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Alternative Raw Materials and Blending of Pulp to Improve Strength Properties

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Abstract— In this paper, Characterization of different unconventional pulping raw materials was carried out. The studies was done in terms of their contents in ash content, cellulose, ethanol–benzene solubility, , hollocelulose, lignin and hot water and 1% soda solubility was carried out. The use of blending of long fibered pulps with short fibered pulp is an important aspect of paper making .Morphological and Chemical nature of hard and soft wood are in many ways different from each other. Soft wood lack certain factors such as drainage, wet strength and press rolls tendency of sticking. To overcome these issues blending plays an important role. Pulp blending can be done in three distinct ways chips blending, pulp blending before beating and pulp blending after beating. Before pulp beating the properties improves the physical strength marginally. But after beating at 1500 revolutions in a PFI helps to improve the strength properties and resulted in increased pulp yields column.

Index Terms—Blending, Beating, Long fibered, Pulping, Short fibered

I. INTRODUCTION

An alternate source of woody raw materials for pulp and paper production is the use of non-woody fibers from field crops and agricultural residues. In many countries, non-woody fibers are mainly used for the production of specialty papers. Non-wood fibers and the blending of fibers could become important raw materials in this transformation [1-3]. The main sources of non-woody raw materials include agricultural residues such as rice straw, wheat straw, bagasse, jute fibres, hemp and jute stalks, or plants that are grown specifically for the fiber, such as bamboo, reeds. Non-woody plants have several advantages over woody fibre sources such as short growth cycles, less irrigation requirements and good lignin content.[1]

The Paper industry is expanding rapidly to fulfill the demand for pulp and paper products but due to the shortage of raw materials it is facing difficulties in managing the gap between demand and supply It is due to the increase in population growth and advancement in civilization. In the last three decades. There is constant pressure in order to explore available nonwood[2] resources for pulp and paper making. So to meet the raw material demand from the local areas and to substitute pulpwood, which is becoming scarce and other forest-based industries which have further forced the pulp and paper industry to seek other cellulosic raw materials which are available in sufficient amounts at a reasonable price.

The restricted supply of high-quality pulpwood and the rising prices of utilities will force paper mills to adopt new technologies to conserve energy minimum inputs, keeping environmental aspects in view much efforts have been directed towards finding a chemical pulping process giving higher pulp yield coupled with economic and environmental considerations.

The purpose of this study is to find an alternative source with maximize use of non-woody plant fibers for paper pulp production. Here in this work an approach to revise and evaluate the chemical composition [3] of different non-woody plant fibers in blending of different fibers during pulp and papermaking so that it will help in improving the industrial processes in which they are used as raw materials.

II. METHODOLOGY

Preliminary analysis

The stalks of ipomoea Carnea of around one or two years of age and bamboo was collected, cleaned, chipped & screened. Wood dust passing through 60 meshes and retained through 80 meshes was used for proximate analysis. Table I shows the results of the proximate analysis.

The chips passing through 30 mm screen but retained on a 3 mm screen were collected and air dried.

Table I. Proximate Chemical Analysis of Ipomoea Carne Jacq

S.No.	Particulars	Sample I	Sample II	Sample III	Rice straw	Bamboo
1	Ash content	6.14	6.20	6.10	15.0	4.1
2	Cold water solubility	8.43	6.21	7.53	11.0	4.42
3	Hot water solubility	12.60	12.05	14.10	12.5	5.8
4	Ether solubility	3.04	3.70	3.14	3.1	1.2
5	Alcohol benzene solubility	8.46	7.95	7.45	5.9	4.3
6	1%NaOH solubility	28.6	28.4	29.4	28.1	26
7	Pentosan content	17.60	16.89	16.9	17.1	17.7
8	Lignin content	18.08	18.01	18.00	18.0	26.2
9	Holocellulose content	67.49	66.5	66.9	66.9	67.3
10	Hemi cellulose content	22.40	22.67	22.89	21.15	22.1
11	Alpha cellulose content	46.45	47.45	47.28	44	37
12	Acetyl content	4.32	4.49	4.59	4.4	2.5
13	Methoxyl content	4.76	5.25	4.79	4.9	3.1
14	Uronic anhydride	3.45	3.45	3.78	-	-

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Fiber Morphology

For the morphological study, a few samples of ipomoea Carnea were subjected to physical , chemical and mechanical maceration to separate the individual cellular elements from each other without damage. It involves the use of hot acetic acid and sodium chlorite solution[4] to remove most of the lignin and other cementing materials without appreciable degradation of the cellulosic tissue (13-17). As per BIS: 5285 – 1969,the microscopic slides of cellular materials were prepared. The microscopic slides were projected at a magnification of 40 X and fiber lengths were measured, while the fiber width and cell wall thickness were measured by measuring the projected images at a magnification of 160 X. Results are reported in Table II.

Table II. Morphological Characteristices of Ipomoea Carnea and Bamboo

S.No.	PARTICULARS	SAMPLE I	SAMPLE II	SAMPLE III	AVERAGE	BAMBOO
1	Basic Density	0.29	0.30	0.30	0.29	0.52
2	Fiber Length	0.68	0.63	0.69	0.66	1.70
3	Fiber Width	33.18	33.0	32.4	32.86	23.60
4	Lumen Width	30.00	28.42	24.5	27.6	9.50
5	Cell wall thickness	1.40	1.50	1.58	1.47	7.00
6	Flexibility coefficient	110.6	116.11	132.24	119.65	248.42
7	Ratio of length to width	0.020	0.019	0.021	0.020	72.03
8	Ratio of twice cell wall thickness to fiber width	0.084	0.09	0.097	0.089	0.59
9	Wall fraction	8.4	9	9.7	8.9	59.30
10	Runkel ratio	0.093	0.105	0.128	0.106	1.47
11	Ratio of wall thickness	0.046	0.052	0.064	0.053	0.74

III. PREPARATION OF PULPS AND BLENDS

Blending of long fiber raw material pulps with short fibered raw material pulps were made in three sets. Set (i):- .Different proportions of blending of chips and pulping process Set (ii):- Different proportions of blending of unbeaten pulps and pulping process before beating. Set (iii):- Different proportions of blending of beaten pulp before sheet formation [7]

Pulping of Raw Materials

In a rotatory WEVERK make electrically heated digester of 0.02 m3 capacity the screened chips of ipomoea carnea and bamboo were cooked separately. [10] Cooking was done by soda as well as kraft processes. The cooking condition and results are shown in Table 3&4.

Pulping Process of Blending Chips

The blending of short fibered Ipomoea carnea chips and bamboo chips in different proportion was carried outing different ratio i.e. 100:00,90:10,80:20,70:30,60:40,50:50,40:60,70:30,80:20,90:10,00:100. Table 4 shows the different blends which were cooked by soda processes under cooking conditions.The pulps of different blends were washed, crumbled and screened. These pulps were beaten in PFI mills up to a freeness level 45+_oSR.

Blending of Pulps

The Ipomoea carnea pulp and bamboo pulps were blended in a set of different proportions which is carried out separately and then the mixed pulps were beaten to a freeness level of 45+_oSR. These beaten ipomoea carnea pulps was then blended with bamboo and analyzed. Table 5 shows the results of the blending of fibres.[8]

Pulp Evaluation

The standard hand sheets obtained from the admixtures of 60 g/m2 were made in sheets using a British sheet forming machine. These sheets were pressed and dried as per TAPPI standard methods, T-205im-80. These sheets are conditioned at a temperature [9] of 25+_2oC and with relative humidity 65+_2%. They are evaluated for various physical strength properties. Table 6 shows the results of strength properties.

IV. RESULTS & DISCUSSION:

The Proximate chemical analysis gives the idea that the test samples of wood belong to hardwood, softwood, or nonwood samples. After performing the preliminary analysis the sample is tested for various parameters such as ash content, alcohol, benzene solubility, and many other parameters. Proximate analysis is shown in Table I.

Morphological characteristics of the sample of wood taken for investigation are shown in Table II. One end of the Ipomoea carnea fibers is tapered and at the other it is slightly tapered. The thickness of the cell wall is very low so the low wall fraction and Runkel ratio give the stronger paper. The fiber width and lumen diameter of Ipomoea carnea are almost similar to a softwood like pinus kesiya.

The thin-walled and wide lumen fibers of Ipomoea Carnea will break easily and form a double-walled ribbon structure on delignification. The sample taken for investigation shows plastic deformation, and thus it shows more surface contact and fiber bonding . It gives good physical strength and less porosity. As a result of the inability of the fibers to collapse when dried after beating papers made from thick-walled fibers have high bulk, stiffness, and compressibility and in general higher opacity and resiliency than thin-walled fibers. Table III shows the cooking condition of ipomoea carnea and bamboo.

Table III. Optimisation of Cooking Condition

S.No	Particulars	Unit	1	2	3	4	5	6	7	8	9
1	Temperature	oC	160	165	170	160	165	170	160	165	170
2	Cooking condition	%	17	18	19	17	18	19	17	18	19
3	Bath ratio	Ratio	1:4	1:4	1:4	1:4	1:4	1:4	1:4	1:4	1:4
4	Time to Temp.	Hrs	1.5	1.5	1.5	2	2	2	2.5	2.5	2.5
5	Unbleached pulp yield	%	42.4	42.17	39.9	42.6	40.49	39.87	42.87	41.63	38.18
6	Pulp Kappa No.	Num	23.07	22.05	17.92	24.13	19.24	16.84	25	19.45	15.56
7	Reject	%	1.19	1.2	0.07	1.72	1.04	0.07	2.98	0.68	0.05
8	Free Alkali	Gm/l	2.53	4.87	5.16	2.56	4.0	5.56	2.8	4.27	4.99
9	Viscosity	centipois	6.3	6.8	4.6	6.7	5.2	4.7	7.4	5.4	3.3

Table IV shows results of preliminary experiments carried out at different cooking chemical, time and temperature. Optimum condition as per the experimental results obtained that for ipomoea the suitable condition the suitable condition were found to percentage of active alkali 17%,time 1. 5hrs,temperature 165oC ,kappa number 21,viscosity 6.3centipoise

Table IV. Kraft Pulpingof Ipomoea Carnea &Bamboo

S.No.	Particulars	Units	IPOMOEA CARNEA	BAMBOO
1	Active alkali	%	17	17
2	Sulphidity	%	20	20
3	Time to minimum temp.	Min	90	90
4	Time to maximum temperature	Min	120	120
5	Maximum temperature	°C	165	165
6	Liquor to wood ratio	Ratio	4:1	4:1
7	Unbleached pulp yield	%	42.17	46.4
8	rejects	%	4.87	3.5
9	Kappa number	No.	22	29

Table V. Strength Properties of Ipomoea Carnea and Bamboo Kraft Pulps

S.No	FURNISH IPOMOEA:BAMBOO		BLENDING BEFORE BEATING			BLENDING AFTER BEATING			CHIPS BLENDING		
	IPOMOEA	BAMBOO	BURST INDEX	TEAR INDEX	TENSILE INDEX	BURST INDEX	TEAR INDEX	TENSILE INDEX	BURST INDEX	TEAR INDEX	TENSILE INDEX
1	100	00	3.80	4.01	70.42	3.92	3.71	70.42	3.82	3.72	70.42
2	90	10	3.92	4.44	70.01	3.84	3.80	69.40	3.74	3.75	68.44
3	80	20	4.32	4.81	69.98	3.60	4.07	68.60	3.72	3.89	65.79
4	70	30	4.33	4.88	69.50	3.94	4.21	67.25	3.94	3.92	65.34
5	60	40	4.37	4.89	69.49	4.10	4.30	65.9	4.02	4.05	64.95
6	50	50	4.61	4.90	69.32	4.20	4.70	65.7	4.11	4.32	64.66
7	40	60	4.76	5.00	68.78	4.24	5.03	65.65	4.15	4.83	63.72
8	30	70	4.84	5.00	68.47	4.31	5.09	64.65	4.17	5.21	63.22
9	20	80	4.86	5.16	68.4	4.80	5.30	64.32	4.21	5.22	64.3
10	10	90	5.30	5.42	67.92	5.20	5.45	64.10	4.27	5.38	63.9
11	00	100	5.34	5.49	62.50	5.35	5.62	64.09	4.34	5.42	63.42

Table V shows the results of the physical strength properties of ipomoea carnea and bamboo Kraft pulps. Ipomoea carnea and bamboo were mixed in different proportions. Blending was done after beating and before beating. Blending of pulp after beating shows the burst index and tear index increasing, and the tensile index decreases with an increase in bamboo proportions in blends before beating due to variation in morphological characteristics of ipomoea carnea. This shows under and over the beating of one or other pulp affecting the strength properties adversely.

Table VI. Physical Properties of Ipomoea Carnea Pulp Bleached with Bamboo

FURNISH		BRIGHTNESS %	POST COLOUR NUMBER	BREAKING LENGTH	POROSITY
IPOMOEA	BAMBOO				
100	00	84.0	7.42	7.86	0
90	10	84.10	7.44	7.65	0
80	20	83.45	7.46	7.42	4
70	30	83.76	7.69	7.08	9
60	40	83.70	7.92	6.99	16
50	50	83.35	8.24	6.84	25
40	60	82.90	8.28	6.14	25
30	70	82.75	8.53	6.02	50
20	80	82.70	9.07	7.24	55
10	90	82.55	9.33	7.21	63
00	100	81.05	9.65	6.96	100

The deterioration in strength properties is due to same treatment of both raw materials though they require different treatment because of different composition. The strength properties deteriorate during beating due to variation in morphological characteristics of ipomoea carnea and bamboo. Hence the strength properties of separately cooked pulp blends beaten together shows an improvement over strength properties of pulp obtained from chips blending. Excellent strength properties are obtained when pulps are blended after beating separately.

V. CONCLUSION:-

The chemical composition of different plant fibers used as raw materials and blending of long and short fiber for pulp and papermaking has been summarized. Here with special emphasis in the chemistry of short and long fiber blending has been done. It can be concluded that on the observation that blending of long fibered pulps with short fibered pulps in the process after beating the pulps gives better strength properties as and when compared with other pulps. Percentage of long fibered materials in the blends of the pulp can be based on the properties of desired final product. Here separate cooking and beating of the pulps together shows an improvement over cooking of mixed chips. This study will help to share valuable information that will lead to a better utilization of non-woody plant species.

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