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Pulping and physical strength properties of bodha and carrot grass as raw material for hanmade paper making

R.K. Jain, A.K. Sharma, Atul Kumar and Sushil Kumar[1]

Kumarappa National Handmade Paper Institute, Sikarpura Road, Sanganer, Jaipur (Rajasthan)

[1]National Research Centre for Weed Science, Adhartal, Jabalpur (Madhya Pradesh)

E-mail: knhpi@sancharnet.in

ABSTRACT

Scarce availability and rising cost of traditionally used raw material like cotton hosiery waste has forced to search for alternate and cost effective cellulosic raw materials for sustainability and to improve its competitiveness. Bodha grass (*Chloroxylon coloratus*) and carrot grass (*Parthenium hysterophorus*) as lingo-cellulosic raw material were evaluated for pulping and physical strength to produce handmade paper and related products. The physico-chemical analysis of bodha grass and carrot grass indicated higher content of cellulose (77.78%) and lower contents of lignin (16%). The pulp produced by cold soda prosess was of poor quality and was not found suitable for hand madepaper making. Pulp of good strength properties was obtained by hot soda and alkaline peroxide process. Blending of bodha grass and Parthenium pulp in diferent ratio (20 to 40%) with hosiery waste pulp resulted good strength properties in respect of tensile index 20-34.5 (Nm/gm), tear index (13-25.00 mN.m^2/gm) and burst index (1.9-3.0 kPa. m^2/gm) making it suitable for producing an affordable quality of handmade paper. The possibility of utilization of these weed species to produce handmade paper may provide an opportunity for employment generation and income enhancement among the rural masses and helping in conservation of natural resources.

Key words : *Chloroxylon coloratus*, Handmade paper, *Parthenium hysterophorus*, Physical strength properties, *Chloroxylon coloratus*

The conventional raw materials like bamboo, hard and soft wood yielding plant species used for cellulose based industries are depleting rapidly. Today, handmade papers are playing an increasingly important role in the modern society and these are finding expanding outlets almost in every field. In recent past, there has been considerable progress in the production of industrial grade papers but the progress made in the field of special papers is meager and insignificant. Huge quantity of such papers is still being imported to meet the increasing demand. Handmade paper industries can play a vital role because of its low capital investment, high employment potential and minimum gestation period. This industry can produce different grades of paper by utilizing agriculture residues, secondary fibers, forest waste besides providing employment to rural mass. Various alternative lignocellulosic raw materials like banana fiber obtained from waste banana leaf/stem, *Calotropis procera*, *Cannavis sativa*, jute *etc*. have been identified by the scientists of Kumarappa National Handmade Paper Institute, Jaipur (India) (Jain *et al*. 2007). Realizing the above facts, pulping and strength properties of two weed species for handmade paper making were evaluated.

Bodha grass (*Chloroxylon coloratus*) grows abundantly as a weed along with tree species *Pterocarpus santalinus* (Red Sanders) in the deciduous tracts of Andhra Pradesh in India. This species of graminae has wild look, bushy panicle that makes it inedible to bovines when mature, but are edible when young and tender. Local inhabitants use this weed as a thatching material but it is a great fire hazard (Anonymous 2006). The commercial use of this grass has been considered of great benefits for the local communities which are dependent upon the forests wealth. Carrot weed *(Parthenium hysterophorus* L.) is a weed of waste land, crop and forest land infesting about 35 million hectares land in India (Sushilkumar and Varsheny 2007). This weed occurs abundantly throughout the year but more during rainy season. It has been reported to reduce crop productivity and affect biodiversity besides causing health related problems in man and animals (Sushilkumar 2005). These weeds possess cellulogic material which may be used in paper and handmade paper making besides other uses like in plywood and compost making. The present study evaluates the suitability of these two abundantly occurring weed species in handmade paper making in the

context of pulp yield and physical strength properties.

MATARIALS AND METHODS

Bodha grass (*C. coloratus*) and Parthenium (*P. hysterophorus*) were collected and supplied by Andhra Pradesh Forest Department, Hyderabad and National Research Centre for Weed Science, Jabalpur , respectively for their evaluation to explore the possibility to use them as the raw material in handmade paper making. The chips powdered in a Willey mill and portion passed through 40 mesh and retained on 60 mesh was taken for proximate chemical analysis. Chemical composition of bodha grass and Parthenium with respect to ash, lignin and cellulosic contents was carried out by TAAPI Standard (14) methods.

Pulping of bodha grass and Parthenium

The raw materials of *C. coloratus* and *P. hysterophorus* were reduced to small sizes of 1.0 to 1.5 cm with the help of chopper. The chopping material was prepared for cold, hot soda digestion and alkaline peroxide pulping. The pulp product under different conditions was evaluated for their strength properties after beating these to various Canadian Standard Freeness (CSF) in laboratory beater.

Cold soda pulping : Bodha and carrot grasses were subjected to different chemical dosage under conditions of cold alkali digestion at room temperature on 300 CSF at 24 hours with bath ratio of 1:10 (Table-2).

Hot soda pulping : The raw material was cooked by means of open boiling with different dosages of sodium hydroxide at atmospheric pressure for three hours excluding time to raise the boiling temperature keeping initial bath ratio at 1:8 in all the cases.

After washing, the fiber was beaten in laboratory beater to 400 and 300 ml CSF. The unbleached pulp yield, rejects were determined. The black liquor after each digestion was collected for determination of total solids and residual active alkali. The beaten pulp was screened in vibratory screen for making laboratory sheets of 60 gsm. The physical strength properties of the hand sheets were recorded with the help of standard equipments. The mean of 5 replications was tabulated.

Alkaline peroxide pulping : The raw material was cooked by alkaline peroxide pulping process (APP) with different doses of sodium hydroxide (4-10%) and 2 per cent hydrogen peroxide after treating it with 0.5% EDTA at pH-5.0. The time, temperature and bath ratio in all cases were maintained at 3 hrs, 95^0C and 1:8, respectively. After washing, the pulp was beaten in laboratory beater to 400 and 300 ml CSF. Laboratory hand sheets of 60 gsm were made after screening the pulp in vibratory screen. The physical properties of hand sheets were recorded and mean of 5 replications were tabulated.

These pulps were also blended with different ratio of mixed hosiery waste at 300 ml CFS standared equipments. The strength properties of the sheet were evaluated.

RESULTS AND DISCUSSION

Proximate chemical analysis

Proximate chemical analysis of grasses showed that it is characterized by high holo cellulosic content and low lignin content, which make them suitable for handmade paper making (Table 1).

Table 1. Chemical composition of bodha grass and Parthenium.

Particular (in %)	Bodha grass	Parthenium
Dust	-	5.0
Moisture	5.0	7.2
Ash	6.8	13.0
Lignin	16.0	16.3
Cellulose	76.6	78.1

Cold soda pulping : Pulping by cold soda process of bodha grass and Parthenium with different chemical dosage resulted in 73.65 to 90.60% (Table-2) yield. Pulping by cold soda process using 4-10% sodium hydroxide on raw material of Parthenium and bodha did not yield good result as the pulp produced was of very poor quality and could not be converted in to paper.

Table 2. Cold alkali digestion of bodha grass

Parameters	Weed name	NaOH (%)		
		4	6	8
Pulp Yield (%)	Bodha grass	90.65	84.0	77.60
	Parthenium	90.11	83.19	76.12
Residual active Alkali (g/l)	Bodha grass	0.65	1.00	1.78
	Parthenium	0.45	0.76	1.51

Hot soda pulping : Better results were obtained by hot soda pulping for both the weed species which resulted in high pulp yield (75 to 80%) and better strength properties in *C. coloratus* but less yield (54-65%) and better strength properties of Parthenium (Tables 3). Optimum results with respect to pulp yield and strength characteristic were obtained by pulping the raw material with 10% hot caustic. Residual alkali was about 1.31 and 0.9 g/l of C. *coloratus* and *P. hysterophorus*, respectively which will have to be taken care when considering this process for industrial application (Table 3).

Alkaline peroxide pulping : The pulp yield by alkaline peroxide pulping varied 68 to 80 and 44 to 60% in *C. coloratus and P. hysterophorus*, respectively. The strength characteristics of APP pulps were superior to hot and cold soda pulps (Table 4).

Blending of pulp of *C. coloratus* with hosiery waste improved its strength properties and can be used for making different varieties of paper products. (Table 5). The results showed that these grasses were suitable raw material for producing variety of handmade papers/product after blending them with mixed coloured hosiery waste.

This study revealed that Parthenium can produce pulp suitable for handmade paper by soda pulping processes. Pulp of good strength properties could be produced by alkaline peroxide process (APP). The cost of pulp production from Parthenium, Jute and *Cannavis sativa* fibre was Rs 24, 33 and 28/kg, respectively (personal communication). Parthenium pulp in blending with long fibre can produce variety of papers and boards like file covers *etc*. Other aspect of using Parthenium as raw material need to be considered carefully as handling of the material may be hazardous for the workers and may create health problems in such cases.

Bodha and Parthenium grasses were found to contain higher content of cellulose and lower content of lignin making them suitable for handmade paper making. The optimized pulping conditions may result in production of an affordable quality of handmade paper with moderate strength properties which may further be improved by blending with commonly used hosiery pulp. The handmade paper produced with blended pulp was found to be cost competitive and suitable for conversion in to various products. The possibilities of utilization of these material for handmade paper making should help in conservation of environment besides providing a cost effective raw material for handmade paper industry and also employment generation among the rural areas.

Table 3. Hot alkali digestion of bodha grass (*C. coloratus*) and Parthenium (*P. hysterophorus*) at different NaoH (%) and CSF (ml).

Parametres		**NaOH(%)**							
		4		6		8		10	
Yield (%)	*Cc*	80.0		79.7		77.7		75.1	
	Ph	65.0		63.5		57.4		54.1	
Residual active alkali (g/l)	*Cc*	0.0		0.5		1.0		1.3	
	Ph	Nil		0.1		0.2		0.9	
		CSF (ml)							
		400	300	400	300	400	300	400	300
Tensile Index (N. m/g)	*Cc*	13.2	14.0	14.6	15.1	16.1	16.9	19.1	19.5
	Ph	17.0	18.0	21.8	21.9	24.1	25.3	26.1	27.4
Tear Index (mN. m^2/g)	*Cc*	8.0	8.2	9.2	9.5	9.7	10.0	10.9	11.0
	Ph	4.1	4.9	6.1	7.8	9.1	10.0	10.2	10.6
Burst Index(KPa.m^2/g)	*Cc*	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.0
	Ph	1.2	1.3	1.5	1.5	1.8	1.9	2.0	2.5
Folding Endurance (No.) (Double Fold).	*Cc*	7	7	9	10	12	14	18	22
	Ph	123	132	140	151	181	190	221	291
Brightness (%)	*Cc*	19.3	19.0	18.0	18.1	17.8	17.0	17.0	17.0
	Ph	25.6	25.0	23.6	23.0	20.1	19.8	14.1	13.4

Ch- Chloroxylon coloratus; Ph- Parthenium hysterophorus

Table 4. Alkaline peroxide pulping of bodha grass (*C. coloratus*) and Parthenium (*P. hysterophorus*) at different NaOH

Parameters		NaOH (%)							
		4		6		8		10	
Yield (%)	*Cc*	79.9		75.6		71.5		68.5	
	Ph	60.0		56.0		50.0		44.2	
Residual active alkali(g/l)	*Cc*	nil		0.15		0.96		1.52	
	Ph	0.5		1.0		1.5		1.9	
		CSF (ml)							
		400	300	400	300	400	300	400	300
Tensile Index (N. m/g)	*Cc*	13.90	14.3	15.1	16.0	17.0	18.9	12.0	20.5
	Ph	21.2	22.1	24.0	25.7	25.8	26.3	27.0	27.9
Tear Index (mN. m^2/g)	*Cc*	8.4	8.9	9.4	10.3	10.7	11.0	11.9	12.2
	Ph	6.8	7.1	9.0	9.1	9.7	10.1	11.0	11.5
Burst Index (KPa.m^2/g)	*Cc*	0.66	0.67	0.77	0.83	0.88	0.94	1.00	1.08
	Ph	1.2	1.3	1.6	1.7	1.7	1.9	1.9	2.0
Folding Endurance (No.) (Double Fold).	*Cc*	10	14	16	19	21	25	28	30
	Ph	100	111	190	198	220	250	280	300
Brightness (%)	*Cc*	28.1	28.0	27.5	26.4	25.8	24.3	22.3	21.1
	Ph	23.0	22.0	20.9	20.9	19.7	19.8	18.9	18.1

Cc- Chloroxylon coloratus; Ph- Parthenium hysterophorus

Table 5. Blending studies of bodha grass and Parthenium (8% APP) with different per cent of mixed hosiery waste at 300 ml CSF.

Particulars	Bodha -80% Hosiery-20%	Bodha -70% Hosiery-30%	Bodha-60% Hosiery-40%	Carrot-80% Hosiery-20%	Carrot-70% Hosiery-30%
Tensile Index(N. m/g)	20.21	27.40	31.90	28.90	30.40
Tear Index (mN. m^2/g)	13.10	21.90	23.10	15.50	23.91
Burst Index, (kPa.m^2/g)	1.90	2.00	2.50	2.10	2.50
Folding Endurance(No.) (Double Fold).	70	125	200	200	275

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