Response of Rajkoroi (*Albizia richardiana* King and Prain) Wood for Various Alkaline Pulping Processes

D. Biswas, M. Misbahuddin and U. Roy
Bangladesh Forest Research Institute, P.O. Box 273
Chittagong 4000, Bangladesh
E.mail: dbiswas1961@yahoo.com

Abstract

The response of rajkoroi (*Albizia richardiana* King and Prain) wood for making pulp in NS-AQ (Neutral Sulphite Anthraquinone), soda, soda-AQ and kraft pulping processes was assessed by different alkali doses and pulping time. The temperature was maintained at 170°C in all cases. Results showed that the species was not suitable for making pulp in NS-AQ process. Pulps could be made in soda process but the amount of uncooked material (rejects) was high. Addition of 0.1% AQ in soda liquor gave better results in delignification. The species responded very well towards kraft process. Bleachable grade kraft pulp was obtained even with 14% active alkali with a pulp yield of 48.2%. The pulp yield of rajkoroi was comparable to other hardwood species widely used in pulp and paper mills of Bangladesh.

Hand sheets from soda, soda-AQ and kraft pulp of rajkoroi were made. The physical strength properties likely tear, tensile and burst were evaluated. Kraft pulp was superior to the pulp produced either in soda and soda-AQ processes but slightly inferior to the pulp produced from commonly used hardwood species. The pulp of this species could be blended with imported softwood pulp for making moderate quality writing, printing and wrapping paper.

সারসংক্ষেপ

রাজকরই (*Albizia richardiana* King and Prain) কাঠের মণ্ড তৈরিতে এন এস-একিউ (নিউট্রাল সালফাইট এ্যানথ্রাকুইনন), সোডা, সোডা-একিউ এবং ক্র্যাফট পদ্ধতির প্রভাব যাচাই করা হয়েছে। ১৭০°সে. তাপমাত্রায় ক্ষারের মাত্রা এবং মণ্ড তৈরির সময়ের ভিন্নতায় মণ্ড তৈরি করা হয়েছে। এ প্রজাতি হতে এন এস একিউ (NSAQ) পদ্ধতিতে মণ্ড তৈরি সম্ভব হয়নি। সোডা পদ্ধতিতে মণ্ড তৈরি সম্ভব হলেও মণ্ড হয়নি এমন চিপসের পরিমাণ বেশি ছিল। তবে এ পদ্ধতিতে ০.১% একিউ মিশানোর ফলে ডিলিগনিফিকেশনে ভাল ফলাফল পাওয়া গেছে। ক্র্যাফট পদ্ধতিতে ১৪% ক্ষারীর মাত্রায় শতকরা ৪৮.২ ভাগ বিরঞ্জন যোগ্য মণ্ড তৈরি করা যায়। প্রাপ্ত মণ্ডের পরিমাণ বাংলাদেশের মণ্ড ও কাগজ মিলে তৈরি হার্ডউড মণ্ডের পরিমাণ সমতুল্য।

সোডা, সোডা-একিউ এবং ক্র্যাফট মন্ডের হ্যান্ডশীট তৈরি করা হয়েছে এবং ভৌত শক্তি যেমন টিয়ার, টেনসাইল এবং বার্স্ট নির্ণয় করা হয়েছে। ক্র্যাফট পদ্ধতিতে তৈরি মণ্ডের গুণগত মান সোডা এবং সোডা-এ কিউ পদ্ধতিতে তৈরি মণ্ডের চেয়ে উন্নততর কিন্তু কাগজ কলে সচরাচর হার্ডউড হতে তৈরি মণ্ডের চেয়ে নিম্নমানের। মণ্ডের পরিমাণগত দিক বিবেচনা করে এ প্রজাতির মণ্ড আমদানিকৃত সফ্টউড মণ্ডের সাথে মিশিয়ে মধ্যম মানের লেখা, ছাপা এবং মোড়কে ব্যবহৃত কাগজ তৈরি করা সম্ভব।

Key words: *Albizia richardiana*, alkaline pulping, kraft process, neutral sulphite anthraquinone, soda, soda-AQ

Introduction

The demand of forest resource increases gradually with the continuous increase in population. However, the incremental rates of our demand and the supply of the natural resources are not the same. As a result forest resources are becoming scarce everyday. On the otherhand, the consumption of paper, board and newsprint has been growing at a robust rate of 20% annually in the last five years. The per capita consumption of paper is about 6 kg/year for 150 million people (Anon. 2010). This will grow in the future with the progress of the government policy of illiteracy reduction. The government sector pulp and paper mills likely Khulna Newsprint, North Bengal Paper and Sylhet Pulp Mills were laid off due to raw material crisis and lack of fresh investment. The Karnaphuli Paper Mill is not in a position to reach their targeted levels of daily paper production due to the deficit of raw material supply. Therefore, immediate action is necessary to find out new source of raw material for pulp and paper mills for attaining self sufficiency in paper production.

Albizia richardiana, locally called rajkoroi, is a first growing medium density hardwood species of the family Leguminasae. The wood is light yellow in colour. Sapwood and heartwood are indistinguishable. The species has been planted as avenue tree by the roadside and also in parks and gardens in Bangladesh (Das 1990). The species is largely available in Patuakhali, Barguna, Bagerhat, Barisal, Jhalakathi, Madaripur, Pirojpur districts and in small patches in other districts of Bangladesh. It is used for making cheap furniture, boat and as fuel wood (Das and Alam 2001). There is no information on pulping of rajkoroi in various alkaline pulping process. Therefore, the study has been taken to assess the pulp making characteristics of rajkoroi in NS-AQ (neutral sulphide anthraquinone), soda, soda-AQ and kraft process.

Materials and Methods

Raw material processing

Rajkoroi logs were converted into planks and then chipped using a laboratory chipper. The chips were screened to remove oversized, pin chips and dust. Finally, the screened chips were hand sorted to remove all pieces of knots, barks and decayed wood. The accepted chips were about 20 mm in length, 10 mm in width and 3 mm in thickness. The chips were then air dried and stored in sealed polythene bag for chemical analysis and pulping experiment.

Chemical analysis

Part of the chips was ground in a Wiley Mill and screened. That fraction which passes through the 40 mesh screen and is held on the 60 mesh screen was used for determining the percentage of chemical constituents. Alpha-cellulose was measured according to Browning (1967) and lignin content of the species was measured following Tappi test methods T 222. The amounts of soluble components in various solvent systems were determined according to Tappi test methods T204 (alcohol benzene), T 207 (cold and hot water) and T 212 (1% NaOH).

Pulping

The pulping experiments were carried out with air dry chips equivalent to 250 g of oven dry chips in 2 liter stainless steel autoclaves heated in a temperature controlled air bath. Liquor to wood ratio was 4:1 in all the cooks (l/kg). The pulping conditions for various pulping processes are given in Table 1.

All cooks were done at maximum temperature of 170°C. A cooking temperature profile of 90 min. from room temperature to 170°C (rise of temperature from room temperature to 80°C in 30 min.

Table 1. Pulping conditions in NS-AQ, soda, soda-AQ and kraft processes.

Parameters	Pulping processes			
	NS-AQ*	Soda	Soda-AQ	Kraft**
Cooking chemicals (Analytical grade)	Na_2SO_3 and Na_2CO_3	NaOH	NaOH	Na_2S and NaOH
Anthraquinon (AQ) based on oven dry material	0.1%	--	0.1%	--
Total alkali charge as NaOH	14-24%	14-18%	14-18%	12-18%
Pulping time (min.)	180 and 210	120 and 150	120	120

*Alkali ratio for NS-AQ was 0.83, ** Sulphidity level for kraft process was 25%

and from 80°C to 170°C in 60 min) was maintained. After cooking, the chips were discharged and the black liquor was collected for residual alkali determination. The cooked fibers were taken in a screen box and washed overnight under running water to wash out the residual liquor. The washed material was stirred slightly with water in a bucket by a slow speed electric mixture. The pulp slurry was then screened in a Johnson vibratory screen to separate any uncooked material from the pulp. The wet pulp was put in a canvas bag and pressed in a screw press to remove excess water, and then samples were taken for dry matter content. The pulp yield was determined. The screening rejects were collected dried and then weighted. The kappa number of pulp was determined using Tappi test methods T 236 cm-85.

Hand sheet making and physical testing

The pulps produced in soda, soda-AQ and kraft processes were beaten in a PFI mill to attain Canadian Standard Freeness (CSF) of 450 and 250 ± 3 ml (SCAN-C 21:65) and handsheets were made. These were then conditioned at 23±1°C temperature and 50±1% relative humidity and tested according to SCAN-C 28:69 for determining the physical strength properties.

Results and Discussion

Chemical compositions

The chemical compositions of rajkoroi were determined and the values are given in Table 2. It was found that the cold and hot water solubles of the species was 1.63 and 3.30% respectively. The lignin content of the species was 22.7%. This is lower than the widely used hardwood species (24-30%) in pulping. The lower lignin content is advantageous for easy pulping. The α-cellulose of rajkoroi was 44.7%. The cellulose content in rajkoroi was almost similar and in some cases higher than many hardwoods grown in Bangladesh (Razzaque *et al.* 1997). The α-cellulose is directly responsible for pulp yield.

Pulping

The pulp yield and kappa number of pulps made from rajkoroi in NS-AQ, soda,

Table 2. Chemical composition of *Albizia richardiana* wood.

Chemical component	Percentage
Cold water solubles	1.63 (1.57 - 1.70)
Hot water solubles	3.30 (3.26 - 3.32)
1% caustic soda solubles	16.30 (16.06 - 16.64)
Alcohol-toluene solubles	3.72 (3.49 - 3.83)
Lignin	22.7 (21.0 - 23.9)
Alpha-cellulose	44.7 (44.5 - 44.8)

soda-AQ and kraft process are presented in Table 3. It was found that in NS-AQ process the chips were not cooked even at high alkali doses. Longer cooking time did not work as well in NS-AQ process. Mechanical refining was required to separate the fiber. The kappa number was very high which indicated that the species is not suitable for making chemical grade pulp in NS -AQ process.

The species was also tried to make pulp in soda process. Lowest dose of chemicals failed to convert the chips into pulps. With the increase of alkali dose, the kappa number dropped from 67.1 to 35.1. The result indicated that the species could not pulp at this condition. When the pulping time was increased from 120 min. to 150 min. the bleachable grade pulp having 46.3% yield was obtained at 18% active alkali. The high active alkali requirement along with increased pulping time would not be economical. Rajkoroi responded well with addition of 0.1% AQ in soda process. AQ was added to act both as a delignification enhancer and carbohydrate preserving catalyst during pulping. The kappa number of the pulp produced with an alkali charge of 16% dropped to 22.2 in soda-AQ process. At this alkali charge pulp yield was also increased by 4.1 percent unit. Previous results also showed that a small addition of AQ in soda cooking enhances the rate of delignification with improved yield (Akhtaruzzaman *et al.* 1987, Das *et al.* 1990, Fossum *et al.* 1980, Kubes *et al.* 1980, Jahan and Mun 2004).

The delignification was found much easier in case of kraft pulping for rajkoroi. At 12% active alkali, the kappa number was 21.8 with the pulp yield 48.6. The amount of rejects was low. It showed that the requirement of cooking chemical is very low. The pulp yield of rajkoroi is comparable to most hardwood species for making bleachable grade pulp (Bose *et al.* 1995). With the increase of cooking chemical concentration, the kappa number lowered slightly.

The kappa numbers of the pulps of rajkoroi are plotted against active alkali dose for NS-AQ, Soda, Soda-AQ and for kraft pulping process (Fig. 1). For soda process, the desired level of delignification could not be reached either with the increment of cooking chemicals or of pulping time. However, when AQ was added comparable delignification was observed at 16% alkali concentration. Among the chemical pulping process, the kraft pulping process is more suitable and 14% alkali is found optimum. NS-AQ could not produce pulp from rajkoroi at all.

Table 3. Pulp yield and kappa number of *Albizia richardiana* wood at different alkaline pulping processes.

Pulping time (min.)	Pulping process	Active alkali (%)	Chemical consumption (%)	Rejects (%)	Screened yield (%)	Kappa No.
180	NS-AQ	14	9.4	Needs mechanical refining	70.2	97.3
		16	9.7		68.0	94.4
		18	10.3		65.4	86.4
		20	11.3		65.5	86.4
		22	13.0		65.6	85.4
210	NS-AQ	22	11.7		65.1	83.2
		24	12.5		64.4	81.9
120	Soda	14	12.5		55.6	67.1
		16	13.8	3.71	46.8	38.8
		18	14.5	1.45	46.5	35.1
150	Soda	16	15.6	2.51	45.8	30.0
		18	15.8	1.23	46.3	23.9
120	Soda-AQ	14	13.2	9.65	52.9	37.8
		16	14.0	1.42	50.4	22.2
		18	15.7	1.07	49.7	19.9
120	Kraft	12	11.6	1.95	48.6	21.8
		14	12.5	1.03	48.2	19.0
		16	13.2	0.51	46.8	18.5
		18	13.5	Nil	44.6	16.3

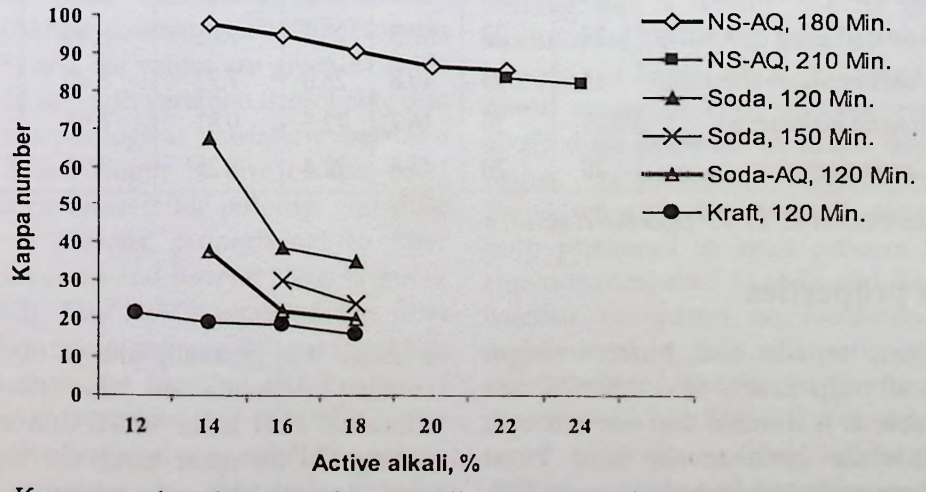

Figure 1. Kappa number change with active alkali variation for NS-AQ, soda and kraft process.

Table 4. Physical strength properties at 450 ml. and 250 ml. CSF of *Albizia richardiana* pulp.

Pulping time (min.)	Pulping process*	Tear index $mN.m^2/g$		Burst index $kPa\ m^2/g$		Tensile index Nm/g	
		450	250	450	250	450	250
120	S_{14}	5.60	5.32	3.75	3.98	38.7	54.1
	S_{16}	6.15	6.05	3.10	3.82	32.6	41.5
	S_{18}	6.30	6.08	3.09	3.40	30.3	36.2
150	S_{16}	5.27	4.90	3.15	3.58	36.6	45.6
	S_{18}	4.75	4.63	2.85	3.49	34.9	45.7
120	SAQ_{14}	5.95	5.37	3.30	4.85	43.5	50.9
	SAQ_{16}	6.25	5.48	3.20	4.38	37.3	49.7
	SAQ_{18}	6.02	5.90	3.25	4.04	35.1	50.1
120	K_{12}	7.75	6.85	3.70	4.79	50.5	68.4
	K_{14}	7.40	6.68	3.53	4.60	45.1	54.5
	K_{16}	7.32	6.35	3.30	4.46	40.2	49.1
	K_{18}	7.20	5.83	3.15	4.17	38.5	45.5

* The values in subscripts represent the active alkali (%) used for pulping

Table 5. Comparison of strength properties of *Albizia richardiana* and other hardwood species at 450 ml. CSF.

Wood species	A.A (%)	Sulphidity (%)	Screened yield (%)	Kappa number	Tear index $mN.m^2/g$	Burst index $kPa.m^2/g$	Tensile index Nm/g
Raj koroi (*Albizia richardiana*)	14	25	48.2	19.0	7.40	3.53	45.1
[1]Chakua koroi (*Albizia chinensis*)	14	25	50.5	25.7	7.05	5.45	70.5
[1]Kadam (*Anthocephalus chinensis*)	14	25	49.8	28.0	7.72	5.80	80.0
[2]Simul (*Salmalia malabarica*)	15	20	46.7	22.5	9.81	4.97	75.6
[2]Minjiri (*Cassia siamea*)	20	20	43.4	22.4	8.25	3.93	68.7

[1]Akhtaruzzaman *et al.* 1997, [2]Hossain *et al.* 1978

Strength properties

The tear, tensile and burst strength properties of pulp at 450 and 250 CSF are given in Table 4. It showed that tear strength decreased while both tensile and burst strength increased with the decrease of CSF as usual. It is generally known that the tear strength depends on the strength of individual fiber cells, which decreases with beating. On the other hand, the tensile and burst strength depends on strong fiber to

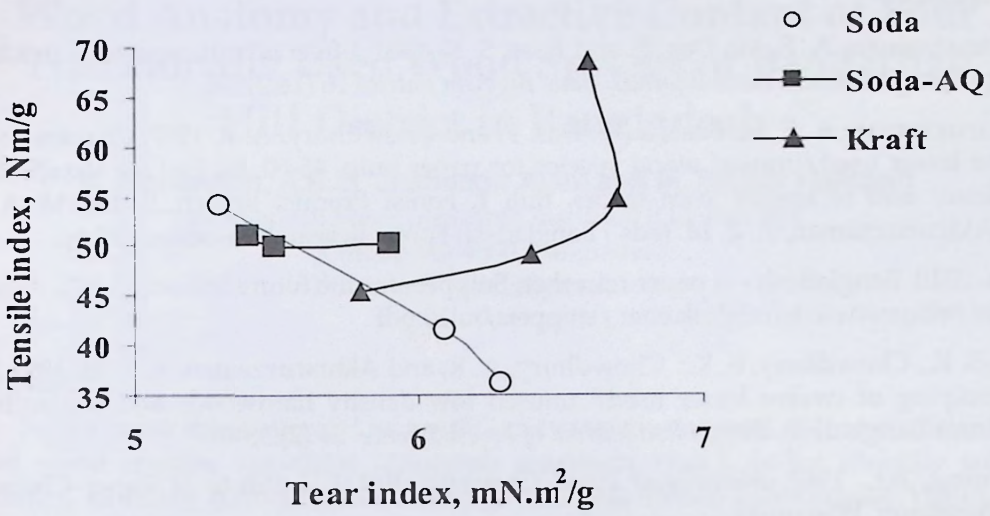

Figure 2. Tear-Tensile plots at 250 ml CSF of *Albizia richardiana* for various pulping process (pulping time 120 min.).

fiber bonding that results the increase of bond potential with the progress of beating. In the present study, the tensile index of pulps made in kraft process is found slightly higher than that of soda alone and soda-AQ process. The pulp quality was assessed by tear-tensile relationship for the pulp at 250 ml CSF (Fig. 2) and the results showed kraft pulp is slightly superior. On the contrary, the strength of the rajkoroi pulp is inferior compared to commonly used hardwood species for pulping (Akhtaruzzaman *et al.* 1997, Hossain *et al.* 1978) and the values are given in Table 5. The pulp strength variation is probably due to the morphological variation between species. Fiber length is one of the most important parameters for pulping, and pulp strength is directly proportional to fiber length (Haygreen and Bowyer 1982, Wimmer *et al.* 2002). Das (1990) reported the fiber length of *A. richardiana* was 1.01 mm and this is lower than the most of the hardwood species (Akhtaruzzaman *et al.* 1997). Short fiber length of rajkoroi may result to produce inferior quality pulp. This pulp can be blended with long fiber pulp to optimize strength for producing writing, printing and wrapping paper.

Conclusion

Rajkoroi is not a suitable species for making pulp in NS-AQ process. It cooked well in soda process but kappa number was too high. Longer cooking time helped in pulp making but it would not be economical. Addition of 0.1% AQ gave better results in lowering of kappa number. Delignification is found easier in kraft process even at low alkali dose. Increase in alkali dose did not bring remarkable beneficial effect. Considering physical strength properties, the pulp produced in kraft process is slightly superior compared to soda and soda-AQ but inferior compared to hardwood species widely used in pulp and paper mill. In this aspect pulp of this species produced in kraft process could be blended with imported soft wood pulp for making moderate quality writing, printing and wrapping paper.

References

Akhtaruzzaman, A. F. M.; Das, P. and Bose, S. K. 1987. Effect of anthraquinone in alkaline pulping of *Acacia auriculiformis*. *Bano Biggyan Patrica* 16 (1&2):3-9.

Akhtaruzzaman, A. F. M; Bose, S. K.; Das, P. and Chowdhury, A. R. 1997. Characterization of lesser used/unused wood species for paper pulp. 46-60. In: *End use classification of lesser used or unused wood species,* Bull 1. Forest Product Branch. Sattar, M. A. and Akhtaruzzaman, A. F. M. (eds.) Bangladesh Forest Research Institute. 117 pp.

Anon. 2010. Bangladesh – a paper refresher, Snippets for the future industry 14(7). Available in online:www.wirefabrik.com /snippets/jul10.pdf

Bose, S. K.; Chowdhury, S. K.; Chowdhury, A. R, and Akhtaruzzaman, A. F. M. 1995. Kraft pulping of twelve lesser used/ unused low density hardwoods and one softwood from Bangladesh. *Bangladesh Journal of Forest Science.* 24 (2):35-40.

Browning, B.L. 1967. *Methods of Wood Chemistry.* Vol.-1. Institute of Paper Chemistry, Appleton, Wisconsin.

Das, D. K. 1990. *Wood anatomy of koroi (Albizia spp.) of Bangladesh.* Bulletin 10, Wood Anatomy Series, Bangladesh Forest Research Institute. 36 pp.

Das, D. K. and Alam, M. K. 2001. *Trees of Bangladesh.* Bangladesh Forest Research Institute, Chittagong. 342 pp.

Das, P.; Bose, S. K. and Akhtaruzzaman, A. F. M. 1990. Effect of anthraquinone in kraft and soda pulping of bagasse. *Bano Biggyan Patrica* 19 (1&2):19-23.

Fossum, G.; Hagglund, S and Lindovist, B. 1980. Alkaline pulping of pine and birch with anthraquinone as an additive-Part 2, soda pulping. *Syensk Papperstidning* 83 (16): 445-450.

Haygreen, J. G. and Bowyer, J. N. 1982. *Forest Products and Wood Science An introduction,* Iowa State University Press/ First edition/third edition 495 pp.

Hossain, S. M.; Siddique, A. B. and Das, P. 1977. Investigation on the possibility of making sulphate pulp from rubber wood *(Hevea brasiliensis). Bano Biggyan Patrica* 6(2):54-57.

Jahan, M. S. and Mun, S. P. 2004. Effect of tree age on the soda-anthraquinone pulping of Nalita wood *(Trema orientalis). Korean J. Ind. Engg. Chem.* 10 (5): 766-771.

Kubes, G. J.; Fleming, B. L. Macleod, J. M. and Bolker, H. I. 1980. Alkaline pulping with additives= a review. *Wood Science and Technology* 14(3): 207-228.

Razzaque, M. A.; Das S. C.; Akhter, S. and Sayeed, M. 1997. Chemical composition and water repellency of lesser used/unused wood species for paper pulp. 73-82. In: *End use classification of lesser used or unused wood species,* Bull 1. Forest Product Branch. Sattar, M. A. and Akhtaruzzaman, A. F. M. (eds.) Bangladesh Forest Research Institute, Chittagong. 117 pp.

Wimmer, R.; Downes, G.M.; Evans, R.; Rasmussen, G. and French, J. 2002. Direct effects of wood characteristics on pulp and hand sheet properties of *Eucalyptus globulus. Holzforschung* 56 (3):244-252.