POTENTIALITY OF PIGEON PEA (ARHAR) PLANT FOR PULPING

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ABSTRACT

A study was conducted to evaluate the suitability of Pigeon pea stem for making paper pulp. Pigeon pea (*Cajanus cajan*) stem is characterized by shorter fibres compared to hardwood species. Medium quality pulp was obtained from this plant. The pulp may be suitable for making good quality writing and printing papers. The demand of the raw materials for pulping can be met if Pigeon pea is planted along the 1,45,000 km roads in Bangladesh.

INTRODUCTION

Pigeon pea (*Cajanus cajan*), commonly known as Arhar, is a tropical crop. It is planted in flat and hilly lands, on field bunds or as hedges. With proper time of planting at ideal conditions, population ranges from 5,00,000–6,50,000 plants per hectare (Gowda and Kaul 1982). Arhar has a multipurpose use. The juice of the young leaves is used as a medicine for the treatment of jaundice (Nadkarni 1954). Green seed is used as a vegetable. As the stem does not require splitting and since it dries very quickly, the plant is very popular as fuel to the villagers. Other advantages of Arhar cultivation include conservation and nitrogen enrichment of the soil (Alim 1985).

Arhar plant has a woody structure having a low specific gravity (0.42) as found by Sattar (1985). It is characterized with high holocellulese (76.9%) and low lignin (19.6%) contents as determined by Razzaque *et al.* (1985) These facts favour its use as a raw material for pulping. There is an alarming scarcity of fibrous raw materials for making pulp in Bangladesh. For the survival of our pulp and paper industries, a suitable alternative raw material should be identified on a priority basis To this end, this study was conducted.

MATERIAL AND METHODS

Arhar plants were collected in green condition from the Forest college campus

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at Chittagong. The stem was hand-cut into 25–50 mm long and 2–7 mm thick pieces without removing the bast fibre of the plant. These were then air-dried and stored in sealed polythene bags. The moisture content of the chips was then determined.

Match stick size specimens were randomely collected and macerated in a solution of 10% chromic acid and 10% nitric acid. Temporary slides were made from the macerated fibres after thoroughly washing them with distilled water for determination of fibre length. Fibre diameter and cell-wall thickness were measured from the cross-section of samples by means of a compound microscope. Lumen diameter was calculated by subtracting cell-wall thickness from fibre diameter.

Three kraft pulping experiments were carried out in a 23 *l* rotating digester using indirect heat with steam. Before charging the chips, the digester was first heated to raise the temperature to about 80°C. Air dry chips equivalent to 1550 g oven dry weight were used in all the cooks. Cooking condition of 14% active alkali as Na_2O, 25% sulphidity, 4 : 1 liquor to wood ratio, 90 minutes to raise the temp to cooking temp of 170°C were maintained in all the cooks. The cooking time was varied at three levels of H-factor to get three values of kappa number.

At the end of the digestion the pressure inside the digester was released and the black liquor was drained off. The chips were then dumped into a screen box. The cooked chips were washed and then disintegrated. The pulp obtained was screened in a vibratory screen. The screened pulps were damp-dried, shredded, weighed and sampled for moisture content. The yield and kappa number of the pulp were then determined. The screenings were also dried and weighed. The strength properties of the pulp were determined on test sheets prepared after beating the pulp in a Valley beater machine for different durations. The hand sheets made were kept in a testing room at 23 ± 1°C and 50 ± 1% relative humadity. All the sheets were tested according to Scan Test Methods.

RESULTS AND DISCUSSION

Fibre dimension data are given in Table 1. It is observed that the fibre length and lumen diameter of Arhar plant are similar to these of Lantana, Jute stick and Dhiancha plants. The fibre diameter and cell-wall thickness of Arhar fibre are lesser than those of hardwood species mentioned in the table. The smaller fibre length compared to the hardwoods indicates poorer paper making properties with Arhar plant fibre. However, the thinner cell-wall of the fibre with almost similar lumen diameter compared to the hardwood species may result in improved bonding in paper making.

The characteristics of the pulp obtained from Arhar plants are given in Table 2. The yield of the pulp was better than that from the hardwood species (Table 3). However, this plant yielded more screenings. This is because the chips were handmade. Such kind of chips are difficult to be impregnated with chemicals and thus result in more screenings (Zaman and Virkola 1979). The screenings are expected to be lower when the chips are macine made.

Table 1. Fibre dimensions of Arhar plant compared with those of other grass and hardwood species

Sl. No.	Local Name	Average				References
		Weighted fibre length mm	Fibre dia micron	Cell-wall thickness micron	Lumen dia micron	
1.	Arhar (*Cajanus cajan*)	0.77	15	1.4	12	
2.	Lantana (*Lantana aculeata*)	0.83	22	4.5	13	Siddique and Chowdhury 1982
3.	Jute stick	0.84	27	2.8	21	Siddique and Chowdhury 1982
4.	Dhaincha (*Sesbania bispinosa*)	0.79	34	8.0	18	Siddique and Chowdhury 1982
5.	*Albizia falcataria*	1.25	29	4.7	20	Zaman *et al.* 1971
6.	Simul (*Bombax ceiba*)	1.87	27	8.4	10	Siddique and Chowdhury 1982
7.	Gamar (*Gmelina arborea*)	1.19	28	5.0	18	Siddique and Chowdhury 1982

Table 2. Kraft pulping of Arhar plant (Constant cooking conditions of 14% AA as Na_2O, 25% sulphidity, liquor-to-wood ratio of 4 : 1, rise to cooking temp of 170°C in 90 min)

Cook No.	H-factor	Total yield	Screening rejects	Kappa No.	Chemical consumption	Physical strength properties at							
						450 C. S. F.				250 C. S. F.			
						Density	Tear index	Burst index	Tensile index	Density	Tear index	Burst index	Tensile index
		%	%		%	kg/m³	mN. m²/g	kpa. m²/g	Nm/g	kg/m³	mN. m²/g	kpa. m²/g	Nm/g
1.	2000	51.0	4.3	21.6	12.1	705	6.0	4.0	70.3	900	4.0	6.0	87.5
2.	2500	49.6	4.6	19.3	12.4	730	5.8	4.3	65.5	840	4.3	6.0	88.0
3.	3000	49.4	4.1	22.5	12.5	725	5.8	4.0	63.4	850	4.3	5.8	84.6

Table 3. Comparison of physical strength properties of kraft pulp from Arhar plant with corresponding pulps from hardwood species

Sl. No.	Name of species	Total yield %	Kappa No.	Physical strength Properties at 450 C S F				References
				Density kg/m³	Tear index mN. m²/g	Burst index kpa. m²/g	Tensile index Nm/g	
1.	Arhar	49.6*	19.3	730	5.8	4.3	65.5	
2.	*Albizia falcataria*	49.4	18.0	740	8.9	8.2	103.0	Zaman *et al.* 1971
3.	Simul	46.7	17.0	560	10.7	3.6	65.6	Razzaque *et al.* 1970
4.	Gamar	46.3	17.9	590	8.1	4.7	72.3	Hossain *et al.* 1978

**Screening rejects* 4.6%

The tearing strength of the pulp was rather poor. The burst index and tensile index of the pulp compared favourably with those from other hardwoods. These properties were however better than those from Simul. Kraft Arhar pulp can be used in making paper which does not require superior tearing strength. Thus, writing and printing papers can be made from it.

POTENTIALITY OF ARHAR PLANTATION

There are three chemical pulp mills in Bangladesh with a daily production capacity of about 300 tons of pulp. This means that the daily demand of fibrous raw materials for pulping is about 750 tons. Thus, the annual demand is about 2,25,000 tons. If Arhar is planted along the sides of 1,45,000 km of roads in Bangladesh, it is possible to obtain 7,68,500 tons of raw materials every year (Appendix–1). This is a much under estimated figure. In actual practice, the potentiality of availability of Arhar plant will be much more. However, even with the availability of 7,68,500 tons of Arhar plant, the total demand of the raw materials for pulp industries of the country can be wholly met from the roadside plantation of Arhar. Over and above, there will be an excess of 5,43,500 tons of raw materials. This will be a potential source of firewood. Then the country can also seriously think of establishing more pulp and paper mills. If first year Arhar plantation in forest areas is included, total availability of the plant in the country may exceed 9,00,000 tons every year (Alam 1985). Thus the surplus to be used as fuel can be 7,00,000 tons.

CONCLUSIONS

Arhar plant possesses shorter fibres than the hardwood species like Gamar, Simul and *Albizia falcataria*. Medium quality pulp was obtained from this plant

by the kraft process. The tearing strength of the pulp was makedly inferior. It is possible to make good quality writing and printing papers from kraft Arhar pulp. The total demand of raw materials for pulping can be met from the roadside plantation of Arhar in Bangladesh. In addition, there will be a potential excess of Arhar stem for fuel.

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Appendix - 1. Potential benefits from Arhar plantation along the roadsides for getting raw materials for pulping

i.	Available roads (including railway track and canal banks in Bangladesh	:	1,45,000 km (90,000 miles)
ii.	No. of plants/km if plantation is made accross 30 cm along both the sides of the roads and if plantation distance is 10 cm x 10 cm	:	10,000 x 4 x 2 = 80,000 53,000 (considering 33% mortality rate)
iii.	Plant stem available /year/km (considering 0.1 kg of mass/plant*)	:	$\frac{53,000 \times 0.1}{1000} = 5.3$ ton/a
iv.	Plant stem available along the plantation of roadways of 1,45,000 km	:	1,45,000 x 5.3 = 7,68,500 ton/a
v.	Requirement of raw materials for three chemical pulp mills (300 ton of daily pulp production capacity and 300 operative day/annum)	:	$\frac{300 \times 300}{0.4} = 2,25,000$ ton/a
vi.	Excess of raw materials after meeting demands of pulp mills	:	7,68,500–2,25,000 ton/a = 5,43,500 ton/a

**This figure has been conservatively estimated*