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STUDIES ON NEUTRAL SULPHITE PULPING OF SESBANIA sesban.

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Abstract

High yield pulps suitable for paper making have been prepared from Sesbania sesban by neutral sulphite pulping process. The cooking liquor contained essentially Na2So3 and Na2CO3 (Cold pH 10 to 12). The Total chemical charge was 14 to 20% (as Na2O). The cooking resulted in chemically defibered high yield pulps (58 to 64% on O.D. raw material basis) with Kappa number 48 to 53, having brightness of 39 to 41% elrepho at a sodium sulphite charge of about 80 to 85% of the total alkali (as Na2O), cooking time at maximum temperature (170°C) was 180 to 210 min. On the basis of these investigations, it was concluded that the best quality pulp having optimum value for Kappa number, rejects, pulp yield, tear, tensile, burst and fold was obtained at a total chemical charge of 20% (as Na2O), alkali ratio of 0.85, temperature 170°C and time at temperature of 210 minutes. The pulps were bleached with a CEHH bleaching sequence producing pulps in the yield range of 51 to 53% with a brightness level of around 76% elrepho. The unbleached and bleached pulps were beaten to various levels of freeness and evaluated for physical strength properties. The pulp evaluation data showed that S. sesban is one of the most potential non-wood fibrous raw material and can be used for making various grades of paper.

Introduction

Cellulosic fibres are produced through permanent regrowth not only from trees but also from large number of non-woody plants and agricultural tissues. The non-woody plants represent one of the major sources of fibrous raw materials for many developed countries of the world. Increasing difficulties in the procurement of woods have caused increasing interest in the utilization of non-woody fibrous plants. In some countries especially where wood is scarce, non-woody fibres are consequently more common as raw material to be used for pulp, paper and board manufacture.

One of the objective of the present investigation is to find out some suitable non-woody fibrous raw materials to supplement and to overcome the problem of raw material shortage to some extent experienced by the Indian Pulp and Paper Industries. Taking into consideration various strategy including the man-mad forest plantation, the forest based raw materials are in tremendous short supply and cannot meet the projected paper capacities. Hence it will force the industry to look towards alternative fibrous raw material other than wood and bamboo. There is still wide scope for indentifying some new potential non-woody fibrous plants for pulp and paper making. Moreover, the paper making operation based on non-wood pulps is confined to a large extent among the developing nations. Most of the developing nations are facing foreign exchange shortage and therefore severe restrictions are imposed on pulp imports. This situtation is likely to continue and paper industry in these countries, have to depend increasingly on the locally available non-wood pulps, mills will be obliged to use non-wood pulp as much as possible in their fibre furnish.

The structure of the group of non-woody fibrous raw materials in India is significantly different from the compositon of that group in other countries and regions, since in India bamboo alongwith other non-woody fibres including agricultural residue is the most important pulping raw material. Only a very little amount of information is available on the pulping of non-woody fibrous raw materials.

Searching for possible new crops of non-woody plant material involves the examination of a large number of plant samples. To check the suitability of a particular raw material in question for pulp and paper making, the initial tests involves consideration of anotomical characteristics, chemical composition, yield of fibrous constituents and a qualitative, physical and visual appraisal of the plants. Considerable amount of work[1,2] have already been done to study the effect of anatomical characteristics and chemical properties of wood fibres on the nature and quality of pulp. The combined effect of physical characteristics of the raw material thus determine the ultimate properties of the pulp and paper.

Over the past decades, high yield sulphite pulping of hard-woods has been investigated as a means of making a low cost pulp for the production of news print, printing and tissue papers. Different combinations of pulping variables viz. presteaming/liquor impregnation procedure, cooking liquor pH, Sodium sulphite/sodium bisulphite content, cooking temperature, time and liquor to wood ratio etc., have been tried.

There is no other single pulping process that is as versatile as sulphite. Well defined marketable pulp products can be produced over a range of 30 to 90% yield and over a pH range of 1 to 13. Conventional sulphite is characterized, among other properties, by its high unbleached brightness and moderate physical strengths, the high initial brightness and subsequent ease of bleaching are of significant economic importance.

Perhaps the most promising development in the past few years for the production of Kraft-like sulphite pulp has been the discovery that neutral sulphite pulping with anthraquinone, can result in a pulp that is close in physical strength to conventional kraft pulp, but at a significantly higher yield. According to Ingruber[3], alkaline sulphite cooking corresponds to a cold liquor pH of 10 to 13.5 with liquor containing mainly Na2So3 and NAOH. Neutral or semi alkaline sulphite (NS or SAS) corresponds to a cold liquor pH of 12.5 with the liquor containing mainly Na2So3 and Na2Co3. Such pulps both unbleached and bleached have now been in commercial production for many years. Normally these pulps are mixed in the furnish for the production of printing papers such as newsprint, magazine paper and base paper for coating.[4-6] The preliminary conclusions from these studies indicated that this process is very interesting for its economy and pulp quality, but is stil in the development stage. The most promising initial applications of the process seem to be in the production of packaging grades and news reinforcement. The present investigations include the evaluation of moderately neutral sulphite pulps of Sesbania sesban, a non-woody fibrous plant of immense importance.

Botanical Description and Anatomical Characteristics of Sesbania sesban[7]

The name of this plant is different in different Indian languages and the common name of this plant in Hindi is Jainti, Jait and Rawasan. Sesbania sesban is a soft wooded, quick growing, short lived, shrub, 1.8 to 6 metre high, cultivated throughout the plains of India upto an altitude of 1200 Metre.

S. sesban can grow under widely different conditions and can provide large quantities of green manure. However, it is recommended for cultivation in regions liable to periodic innudation. It can also be grown under water logged condition and acid soils. It withstands salt concentration of 0.4 to 1% in seeding stage and 0.9 to 1.4% towards maturity. The leaves and pods dry up as a result of frost. S. sesban is propagated through seeds. When grown as a shade plant in orchards, it is sown parallel to the row of young orchard plants about a foot from their periphery. It grows to about 4.5 to 6 Metre on rich alluvial soil in one season. Leaves 7.5 to 15 cm. long, paripinnate, leaflets 8 to 20 pairs, linear oblong, glabrous, entire mucronate to acuminate, 6.0 to 25 mm × 2.5 to 6.0 mm flowers yellow or yellow spotted red to purple or with standard petals coloured purple or brown from outside, in 8 to 10 flowered, lax, axillary recemes, 2.5 to 14.0 cm. long pods 12.5 to 22.5 cm × 0.25 to 0.37 cm. pendulous, weak distinctly torulose, twisted, sharply beaked 20 to 30 seeded and septate.

As the plant is quick growing, it is valued as a temporary hedge in North India, If left unclipped, it forms a low windbreak. S. sesban is used on borders of nursery beds so as to protect young seedings from cold or hot winds. S. sesban is grown as support to betal, pepper and grape vines and cucurbitãceous plants and also to support sugar–cane. S. sesban is grown as a perinnial manure crop. The plant stands lopping well and produces regrowths very quickly. Excellent green manure is obtained when the plants are 60 cm high, lopped leaves can be used for compost in a corner of the field. A compost pit of 280 cm × 180cm × 90cm in any field is sufficient to meet the basic requirements of manure for an acre of land. The plant is especially rich in nitrogen (4%) and exceeds the minimum of 2% over which organic nitrogeneous materials render nitrogen available for plant growth. It nutrifies soil easily and used as green manure. The leaves are reported to improve the productivity and physical condition of saline soils significantly, manuring consecutively for three years is reported to increase the humus content of soil by 33% and decrease the salt content to a similar extent. S. sesban is classed under famine foods because of its seeds, which are rich in proteins. In Bihar, the flower are eaten as vegetable. The leaves on analysis showed that these contains (on dry wt. basis) protein 26.6%, phosphorus o.34%, indicating that the leaves of S. sesban are a good source of proteins, calcium and phosphorus.

Pigments isolated from the flowers include a complex of cyanidin and delphindin glycoside acylated with gallic and an unidentified acid. At least six flavonols, magnesium and traces of iron are present. The seeds contain protein 33.7%, fat 4.8%, N-free extract 18.2%, cellulose 28.3%, ash 4.2% and vitamin–C 0.0894%. S. sesban seed protein is of poor quality because of the presence of canavanine, which is a competitive inhibitor or arginine. The occurrence of canavanine in the seeds of this species distinguishes it from others .Untreated seeds from formosa are reported to be highly toxic and cannot be used as feed or protein supplement for live stock.

Bark is the source of a fibre used for making ropes. The plant yields about 56 tonnes of green matter per hectare. The bulk density of the chips is about 230 to 245 kg/M^3. Charcoal obtained from the plant is used for gun powder. S. sesban plant is used as a fuel in jaggery industry. S. sesban is grown in Deccan to furnish poles as a substitute for bamboo and for roofing huts. The plant is used as a nurse in forest plantations. The wooden toys are made from its wood in Burma. In Africa, the stems are used for arrows and pipes. S. sesban is a common cottage ornament. The leaves and flowersare used in religious offerings. The plant yields an isecticide and is also used in making inks.

Among the pests, prodenia litura, the tobacco caterpillar scalaris causes severe damage to S. sesban in South India and Bengal. Its larvae funnel through the main stem and practically eat away the contents of the stem leaving the epidermis only. It is controlled by uprooting the stems immediately after harvesting and burning them. D.D.T. (0.05%) and B.H.C. dust (5%) are cheap and effective, while product 1250 and parthion are also effective against the pests.

The plant is credited with galactogogue properties. The seeds are stimulant, emmenagogue and astringent and useful in checking diarrhoea and reducing enlargement of the spleen. In the form of ointment, the seeds are used to cure itches and various other skin eruptions.

Experiment

Raw Material Preparation

For the present investigations the S. seban was procured from nearby regions and chopped by hand to cut chips of approximately 20 mm in length and further screened and those passing through 12.7 mm screen but retained on a 6.4 mm screen were collected. The accepted chips were air dried under atmospheric conditions, the moisture content of the fresh (green) chips vary from 55 to 60% while that of air dry chips vary from 8 to 12%

Proximate Chemical Analysis :

The selected air dried material was disintergrated in the laboratory WEVERK disintegrator. The portion passing through 40 mesh sieve but retained on 60 mesh sieve was utilized for proximate chemical analysis. The proximate chemical analysis was carried out as per standard TAPPI procedures and the results of proximate chemical analysis are reported in TABLE-I.

TABLE - I

PROXIMATE CHEMICAL ANALYSIS OF S. *sesban*.

SL. NO.	PARTICULARS	PERCENTAGE VALUES*
1.	COLD WATER SOLUBILITY	2.37
2.	HOT WATER SOLUBILITY	6.30
3.	ALCOHOL-BENZENE SOLUBILITY (1:2 V/V)	4.45
4.	1 % SODIUM HYDROXIDE SOLUBILITY	24.70
5.	LIGNIN	17.65
6.	PENTOSAN	19.00
7.	HOLOCELLULOSE	73.23
8.	HEMI CELLULOSE	27.80
9.	ALPHA CELLULOSE	45.24
10.	BETA CELLULOSE	11.12
11.	GAMMA CELLULOSE	16.42
12.	ASH	1.40
13.	SILICA	0.38
14.	ACETYL CONTENT	2.61
15.	METHOXYL CONTENT	3.70

* % ON O.D. WOOD.

Maceration and Cellular Elements Measurement

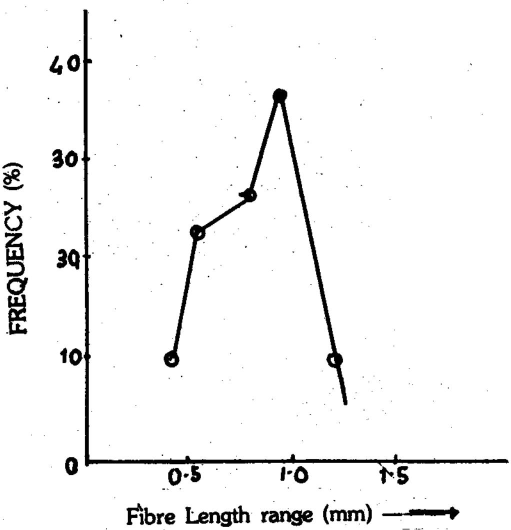
Transverse and longitudinal sections of 20 to 30 mu thickness of S. sesban plants were cut on Lietz base sladge microtome 1300. For morphological study, the samples were subjected to a chemical physical maceration to separate the individual cellular elements from each other without damage. It involves the use of a hot aqueous acetic acid, sodium chlorite solution to remove most of the lignin and other binding materials without appreciable degradation of the cellulosic tissues. The microscope slides of cellular material were prepared according to IS method 5285-1969. Microscope slides were projected at a magnificantion of 40x and the fibre length were measured, while the fiber width and cell wall thickness were obtained by measuring the projected images at a magnification of 160x. The values of density, fibre length, fibre diameter, lumen diameter, cell wall thickness and different ratios of the above dimensions are reported in TABLE-II. The frequency percentage curves of fibre length, fibre diameter, lumen diameter and cell wall thickness are represented in figures 1 and 2.

TABLE - II

MORPHOLOGICAL CHARACTERISTICS OF S. sesban

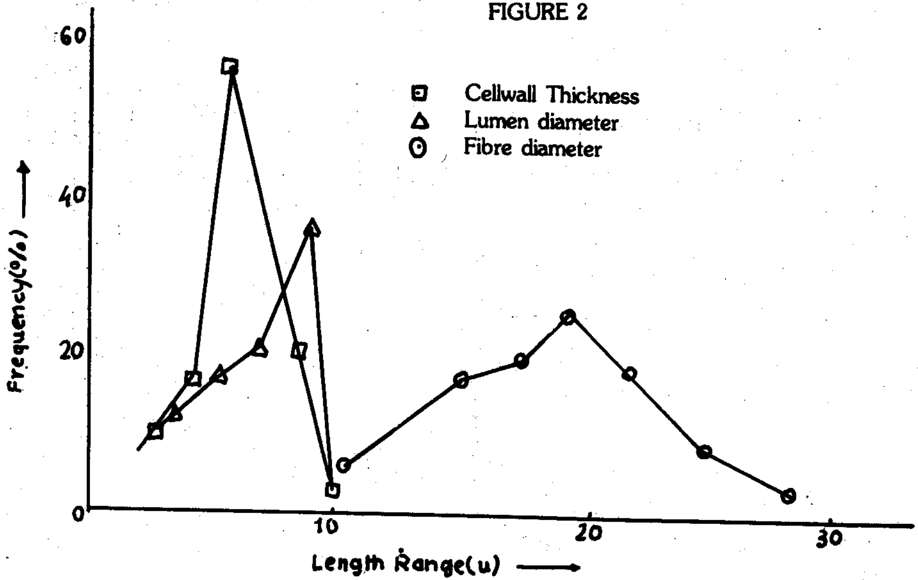
SL. NO.	PARTICULARS	VALUES
1.	COLOUR	PALE WHITE
2.	DENSITY G/CM³	0.498
3..	FIBRE LENGTH, (L) mm	
	AVERAGE	0.914
	VARIATION	0.410 to 1.12
4.	FIBRE WIDTH, (D)	
	AVERAGE	19.174
	VARIATION	10.355 to 28.120
5.	LUMEN WIDTH, (d)	
	AVERAGE	8.714
	VARIATION	3.450 to 9.784
6.	CELL-WALL THICKNESS,(W)	
	AVERAGE	5.235
	VARIATION	2.60 to 9.756
7.	FLEXIBILITY COEFFICIENT (d/D) X 100	45.44
8.	RATIO TWICE CELL WALL THICKNESS TO FIBRE WIDTH (2 W/D)	0.546
9.	RUNKEL RATIO, (2 W/d)	1.20
10.	RATIO OF CELL WALL AREA TO TOTAL CROSS SECTIONAL AREA (Muhlesteph Ratio)	81.3
11.	RATIO OF LENGTH TO WIDTH (L/D)	47.66
12.	RATIO OF CELL WALL THICKNESS TO LUMEN WIDTH (W/d)	0.60

FIGURE 1



PLOTS OF FIBRE LENGTH RANGE (mm)
VERSUS FREQUENCY (%) FOR S. SESBAN.

FIGURE 2



PLOTS OF LENGTH RANGE (-u) OF CELL WALL THICKNESS, LUMEN DIAMETER AND FIBRE DIAMETER VERSUS FREQUENCY (%) FOR S. SESBAN

Pulping Studies

For optimization of pulping conditions, 100g of o.d.chips were cooked in a Weverk laboratory rotary digester with stainless steel bombs of 1 litre capacity. During these studies technical grade chemicals were used excepting sodium sulphite, which was of analytical grade. All dilutions were made with tap water. Cooks were made under these conditions :

Total alkali (as Na2O)	= 14–20%
Alkli ratio (Na2So3 : Total alkali)	= 0.6–0.95
Wood to liquor ratio	= 1:3.5
Time to maximum temperature	= 90 min.
Time at maximum temperature (170°C)	= 180 & 210 min.

The pulping studies were made using different ratios of sodium sulphite and sodium carbonate to determine the optimum ratio. Time at temperature was also varied to study the effect of cooking time. On the basis of these investigations, it was concluded that the best quality pulp having optimum value for kappa number, rejects, pulp yield, tear, tensile, burst and fold was obtained at a total chemical charge of 20% (as Na2O), alkali ratio of 0.85, temperature 170°C and time at temperature of 210 minutes. During cooking, the digester pressure was reduced by gas relief until the temperature reached 105°C. The charge was then blown from the digester and the chips were defibred through a Bauer laboratory refiner with a plate clearance of 0.40mm. The pulp was washed and screened through a laboratory vibratory flat Weverk screen with 0.2mm slots and the screened pulp was washed, pressed and crumbled. The pulp was analysed for yield, rejects and Kappa Number. Spent liquor pH was also determined. The results of these studies are reported in Tables III to VI.

TABLE III

COMPOSITION OF COOKING LIQUOR AND CHARACTERISATION OF S. sesban NS PULPS AT 14 % TOTAL ALKALI (AS NA2O)

COOKING LIQUOR COMPOSITION	SERIES I					SERIES II				
SODIUM SULPHITE ⋆	8.40	9.80	11.20	12.60	13.30	8.40	9.80	11.20	12.60	13.30
SODIUM CARBONATE ⋆	5.60	4.20	2.80	1.40	0.70	5.60	4.20	2.80	1.40	0.70
ALKALI RATIO	0.60	0.70	0.80	0.90	0.95	0.60	0.70	0.80	0.90	0.95
pH	11.20	10.85	10.50	10.00	9.56	11.20	10.85	10.50	10.00	9.56
PULP DATA										
UNSCREENED YIELD %	75.60	71.00	67.14	67.50	70.50	72.00	68.90	65.20	66.00	68.60
SCREENED YIELD	71.40	67.00	63.34	63.90	66.60	68.00	65.10	61.70	62.80	64.90
REJECTS %	4.20	4.00	3.80	3.60	3.90	4.00	3.80	3.50	3.20	3.70
KAPPA NO.	89.4	75.00	68.00	66.40	72.00	87.20	73.00	65.60	62.50	69.40
SPENT LIQUOR pH	8.30	8.20	8.10	7.80	7.40	8.20	8.10	8.00	7.70	7.50

⋆ O.D. WOOD AS NA2O
SERIES I 180 MIN at 170°C, SERIES II 210 MIN. AT 170°C.

TABLE IV

COMPOSITION OF COOKING LIQUOR AND CHARACTERISATION OF S. sesban NS PULPS AT 16 % TOTAL ALKALI (as Na2O)

COOKING LIQUOR COMPOSITION	SERIES I					SERIES II				
SODIUM SULPHITE *	9.60	11.20	12.80	14.40	15.20	9.60	11.20	12.80	14.40	15.20
SODIUM CARBONATE *	6.40	4.80	3.20	1.60	0.80	6.40	4.80	3.20	1.60	0.80
ALKALI RATIO	0.60	0.70	0.80	0.90	0.95	0.60	0.70	0.80	0.90	0.95
pH	11.30	10.90	10.54	10.10	9.60	11.30	10.90	10.54	10.10	9.60
PULP DATA										
UNSCREENED YIELD %	73.60	68.20	64.50	65.70	67.40	70.20	66.50	62.60	63.00	66.40
SCREENED YIELD %	70.60	65.40	62.30	63.30	64.70	67.40	63.80	60.60	59.80	63.90
REJECTS %	3.00	2.80	2.20	2.40	2.70	2.80	2.70	2.00	2.20	2.50
KAPPA NO.	83.60	71.40	63.80	63.00	70.00	80.00	68.40	60.70	58.40	62.00
SPENT LIQUOR pH	8.30	8.30	8.00	7.80	7.50	8.20	8.10	8.00	7.70	7.40

* O.D. WOOD AS NA2O
SERIES I 180 MIN at 170°C, SERIES II 210 MIN. AT 170°C.

TABLE V

COMPOSITION OF COOKING LIQUOR AND CHARACTERISTICS OF S. sesban NS PULPS AT 18 % TOTAL ALKALI (as Na_2O)

COOKING LIQUOR COMPOSITION	SERIES I					SERIES II				
SODIUM SULPHITE *	10.80	12.60	14.40	16.20	17.10	10.80	12.60	14.40	16.10	17.10
SODIUM CARBONATE *	7.20	5.40	3.60	1.80	0.90	7.20	5.40	3.60	1.80	0.90
ALKALI RATIO	0.60	0.70	0.80	0.90	0.95	0.60	0.70	0.80	0.90	0.95
pH	11.44	10.90	10.58	10.13	9.64	11.40	10.90	10.58	10.13	9.64
PULP DATA										
UNSCREENED YIELD %	71.70	65.42	62.57	63.17	65.82	68.40	63.90	60.42	61.00	64.20
SCREENED YIELD %	68.90	62.92	61.07	61.57	63.92	65.80	61.70	59.22	59.70	62.50
REJECTS %	2.80	2.50	1.50	1.60	1.90	2.60	2.20	1.20	1.30	1.70
KAPPA NO.	78.00	66.50	57.20	53.40	62.80	70.50	64.00	54.00	55.70	58.60
SPENT LIQUOR pH	8.40	8.30	8.10	7.90	7.60	8.30	8.20	8.10	8.00	7.70

* % O.D. WOOD AS Na_2O

SERIES I 180 MIN at 170°C, SERIES II 210 MIN. AT 170°C.

TABLE VI

COMPOSITION OF COOKING LIQUOR AND CHARACTERISTICS OF S. sesban NS PULPS AT 20 % TOTAL ALKALI (as Na_2O)

COOKING LIQUOR COMPOSITION	SERIES I					SERIES II				
SODIUM SULPHITE *	12	14	16	18	19	12	14	16	18	19
SODIUM CARBONATE *	8	6	4	2	1	8	6	4	2	1
ALKALI RATIO	0.60	0.70	0.80	0.90	0.95	0.60	0.70	0.80	0.90	0.95
pH	11.50	10.92	10.60	10.16	9.64	11.50	10.92	10.60	10.16	9.64
PULP DATA										
UNSCREENED YIELD %	69.30	63.18	60.78	62.20	64.50	66.70	61.20	58.74	59.70	63.00
SCREENED YIELD %	66.70	61.28	59.58	60.80	62.80	64.60	59.50	57.82	58.50	61.60
REJECTS %	2.60	1.90	1.20	1.40	1.70	2.10	1.70	0.92	1.20	1.40
KAPPA NO.	76.40	62.30	53.00	58.40	61.00	66.70	58.30	49.20	51.40	55.60
SPENT LIQUOR pH	8.30	8.20	8.10	7.90	7.60	8.30	8.20	8.20	7.80	7.50

* % O.D. WOOD AS NA_2O
SERIES I 180 MIN at 170°C, SERIES II 210 MIN. AT 170°C.

Bleaching Studies :

The bleaching of S. sesban neutral sulphite pulps were studied using a CEHH bleaching sequence. The bleaching conditions alongwith the results are tabulated in Table-VII.

Pulp Evaluation :

The unbleached and bleached pulp were beaten in a PFI mill with a beating pressure of 1.8 kgs/cm to different freeness levels and sheets of 60 g/m^2 were prepared on a standard British sheet forming machine. These hand sheets were evaluated as per ISI standard for their different physical stregth properties at a relative humidity level of 65 + 2% and a temperature of 27 · 2°C. Pulp evaluation results are tabulated in Table-VIII and IX.

TABLE VII

BLEACHING CONDITIONS AND CHARACTERISTICS OF S.sesban NS BLEACHED PULP.

SL. NO.	PARTICULARS	PULP NUMBERS 1	2	3	4
1.	UNBLEACHED PULP KAPPA NO.	53.60	52.80	49.00	48.20
2.	CHLORINATION STAGE (C)				
	CHLORINE APPLIED AS AVAILABLE Cl2 ON PULP %	8.00	7.89	7.30	7.12
	CHLORINE CONSUMED AS AVAILABLE Cl2 ON PULP %	7.90	7.86	7.29	7.10
	FINAL pH	1.8	1.7	1.9	1.8
3.	ALKALI EXTRACTION STAGE (E)				
	NaOH ADDED ON PULP %	1.8	1.8	1.8	1.8
	INITIAL pH	11.3	11.2	11.4	11.2
	FINAL pH	10.0	10.2	9.7	9.9
4.	HYPOCHLORITE 1ST STAGE (H1)				
	HYPO ADDED AS AVAILABLE Cl2 ON PULP %	2.8	3.0	2.8	2.7
	HYPO CONSUMED AS AVAILABLE Cl2 ON PULP %	2.76	2.94	2.75	2.68
	FINAL pH	7.8	7.9	7.8	7.7
5.	HYPOCHLORITE 2ND STAGE (H2)				
	HYPO ADDED AS AVAILABLE Cl2 ON PULP %	1.1	1.2	1.0	0.9
	HYPO CONSUMED AS AVAILABLE Cl2 ON PULP %	1.02	1.13	0.98	0.86
	FINAL pH	7.7	7.7	7.8	7.7
6.	TOTAL Cl2 ADDED ON PULP %	11.90	12.09	11.10	10.72
7.	TOTAL Cl2 CONSUMED ON PULP %	11.68	11.93	11.02	10.64
8.	BLEACHING LOSSES %	10.6	10.2	9.8	9.3
9.	BLEACHIED PULP YIELD %	52.75	52.26	51.78	50.80
10.	VISCOSITY CED (0.5 %) Cp	11.4	11.3	11.0	11.2
11.	BRIGHTNESS (Elrepho), %	76.0	76.4	76.8	76.6
12.	PROCESS VARIABLES	C	E	H1	H2
	CONSISTENCY %	3	10	10	10
	TEMPERATURE °C	25 ± 2	60 ± 2	45 ± 2	45 ± 2
	TIME, MINUTES	30	90	60	120

TABLE VIII

PULPING CONDITIONS, CHARACTERISTICS AND PULP EVALUATION DATA FOR S. sesban NS PULPS AT 18 % AND 20 % TOTAL ALKALI CHARGE (AS Na_2O) (210 MINUTES AT 170°C)

SL. NO.	PARTICULARS	18% TOTAL ALKALI (AS Na_2O)		20% TOTAL ALKALI (AS Na_2O)	
A	PULPING CONDITIONS & CHARACTERISTICS				
1.	SODIUM SULPHITE*	14.4	15.3	16.0	17.0
2.	SODIUM CARBONATE*	3.6	2.7	4.0	3.0
3.	ALKALI RATIO	0.80	0.85	0.80	0.85
4.	COOKING LIQUOR pH	10.60	10.52	10.60	10.61
5.	SCREENED PULP YIELD %	59.58	58.2	57.82	56.0
6.	KAPPA NO.	53.0	52.8	49.20	48.2
7.	SPENT LIQUOR pH	8.10	7.9	8.20	7.90
8.	APPARENT SULPITE (as Na_2SO_3) gpl	6.4	6.2	6.1	5.8
B	PHYSICAL PROPERTIES				
9.	PFI REVOLUTIONS NOS.	2000	2040	1960	2100
10.	FREENESS °SR	41	43	42	45
11.	DRAINAGE TIME sec	17.0	17.5	16.70	17.80
12.	APPARENT DENSITY (g/cm^3)	0.70	0.74	0.73	0.77
13.	TEAR IDNEX (mN m^2/g)	5.21	5.11	4.82	4.75
14.	BURST INDEX (K Pa m^2/g)	4.86	4.90	5.05	5.12
15.	TENSILE INDEX (Nm/g)	52.34	53.53	53.0	55.67
16..	FOLDING ENDURANCE (Kohler Molin)	220	226	230	247
17.	POROSITY (Bendtsen) Ml/min	150	140	140	110
18.	BRIGHTNESS (Elrepho) %	38.6	39.0	38.50	40.20

* % O.D. WOOD AS Na_2O

TABLE IX

PHYSICAL STRENGTH PROPERTIES OF S.sesban NS BLEACHED PULPS

SL. NO.	PARTICULARS	PULP NUMBERS 1	2	3	4
1.	PFI REVOLUTION (NO)	1400	1450	1400	1500
2.	FREENESS (°SR)	44	45	44	46
3.	DRAINAGE TIME (Sec)	19.0	19.2	19.0	19.4
4.	APPARENT DENSITY (g/cm³)	0.80	0.83	0.84	0.86
5.	TEAR INDEX (mN m²/g)	4.22	4.16	3.83	3.76
6.	BURST IDNEX (KPa m²/g)	3.50	3.76	4.10	4.35
7.	TENSILE INDEX (Nm/g)	42.60	45.47	47.10	48.80
8.	FOLDING ENDURANCE (Kohler Molin)	109	113	118	122
9.	POROSITY (Bendsten) (ml/min)	110	105	95	90
10.	BRIGHTNESS (Elrepho, %)	71.40	71.0	70.8	70.2
11.	OPACITY (%)	84.2	83.0	83.6	81.0

Fibre Classification Studies :

The fibre classification studies of S. sesban unbleached and bleached neutral sulphite pulps were made with the help of Bauer-McNett fibre classifier using screens with mesh numbers 20, 60, 80 and 120. The results of fibre classification studies are reported in Table-X.

TABLE X

BAUER-MCNett FIBRE CLASSIFICATION DATA OF S.sesban NS PULPS

SL.	MESH SIZE	UNBLEACHED PULP FREENESS = 15°SR LAPPA NO. = 52.8 %	BLEACHED PULP FREENESS = 17°SR %
1.	+20	16.8	3.4
2.	-20+60	42.4	36.4
3.	-60+80	19.6	25.2
4.	-80+120	6.8	14.0
5.	-120	14.4	21.0

Results and Discussions :

The results of proximate chemical analysis indicated that the plants of S. sesban have moderate quantities of solubles, thereby creating lesser pitch troubles with improved homogenities in the paper sheet the S. sesban plants have low lignin and high alpha cellulose content, thereby requiring lesser amounts of cooking chemicals with shorter cooking cycle and gives comparatively higher pulp yields.

The S. sesban non-woody fibrous plant consist of polygonal sclerenchyma cells and the thickening of cells is due to the deposition of lignin. The microscopic studies of transverse as well as longitudinal sections of S. sesban revealed that the S. sesban have a large number of vessels arranged in a scattered manner and they form diffuse porous wood. The vessels of S. sesban are small having oblique septa. These vessels are short, barrel shaped having numerous pits. The longitudinal section of S. sesban are having unicerate modullary rays. The fibres of S. sesban are thick walled with gradually tapering pointed ends, smooth walls, narrow lumen and very sparse slit like pits.

The most important factors influencing neutral sulphite cooking were the tota alkali charge and the alkali ratio (Na2So3 : total alkali, both as Na2O). Especially when the aim is to produce fully defibred pulps, the impregnation of cooking liquor into the chips is necessary. The influence of the total alkali charge and the alkali ratio on Kappa number during the course of S. sesban NS pulping is shown in figures 3 and 4. These figures clearly showed that the alkali ratio should be in the range of 0.80 to 9.85, to achieve as low a Kappa number as possible. An increase in total alkali charge accelerates the delignification. It was also found that the sodium sulphite charge has a greater influence on delignification than the total alkali charge. Figures 5 to 8 showed the influence of alkali ratio on pulp yields and rejects. The pulp yields and rejects both decreased as the amount of sodium sulphite or alkali ratio increased upto a level of 0.80 to 0.85 and beyond that the pulp yield showed an increasing trend and it is due to the fact that pH of the cooking liquor decreased as the amount of sodium sulphite increased in the total alkali. Although in neutral sulphite pulping, sodium sulphite is the main delignifying agent but at lower pH level it is comparatively less effective than at higher pH level i.e. the rate of delignification increased at higher pH level. The more the pH of the neutral sulphite cooking liquor, the higher will be the rate of delignification and shorter will be the cooking cycle. The increase in yield beyond 0.85 alkali ratio is due to the fact that beyond this alkali, ratio, the pH of the cooking liquor showed a decreasing trend thereby reducing the rate of delignification and the cookings were made for a particular time during which the complete delignification could not be achieved. The delignification stops at a Kappa number level of around 50. With an increase in the sodium sulphite charge and cooking time, a lower Kappa number may possibly be achieved. The retarded delignification in neutral sulphite cooking may be due to the rapid decrease in the cold pH already in the early stages of cooking. Most of the chemicals of the cooking liquor charged consumed till the digester temperature raised upto the maximum temperature. This is why, the cooking method has been called neutral sulphite (NS) or semi-alkaline sulphite (SAS) cooking. The most interesting aspects of the NS or SAS pulping process are comparatively brighter pulps with high yields.

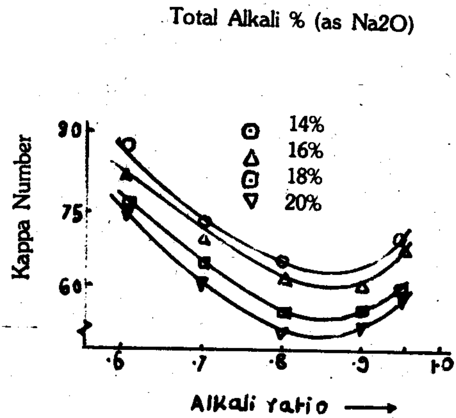


FIG 3

PLOTS OF ALKALI RATIO VERSUS KAPPA NUMBER DURING NEUTRALSULPHITE PULPING OF S. SESBAN AT 170°C (180 MIN)

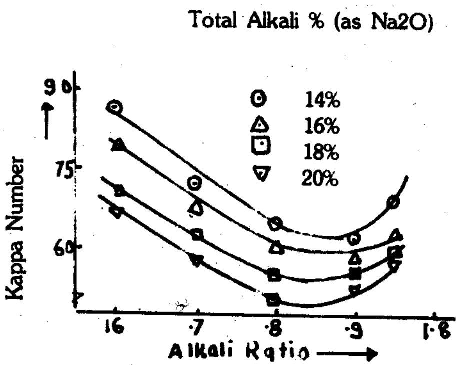
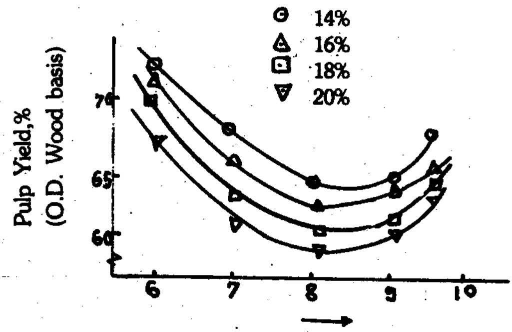


FIG 4

PLOTS OF ALKALI RATIO VERSUS KAPPA NUMBER DURING NEUTRAL SULPHITE PULPING OF S. SESBAN AT 170°C (210 MIN)

Total Alkali % (as Na2O)

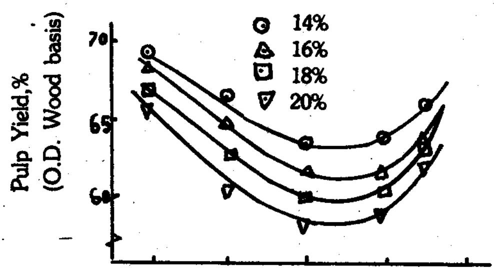


ALKALI RATIO ——

PLOTS OF ALKALI RATIO VERSUS PULP YIELD DURING NEUTRALSULPHITE PULPING OF S. SESBAN AT 170ºC (180 MIN)

FIG 5

Total Alkali % (as Na2O)



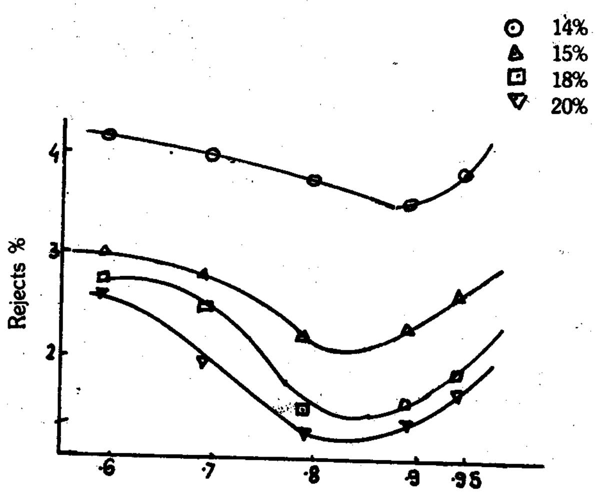
ALKALI RATIO ——

PLOTS OF ALKALI RATIO VERSUS PULP YIELD DURING NEUTRAL SULPHITE PULPING OF S. SESBAN AT 170ºC (210 MIN)

FIG 6

FIG 7

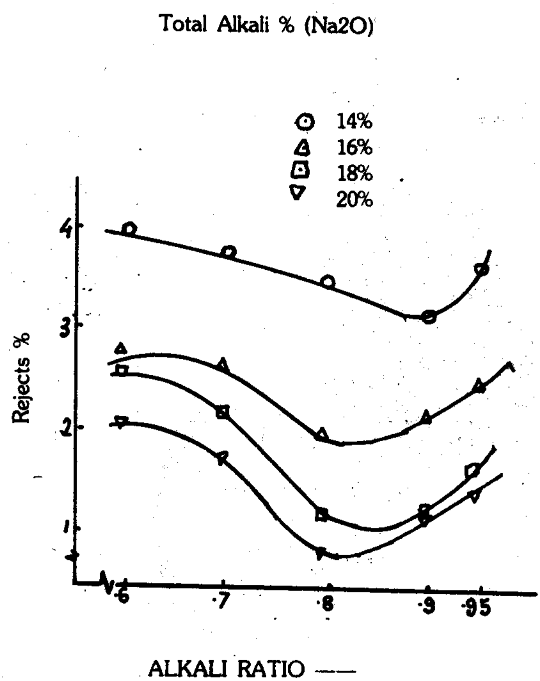
Total Alkali % (as Na2O)



ALKALI RATIO ——

PLOTS OF ALKALI RATIO VERSUS REJECTS DURING NEUTRALSULPHITE PULPING OF S. SESBAN AT 170°C (180 MIN)

FIG 8



PLOTS OF ALKALI RATIO VERSUS REJECTS DURING NEUTRAL SULPHITE PULPING OF S. SESBAN AT 170°C (210 MIN)

The laboratory experiments showed that chemically defibred pulps with a Kappa number of about 50 Can easily be produced under varying cooking conditions. The optimum bleaching conditions for these pulps were not determined and only some indicative bleaching experiments were carried out. The brightness of unbleached pulp varies between 41 to 44% (Elrepho). Because of rather high Kappa number, the chlorine consumption in slightly higher. Pulps with brightness level of 77 % (Elrepho) were obtained as a result of CEHH bleaching sequence. The effect of bleaching on paper making properties are shown in Table-IX.

One of the most interesting aspects of the neutral sulphite process is the comparatively higher pulp yields. The total yield for chemically defibred pulp varies between 59 to 64% at Kappa number 49 to 58. The yield of fully bleached pulps is in the range of 51 to 53% on O.D. wood basis. The neutral sulphite process produced brighter pulp than the kraft process, but the pulp is darker in colour than conventional sulphite pulps. The brightness improved with an increase in the alkali ratio and the total alkali charge.

The total hemicellulose content of neutral sulphite pulp is high. The high hemicellulose content and the high yield of neutral sulphite pulps are partly due to the stabilization of hemicelluloses (Xylan and glucomannan) and partly due to the mild alkaline cooking conditions, which preserve the hemicelluloses in the pulp[8,9]. The high hemicellulose content and its high degree of polymerization improve papermaking properties depending on fibre bonding ability.

The unbleached and bleached neutral sulphite pulps of S. sesban are more easily beaten in PFI mill upto a desired level of freeness. It means a comparatively shorter time is required to beat neutral sulphite pulps thereby requiring less energy during beating and refining. Tables-VIII and IX showed the strength properties of unbleached and bleached pulps. Comparison between strength properties of unbleached and bleached pulps of same Kappa number and freeness (Table-XI) indicated that bleaching does not markedly change the paper-making properties of neutral sulphite pulps. The strength potential of a particular type of pulps are indicated in Table-IX and X. Neutral sulphite pulps of S. sesban have good bonding ability thereby showed comparatively higher values of strength properties. The tear index of neutral sulphite pulps are relatively higher and is probably caused by the properties of the fibre i.e. stiffness combined with good bonding ability.

TABLE XI

COMPARISION BETWEEN STRENGTH PROPERTIES OF S.sesban UNBLEACHED AND BLEACHED PULPS OF SAME KAPPA NUMBER AND SAME FREENESS LEVELS. (20 % TOTAL ALKALI AS Na_2O, 210 MIN. AT 170°C)

SL. NO.	PARTICULARS	UNBLEACHED PULP	BLEACHED PULP
1.	KAPPA NO.	48.20	48.20
2.	FREENESS, (°SR)	45	46
3.	DRAINAGE TIME, (Sec.)	17.80	19.40
4.	APPARENT DENSITY (gm/cm3)	0.77	0.86
5.	TEAR INDEX (mNm^2/g)	4.75	3.76
6.	BURST INDEX (KPa m^2/g)	5.12	4.35
7.	TENSILE INDEX (Nm/g)	55.67	48.80
8.	FOLDING ENDURANCE (Kohler Molin)	247	122
9.	POROSITY (Bendtsen) (ml/min)	110	90
10.	BRIGHTENSS (Elrepho %)	40.20	76.6

Bleaching seems to have only minor effects on strength properties (Table-XI). The strength properties slightly showed a decline trend as a result of belaching. In addition to brightness, opacity is an important property for many grades of paper. Neutral sulphite pulps have a high light scattering coefficient. The higher yield neutral sulphite pulps contain fewer fibres per square metre at the same grammage, but the light scattering ability is still good because the fibres are stiff and uncollapsed providing a large optically activa area, but bonding ability is good due to high fibre plasticity and good bonding properties.

Conclusions

The present investigation was unertaken to use Sesbania sesban - a potential non-woody fibrous plant for pulp and paper making and to know the effect of fibre dimensions on the formation and structure of paper. S. sesban is a soft wooded, quick growing, short lived shrub, cultivated throughout the plains of India, upto an altitude of 1200 metre. It can also be grown under water logged conditions and acid soils. It is propagated through seeds. It nutrifies soil easily and used as green manure. S. sesban bark is the source of a kind of fibre used for making ropes. The plant yields about 56 tonnes of green matter per hectare. The packing density of S. sesban chips is about 230-245 kgs/M^3. The abundant availability and fibre dimensions indicated that it is one of the most promising non-woody fibrous raw material for pulp and paper making.

The neutral sulphite process offers many advantages including its high unbleached and bleached pulp yield. The yield of NS S. sesban pulps decreased with increase in cooking time and with increase in total chemicals. The Kappa number drcreased both with an increase in cooking time and increased chemicals. The production of NS pulps is quite economic in comparison to other process. The NS process is free from foul odour from liquor and condensates. The pulps are easy to bleach (less chemicals and stages, the alkali demand is especially lower) which means lower effluent flow and lower fresh water consumption. The S. sesban NS unbleached pulps have comparatively higher brightness. Inspite of their higher yields S. sesban NS pulps cooked at 0.80 to 0.85 alkali ratio have exceptionally good paper making properties. Some drawbacks of the NS process include longer cooking times to produce pulps with low Kappa numbers and higher pulp yield decreases the calorific value of the spent liquor.

The present investigations revealed that the NS process is simple and economical, with a low pollution load. In this context, the NS process applied to S. sesban is quite promising to obtain higher pulp Yields but much work is still needed for further development of the process.

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