Studies on Alkaline Sulphite and Alkaline Sulphite-Anthraquinone Delignification of Ipomea Carnea Jacq.

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ABSTRACT:– *The present investigation evaluate the moderately alkaline sulphite pulps of Ipomea carnea Jacq. a non woody fibrous plant of great promise, in production of various grades of paper. The chips of Ipomea carnea were digested with varying dose of Na_2SO_3 and NaOH (both expressed as Na_2O).*

In first set of experiment, the NaOH doses were varied from 0.75% to 8.5%, while keeping the Na_2SO_3 dose constant (at 10.5% as Na_2O). In second set of experiment, the chips were digested with varying dose of Na_2SO_3 i.e. from 6.5% to 12.5%, while keeping the NaOH dose constant at 6.5%. The effect of temperature, ranging from 150°C to 180°C, on pulp yield were also studied. The cooking time varied from 60 to 210 minutes at a maximum cooking temperature of 175°C. At optimum cooking conditions i.e. NaOH 6.5% and Na_2SO_3 10.5% (both as Na_2O), temperature 175°C, time at temperature 180 minutes and liquor to wood ratio 3.5 : 1, the pulp yield during Alkaline sulphite process was found to be 48.52% and Kappa number 31. During Alkaline sulphite-an thraquinone process, the pulp yield increased to 49.26% at the same Kappa number. Spent liquor characteristics at optimum pulping condition were analysed for various physico - chemical properties. The unbleached pulps were bleached using CEHH sequence which gave 81.5% and 82.3% brightness, (Elrepho) in case of AS and AS-AQ pulps respectively. Both unbleached and bleached pulps were evaluated for various physical strength properties.

INTRODUCTION

Cellulosic fibres are produced not only from trees but also from large number of non-woody plants including agricultural residues. The non woody plants

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represent one of the major source of fibrous raw materials for many developing nations. Increasing problems in the procurement of woods have increased interest in the utilisation of non - woody fibrous plants. In some countries especially where wood is scarce, non-woody fibres, consequently, are more common as raw material.

With the tremendous increase in population and literacy, the planning commission has indicated that the paper and board production will need to be increased to about 42.5 lakh tonnes by the end of this century (1). The biggest bottle neck in meeting the targeted production of paper and board will be the availability of cellulosic raw materials from existing forest resources, which are already in short supply and are barely able to sustain the present level of production. Increasing demand of fibrous raw material for paper and board production affected the environment and natural ecosystem due to mass cutting of forests. Therefore, it is essential that in the developing countries like ours, where the forest cover is already below the required level, the main emphasis should be given on the utilisation of agricultural residues and non-woody fibrous materials for the production of high yield pulps with the latest pulping technology which in turn will help in reducing the environmental pollution to some extent.

Ipomea carnea Jacq. is a common weed and locally known as 'BESHARAM'. Because of its high adaptability and resistance towards adverse climatic conditions, it may grow in all types of climate and soils-marshy as well as dry. A large diffused or straggling shrub with milky juice, native to South America, it was introduced in India as an ornamental plant. The plant was originally used for making fence for the road side fields, but due to its massive growth and rapid propagation it has grown rapidly in barren waste lands both under rainfed and irrigated conditions. Plantation of Ipomea carnea may be undertaken in the month of June-July with the on-set of monsoon. Shoots are fast growing and attaining optimum size in about a year's time. The yield of Ipomea carnea is about 15-20 BDMT/Hectare/Year (2). Preliminary studies of Ipomea carnea showed its suitability for pulp and paper making.

Over the past dacades, high yield sulphite pulping of hardwoods has been investigated as a means of making a low cost pulp for the production of newsprint, printing papers, and tissue papers. Different combinations of pulping variables viz., presteaming/ liquor impregnation, cooking liquor pH, sodium sulphite/ sodium bisulphite content, cooking temperature, time and liquor to wood ratio etc., have been tried. Sulphite pulping under moderate alkaline conditions, uses caustic (NaOH) and sodium sulphite (Na_2SO_3), to produce a pulp having strength properties similar to that of kraft pulp (3). The alkaline sulphite approach does not produce odoriferous sulphides (such as CH_3SH and $(CH_3)_2S_2$ that are commonly produced in the kraft pulping/chemical recovery system.

The anthraquinone (AQ), has also been found to be a most effective pulping aid, as accelerator of delignification and protector of carbohydrates in alkaline environment. With the addition of AQ, both the cooking kinetics as well as the compositions and the properties of the resulting pulp are profoundly altered (4). Because of the high paper strength they produce, comparisons are generally made with the common kraft process with and without AQ, but they are distinctly different from this process in chemistry, reaction mechanism, lignin to carbohydrate ratio, degradation of cellulose and hemicelluloses etc. The emergence of sulphite process at moderate alkalinity with AQ as its essential additive offers the industry a pulp of kraft like strength at higher yield and better bleachability than conventional kraft pulp and substantially reduction in air pollution (5). The capital cost required to convert an existing kraft pulp mill to an alkaline sulphite mill would be significantly less than that required to renovate a kraft mill to comply with increasingly stringent air quality standards, including lower TRS levels at the recovery stack exit.

One of the attractive features of the AS-AQ process, in comparison to the conventional kraft process is its ability to produce strong pulp without Kraft odor and its low requirement of caustic soda. Kraft process necessitates the operation and maintenance of large units for the re-causticisation of the spent pulping liquor at considerable expense and fossil fuel consumption. With the moderately alkaline process the necessary moderate alkalinity can be provided by soda ash, which is available directly from the recovery process. Thereby the causticistion unit can be completely eliminated. The

AS-AQ process has advantages over the common kraft process in economy, greater product flexibility and complete elimination of kraft odor. The most promising initial applications of the process seem to be in production of packaging as well as newsprint grades of paper (6 and 7). The present investigations include the pulping by moderate AS and AS-AQ process taking Ipomea carnea as a raw material.

EXPERIMENTAL METHODOLOGY

Raw Material Preparation

The stalks of Ipomea carnea were collected from nearby regions of Saharanpur. The stalks were chipped and screened. The chips passing through 30mm screen and retained on a 20mm screen were collected. The accepted chips were air dried under atmospheric condition.

Proximate Chemical Analysis

The proximate chemical analysis of Ipomea carnea was carried out as per standard TAPPI procedures (8). The physical and chemical characteristics of Ipomea carnea are reported in Table-I.

Table-I

Proximate Chemical Analysis of Ipomea carnea and their comparison with Bagasse and Bamboo.

Sl. No.	Particulars (%)	Ipomea carnea	Bagasse (9)	Bamboo (10-11)
1.	Cold Water solubles	3.90	5.91	7.60
2.	Hot Water solubles	9.30	7.85	8.50
3.	Alcohol-benzene solubles (1 : 2 V/V)	4.65	6.30	3.40
4.	1% NaOH solubles	24.44	33.60	26.80
5.	Lignin	16.59	20.30	24.30
6.	Pentosan	17.30	23.85	18.30
7.	Holocellulose	72.00	70.60	71.50
8.	Hemicellulose	21.20	28.45	27.60
9.	Alpha cellulose	43.21	42.00	43.50
10.	Beta cellulose	10.00	---	13.40
11.	Gamma cellulose	18.00	---	14.00
12.	Ash	6.45	3.80	2.10
13.	Acetyl content	2.05	---	2.50
14.	Methxyl content	3.06	---	3.10

Morphological Characteristics

The various morphological characteristics i.e. wood density, fibre length, fibre diameter, cellwall thickness, lumen diameter, and various derived relationship of Ipomea carnea are tabulated in Table-II.

Table-II

Morphological characteristics of Ipomea carnea Bagasse, Bamboo, Picca abies and Pinus kesiya.

Sl. No.	Particulars	Ipomea carnea	Bagasse	Bamboo	Picca abies	Pinus kesiya
1.	Density, gm/cm^3	0.29	---	0.52	---	---
2.	Fibre length. L(mm)	0.62	1.2	1.70	2.25	2.32
3.	Fibre width.D (μ)	33.18	---	23.60	41.70	40.70
4.	Lumen width.d (μ)	30.34	20.0	9.50	35.70	34.75
5.	Cellwallthickness w. (μ)	1.47	---	7.00	6.00	5.85
6.	Flexibility coefficient.d/D x 100	91.46	---	40.56	85.54	85.62
7.	Ratio of length to width.L/D	18.68	85.0	72.03	53.96	57.00
8.	Ratio of twice cellwall thickness to fiber width. 2 w/D	0.10	---	0.59	0.29	0.29
9.	Wall fraction 2 w/D x 100	8.89	---	59.30	29.00	29.00
10.	Runkel Ratio. 2 w/d	0.97	---	1.47	0.34	0.51
11.	Ratio of Wall thickness to lumen width. w/d	0.05	---	0.74	0.17	0.25

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PULPING STUDIES

For the optimisation of pulping conditions, the chips of Ipomea carnea were cooked in laboratory WEVERK rotary electrically heated digester ($0.02 m^3$ capacity), having 4 bombs of 1 liter capacity each, furnishing sufficient pulps for evaluation as well as for conducting bleaching experiments. During these studies, the technical grade chemicals were used except that of sodium sulphite, which was of analytical grade. During the course of pulping, the liquor to wood ratios of 3.5 : 1 was maintained and following time schedule for heating the digester was adopted.

Time from room temperature to 105°C
= 45 minutes.

Time from 105°C to maximum temperature
= 45 minutes.

The pulping studies were made using different ratios of sodium sulphite to sodium hydroxide, different time periods and different temperatures to know optimum pulping conditions. During cooking, the digester pressure was reduced by gas relief at 105°C. At the end of cooking, the charge was passed through a defibrator with a plate clearance of 0.15 mm, followed by a second pass at 0.10 mm, plate clearance. The pulp was screened through a laboratory flat WEVERK screen with 0.15 mm slits and the screened pulps were washed, squeesed and crumbled. The pulp yield and Kappa numbers were determined. The spent liquors were analysed for residual sulphur dioxide and pH. The results of these studies are reported in Tables-III to V.

Alkaline Sulphite - Anthraquinone Pulping

The AS-AQ pulping studies on Ipomea carnea have been done using the same process conditions, as in case of AS pulping but with the additions of small amounts of AQ i.e. (0.1% on o.d. raw

Table-III

Effect of Amount of Sodium Sulphite and Cooking Time during Alkaline Sulphite Pulping of Ipomea carnea.

Sl. No.	Chemical charge %. (on o.d. wood basis, as Na_2O) Na_2SO_3	NaOH	Time at temp 175°C (min)	Spent SO_2 (gpl)	Liquor pH	Ipomea carnea Yield (%)	Kappa (no)
			Effect of Sodium Sulphite				
1.	6.5	6.5	180	6.8	9.0	57.55	65
2.	7.5	6.5	180	7.1	9.0	56.45	58
3.	8.5	6.5	180	7.7	9.2	55.00	45
4.	9.5	6.5	180	8.0	10.4	54.21	39
5.	10.5	6.5	180	8.1	10.5	48.50	31
6.	11.5	6.5	180	8.9	10.5	47.60	29
7.	12.5	6.5	180	9.5	10.5	44.48	27
8.	6.5	6.5	210	6.4	8.9	56.30	61
9.	7.5	6.5	210	7.1	9.3	53.50	51
10.	8.5	6.5	210	7.1	9.3	52.30	41
11.	9.5	6.5	210	8.1	9.4	44.00	33
12.	10.5	6.5	210	8.4	10.3	46.00	28
13.	11.5	6.5	210	8.6	10.3	44.15	28
14.	12.5	6.5	210	9.0	10.4	41.50	24
			Effect of Cooking Time				
15.	10.5	6.5	30	10.1	10.1	69.00	86
16.	10.5	6.5	60	9.7	10.2	67.00	75
17.	10.5	6.5	90	9.5	10.3	66.00	55
18.	10.5	6.5	120	8.9	10.2	61.50	47
19.	10.5	6.5	150	8.4	10.2	56.50	38
20.	10.5	6.5	180	8.1	10.5	48.50	31
21.	10.5	6.5	210	8.4	10.3	41.00	26

Time from room temperature to 105°C = 45 minutes
Time from 105°C to 175°C = 45 minutes
Liquor to wood ratio = 3.5 : 1

Table-IV

Effect of Amount of Sodium hydroxide and Cooking Time, during Alkaline Sulphite Pulping of Ipomea carnea.

Sl. No.	Chemical charge %, (on o.d. wood basis, as Na_2O) Na_2SO_3	NaOH	Spent SO_2 (gpl)	Ipomea carnea Liquor pH	Yield (%)	Kappa (no)
1.	10.5	0.75	6.4	7.4	60.50	58
2.	10.5	1.50	6.8	8.1	59.00	57
3.	10.5	3.00	7.3	8.9	58.18	53
4.	10.5	3.50	7.6	9.4	57.50	51
5.	10.5	4.50	7.9	9.7	55.00	45
6.	10.5	5.50	8.1	9.9	52.00	40
7.	10.5	6.50	8.3	10.2	48.50	31
8.	10.5	7.00	8.4	11.1	45.12	24
9.	10.5	7.50	9.2	11.6	42.50	23
10.	10.5	8.50	9.4	12.0	36.00	21

Time from room temperature to 105°C, minutes = 45 minutes
Time from 105°C to 175°C, minutes = 45 minutes
Time at temperature, minutes = 180
Liquor to wood ratio = 3.5 : 1

Table-V

Effect of Temperature, during AS Delignification of Ipomea carnea.

Cooking Parameters:
Liquor to wood ratio = 3.5 : 1
Time at max temperature, minutes = 180
Sodium sulphite, % (as Na_2O) = 10.5
Sodium hydroxyde, % (as Na_2O) = 6.5

Particulars Plant Species	Ipomea carnea				
Maximum temp. (°C)	150	160	170	175	180
Pulp Yield, (%)	67.0	62.5	56.0	48.52	42.2
Kappa No.	68	58	54	31	28

material basis) and the results of these studies are reported in Table-VII.

Spent Liquor Characteristics

The spent liquors obtained as a result of AS pulping of Ipomea carnea were analysed for total solids, inorganics, organics, calorific value, BOD and COD as per TAPPI Standard Methods and results are reported in Table-IX.

BLEACHING STUDIES

A four stage (CEHH) bleaching sequence was applied to selected pulps of Ipomea carnea. The bleaching conditions and results are given in Table-X.

Table-VI

Strength Properties of Ipomea carnea Unbleached AS Pulps.

Plant species	Beating time (min)	Freeness (°SR)	Drainage time (sec)	Tear index (mNm²/g)	Burst index (kpam²/g)	Tensile index (Nm/g)	Folding endurance (no)	Brightness (%)
	0	15	4	0.83	3.48	23.23	8	82.5
I. carnea	14	30	13	2.49	4.92	53.48	113	82.0
	26	40	19	3.52	4.72	68.41	160	81.7
	29	45	24	3.64	3.69	68.72	175	81.5

Table-VII

Cooking Conditions and Strength Properties of Ipomea carnea AS-AQ Pulps.

Na_2CO_3 (as Na_2O, o.d. wood basis), %	= 10.8
NaOH, (as Na_2O, o.d. wood basis), %	= 6.2
AQ, (o.d. wood basis), %	= 0.10
Liquor to wood ratio	= 3.5 : 1
Time from room temp to 105°C, min.	= 45
Time at 175°C, min.	= 180
Screened pulp yield, %	= 49.21
Kappa number	= 31

Sl. No.	Beating time (min)	Freeness (°SR)	Drainage time (sec)	Tear index (mNm²/g)	Burst index (kpam²/g)	Tensile index (Nm/g)	Folding endurance (no)
1.	0	15	3	4.18	0.95	25.66	8
2.	15	30	13	5.63	3.11	58.50	125
3.	26	41	19	4.28	3.92	65.43	182
4.	30	45	23	3.97	3.94	68.21	190

Table-VIII

Comparison of Strength Properties of AS and AS-AQ Pulps of Ipomea carnea.

Process	Beating Time (Min)	Freeness (°SR)	Drainage Time (Sec)	Burst index (KPam²/g)	Tensile Index (Nm/g)	Tear Index (mNm²/g)	Folding endurance (Nos.)
	0	12	4	0.75	21.21	3.80	7
	16	30	12	3.12	49.21	6.32	135
AS	28	41	18	3.89	67.23	5.91	176
	31	45	23	3.90	69.92	3.88	176
	0	15	3	0.95	25.66	4.18	8
	15	30	13	3.11	58.50	5.63	125
AS-AQ	26	41	19	3.91	71.43	5.28	19
	30.	45	22	3.92	72.33	3.99	193

Table-IX

Alkaline Sulphite - AQ Spent liquor Characteristics at Optimum Pulping Conditions.

Sl. No.	Particulars	Ipomea carnea
1.	Black liquor solid, %	24.26
2.	Inorganics, %	29.07
3.	Organics, %	70.93
4.	Calorific value, Kcal/g	3116.00
5.	Brook field viscosity at 30°C Lv spindle no. 1 cp.	13.25
6.	pH of liquor at, 30°C	10.0
7.	0Tw at 30°C	18.92
8.	BOD, (mg/l) 5 days at 25°C	29756
9.	COD, (mg/l)	73964.2

Fibre Classification

The fibre classification studies of Ipomea carnea alkaline sulphite pulps were made with the help of Bauer-McNett fibre classifier using screens with mesh number 20, 60, 80 and 150. The results are reported in Table-XI.

Pulp Evaluation

The unbleached and bleached pulps were beaten separately in PFI mill to different freeness levels. Standard sheets of 60 gsm were made on British Sheet forming machine, pressed and dried as per IS Method (8), these sheets were conditioned at 25 - 26°C and 60 - 65% relative humidity and evaluated for various physical strength properties.

Table-X

Bleaching Results and Conditions of Ipomea carnea AS and AS-AQ Pulps.

Sl. no.	Particulars	Ipomea carnea AS	AS-AQ
1.	Unbleached pulp Kappa No.	31	31
2.	Chlorination stage (C)		
	Cl_2 applied as available Cl_2 on Pulp %	5.40	5.40
	Cl_2 consumed as available Cl_2 on Pulp %	5.37	5.35
	Final pH	1.92	1.93
3.	Extraction stage (E)		
	NaOH applied on Pulp %	2.70	2.70
	Initial pH	11.30	11.38
	Final pH	10.22	10.55
4.	Hypochlorite 1st stage (H_1)		
	Hypo added as available Cl_2 on pulp %	1.56	1.56
	Hypo consumed as available Cl_2 on pulp %	1.53	1.50
	Final pH	8.45	8.43
5.	Hypochlorite 2nd stage (H_2)		
	Hypo added as available Cl_2 on pulp %	0.78	0.78
	Hypo consumed as available Cl_2 on pulp %	0.75	0.76
	Final pH	8.15	8.20
6.	Total Cl_2 added on pulp %	7.8	7.8
7.	Total Cl_2 consumed on pulp %	7.50	7.59
8.	Bleaching losses %	10.4	10.4
9.	Pulp Yield %	46.0	46.1
10.	Brightness % (Elrepho)	81.5	82.3

Bleaching conditions	C	E	H	H
Consistency, %	3	10	9	9
Temperature, (°C)	27 ± 2	58 ± 2	45 ± 2	45 ± 2
Time (minutes)	30	120	60	120

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Table-XI

Bauer McNett Fibre Classification of Alkaline Sulphite Pulps.

Sl. No.	Mesh size	Ipomea carnea Unbleached AS Pulps
1.	+ 20	15.2
2.	− 20 + 60	46.80
3.	− 60 + 80	20.5
4.	− 80 + 150	8.2
5.	− 150	9.3

(8). The results of pulp evaluation of bleached and unbleached pulps are reported in Table - VI, VII & XII.

RESULTS AND DISCUSSIONS

The results of proximate chemical analysis shows that Ipomea carnea has got extractives and ash towards higher side in comparison to bagasse and bamboo, but low lignin content, holocellulose and alphacellulose contents are almost similar.

Microscopic studies of Ipomea carnea fibres shows that it contains scattered libriform xylem vessel having smooth walls, wider lumens and can be stained red by Herzberg stain. Comparative Microscopic examination of fibres shows that Ipomea carnea fibres are shorter in length but the fibre width and lumen width are much higher than those of bagasse and bamboo. This resembles with softwood like Pinus kesiya and Picca abies (12, 13). Flexibility coefficient, of Ipomea carnea fibres are comparable with those of tropical pine and spruce. However Runkel ratio is comparatively low. The wall thickness is very low thus giving a low wall fractions. The fibres having lower wall fractions and Runkel ratio give stronger paper. The thin walled wide lumen fibres of Ipomea carnea, collapse easily to double walled ribbon structure on delignification and exhibit plastic deformation, thus, offering more surface contact and fibre bonding (14, 15). This gives good physical strength properties and less porosity. Sheet formation of Ipomea carnea is quite good and also the rattle.

The results of pulping experiments of Ipomea carnea at constant temperature and time but varying doses of sodium sulphite, (i.e. 6.5 to 10.5% as Na_2O), (keeping the sodium hydroxide dose constant)

Table-XII

Strength Properties of Ipomea carnea Bleached AS Pulps.

Plant species	Beating time (min)	Freeness (°SR)	Drainage time (sec)	Tear index (mNm²/g)	Burst index (kpam²/g)	Tensile index (Nm/g)	Folding endurance (no)
	0	12	4	3.80	0.75	21.21	7
I. carnea	16	30	12	6.12	3.12	49.21	135
	28	41	10	5.91	3.89	67.25	176
	31	45	23	3.88	3.90	69.92	176

indicate that the amount of sodium sulphite charge has a considerable influence on the rate of pulping and give a spent liquor pH close to 10. Table III and figure 1 and 2 indicate that both the pulp yield and Kappa number show a continuously decreasing trend. The decrease in pulp yield and Kappa number is due to increasing dose of sodium sulphite, which is responsible for enhanced delignification. These figures also indicate that both the Kappa number and pulp yield decrease when cooking is extended beyond 180 minutes at 175°C, while keeping other cooking conditions constant. At maximum cooking time 210 minutes carbohydrates degradation take place, resulting in drop in pulp yield, where as kappa number practically remained constant.

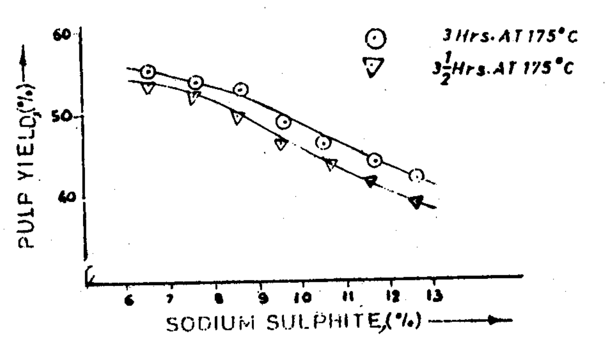


Fig.1: PLOTS OF PULP YIELD Vs SODIUM SULPHITE DOSES, (%) DURING AS PULPING.

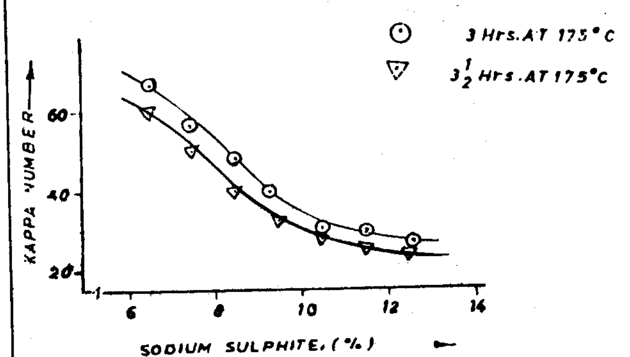


Fig.2: PLOTS OF KAPPA NUMBER Vs SODIUM SULPHITE DOSE (%) DURING AS PULPING.

In second set of experiment, conducted at constant chemical dose of 10.5% Na_2SO_3 and 6.5% NaOH, 175°C temp with varying time 60-210 minutes. The plots of pulp yield and Kappa number

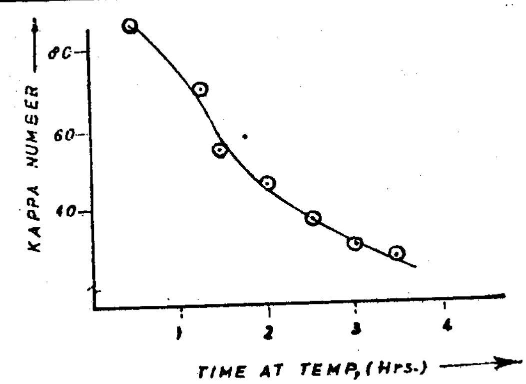


Fig.3: PLOTS OF KAPPA NUMBER Vs TIME AT TEMP (Hrs.) DURING AS PULPING.

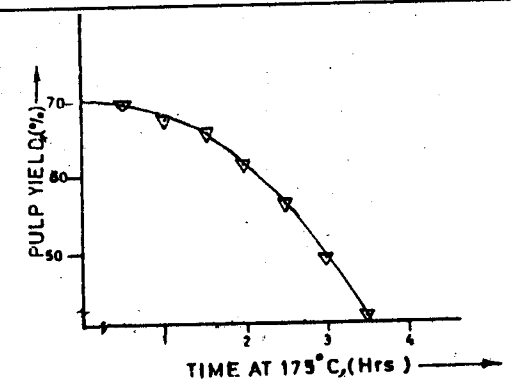


Fig.4: PLOTS OF COOKING TIME Vs PULP YIELD DURING AS PULPING.

Vs time at temperature (Fig. 3 and 4), indicate that the rate of cooking is found to be comparatively low in early stage of cooking and it increase steadily on increasing the time of cooking at 175°C. This also indicates that the cooking beyond 180 minutes affects adversely the carbohydrates contents.

Another set of experiment conducted with varying dose of NaOH (as Na_2O), keeping the dose of Na_2SO_3 constant (Table IV and figure 5 & 6)

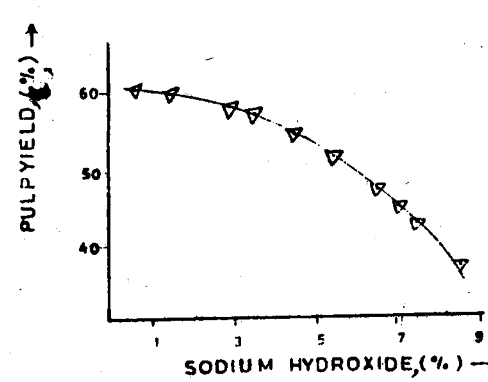
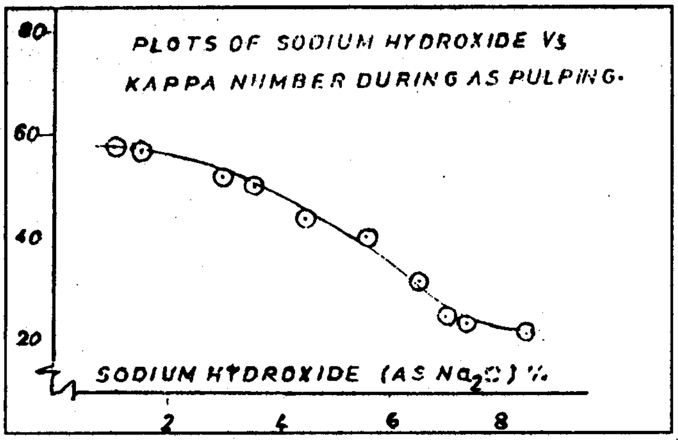


Fig.5: PLOTS OF KAPPA NUMBER Vs TIME AT TEMP (Hrs.) DURING AS PULPING.



indicate that the rate of delignification reaction shows an indirectly proportional relationship with both the pulp yield and Kappa number. On increasing the caustic soda charge from 0.75% to 8.5% (keeping the sodium sulphite dose constant at 6.5% as Na_2O) the Kappa number decrease from 58 to 21 and the pulp yield decreased from 65% to 36%. Figures 5 and 6 clearly indicate that there is a sharp decrease in pulp yield and Kappa number beyond an alkali dose of 6.5%. The sharp decrease in pulp yield and Kappa number or high rate of delignification is undoubtedly due to the high alkali concentration in the cooking liquors.

The results of experiments conducted at optimum level of cooking parameters except temperature which was varied from 150 to 180 °C (Table V and figure 7) clearly indicate that the rate of drop in

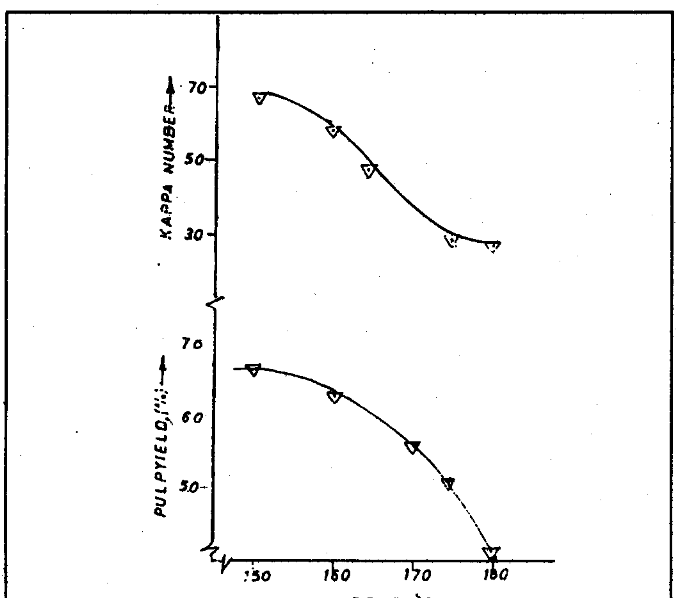


Fig.7: PLOTS OF PULP YIELD AND KAPPA NUMBER Vs TEMP (°C) AT TIME FOR MAX.TEMP 3HRS. DURING AS PULPING.

Kappa number increases with increase in temperature and the magnitude of this decrease is found to be maximum around a temperature of 175°C.

Similarly the pulp yield also shows a continuously decreasing trend with temperature but again the magnitude of decrease in pulp yield is found to be maximum beyond 175°C. Therefore based on cooking experiments, it can be concluded that a temperature of 175°C could be considered as optimum temperature for getting better results.

The tearing strength of Ipomea carnea AS pulps shows an improvement over the tearing strength of Soda, Kraft, Alkali oxygen and Alkali peroxide pulps of Ipomea carnea (1). The tearing strength of Ipomea carnea pulp decreases with increasing Kappa number, while burst index and tensile index remain constant within the range of Kappa number 21 up to 70. Burst index and tensile index tend to increase with increasing Kappa number from 26 to 31 and then decrease (Table VI).

The addition of a small amount of AQ (0.1%) during alkaline sulphite pulping of Ipomea carnea (Table VII) shows a significant influence both on pulping characteristics and on the overall strength properties of these pulps. A same level of Kappa number is achieved in alkaline sulphite anthraquinone pulping of Ipomea carnea at the same temperature and chemical charge with a substantial reduction in time at temperature. The AS-AQ pulps shows good response towards bleaching and produce much brighter pulps than alkaline sulphite pulps. As can be seen from (Table VIII), the tensile, tear and burst are slightly better in AS-AQ pulp, when compared to AS pulps.

The results of AS-AQ spent liquor analysis obtained from Ipomea carnea under the optimum condition is given in Table-IX. The calorific value of spent liquor is little higher due to the presence of high solid contents. The silica content in the spent liquor is found to be very low. The less silica content and higher calorific value has its own advantages in chemicals recovery process. The values of Biochemical oxygen demand and chemical oxygen demand of Ipomea carnea spent liquor are lower in comparison to BOD and COD values of spent liquor of other pulping process of Ipomea carnea (1).

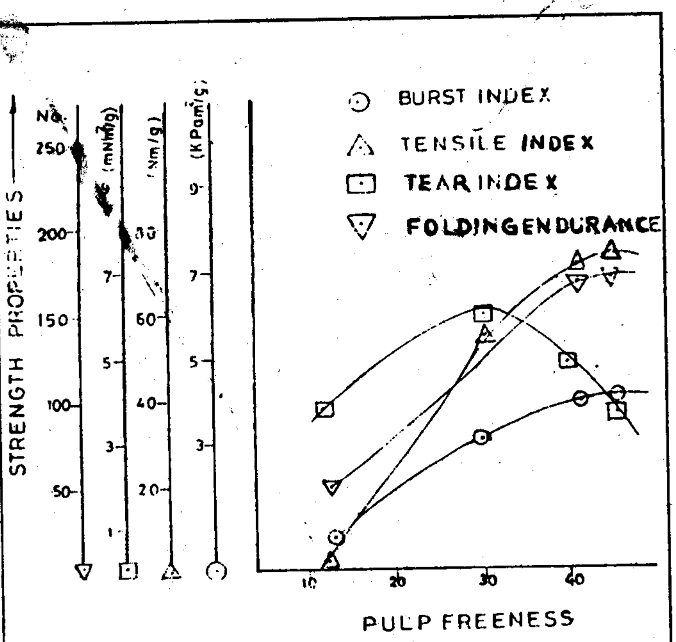


Fig.8: PLOTS OF STRENGTH PROPERTIES Vs FREENESS (°SR) DURING AS PULPING.

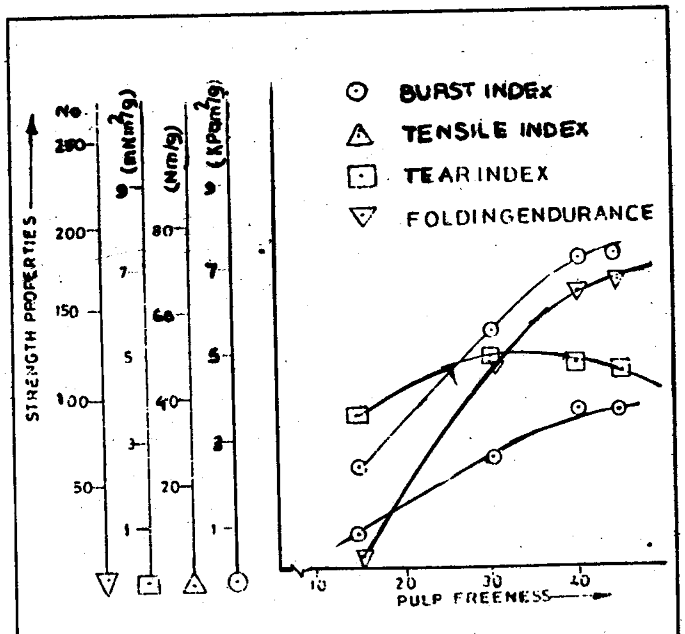


Fig.9: PLOTS OF STRENGTH PROPERTIES Vs FREENESS OF BLEACHED AS PULPS.

The Ipomea carnea alkaline sulphite pulps shows good response towards bleaching. Ipomea carnea shows lower value for opacity with a brightness level of about 81.5% (Elrepho). The brightness increased to 82.3% (Elrepho) in case of AS-AQ pulps bleached in CEHH sequence. The unbleached pulps also possessed a comparatively higher level of brightness, due to the high initial brightness, the total chlorine consumption is low during bleaching of and Ipomea carnea AS and AS-AQ pulps. (Table-X).

The pulps of different Kappa number were beaten to different °SR levels. The physical strength properties of unbleached and bleached Ipomea carnea AS pulps are reported in Table XII to XIII and figure 8 and 9. The freeness of unbeaten pulps are 15-16°SR. The plots of pulps freeness versus various physical strength properties of Ipomea carnea unbleached and bleached AS pulps were shown in figure 8 and 9 respectively. The plots clearly indicate that maximum strength properties of both unbleached and bleached pulps at optimum pulping condition are obtained at a freeness of 41±1°SR.

CONCLUSION

The long digestion time required for alkaline sulphite pulping of Ipomea carnea pulps can be reduced by increasing the alkalinity of cooking liquors to a pH level of 10 or above and still produce pulp superior to kraft. With increased alkalinity, the rate of delignification also increased and approached to that of kraft. The selectivity at moderate alkalinity was slight superior to, and at high alkalinity was equal to that of kraft. The proportion of sodium hydroxide greatly influenced the rate of delignification during alkaline sulphite pulping. The unbleached and bleached AS pulps of Ipomea carnea showed good strength properties, especially burst and tensile. The tear is largely governed by the alkalinity of the cooking liquor and reaching a maximum at a terminal pH of 9 to 11. AS pulps delignified much more readily than kraft pulps with conventional bleaching sequences.

The results of present investigations demonstrates advantage of alkaline sulphite process over kraft process. It has produced increased pulp yield, higher pulp strength, higher brightness besides lower fuels and power consumption. It provides a simplified and more economical pulping process with little odor as an alternative to kraft process.

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REFERENCES

1. Dutt, Dharm, Pulping studies of Cannabis stiva and Ipomea carnea, Ph.D. Thesis, Institute of Paper Technology (University of Roorkee) Saharanpur, 1994.
2. Tiwary K.N. etal. "non-wood plant fibre pulping progress repot No. 13 p 105-109.
3. Ingruber O.V. Paper presented at the CPPAITS annual meeting Montreal Que Jan 1980.
4. Ingruber O.V. Pulp and Paper Manufacture 3rd eddition Vol. 4, Sulphite Science and Technology, The text book committee of paper industry 1985 p 42-43.
5. Upadhyaya J.S., Dutt Dharm IPPTA Vol. 1 No. 1, March 1989.
6. Macleod J.M. and Fleming B.I. Tappi 66 (2) 81-82 1983.
7. Ingruber O.V. AICHE symposium series 200, New process alternative in the first industries 76 196-208, 1980.
8. IS: 6213 (part x)-1975 IS: 6213 (part IV)-1971 IS: 6213 (part viii)-1973 IS: 1060 (part I)-1966.
9. Biswas B.A. IPPTA Vol. 7 Conference No. 14-20 1970.
10. Krishnagopalan A., Kutsch N.P. & Simand G.L. IPPTA 12(1) 9-19 (1975).
11. Upadhyaya J.S., Singh Sunder Pal, Dutt Dharm and Gupta Geeta Research & Industry Vol. 36 Sept 1991 174-183.
12. Rao F.G. etal IPPTA xv (3): 65 1978.
13. Rydholm S.A. "Pulping Process" Interscience New York 1967 p 51.
14. Ref 13 p 1156.
15. Ref 13 p 53.