Blending of Nonwood Fiber Pulps for Making Paper

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ABSTRACT

Blending of kash (Saccharum spontaneum) pulp with jute (Corchorus capsularies) or cotton stalk (Gossypium herbaceum) pulps and their properties were studied. Experimental data were very well fitted in a model. Blending of jute or cotton stalk pulps to kash (Saccharum spontaneum) pulp improved the physical properties. The effect of bleaching on blended pulp and effect of beating on blended bleached and unbleached pulps were also investigated. Depending on the blending materials bleachability was different. Kash (Saccharum spontaneum) - jute (Corchorus capsularis) blend pulp was easier to bleach. Enzyme pretreatment prior to TCF and ECF bleaching enhances the paper properties.

INTRODUCTION

The world paper consumption is increasing continuously. It has been estimated that during the next 15-20 years it will be doubled and even tripled in many developing countries. Globally the forest resources are however diminishing while the paper demand is increasing (1,2). To conserve wood resources, nonwood fiber plants can be substituted for wood pulping.

The production of nonwood pulp and paper take place mainly in China and India (1). The short fiber pulp improves the surface properties of the printing paper and requires less refining. Furthermore nonwood fibers with thinner fiber dimensions than those for fibers in hardwoods produce very smooth paper surface (3). However, the large-scale use of these raw materials poses technical and economical problems in relating to collecting, storing and availability of enough materials near the pulping mill. Therefore, blending of different nonwood pulp could provide economically acceptable pulping of nonwood materials on a small scale.

There are numbers of reports are available on the strength properties of the blended pulps. But the findings are contradictory. The breaking length and burst factor of the blended pulp were higher than the value calculated from its components (4,5), other reports showed that these value was lower the calculated one (6,7). Bovin and Teder (8) suggested that the tear factor of a chemical pulp mixture could be predicted with linear addition if the component are beaten to such an extent that they are located on the same side of the maxima of their respective tear factor-breaking length curve. In our previous study (9), it was seen that pulp mixture of jute and cotton stalk pulps showed higher properties than the calculated. The pulp strength properties are very complicated. Thus it is necessary to study how different nonwood pulps behave on their blending.

The objective of this study is to develop a correlation of different proportion of kash

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Table- 1 : Pulping conditions and results of nonwood pulp

Raw material	Temp., °C	Time, h	Liquor ratio	NaOH, %	AQ, %	Yield, %	Kappa number
Kash	170	1	6:1	14	-	55.6	18.9
Cotton Stalk	170	1	6:1	18	0.1	46.5	34.5
Jute	170	1	5:1	16	0.05	62.2	19.1

Table- 2 : Bleaching conditions of nonwood pulps

Stage	Temp., °C	Time, h	Consistency, %	H_2O_2	NaOCl, %	NaOH	Xylanase, IU/g pulp
P	60	1	10	3	-	1	-
EZ	50	2	5	-	-		3.5*
H	40	1	4	-	-		-

* pH = 6 was adjusted CH_3COOH

(Saccharum spontaneum) pulp to jute (Corchorus capsularis) or cotton stalk *(Gossypium herbaceum)* pulps mixture with strength and optical properties. The effect elemental chlorine free (ECF) and total chlorine free (TCF) bleaching of the blended pulp have been studied. The beating effects of jute-cotton stalk-kash blended unbleached and bleached pulp have also been studied. During ECF bleaching sequence emphasis was laid on enzyme pretreatment.

EXPERIMENTAL

MATERIALS

Jute, cotton stalk and kash were used in this study. These materials were cutted to 2-3 cm in length and all dirty materials were removed.

PULPING

Pulping experiments were performed in a 20 liters capacity rotary digester heated to a desired temperature by an electric coil in about 90 minutes. After the time at maximum temperature, the pulp was washed, disintegrated, screened and kept in a refrigerator for the experiments. Jute, kash and cotton stalk pulps were prepared under the optimum conditions, which were developed previously (10). Pulping conditions and results are given in Table-1.

BEATING AND BLENDING

Jute, kash and cotton stalk pulps were beaten independently in a laboratory beater to a freeness of about 45°SR. Then the pulp blends were prepared by blending jute pulp with kash pulp and kash pulp with cotton stalk pulp. The blends were run in a disintegrator for through mixing. Blending of 20% unbeaten jute pulp to equivalent amount of unbeaten cotton stalk and kash pulps, i.e. 40% each was done in disintegrator to allow maximum use of nonwood raw materials. This blended pulp was then beaten to different freeness range.

BLEACHING

Bleaching experiments were carried out in a thermostatic water bath with constant starring. Beaten blended pulps of kash to jute or cotton of 50:50 ratio and jute-kash-cotton stalk (20:40:40) were bleached under constant conditions by using 1 to 3 step procedure including enzyme (EZ), hydrogen peroxide (P) and hypochlorite (H). One set of bleaching expriments were done before beating for pulp mixture containing 20% of jute pulp and equivalent amount of cotton stalk and kash pulps, i.e. 40% each. Table-2 gives bleaching conditions.

PAPERMAKING

The bleached and unbleached pulps were made into 60g/m² handsheets according to German Paper Engineer's and Chemist's Methods 106. The handsheets were used for Tensile, Burst, Tear, Fold, Opacity and Brightness testing according to Tappi

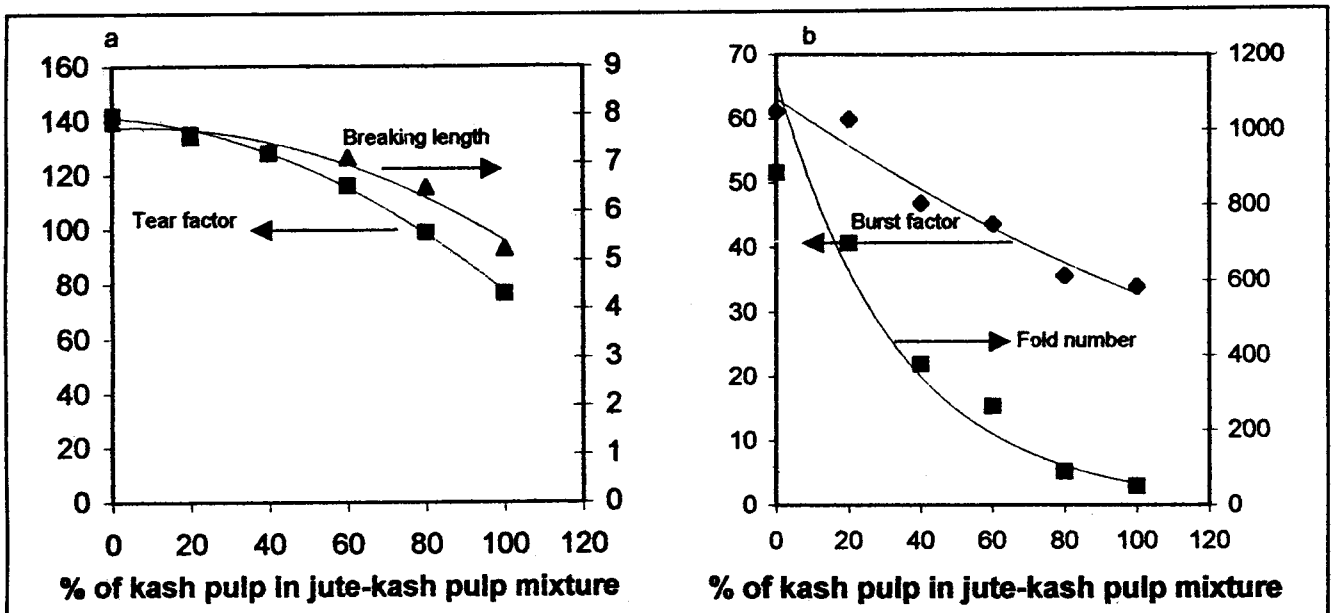

Fig. 1 : Dependence of physical properties of handsheets on the blending of kash pulp with jute pulp.

Standard Test Methods

RESULTS AND DISCUSSION

The experimental data are fitted in the model, which is shown in Table-3. Figure 1 shows the dependence of paper properties of handsheets of pulps mixture containing kash and jute pulps. From the Figure it is evident that breaking length, burst factor, tear factor and fold number are increased steadily as the ratio of jute pulp addition increased. The figure 1a shows evidence of synergistic effects on breaking length and tear factor in the pulp blend. It is seen from the curve that the breaking length and tear factor are higher than the calculated value from the percentage of individual pulp. The breaking length curve is flatten with the components containing more than 70% kash pulp whereas tear factor curve is flatten after 40% of kash pulp in a

Table- 3 : Regression equations of the dependence of the physical properties of handsheets on the blending of jute or cotton stalk pulps with kash pulp

Blend Type	Property	Equation	R^2
Jute-Kash	Breaking length (km)	$7.725 + 0.0031k - 0.0002k^2$	0.9615
	Burst factor, $g/cm^2.m^2/g$	$63.125 - 0.385k + 0.0008k^2$	0.9541
	Tear factor, $g.m^2/g$	$141.05 - 0.1139k - 0.0052k^2$	0.9983
	Double fold number	$1132.8e^{-0.299K}$	0.9635
	Brightness, %	$35.295 - 0.0116k$	0.9884
	Opacity, %	$95.729 - 0.116k$	0.4049
Cotton stalk-Kash	Breaking length (km)	$6.2379 + 0.0057k - 0.0005k^2$	0.9905
	Burst factor, $g/cm^2.m^2/g$	$42.75 - 0.018k + 0.0016k^2$	0.8965
	Tear factor, $g.m^2/g$	$90.56 - 0.0732k - 0.0005k^2$	0.9406
	Double fold number	$400.72 + 6.631k - 0.0358k^2$	0.9886
	Brightness, %	$18.109 - 0.1698k$	0.9666
	Opacity, %	$99.489 - 0.0528k$	0.9847

k = % of kash pulp in the mixture

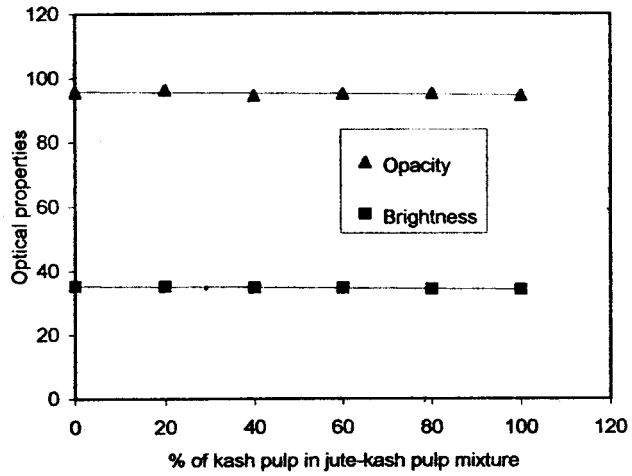

Fig. 2 : Dependence of optical properties of handsheets on the blending of kash pulp with jute pulp.

mixture. Figure 1b gives the clear evidence of lower double fold number than that expected theoretically from the pulp mixture. A few amounts of kash pulp in kash-jute pulp blend reduce the huge of double fold number. Burst factor shows almost linear relationship with the component proportion of these two pulps.

The furnish of paper consists of different shaped and natured fibers and additives., Normally the furnish of fine papers consist of 20-40% long fibers, the rest being shorter and thinner fibers and fillers. Short fiber provides printing properties while the long fiber give strength of paper, ensuring runability on the paper machine. Good opacity value in paper originates from the larger amount of fibers per unit of volume as in hardwoods and in nonwood. Figure-2 shows very good opacity of about 95% for kash-jute unbleached pulp mixture. Experimental data of opacity is not well fitted with the model. Actually, the individual pulp posses almost equal opacity and brightness. Consequently, there is no dependence on these properties on the proportion of individual pulp in the mixture. Therefore, the mean of the opacity value is fitted with the parallel line of X-axis. But unbleached brightness of jute pulp is slightly increased with addition of kash pulp in the mixture and the brightness data is well fitted with the model.

Physical properties of handsheets of kash-cotton stalk blend pulp are shown in Figure-3. The properties are very well correlated with the experimental data. the breaking length and burst factor are slightly higher than the calculated from the individual pulp in a mixture. An addition of cotton stalk pulp in kash pulp increases the breaking length and burst factor value. At 50:50, kash-cotton stalk pulp ratio, breaking length and burst factor are about 5.9 and 38, respectively (Figure 3a). Figure 3b shows the clear decreased of tear factor and double fold number with the increase of kash pulp in the pulp mixture. The tear factor of kash-cotton stalk pulp mixture is lower than the expected from the individual pulp in a mixture. About 12% of tear factor value are lost with an addition of 50% kash pulp to cotton stalk pulp.

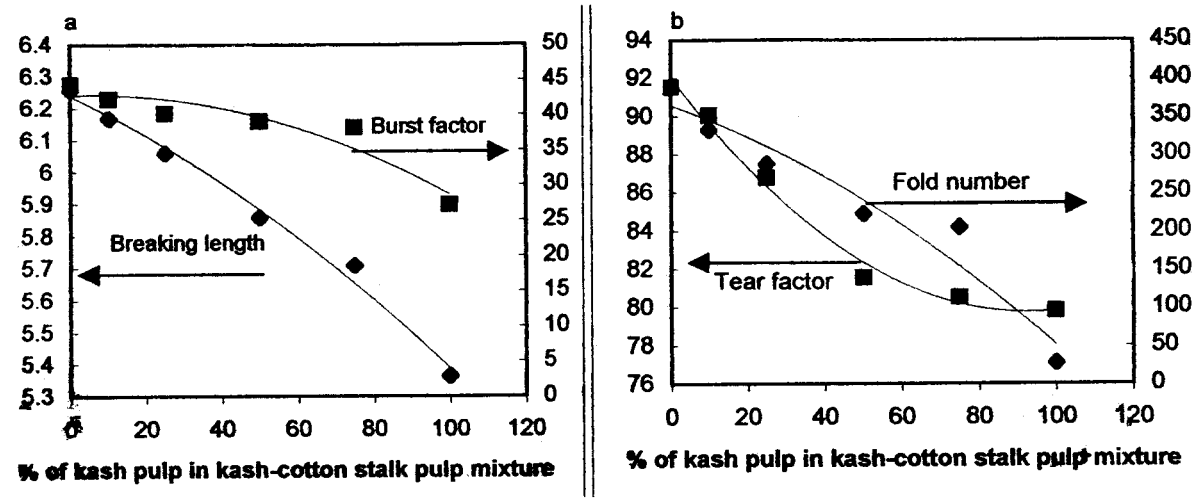

Fig. 3 : Dependence of physical properties of handsheets on the blending of kash pulp with cotton stalk pulp.

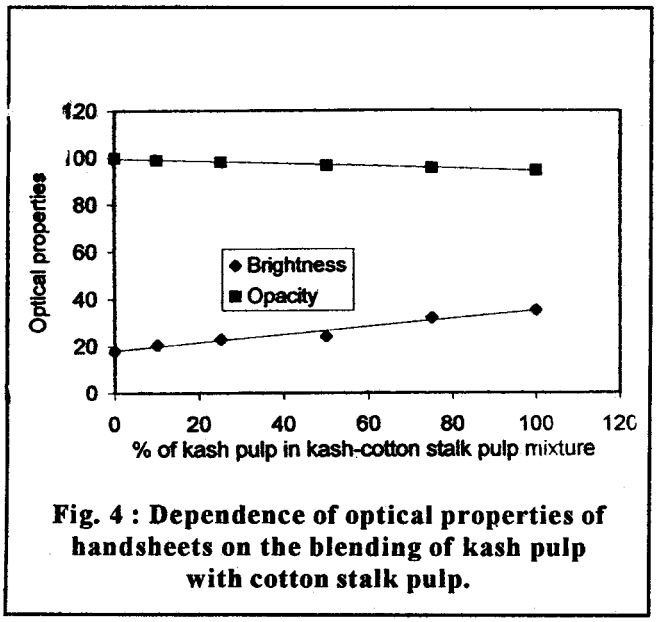

Fig. 4 : Dependence of optical properties of handsheets on the blending of kash pulp with cotton stalk pulp.

Figure-4 represents the dependence optical properties on the proportion kash and cotton stalk pulp. The experimental data are very well fitted with the model (Table-2). Brightness value is increased and opacity value is decreased with the increase of kash pulp in the kash-cotton stalk pulp mixture.

Table-4 lists the bleaching results and the properties of the paper sheets prepared from different pulps blend. For kash-jute, it can be seen that the effect of the enzyme step prior to peroxide (P) and P-H is beneficial as it increases brightness and opacity significantly and also strength properties of the pulp from the P sequence. In case of kash-cotton stalk pulp mixture, acceptable physical properties could be obtained with H_2O_2 and enzyme-H_2O_2 bleaching sequences. The H_2O_2 treatment gives brightness and opacity of 52.1% and 92%, respectively. But with the introduction of enzyme pretreatment of kash-cotton stalk pulp mixture of H_2O_2 bleaching gives 2.3 and 3.3 points higher brightness and opacity value, respectively. NaOCl treatment improves the brightness but deteriorate the physical properties. In the case of jute-kash-cotton stalk pulp mixture bleaching, good optical properties are observed but physical properties are deteriorate with the introduction of enzyme in both P and P-H sequences. Enzyme treatment slightly increases the brightness but decreases the opacity.

The effects of beating on the paper properties of jute (20%) - kash (40%) - cotton stalk (40%) pulps mixture are given in Table-5. From Table 5 it can be

Table- 4 : Effect of bleaching on the paper properties beaten blended pulps

Type of blend	Bleaching Processes	Breaking length (km)	Burst factor	Tear factor	Double fold number	Apparent density (kg/m³)	Brightness, % Tappi	Opacity, % Tappi
Kash-jute	H_2O_2 (P)	6.213	39.5	105.2	252	512.3	53.2	91.6
	EZ-P	6.352	40.2	106.1	288	522.6	56.3	95.6
	P-H	4.162	32.1	88.6	108	578.4	75.9	88.1
	EZ-P-H	4.133	33.4	88.3	106	589.1	77.3	88.6
Kash-Cotton stalk	H_2O_2 (P)	5.440	39.1	84.6	96	522.7	52.1	92.0
	EZ-P	5.365	39.2	83.4	98	539.5	54.4	95.3
	P-H	3.835	29.9	75.0	91	607.6	73.7	88.5
	EZ-P-H	4.156	32.5	76.2	95	606.1	75.1	86.7
Jute-kash-cotton stalk	H_2O_2 (P)	6.212	38.5	85.2	103	521.3	52.2	92.6
	EZ-P	6.208	38.1	84.9	109	526.8	54.6	92.1
	P-H	3.895	28.1	69.2	58	549.9	73.8	86.1
	EZ-P-H	3.457	23.7	67.4	39	553.8	75.8	82.4

Table- 5 : Effect of beating on the paper properties of jute-kash-cotton stalk bleached and unbleached pulp mixture

Type of pulp	°SR	Breaking length (km)	Burst factor	Tear factor	Double fold number	Apparent density (kg/m³)	Brightness, % Tappi	Opacity, % Tappi
Unbleached	15	3.460	24.0	96.8	18	486.1	26.9	98.0
	25	4.827	31.4	106.3	28	491.5	27.3	98.4
	42	5.734	41.2	84.9	152	544.6	27.6	98.5
	59	7.018	42.5	81.2	352	607.7	27.2	99.2
Bleached	16	3.241	21.0	95.2	15	488.2	75.2	88.4
	27	3.958	26.4	89.6	26	495.2	74.8	89.5
	40	4.785	32.5	83.2	94	552.3	73.1	91.2
	58	5.754	33.6	77.5	128	611.4	72.5	92.6

seen that the strength properties and opacity increase and brightness decreases as the beating degree increases. The tear strength of unbleached pulp mixture is increased at the initial stage of beating then it is decreased with the increase of beating degree but the tear strength of unbleached pulp mixture is decreased continuously within the entire stage of beating. The pulp mixture of jute-kash-cotton stalk is capable of forming of slightly high breaking length but with lower tear strength than the karft pulp of bamboo (11) which is being used in the paper mills of Bangladesh.

CONCLUSIONS

The following points may be concluded from this study :

- The addition of jute or cotton stalk pulp to kash pulp improves the paper properties.
- The experimental data are well fitted with the model.
- TCF bleaching of blended pulps gives acceptable physical properties and opacity but lower brightness. ECF bleaching of blended pulps increases brightness but decreases physical properties.
- With the introduction of enzyme pretreatment prior to bleaching slightly increases the paper properties.

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