and to use separately for which each might be suitable. Earlier studies (9, 10) reveal that the two types of fibres differ markedly in their pulping and papermaking behaviour and hence, for best results the two components of kenaf should be pulped separately. The woody fraction is more suitable for mechanical pulp whereas chemical pulp may be prepared from the bark fraction.

The bark of kenaf which contains bast fibre represents 25 to 35 percent of the dry weight whereas the core stalk of kenaf plant represents 65 to 75 percent of the dry weight of the whole plant. This paper discusses the results obtained in our laboratory on the characteristics of fibre dimensions, chemical components, pulping and bleaching characteristics.

Table 1 Chemical components of kenaf

Component	Core	Bast	Pith
Ash %	2.22	3.53	4.47
Cold water	7.17	7.31	10.08
Hot water solubility %	8.22	8.59	12.20
Alcohol-benzene Solubility %	2.04	1.42	1.74
1 % NaOH solubility, %	30.98	25.02	39.75
Pentosan %	16.51	14.32	17.56
Lignin %	21.12	11.32	15.03
Holocellulose, %	77.21	79.54	78.20

Table 2 Fibre dimensions of Kenaf

Component	Core fibre	Bast fibre
Average fibre length, mm Arithmatic	0.35	1.10
Weight	0.52	1.69
Weight distribution	0.72	2.19
Length range, mm	04-08	10-20
Content, %	77.3	59.5
Coarseness, mg/m of fibre	0.10	0.11
No. of fibre/gm of sample	$327x10^7$	$688x10^6$
Content of fines (0.4 mm) %	37.47	3.67
Lumen diameter (μm)	11.11	3.86

Chemical composition

Table 1 depicts the chemical composition of kenaf showing that the lignin content in the core is higher (21-12%) while in the bast fibre it is lower (11.32%) The lignin content in the pith is higher than that in the bast and lower than in the core. The pith of kenaf contains more ash, water extractives and 1% NaOH extractives than the core and the bast. The holocellulose content in bast is highest (79.54%) followed by pith (78.20%) and core (77.21%) On the other hand the core and pith contain more Pentosan than bast.

Fibre Characteristics

The fibre analysis results are recorded in Table 2. From the table it is observed that the bast of Kenaf has much longer fibres and less fines than the core. It is also observed that bast fibres have thicker cell walls with smaller lumens, while the core fibres have thinner cell walls with larger lumens. The lumen diameter of the core fibre is about three times that of the bast fibre but the thickness of cell wall of the core fibre is only half that of the bast fibre (11).

Soda and Sulphate pulping of kenaf bark

The pulping results depicted in Table 3 and 4 indicate that the unbleached pulp yield and Kappa no. in case of soda pulps are in the range of 45-50% and 28-37 and in case of sulphate unbleached pulps in the range of 47.7-52% and 26-35 respectively. The data on physical characteristics of pulps indicate that under similar cooking conditions, the physical strength properties of soda and sulphate pulps are significantly higher. (11)It is reported that whole kenaf at 16% total active alkali, gives pulp yield of 50.0 and kappa no. 26.0.

Strength properties of bleached kraft pulp

The bleaching results (Table 5) indicate that soda and kraft pulps from kenaf bark differed mainly in their response to bleaching. As expected from its higher kappa number soda pulp consumed higher bleaching chemicals but gave a higher yield of bleached pulp with better strength properties compared to sulphate pulp which although consumed lesser bleaching chemicals, showed considerable degradation of strength properties under the identical bleaching conditions. The pulps were beaten in Lampen mill to about 250 + 10 ml. CSF and standard sheets of 60 gsm were prepared and the physical strength

Table 3 Characteristics of kenaf bark soda pulp

Active alkali as Na_2O (%)	Pulp yield (%)	Kappa No.	Tensile index (Nm/g)	Stretch (%)	Tear index (mNm^2/g)	Burst index ($Kpam^2/g$)
16	49.8	36.6	63.15	2.20	12.07	4.77
18	48.4	32.4	61.68	2.53	12.21	4.38
20	46.5	29.8	60.15	2.73	14.66	4.29
22	45.3	27.7	58.98	2.50	8.82	3.92
Total time 3 hr. Bath ratio- 1 : 6 Temp. 170°C						

Table 4 Characteristics of kenaf bark sulphate pulp

Active alkali as Na_2O (%)	Pulp yield (%)	Kappa No.	Tensile index (Nm/g)	Stretch (%)	Tear index (mNm^2/g)	Burst index ($Kpam^2/g$)
16	51.7	34.2	53.17	2.2	12.34	3.77
18	50.2	31.3	63.58	2.9	14.11	5.60
20	49.0	28.7	65.60	2.9	8.39	5.68
22	47.7	26.0	67.20	2.5	9.98	5.83
Sulphidity 25%, Total time 3 hr. Bath ratio- 1 : 6 Temp. 170°C						

Table 5 Strength properties of bleached kenaf bark pulp

Characteristics	Soda pulp*	Kraft pulp**
Pulp yield (%)	41.8	41.4
Apparent density (g/cm^2)	65.08	65.62
Tensile index (Nm/g)	32.22	49.10
Stretch (%)	2.0	1.77
Tear index (mNm^2/g)	8.30	6.31
Burst index (Kpam^2/g)	2.70	2.39
Brightness (% ISO)	56.8	54.4
Opacity, (%)	95.8	97.1
Chlorine 2.5% Hypochlorite- 8.5% NaOH-2% Kappa No. 29.8=28.7		

properties of conditioned hand sheets were tested.

High yield pulps from kenaf whole stalk

The result recorded in Tables 6, 7 and 8 indicate that pulps in high yield (85%) could be prepared from kenaf by cold soda and sulphite process.Cold soda pulps have higher strength properties than alkaline sulphite pulps. The yield and brightness of the pulps are much higher in alkaline pulps. At similar yield value and tensile index and burst index of cold soda pulps the alkaline sulphite pulps are likely to be similar but tear index is more in alkaline sulphite pulps (1).

Newsprint grade refiner mechanical pulps from kenaf sticks

The data on fibre classification of refiner - mechanical pulps (Table 9) indicate that there is a considerable accumulation of fines (passed 100 mesh) under the conditions studied. The highest amount of fines (40.7%) is produced at a freeness level of 500 ml. CSF The properties of blends (Table 10) indicate that the strength properties and opacity of pulp sheets are satisfactory for newsprint manufacture. Bleaching of bast fibres was not done. The initial brightness of the pulp is lower. The brightness can, however be increased by bleaching bast fibre fraction using alternative bleaching chemicals and optimising bleaching conditions. It is evident from Table 9 and 10 that the quality of pulp improves as the plate clearance is reduced resulting in corresponding increase in fines fraction. This is in agreement with the observed behaviour of mechanical pulps (12) that the fines from mechanical pulp show increased fibre bonding because of their increased surface area and the void spaces between are filled with fines and thus increase density of packed sheets (1).

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Table 6 Cold soda pulping of kenaf whole stalk

Chemical (NaOH) (g/l)	Pulp yield (%)	Tensile index (Nm/g)	Stretch (%)	Tear index (mNm^2/g)	Burst index (Kpam^2/g)	Folding endurance	Brightness (% ISO)	Opacity (%)
6.6 (3.9%)	76.0	26.17	1.13	3.34	0.55	2	29.8	95.8
10.0 (6.0%)	71.5	34.58	1.04	3.95	0.90	4	30.2	96.2
Na_2CO_3-1%, Bath ratio 1:6, Temp. 130°C, Time- 2 hr.								

Table 7 Alkaline sulphite pulping of kenaf whole stalk (using sodium carbonate)

Chemical (Na_2SO_3) (g/l)	Pulp yield (%)	Tensile index (Nm/g)	Stretch (%)	Tear index (mNm^2/g)	Burst index (Kpam^2/g)	Folding endurance	Brightness (% ISO)	Opacity (%)
4 (2.4%)	81.2	22.49	1.18	4.58	0.64	2	47.3	97.1
5 (3.0%)	78.8	25.37	1.12	4.48	0.61	2	45.8	96.4
6 (3.6 %)	74.4	20.80	1.31	5.09	0.59	2	45.7	97.1
Na_2CO_3-1%, Bath ratio 1:6, Temp. 130°C, Time- 2 hr.								

Table 8 Alkaline sulphite pulping of kenaf whole stalk (Using sodium hydroxide)

Chemical (Na_2SO_3) (g/l)	Pulp yield (%)	Tensile index (Nm/g)	Stretch (%)	Tear index (mNm^2/g)	Burst index ($Kpam^2/g$)	Folding endurance	Brightness (% ISO)	Opacity (%)
4 (2.4%)	88.4	18.23	0.98	3.99	0.19	2	53.1	96.8
6 (3.6%)	82.6	17.40	0.90	3.50	0.15	1	52.1	96.4
8 (3.6 %)	77.7	23.27	1.0	4.78	0.49	2	50.3	96.2
NaOH-1%, Bath ratio 1:6, Temp. 130°C, Time- 2 hr.								

Table 9 Refining conditions of kenaf sticks and fibre classification of refiner Mechanical pulps

Refining conditions						Freeness of the refined pulp (ml)	Fibre Classification			
1st pass		2nd pass		3rd pass			Retained on			
Consis-tency (%)	Plate clear-ance (mm)	Consis tency (%)	Plate clear-ance (mm)	Consis tency (%)	Plate clear-ance (mm)		28 mesh (%)	48 mesh (%)	100 mesh (%)	passing through 100 mesh (%)
10	0.381	10	0.254	4	0.127	585	2.9	38.6	26.1	32.0
8.5	0.254	8.5	0.254	4	0.127	600	6.5	27.2	26.1	30.2
10	0.254	4	0.127	-	-	555	5.1	25.7	31.9	37.3
8.5	0.127	4	0.127	-	-	500	3.7	23.1	32.5	40.7

Table 10 Properties of blends (RMP : soda pulps)

Pulp Freeness	Tensile index (Nmg)	Stretch (%)	Tear index mNm^2/g)	Burst index $Kpam^2/g$	Brightness (% ISO)	Opacity (%)
425*	16.68	1.20	3.90	0.78	33.4	97.8
210**	53.51	2.20	12.07	4.77	22.6	99.3
390***	28.71	2.03	4.39	1.71	33.3	98.8
* 100%% RMP Pulp ** 100% unbleached soda pulp from kenaf bast fibre. ***RMP Soda pulp- 10% and unbleached soda pulp from kenaf bast fibre-60%						

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