BCSIR

Available online at www.banglajol.info

Bangladesh J. Sci. Ind. Res. **48(2)**, 105-108, 2013

BANGLADESH JOURNAL OF SCIENTIFIC AND INDUSTRIAL RESEARCH

E-mail: bjsir07@gmail.com

Pulping of different parts of whole green jute (*C. Capsularies*) plant by Kraft process

M. R. Alam*

Department of Applied Chemistry and Chemical Engineering, University of Dhaka. Dhaka 1000 , Bangladesh.

Abstract

The chemical composition of the top, middle and bottom part of green jute plant (GJP) are not alike, thus the yield and strength properties of the pulp produced may vary if these are pulped separately. The alpha -cellulose content increases, whereas hemi-cellulose, lignin, ash and extractives decrease from top to bottom part of GJP. The Kraft pulp yield and strength properties increases (except tear) from top to bottom part of GJP. The pulp produced from GJP was found to undergo rapid beating in comparison to those of muli bamboo, jute cuttings. This indicates less energy requirement during refining operation of the GJP pulp. Low extractive (pectin) and high alpha-cellulose is favorable for pulping.

Keywords: Pulp; Green jute; Cellulose; Lignin; Bamboo

Introduction

Pulp from non-wood fibers plays an important role in balancing regional fiber deficits. Environmentalists claim that non-wood paper making is more sustainable and environmentally friendly than wood based paper production. Jute can be considered as a valuable and annually renewable source of pulp for the manufacture of paper, paperboard because it has a high cellulose and low lignin content in comparison to bamboo, baggage and tropical hardwood. It is comparatively inexpensive than bamboo. Due to scarcity of fibrous raw materials (FRM), the pulp and paper mills of Bangladesh Chemical Industries Corporation (BCIC) utilized green jute plant (GJP) as pulping raw materials from 1994 to1998. Storage of GJP is one of the problems faced after procurement. The heterogeneous characteristics of GJP have been the subject of many investigations. Continued research on the basic processes of conversion procedures and end uses have become imperative to give a clear picture of what is required of the pulp interns of chemical composition and physical state. The climatic condition of Bangladesh is favorable for jute growing. The matured jute plants are about 2.5 to 3.5 meter long and 1.5 to 2.0 cm in diameter. The plant has two distinct parts, an outer fibrous bark and inner stem, the later constituting about two- thirds of the plant. The diameter of the whole plant is not the same all along. The bottom part has broader diameter that gradually reduces toward to top.

It was reported (Bashiruzzaman *et. al.,* 1964) that the chemical compositions of the three different parts of jute fiber (top, middle and bottom of the plant) are different. According to authors (Bashiruzzaman *et. al.,* 1964) the lignin content and molecular weight of cellulose increases from top to bottom part whereas pentosans (hemi-cellulose) and extractives decreases *i.e*, reverse is the trend.

The degree of polymerization (DP) of the cellulose fraction should be high enough to give high viscosity (Ali *et. al.,* 1988). Lignin has been shown to restrict swelling and decreases the adhesion forces between the fiber because of its hydrophobic nature and its dominant location at the fiber surface (Rydholm SA, 1965).

Materials and methods

Chemical analysis

The GJP was divided into three parts; top, middle and bottom. The average separation of 0.91 meter was termed as the top, 1.78 meter the middle and 0.61 meter the bottom. For chemical analysis, dusts were generated from each part separately and dust were then passed through a 40 mesh and retained on a 60 mesh sieve. These were then analyzed in Karnaphuli Paper Mills (KPM) Research Laboratory as per Tappi method (Tappi standards and Suggested Methods,

*Present address: Polash Urea Fertilizer Factory, Ghorashal.

1970) and the results are shown in Table I along with those for muli bamboo and baggase for the sake of comparison.

Raw materials preparation

The three different parts of the GJP were cut into small chips of 2.54 to 3.81 cm length manually by laboratory hand cutter separately. Average moisture content of each part in the chips was determined. Cooking chemical i.e, white liquor was collected from KPM recovery plant and tested in the laboratory whose composition is shown in Table II.

Pulping

The chips from different parts of GJP were cooked separately in the laboratory in a electrically heated stainless steel rotating autoclave digester having 10 liter capacity. Pulping experiments were carried out with 1 kg equivalent weight of oven dry chips. The same cooking parameters (shown in Table III) were maintained in all experiments. At the end of cooking, the pressure inside the digester was released, the black liquor was drained off and the pulp was washed thoroughly with process water.

Yield

The washed pulp was disintegrated in the laboratory disintegrator machine and then screened out in the laboratory flat vibratory screen with 0.02 mm slots. The screened yield and rejects percentage on even dry chips were determined in each experiment which are shown in Table IV.

Permanganate number, alpha, beta and gamma cellulose of pulp

The potassium permanganate number of each pulp was determined. The pulps were then chemically analyzed for alpha, beta and gamma cellulose content following Tappi method (Tappi standards and Suggested Methods, 1970). The results are shown in Table IV.

Strength properties

The pulps were beaten in the laboratory valley beater maintaining 1.57 percent consistency with constant load (5.5 kg). The SR (Schopper-Riegler) of the beaten pulp were determined and hand sheets were made in a Karl-Frank laboratory sheet making machine. The strength properties like burst tear and tensile at various SR (25, 40 and 45) was determined separately and the results obtained are depicted in Table V.

Solubility percentage of fibrous raw materials vs. beating time and strength properties

For the sake of comparison the beating time of GJP (CVI-1), unretted bast fibre, baggase, jute cutting and muli bamboo are shown in Table VI. The solubility % of 1% NaOH in the above species are also shown in Table VI.

Results and discussion

The different chemical composition found in the various parts of GJP reflects different physiological functions. The alpha-cellulose obtained from different parts of GJP and the

Table I. Proximate chemical analysis of GJP, baggase and muli bamboo (oven dry basis)

	GJP parts				
Chemical Composition	Top	Middle	Bottom	Baggase	Muli Bamboo
C & B Cellulose % (total cellulose)	75.73	76.40	79.41	63.78	58.96
Alpha-cellulose %	40.33	46.71	47.55	41.85	41.25
Hemi-cellulose %	32.68	27.45	26.42	31.96	21.25
Lignin %	19.92	18.60	18	20.24	27.71
Alcohol-Benzene solubility %	3.94	3.67	3.12	2.33	4.37
Hot water solubility %	9.30	7.73	6.73	nd	4.28
1% NaOH solubility %	34.64	33.27	32.78	34.50	21.08
Ash %	3.13	3.58	4.03	3.62	3.32

nd : not determined

Table II. White liquor analysis

NaOH % w/v	6.64
Na_2S % w/v	1.716
Sulphidity % of the white liquor	18.0

Table III. Cooking parameters for top, middle and bottom part of GJP

Quantity of O.D. chips, kg	1
Alkali charged % on O.D. chips as NaOH	20.0
Chips to liquor ratio	1:6
Time to raise the temperature , min	90
Cooking temperature ^oC	170
Cooking time at temperature min	120

corresponding yields are shown in Tables IV and V. The maximum yield and strength properties were found in case of bottom part (Tables IV and V) because of its maximum alpha-cellulose content (47.55 %, Table I). In case of middle part, the value of alpha-cellulose is less than that of bottom part. Similarly the alpha-cellulose obtained in top part is minimum and hence the yield and strength properties are minimum. Papers obtained from bottom part and had high alpha-cellulose content or high quality fibre (Casey, 1966). The degree of polymerization (DP) of the cellulose fraction of the bottom part should be high enough to give high strength. From the above discussions, it is clear that as the value of alpha-cellulose increases, the yield and strength properties also increases from top to bottom part of GJP.

Table IV. Pulp yield and analysis (top, middle and bottom)

Particulars of test	Top	Middle	Bottom
Pulp yield % on O.D. chips	36.82	43.05	48.49
Screen reject % on O.D. chips	0.154	0.136	0.43
$KMnO_4$ Number	16.35	14.55	17.45
Alpha-cellulose % on O.D. pulp	84.0	86.88	88.53
Beta-cellulose % on O.D. pulp	5.02	3.96	3.24
Gamma cellulose % on O.D. pulp	10.98	9.21	8.23

The hemi-cellulose contents of the different parts of GJP are reverse of alpha-cellulose. As the hemi-cellulose (Mian, 1998), decreases, the alpha-cellulose increases (Table I) from top to bottom part. Comparison of jute fibre with other natural fibres indicates that increase of cellulose means decrease of hemi-cellulose (Mian, 1998). In course of experiments with different parts of GJP it is also found that the yield and strength properties decrease as the hemi-cellulose increases. Generally, the fibre bonding increases with the increase of the amount of hemi-cellulose material. The exceptional for decreasing the yield and strength properties in GJP may be explained as the oxidation and degradation reactions hit the hemi-cellulose more rapidly than cellulose (Rydholm, 1965) *i.e*, oxidation and degradation reaction decreases as proceed from top to bottom part of GJP. Another reason for decreasing the yield and strength properties is that the lignin and extractive content are higher in case of top part. Asaduzzaman *et. al.,* 1983, reported that the increase of both lignin and pectin content results in the deterioration of the quality of the fibres and the same trend was also observed in case Table I and Table V respectively. However exceptional bursting strength is observed in case of middle part which is less than both top and bottom part (Table IV). The removal of substances such as hemi-cellulose, lignin and extractive during cooking are higher in case of top part and thus the lower yield and strength properties obtained (Tables I, IV and V) can be accounted for. It is also observed that untreated bust fibre and GJP have a high alkali solubility and the pulp beats rapidly (Alam *et. al.,* 1991) whereas fibrous raw materials with a low solubility content (Alam *et. al.,* 1997a & 1997b; Shafi, 1994) beat with comparatively difficulties and form weak sheets (shown in Table VI). As the value of 1 % NaOH solubility increases, the degree of fungus decay increases and hence causes greater deterioration of untreated jute and GJP than those of jute cuttings and muli bamboo.

Table V. Strength properties of pulp from top, middle and bottom part of GJP

Particulars of test	Top			Middle			Bottom		
Freeness value, ^oSR	25	40	45	25	40	45	25	40	45
Burst factor	42	54	58	32	47	48	37	59	65
Tear factor	200	154	173	129	114	110	150	131	122
Breaking length (meter)	5100	5810	5840	4100	5500	6000	4350	6250	6500

Table VI. Comparison of various non-wood unbleached kraft pulp with muli bamboo

Particulars of test	GJP .CVL-1 (Age 110 days)	Untreated jute fibre	Jute cuttings	Baggase	Muli bamboo
1%NaOH solubility %	34.34	50.05	14.05	34.5	21.08
Yield % on O.D. chips	41.88	47.00	71.8	57.3	46.13
$KMnO_4$ No.	14.30	13.50	22.0	15.0 *	13.50
Pulp strength properties					
Freeness value, ^oSR	45	45	45	330 mL (csf)	45
Beating time min.	25	30	80	nd	82
Burst index KPa m^2/g	5.39	4.41	4.70	4.08	4.61
Tear index mN m^2/g	10.59	20.09	22.75	4.48	26.96
Tensile index Nm/g	65.20	67.40	54.90	56.50	56.32

* kappa no. 330 ml csf, csf: Canadian Standard Freeness

Conclusion

The results of the present investigation can be summed up in the following brief statements.

The bottom part of GJP appears to be more acceptable as the pulping raw material. As the retting of this part is very poor and is heavily contaminate with scales. Jute from this part has little use in jute mills. The alpha-cellulose content increases whereas hemi-cellulose decreases from top to bottom part.

The higher alpha-cellulose content and lower hemi-cellulose, lignin and extractive contents of bottom part of GJP give better pulping and strength properties in comparison with the remaining parts of GJP.

Acknowledgement

It is a great pleasure to express heartiest thanks to the authority of Bangladesh Chemical Industries Corporation (BCIC) for offering all sorts of help including laboratory facilities during the course of this work.

References

Ali and Rahman SM (1988), Viscometric behaviour of cellulose in phosphoric acid, *Bang. J. Sci. Ind. Res.* **XXIII (1-4):** 56-57.

Alam MR, Islam N, Biswas SC and Barua IB (1991), Utilization of untreated jute in paper making. KPM R&D Note No. 238 (Unpublished).

Alam MR, Barua IB, Khan AB (1997a), Innovation to the alkaline semi chemical pulping of muli bamboo, *Bang. J. Sci. Ind. Res.* **32** (1): 79-83.

Alam MR, Islam N and Barua IB (1997b), To study the effect of sulphidity variation in Kraft Pulping of Muli Bamboo, *Bang. J. Sci. Ind. Res.* **32** (1): 111-114.

Asaduzzaman M, Eshaque AKM and Alam S (1983), Relationship between the different grades of jute fibre (Kutcha & Pacca grads) with their lignin and pectin content, *B. J. Jute Fib. Res.* **8**(1&2): 55-57.

Bashiruzzaman M, Mian AJ and Haque MM (1964), The chemical constituents and molecular weight of cellulose in different parts of jute fibre, *J. Textile.* **34:** 910-911.

Casey JP (1966), Pulp and paper chemical technology, 2nd Edition Vol-2, Intrescience Publishers Inc. New York. pp 931.

Mian AJ (1998), Diversification of jute for newer and wider end uses. Seminar on Diversification of jute uses and environment. IJO. Dhaka. May 20-21.

Rydholm SA (1965), Pulping processes. Interscience Publishers, pp 164,1158.

Shafi M (1994), Ph.D. Thesis (University of Dhaka). Pulping of jute by neutral sulphite anthraquinon (NS-AQ); 121,123.

Tappi standards and Suggested Methods (Technical Association of the Pulp and Paper Industry) New York, 1970.

Received: 08 July 2012; Revised:11 April 2013; Accepted: 21 May 2013 .