

Studies on Utilisation of Some Non-wood Fibrous Materials for Paper/Board Making

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ABSTRACT

The morphological characteristics and availability of some of the nonconventional fibrous raw materials suitable for paper and board making are reviewed. The materials studied are sisal fibre, cotton stalk, jute fibre, tuar stalk, coconut husk, corn stalk, saccharum spontaneum, jawar stalk, castor stalk, barseem hay grass, mesta, citronella grass and banana stem. Results of proximate chemical analysis, pulping, physical properties of unbleached pulp and blended pulp are presented. Improvement in strength properties of these pulps due to blending has been highlighted.

INTRODUCTION

The morphological characteristics and availability of some of the nonconventional fibrous raw materials are reviewed below:

Sisal-A Leaf Fibre (Agave Sisalana)

Sisal plant has an eight year growth cycle. The sisal leaves are harvested twice a year. The leaf is 1 to 1.5 m in length with a sharp end tip. The weight of fresh sisal leaf is appx. 1 kg and 1,000 leaves yield 25-35 kg of dry fibres. Sisal hemp consists of strands of filaments 7-12 cm long, white or pale yellowish in colour. The fibre is strong, coarse and hard. The juice of sisal leaves is valuable byproduct for chemical and pharmaceutical industries. High porosity is characteristic of sisal pulp. The pulp is spongy and drains rapidly. These pulps can be blended with secondary fibre pulp to increase the physical properties of paper.

Cotton Stalk

Cotton plant is cultivated mainly for its fibres. The stem portion of the plant is considered as agricultural waste and is used as fuel and manure by farmers. Cotton stalk is a big source of paper making fibre for mills situated in cotton growing areas of Maharashtra, Tamil Nadu and Madhya Pradesh. Structurally, cotton plant stalk is similar to conventional agricultural residue like paddy husk. Depithing of cotton plant is essential to bring down chemical consumption and improve pulp strength. Cotton stalk pulp is stronger due to presence of bast

fibres. The number of cotton plants per hectare averages to about 50,000. According to one estimate, every hectare will be able to give one tonne of dry stalk and total area under cotton cultivation in Vidarbha is 12,231 hectares.

Jute Fibre (Corchorus Capsulris and Corchorus Olitorius)

Jute is an annual, dicotyledonous fast growing plant, cultivated exclusively in hot and humid climate of India and Bangladesh. The stalk grows to height of 2.5 to 3.5m and is cut at maturity about 25cm above the ground. Cut stalks are retted in ponds of stagnant water. Fermentation occurs and the bast fibres are separated from the bark and woody portion of the plant. The bundles or strands of bast fibre have considerable length and are suitable for cordage, sack and burlap manufacture. The average fibre length is 2mm and diameter is about 20 micron. The fibre cavity is wide at places but is constricted by joints at intervals, resulting in cell cavity. The fibres are slender and tapered at the ends. Whole jute is rarely used for pulp and papermaking. Solvage products such as old jute sacks and burlaps are the materials available to paper mills.

Tuar Stalk

It is an annual crop and is used for pulses. The stem portion of the plants are considered as agricultural residue and used as fuel by farmers. Similar to cotton stalk pulp, Tuar stalk pulp is stronger due to presence of bast fibres. However, its availability is very low compared to cotton stalk.

Coconut Husk

The Coconut tree grows to a height of 25m or more, when fully matured. The coconut tree trunk is 300-450 mm in diameter. Coconut is grown in most of the coastal states, though large areas are covered in Kerala, Karnataka and Tamil Nadu. Coconut fibre is elliptical in shape and an average sized husk from one-coconut weighs about 400 gm. Its outer cover is hard glazed skin of 1mm thickness. The husk of matured coconut consists of numerous fibres embedded in the pith. The fibres are 15-35 cm length and their cross sectional thickness varies from 0.1-0.4mm. The bulk density of the fibre is 150-280Kg/m³ and that of pith 80-90 Kg/m³. The elongation at break is 10-15% and water extract of the fibre and pith is acidic. On calcination the pith gives 10-15% ash, the fibre gives 1.5% ash. Due to the stiffness of fibre, it becomes brittle.

Corn Stalk

This crop is found throughout the country. A robust, monocious, annual grass, generally tall, varies in height from 0.5-2.5m. The corn stalks are similar in structure to that of bagasse. The length of the corn stalk is about 1.5 to 2.5m. The fibres in the stalks can be used for making pulp. Pulp suitable for making wrapping papers and paperboards may be obtained by cooking maize stalks with alkali under mild condition. In India, maize is annually planted in an areas of about six million hectares.

Saccharum Spontaneum (Hindi-Kans, Kas)

It is a perennial grass with slender culms, growing in stools or forming continuous cane-brakes with most often aggressive rhizomatous tillering, distributed widely in the subtropical and tropical parts of Asia and Africa. Culms are green, gray, ivory or white, hard but very pith and often hollow in the centre varying in diameter from 5-15 mm; often rooting at the nodes; internodes usually long and nodes always thicker than internodes. Leaves are long, linear, narrow or very narrow or sometimes reduce to the midrib. The green grass is reported to compare favourably with Guinea and Napier grasses while ripe grass is comparable with rice or wheat straws. Pulp suitable for wrapping, writing, printing and grease proof papers can be produced from the grass. Pilot plant trials with the grass have shown that by the soda process, yield of 42% of unbleached and 37.8% bleached pulps suitable for writing paper of satisfactory strength can be obtained. *S. spontaneum* can also be used for the production of hardboards and rayon grade pulps.

Jawar Stalk (Sorghum monech)

Sorghums are cultivated chiefly for their grains, which

form an important staple food in many countries of Africa and Asia including India. It is a stout grass with culms upto 4m or sometimes more in height and 3-4 cm wide near the base, usually sweet; Leaves upto 12 or more blades, 30-75 cm long and 5-8 cm broad; panicle loose or contracted and rather dense, elliptic-lanceolate or oblong, peduncle erect or very seldom goose necked; racemes compact mostly 3-4 noded. Sorghum stalks constitute an useful raw material for the cellulose industry. Cooking with 2-4% nitric acid for 6-8 hours followed by washing and a second cooking with 1% NaOH yields a pulp containing 90-93% alpha cellulose. Depithed stalks of sorghum yield a pulp with 97.7% alpha cellulose. The pulps are short fibred and easy to bleach. This pulp can be used as fillers in long fibred paper finishes. In mixture with wood pulp, sorghum pulps obtained by the alkali digestion process may be used in the manufacture of writing, printing and kraft packaging papers; mixture containing 25-35% sorghum pulps are suitable for newsprint paper.

Castor Stalk (Erandi) Ricinus Communis

It is a annual or perennial bush or occasionally a soft wooded small tree of height 6m or more found throughout India. Leaves are green or reddish about 30-60 cm in diameter, palmately five lobed, flowers monocious, in spikes 30-60cm long, with the staminate flowers on the lower and pistillate flowers on the upper part of the axis; fruit, a capsule covered with soft spin like processes and dehiscing into three 2-valved cocci. The duration of the crop in the annual types of castor varies between 4 and 9 months but the perennial types may continue to bear for 10-15 years. Laboratory and pilot plant trials at the forest Research Institute, Dehradun, have shown that underbarked stems of both the annual and perennial varieties of castor plants can be employed for the production of easy bleaching chemical pulps (yield 61-63%) suitable for writing, printing and wrapping papers and newsprint. Castor stalk contain (O.D. basis) Pentosons 16-17%, Lignin 19-20%, Cellulose (Cros Bevan) 51% and Ash 2%. The pulps obtained are short fibred and have to be blended with about 30% of long fibred pulp like that of bamboo. Castor stems on digestion with lime yield pulp suitable for production of strawboards. Total area under castor cultivation in India is 379 thousand acres.

Berseem Hay Grass (Trifolium alexandrium)

The Berseem grass fibres are short and contain mainly two parts. The upper portion which is long leaf like type and easily pulpable and the bottom portion though it is soft but it is harder than top portion and it is difficult to pulp. The fibres of Berseem hay grass vary in length from 1.4-4 mm.

Mesta (Ambadi) (*Hibiscus cannabinus*)

Mesta is a potentially suitable source of fibres for paper making industry. Indian climate is well suited for cultivation. It is generally grown mixed with other crops such as bajra, jowar, ragi, and cotton. The plant is cultivated mainly as "KHARIF CROP" shown from May to July and harvested in October-November. The crop is ready for harvesting 3-5 months after sowing. For fibre purpose, the harvesting is done at the flowering stage before seed setting; if delayed the fibre obtained is coarse with lustre. The plant is cultivated mainly as a fibre crop in the drier tract of Deccan, AP, Karnataka, Maharashtra, M.P. and Bihar. In other areas it is cultivated on limited scale, as supplementary crop in mixture with others. Fibre is extracted from inner parts of the cortex, outside the cambium layer. The length of Mesta fibre varies from 1.5 to 6 mm and diameter 12-33 microns. The fibres are cylindrical in shape with thickened walls and blunt or pointed ends, polygonal and rounded in cross section with small or large lumen. Two types of fibres, primary and secondary are reported to be present in the bark. The primary fibres arising from terminal meristem are more glossy and flexible than the secondary fibres which arise from cambial activity; the ratio of primary to secondary fibres varies according to the plant height and thickness.

Citronella Grass

This plant grows to a height of about 1.5m. The leaves are strong and slender. It is harder, has a longer life span, flourishes in a less fertile soil and requires less moisture. On an average 8,000 Citronella plant are planted per acre of land. The leaves are ready for first harvest, about six months after planting. The second subsequent harvest can be taken thereafter at 2.5 to 3 months interval. Harvesting is done by cutting leafy portion of the plant about 17-20 cm above the ground. The best stage of harvesting is when the grass attains the height of 1.5 m. This grass is used for the extraction of Citronella oil, which is exclusively used in the scenting of soaps, sprays, and disinfectants and in flavouring of beverages. The grass after extraction of oil has fibre value and can be used to produce pulp suitable for papermaking.

Banana Stem (*Musa cavendishii*)

In Maharashtra state, area under cultivation is about 40,000 hectares based on 30 months cycle (12 months vegetation + 5 months harvesting + 1 month cleaning + 12 months under different crops) effective availability of banana stem is 1,720 stem/hectare per year. Average weight of freshly cut banana stem is 18Kg and moisture content is 92%. Thus 1 stem of

TABLE-1
Proximate Analysis of Agricultural Residues and Nonwood Fibrous Material

| Properties | Sisal Leaves | Cotton Stalk | Gunny Bags | Tuar Stalk | Coconut Husk | Corn Stalk | Saccharum Spont- anium Grass | Jawar Stalk | Castor Stalk (Erandi) | Beer- Seem Hay Grass | Mesta (Ambandi) | Citronel La Grass | Ipomea Cornea GRASS | Banana Stem |
|-------------------------|--------------|--------------|------------|------------|--------------|------------|------------------------------|-------------|-----------------------|----------------------|-----------------|-------------------|---------------------|-------------|
| Moisture Content % | 8.5 | 10.5 | 8.8 | 6.5 | 5.2 | 7.6 | 8.1 | 6.8 | 9.1 | 6 | 5.4 | 8.3 | 6.7 | 6.8 |
| A.D. Basis | | | | | | | | | | | | | | |
| Ash Content % | 9.9 | 12.1 | 1.7 | 6.1 | 10.2 | 7.4 | 8.4 | 5.9 | 1.9 | 12.1 | 1.3 | 9.3 | 4.9 | 10.5 |
| Cold Water Sol. % | 32.5 | 0.3 | 5.6 | 14.9 | 1.5 | 20.6 | 18.6 | 14.2 | 7.2 | 10.1 | 7.9 | 10.7 | 14.4 | 13.7 |
| Hot Water Sol. % | 34.2 | 5.6 | 10.8 | 16.1 | 4.2 | 28.5 | 22.6 | 19.3 | 13.3 | 21.3 | 8.2 | 25.3 | 8.9 | 8.6 |
| 1% NaOH Sol. % | 47.8 | 25.9 | 18.9 | 21.3 | 12.4 | 32.5 | 38.2 | 45.9 | 16.8 | 24.8 | 17.7 | 27.3 | 26.8 | 30.1 |
| Insoluble Lignin % | 15.9 | 23.8 | 1.7 | 19.1 | 25.2 | 31.5 | 22.8 | 18.6 | 19.08 | 18.6 | 28.6 | 18 | 34.1 | 13.7 |
| Holocellulose Content % | 82.1 | 73 | 54.8 | 58 | 35.7 | 32.4 | 62.4 | 45.3 | 55.3 | 74.8 | 56.1 | 74.1 | 76.7 | 68.4 |
| Extractives % | 6.3 | 3.8 | 4 | 0.5 | 2.4 | 3.6 | 7.2 | 9.8 | 15.3 | 1.6 | 11.2 | 6.1 | 6.8 | 5.9 |

(Except Moisture content, all other results are on O.D. Basis)

TABLE-2
Details of Pulping Conditions

| Properties | Sisal Leaves | Cotton Stalk | Gunny Bags | Tuar Stalk | Coconut Husk | Corn Stalk | Saccharum Spont-anium Grass | Jawar Stalk | Castor Stalk (Erandi) | Beer-Seem Hay Grass | Mesta (Ambandi) | Citronel La Grass | Ipomea Cornea | Banana Stem |
|---|--------------|--------------|------------|------------|--------------|------------|-----------------------------|-------------|-----------------------|---------------------|-----------------|-------------------|---------------|-------------|
| Alkali Charge % (o.d. basis of Raw Material) | 10 | 10 | 5 | NIL | 10 | 10 | NIL | 10 | 10 | 10 | 10 | 10 | 10 | NIL |
| Soaking time hrs. In 1% NaOH Sol) | NIL | NIL | NIL | 24 | 24 | NIL | 24 | 24 | NIL | 24 | NIL | NIL | NIL | 48 |
| Cooking Temp/ Pres. (°C/psi) | 162/80 | 160/90 | 180/110 | 170/100 | 165/95 | 160-90 | NIL | 170/90 | 160/90 | 160/90 | 160/90 | 160/90 | 160/90 | NIL |
| Liquor to Wood Ratio | 12:01 | 10:01 | 9:01 | 6:01 | 13:01 | 15:01 | NIL | 7:01 | 15:01 | 10:01 | 15:01 | 10:01 | 10:01 | NIL |
| Cooking Time (min.) at Required Temp/Pressure | 60 | 120 | 75 | 120 | 90 | 120 | NIL | 120 | 180 | 90 | 90 | 120 | 120 | NIL |
| Yield % | 50 | 52.8 | 84.7 | 57.3 | 30 | 50.2 | NIL | 47.1 | 55.8 | 50.8 | 80.2 | 48.7 | 56.3 | NIL |
| Beating time min. | 90 | 60 | 75 | 30 | 30 | 50 | 180 | 15 | 165 | 10 | 160 | 40 | 50 | 180 |
| Freeness °SR | 56 | 55 | 45 | 50 | 45 | 45 | 50 | 45 | 50 | 45 | 55 | 50 | 50 | 45 |

TABLE-3
Physical Properties of the Standard Paper Sheets (Unbleached)

| Property | Sisal Leaves | Cotton Stalk | Gunny Bags | Tuar Stalk | Coconut Husk | Corn Stalk | Saccharum Spont-anium Grass | Jawar Stalk | Castor Stalk (Erandi) | Beer-Seem Hay Grass | Mesta (Ambandi) | Citronel La Grass | Ipomea Cornea | Banana Stem |
|---------------------------------------|--------------|--------------|------------|------------|--------------|------------|-----------------------------|-------------|-----------------------|---------------------|-----------------|-------------------|---------------|-------------|
| GSM | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| Caliper (mm) | 0.12 | 0.11 | 0.16 | 0.12 | 0.21 | 0.21 | 0.14 | 0.19 | 0.12 | 0.12 | 0.13 | 0.17 | 0.18 | 0.13 |
| Burst Index | 5.7 | 3.6 | 2.9 | 3.6 | 3.3 | 3.3 | 4.9 | 3.3 | 2.9 | 3.7 | 1.6 | 3.6 | 2.6 | 5.6 |
| Folding Endurance nos. for 350g. Load | 175 | 15 | 20 | 14 | 10 | 11 | 30 | 12 | 2 | 10 | 2 | 40 | 45 | 135 |
| Tear Index | 12.3 | 5.2 | 3.9 | 7.2 | 7.4 | 4.8 | 10.2 | 6.2 | 5.4 | 7.8 | 5.7 | 9.2 | 8 | 12.1 |
| Air Permeability in secs. | 5 | 3 | 1 | 2 | 2 | 2 | 6 | 2 | 2 | 2 | 2 | 2.5 | 2 | 5 |

| Properties | 80% Corn Stalk Pulp & 20% Cotton Rag Pulp | 50% Gunny Bag Pulp & 50% Waste Paper Pulp | 70% Jawar Stalk Pulp 30% Cotton Rag Pulp | 70% Hay Grass Pulp 30% Waste Paper Pulp | 70% Tuar Stalk Pulp & 30% Waste Paper Pulp |
|--|--|--|---|--|---|
| G S M 60 | 60 | 60 | 60 | 60 | 60 |
| Caliper (mm) | 0.14 | 0.15 | 0.14 | 0.13 | 0.13 |
| Burst index | 4.2 | 3 | 3.9 | 4.33 | 3.9 |
| Folding endurance nos. For 350g. Load | 19 | 25 | 20 | 15 | 18 |
| Tear index | 6.1 | 8 | 10.4 | 9.8 | 8.3 |
| Air Permeability in secs. | 4 | 4 | 5 | 4 | 4 |

banana will yield around 1 Kg of O.D. pulpable material. It is also available in other states such as Andhra Pradesh, Kerala, and some parts of West Bengal. Total area under banana cultivation in India is 383 thousands acres.

EXPERIMENTAL:

This paper presents studies on pulping of some uncommon fibrous materials, which can be potentially used in small- scale paper/board mills. The proximate analysis, pulping conditions and results of sheet testing are given in Table 1, 2 and 3 respectively.

Blending with Rag and Waste Paper Pulp

Some of the above unconventional fibrous raw materials (Corn stalk, waste gunny bags, Jower stalk, Beerseem Hay grass and Tuar stalk pulps) were blended with cotton rag and waste paper pulps.

Standard sheets of blended pulps were prepared. The details of the blending of different fibres and their strength properties are given in Table-4.

CONCLUSION:

From the above tables, it can be observed that the blending of cotton rag/waste paper pulps with these unconventional fibrous materials could improve the strength properties of these pulps.

REFERENCE:

The Wealth of India, Raw materials, Vol. XI, *ibid.* Publication and Information Directorate, CSIR, New Delhi 1976.

** All further Correspondence should be made with the second Author.