Studies on Use of Cannabis Sativa and Ipomea Carnea for Development of Cigarette Paper

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ABSTRACT

Cigarette paper manufacturing is a highly specialised field as it must have several specific requirements such as high strength properties specially tensile and stretch, a specified porosity level, web formation and opacity. In this paper Cannabis sativa ribbons and Ipomea carnea (a non-woody plant commonly known as BESHARAM in Hindi) have been investigated for manufacturing of cigarette paper.

Morphological and chemical studies of Cannabis sativa shows that harvesting time, mode of extraction and sex of plant greatly affects the quality and yield of pulp. To confirm this, the degree of polymerisation of cellulose by light scattering measurement technique of early and delayed harvesting and harvesting at maturity of both male and female Cannabis sativa hemp ribbons have been determined. The male plant harvested at maturity is found superior in quality and quantity of pulp to female plant.

The pulping studies were carried out by alkali - oxygen delignification process, using nine %, NaOH (as such basis), oxygen pressure 5.0 kg/cm², maximum pulping temperature 165 °C and maximum pulping time 180 minutes. The unbleached pulp of brightness 52% (ISO) was bleached using CEH bleaching sequence to produce pulp of brightness 82% (ISO). A blend of 70% Cannabis sativa hemp ribbons pulp and 30 percent Ipomea carnea pulp were beaten separately to 75 °SR and then 45% precipitated $CaCO_3$ (on O.D. pulp basis) was added into the beater for proper mixing in order to raise the freeness of pulp from 75 - 85 °SR. Microscopic examination of laboratory hand sheets shows that hemp ribbons fibers work as a reinforcement fiber network while Ipomea carnea fibers fill in the voids in the network with $CaCO_3$ improving the web formation and opacity. Laboratory hand sheets of substance 23 g/m² and thickness of 23 micrometer containing 70% hemp ribbon pulp and 30% Ipomea carnea pulp and 30% precipitated $CaCO_3$ with 0.1 percent Ammonium phosphate (flame retardant) show even distribution of fiber fillers, desired opacity to hide colour of tobacco, requisite strength enabling to run on high speed cigarette making machine and controlled of Bendtsen porosity 195 ml/min.

INTRODUCTION

Cigarette paper is used exclusively for wrapping of tobacco for making cigarette possessing very rigid specifications. The control parameters are substance, thickness, opacity, porosity, colour combustibility, ash characteristics, and strength etc. It is generally comprised of 70% long fibers and 30% hard wood fibers with 25-35% of precipitated $CaCO_3$ along with some amount of flame retardant and flavouring agents if necessary for special brand (1). Generally speaking, bast fibers such as flax sun hemp, and jute are used

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for cigarette making in India.

Cigarette paper is a strong tissue, unsized, opaque, free from blemishes and pin holes and normally made in the basis weight range of 15-26 g/m^2 and thickness of 13 to 40 micrometer. About 50-60 kg paper as cigarette tissue is employed in manufacturing one million cigarette. The most important properties required for cigarette paper and the qualifying reasons are as follows:

- It must be able to run on the high-speed cigarette making machine. Modern cigarette making machine produces around 10,000 cigarettes per minute. Therefore, in order to confirm the runnability on cigarette making machine the raw material used for cigarette paper must possess high strength properties specially tensile and stretch. The paper reels are slitted in to width of 25-27 mm bobbins and runs on very high speed afterwards. Therefore there is a need to possess a minimum stretch and tensile strength.

- Visual appearance of cigarette is very much important. In order to impart sufficient opacity to hide the coloured tobacco and not visible from outside, at low basis weight, fillers such as precipitated $CaCO_3$ is used which help in regulating the rate of combustion and porosity to provide proper number of puffs. Approximately opacity on the order of 76% Elrepho is maintained.

- The most important property of cigarette tissue is its burning characteristics. The cigarette tissue should burn with the same speed as that of tobacco. Cigarette tissue should burn uniformly and consistently and adjust with the tobacco burning rate (slow or fast) on the basis of combustibility.

  (a) Extra combustible = 38 ± 4 LBT

  (Louisiille Burning Test)

  (b) Combustible = 48 ± 4 LBT

  (c) Semi combustible = 60 ± 4 LBT

  (d) Non combustible > 65 LBT

  The impregnation rate of the flame retardant is an important characteristic for regulating the burning of cigarette at a specific and uniform rate. The flame retardant such as ammonium phosphate and borax-boric acid etc. are added into the stock for controlling the burning of cigarette.

- Cigarette paper is an essential part of cigarette, since, it not only keeps the tobacco intact in the cigarette even when it comes into contact with lips moisture but controls the gas delivery also.

- It must have a specified porosity level thus the fiber blend, the quantity and quality of fillers and degree of beating up to ^{0}SR 85 is of utmost importance. Based on porosity these are classified as low porous, medium porous, high porous, and ultra high porous. However, it must permit air flow from all sides and smoke should be diluted as well as cooled.

- It must be free from flaws, pinholes and wrinkles and present a pleasing appearance (good formation and shade) and must leave an attractive residue while burning though the significant amount of ash as CaO from $CaCO_3$.

To manufacture the tissue paper possessing rigid specification as described above for cigarette making the source of good quality of wood fibre is scarce in India. Therefore there is an urgent need to explore the possibility of usage of nonwoody fibrous plants exhibiting the requisite qualities of pulp to supplement the fibre demand for the above paper. In this paper an attempt has been made to find out an alternative sources of non-wood plants like **Cannabis sativa** and **Ipomea carnea** which are abundantly available in our country.

SELECTION OF RAW MATERIALS

For the development of cigarette tissue, the bast fibers are extracted from Cannabis sativa that is commonly known as soft hemp or true hemp. In India cultivation of Cannabis sativa is permitted in the districts of Almora, Garhwal and Nainital (excluding Tarai and Bhabhar area). The plant is also cultivated to some extent in Jammu & Kashmir, Travancore and Maharastra(2).

Bast fibers are present in the form of ribbons make up around 28% of the whole weight of hemp stalk. The core of the stalk contains short woody fibers. It is observed that the male plant produce high quality of pulp compared to female plant. The reason is that lignification does not takes place so quickly in female plant. The cellulose content in hemp plant increases as the plant matures. The harvesting time of hemp is

Table-1

Physical and Morphological Characteristics of Cannabis sativa bast Fibers and Impomea carnea.

S.N.	Particulars	Units	Cannabis sativa bast fibers	Ipomea carnea
1.	Colour		Greenish White	Greenish White
2.	Moisture	%	30	-
3.	Diameter of stalk	cm	1.5-4.0	2.1-3.5
4.	Average length of stalk	meter	-	1.42
5.	Bast fibers, (Average) O.D. basis	%	28.70	-
6.	Central wood part, (Average) O.D. basis	%	71.30	-
7.	Average fibers length of bast fibers	mm	21.00	-
8.	Average width of bast fibers	μm	19.75	-
9.	Average fiber length of woody fibers	mm	1.76	0.62
10.	Average width of woody fibers	μm	29.54	35.2
11.	Density	g/cm^3	0.326	0.293
12.	Bulk density	kg/m^3	186.50	270

very much important with respect to fiber quality Early harvesting results poor pulping yield and mechanical properties of paper, whereas delayed harvesting creates difficulty to extract ribbons from the core of stem during the process of retting. The fibers obtained from the late harvesting are course, brittle and harsher. The optimum pulp yield of high quality in term of mechanical strength is obtained when plant is about to flower. It is also observed that the quality of pulp cultivated in plain is superior to that in hills. It yields 2-3 dry stems per acre from which 1/2 - 1/4 tonnes of clean fiber are obtained. The quality of fiber depends upon the method of fiber extraction. The fibers are straw white pale brown, yellow pale gray and green in colour. The best quality of fiber is white or straw coloured and has a luster comparable to that the linen.

Ipomea carnia Jacq is a common weed and locally known as 'BESHRAM' because of its high adaptability and resistance toward adverse climatic conditions. It may grow in types of climate and soils marshy as well as dry. The yield of Ipomea carnea is about 15-20 BDMT/Hectare / year (3). Preliminary studies of Ipomea carnea show its suitability for pulp and papermaking.

PHYSICAL AND MORPHOLOGICAL CHARACTERISTICS:

The physical and morphological characteristics of Cannabis sativa and Ipomea carnea are reported in Table-1. The physical characteristic of Cannabis sativa shows that it contains 29%bast fibers and 71% central woody part. (on O.D. wood basis). The central woody part of stem consists of short woody fiber. Bast fibers are as long as 4 to 46 mm with an average of 21 mm and moderately wide-ranging from 6.5 to 52 microns. The fibers are moderately thin to thick walled. The lumen is not uniform in width. It does not exhibit any twist but joints or compressed areas and somewhat swollen fissures are conspicuous (6). Ipomea carnea shows that it contains 87% central wood part (on O.D.wood basis) and 13% bark, which shows the presence of phloem fibers. The average fiber length of woody fiber is 0.62 mm, fiber width 33.18 micrometer, and lumen diameter 33.17 micrometer and cell wall thickness 1.47 micrometers. The thin walled and wide lumen fibers collapse readily to double walled ribbon structure. On delignification Ipomea carnea fiber exhibits plastic deformation offering more surface contact and inter-fiber bonding area. This gives good physical strength properties (7). The fibers of Ipomea carnea are shorter in length but the fiber width, cell wall thickness and lumen diameter resembles with soft

Table-2

Proximate Chemical Analysis of Cannabis sativa bast Fibers & Ipomea carnea.

S.N.	Particulars	Cannabis sativa	Ipomea carnea
1.	Cold water solubles, (%)	3.90	3.90
2.	Hot water solubles, (%)	8.06	9.30
3.	Alcohol-Benzene Solubles, (%) (1:2 V/V)	1.2	4.65
4.	1% NaOH solubles, %	29.00	24.44
5.	Lignin, %	7.30	16.59
6.	Pentosan, %	6.30	17.30
7.	Cross & Bevan cellulose, % (Ash free)	61.20	-
8.	Pentosan in C&B cellulose, %	2.40	-
9.	Alpha cellulose, %	58.80	43.21
10.	Ash, %	5.30	6.45

wood like Pinus kesiya and Picca abies (4). Flexibility coefficient of Ipomea carnea fiber is comparable to those of tropical pine and spuce. However runkel ratio is comparatively low. The cell wall thickness is very low, thus giving a low wall fraction. The fiber having low wall fraction and runkel ratio gives stronger paper (5). Keeping the morphological characters of Cannabis sativa hemp and Ipomea carnea in view, the possibility of manufacturing cigarette tissue from Cannabis sativa and Ipomea carnea are studied in this paper.

CHEMICAL COMPOSITION:

Results of proximate chemical analysis of Cannabis sativa hemp fibers and Ipomea carnea fibers are reported in Table -2. Proximate chemical analysis of hemp fibers indicates that it contains 8.06% water solubles and 1.2% alcohol - benzene solubles. Lignin content is around 7.30%, which is very low and hence requires lesser amount of cooking chemicals and shorter cooking cycle. Cross and Beven cellulose is around 61.20% which gives lower pentosan content i.e. 2.40%. Alpha cellulose content is on higher side, hence gives maximum pulp yield (8). Ipomea carnea fiber contains 9.30% water solubles and 4.65% alcohol benzene solubles. It contains moderate quanitity of lignin that is 16.59%. The consumption of cooking liquor is comparatively less than hardwood. Alpha celluose content are 43.21% where as pentosan

Table-3

Degree of Polymerization of Cotton, Jute and Cannabis sativa bast fibers and Ipomea carnea.

S.N.	Particulars	D.P. by Light Scattering Measurement
1.	Cotton	9400
2.	Jute	8600
3.	Cannabis sativa hemp ribbons from male plant	
	(i) Hemp ribbons harvested at maturity	9300
	(ii) Early Harvested hemp ribbons	8746
	(iii) Delayed harvested hemp ribbons	9345
4.	Cannabis sativa hemp ribbons from female plant at maturity	8200
5.	Ipomea carnea	4506

Table-4

Bleaching Conditions and Results of Alkali-Oxygen Pulp of Cannabis sativa ribbons & Ipomea carnea.

S.N.	Particulars	Cannabis sativa hemp fibers	Ipomea carnea
1.	Unbleached pulp Kappa no.	11.00	29.00
2.	Total Chlorine demand, %	2.75	7.25
3.	Chlorination stage (C)		
	Amount of Chlorine added (on O.D. basis) %	1.73	3.63
	Final pH	2.50	2.05
4.	Alkaline extraction stage (E)		
	NaOH added (on O.D. pulp basis), %	0.74	1.82
	Final pH	9.98	10.20
5.	Hypochlorite stage (H)		
	Hypo added as available. Cl_2 (on O.D. pulp basis), %	1.10	2.36
	Final pH	9.15	9.50
6.	Hypochlorite stage H_2		
	Hypo added as available Cl_2 (on O.D. pulp basis), %	-	1.26
	Final pH	-	9.5
7.	Bleaching losses	9.50	8.0
8.	Bleached pulp yield, %	60.80	42.08
9.	Pulp brightness, °PV	80.0	81.00

Bleaching conditions	C	E_1	H_2	H_2
Consistency, %	4	9	10	10
Temperature, °C	25±2	55±2	45±2	45±2
Retention time, minutes	40	60	60	120
pH	3.0	11.5	12.2	

contents are 17.30%. Therefore it affects the pulp yield. (9)

Degree of polymerisation of alpha cellulose of Cannabis sativa hemp fibers and Ipomea carnea fibers reported in Table-3 are determined by a light scattering measurement method. It is found that degree of polymerisation of hemp fibers is 9300 which is very close to degree of polymerisation of cotton fiber i.e. 9400. It clearly indicates its suitability to produce pulp of high tear and tensile strength. On the other hand the degree of polymerisation of Ipomea carnea is 4500.

PULPING STUDIES:

Hemp ribbons having moisture content 10-12% were hand chopped to length of 40-50 mm. The stalks of Ipomea carnea collected in the vicinity of Saharanpur were hands chopped and screened. The chips passed through 30-mm screen but retained on 25-mm screen were collected. Chopped ribbons and Ipomea carnea accepted chips were cooked separately by alkali-oxygen delignification process in electrically heated rotary digester of capacity 0.02m^3 by adopting following cooking parameters. (6&7)

Molecular oxygen is a specific oxidising agent for lignin but has limitations because of its low solubility in cooking liquor. The problems of mass transfer of oxygen in both the plants are far less than with woods because of the open and more loose anatomical structure. There is no pulp, 20% hemp stalk pulp and 15% reed (Phargmites communis) pulp, 50% hemp ribbon pulp, 30% hemp stalk pulp and 20% jute (Corchorus capsulasis) waste pulp and 25% birch pulp, 60%t hemp ribbon and 15% hemp stalk pulp were found satisfactory to develop cigarette paper. The use of 100% hemp ribbon diffusion problem of dissolved oxygen into these non woody plants because of its more loose structure and low specific gravity

Parameters	C. sativa	I. carnea
- Alkali % (as NaOH)	9	16
- Oxygen Pressure (kg/cm^2)	5	10
- $MgSO_4$ % (as carbohydrate)	0.1	0.1
- Temperature, ^{0}C	165	160
- Time at maximum temperature, ^{0}C	180	120
- Liquor to wood ratio	5:1	4:1

HEMP RIBBONS

At the end of cooking , the pulp was washed, refined and screened through a laboratory vibratory flat screen with 0.25 mm slots. The unbleached and screened pulp yield of hemp ribbons was found 64% at kappa number of 11 whereas the unbleached and screened pulp yield of Ipomea carnea is 45% at kappa number of 29.

BLEACHING:

The bleaching of Cannabis sativa hemp ribbons is done by CEH bleaching sequence whereas bleaching of Ipomea carnea is done by CEHH bleaching sequence. Bleaching conditions and results are reported in table -3. The pulp brightness of Cannabis sativa hemp ribbon is 80^0 PV and the pulp brightness of Ipomea carnea is 81^0 PV.

BEATING:

Both the pulps were beaten separately in WEVERK make valley beater to a freeness level of 75 ^{0}SR. Now Cannabis sativa hemp ribbons and Ipomea carnea beaten pulps were blended in the ratio 70:30. A mix of 65% hemp ribbon and 30% hemp stalk pulp, 50% hemp ribbons pulp, 20% hemp stalk pulp and 30% kenaf ribbon pulp, 65% hemp ribbon furnish for cigarette papers was found to have some disadvantages such as high energy requirement for cutting and refining during stock preparation, high raw material costs and poor formation. Ipomea carnea short fibers are found resuming to fill the voids in the fiber network in order to improve web formation. A partial replacement of hemp ribbon pulp with Ipomea carnea pulp gives controlled porosity and cost price within specific limit.

To the combine furnish 45% precipitated calcium carbonate, was added directly to the beater for good mixing. The addition of calcium carbonate raises the freeness of stock from 75 to 85 ^{0}SR. Flame retardant such as 0.1% ammonium phosphate (on O.D. pulp basis), to improve the combustibility of paper, 0.1% melamine formaldehyde and 0.1% ash conditioner which form an attractive ash on burning are added to the beater.

Laboratory hand sheets of substance 24 g/m^2 were made on British sheet former. These laboratory hand sheets were conditioned at temperature of 27 ± 2 ^{0}C and relative humility 65 ± 2%. These laboratory hand sheets were evaluated as per BIS method for various properties. The laboratory hand sheets of thickness 32.3 micrometer consists of 65.8% of organic matters and 34.2% precipitated calcium carbonate.

Table-5 shows the physical properties of cigarette paper prepared in laboratory and compared with cigarette paper manufactured by mill A . The breaking length of laboratory made hand-sheet is 2910 meter which is higher than that of average breaking length of 2634 meter for mill A. The stretch of hand sheet is 3.54% which is also higher than that of 2.33% for cigarette paper of mill A. The porosity of laboratory made hand sheet is found very close to porosity of mill made cigarette paper. It clearly indicates that the strength properties of laboratory made cigarette paper are enough to run on high speed cigarette making machines. The opacity and brightness of laboratory made hand-sheet are 79% and 81% compared to 81.2 and 78% respectively. The opacity values of laboratory

Table-5

Physical Properties of Cigarette Tissue.

S.N.	Parameters	Units	Laboratory Results	Results of Mill A
1.	Basis weight	g/m^2	24	25
2.	Moisture	%	4.21	3.50
3.	Thickness		37.2	39.2
4.	Breaking length	meter		
	MD		-	3128
	CD		-	2150
	Avg.		2910	2634
5.	Stretch			
	MD		-	3.75
	CD		-	0.92
	Avg.	%	3.54	2.33
6.	Porosity	Bendtsen, ml/min	195	210
7.	Brightness	%	82.1	81.2
8.	Opacity	%	79	78
	Ash (as CaO)		19.1	18.8
9.	Ash (as $CaCO_3$)	%	34.2	33.7

made cigarette paper has sufficient to hide colour of tobacco. The porosity of laboratory made cigarette tissue paper and mill A., Cigarette paper are and respectively. As the result are found quite encouraging the above new raw material blend can produce the suitable pulp for cigarette tissue paper in India.

CONCLUSION:

1. Degree of polymerisation of Cannabis sativa hemp ribbon from male plant harvested at maturity is 9300 that gives superior quality of fiber.

2. A pulp blend of 70% Cannabis sativa hemp ribbon pulp and 30% Ipomea carnea pulp is found suitable for development of cigarette paper. 45% precipitated $CaCO_3$ to the weight of pulp, 0.1% ammonium phosphate, 0.1% malamine formeldehyde and 0.1% ash conditioners are added directly to the beater to raise the freeness of pulp from 75 to 85 °SR.

3. The basis weight and thickness of laboratory made cigarette paper are 24 g/m^2 and 37.2 μm respectively. The average breaking length and the stretch are 2910 m and 3.54% compared to 2634 m breaking length and 2.33% stretch of cigarette paper of mill A.

4. The porosity of laboratory cigarette paper is 195 ml/min. The brightness, opacity and ash (as $CaCO_3$) are 79% PV, 82.1% and 32.2% respectively. The raw material blend, the technology developed can be a very promissing in India in future.

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