Pulping and Papermaking Characteristics of North Kanara Bamboos

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This paper deals with a study of the varieties of bamboos obtained in the forests of North Kanara district in Karnataka. Aspects covered are forestry, physical and chemical properties, fibre morphology, pulping, bleaching and papermaking characteristics.

Bambusa arundinacea (Dowga) constituting about 50% of the total bamboo resources in North Kanara is found to be the best from the point of view of yield, alkali demand, strength properties of pulp and even for transportation and the longest flowering cycle. Next in order of preference is Dendrocalamus strictus (Medar). The resources of other varieties are very limited making the above two varieties the main-stay for paper industry in this region.

Dowga has distinct edge over Medar, with its long flowering cycle, per acre yield, lower alkali demand in pulping, higher pulp yield, fibre morphology and pulp properties. It is indicated that more area be brought under this variety. However, in the existing situation for optimum utilisation of the bamboo resources, a 50 : 50 blend of the two is suggested.

Introduction

Three varieties of bamboo chiefly found in the forests of North Kanara in Karnataka State, are *Bambusa arundinacia* (Dowga), *Dendrocalamus strictus* (Medar) and *Oxytenanthra monostigma* (Chiva). Their forestry data of availability and cycle are given in Table No. I. These varieties constiute the major raw material for the West Coast Paper Mills Ltd. for pulp and papermaking. The quality and various characteristics of the paper produced are greatly governed by the variety of bamboo and pulping process adopted[1]. With the growing shortage of bamboo it becomes necessary to optimise the utilization of the available bamboo resources. As a part of the efforts towards this end a study, in detail, covering the physical, chemical and morphological aspects and pulping and papermaking properties of these bamboo varieties was undertaken.

TABLE-No. I

Forestry Data About Various Bamboos

	Particulars	Medar	Dowga	Chiva
1)	Yield/acre/year, Tonne	0.3	0.6	0.1
2)	Flowering period, years	25–30	40–45	15–20
3)	Cutting rotation, year	3	3	3
4)	Number of bamboos per tonne 10 Ft. length	600–800	200–300	1000–1200
5)	Availability, % (North Kanara)	60	30	10
6)	Approx. tonnes of bamboo carried on truck	4.0	4.7	4.5

N.B.—(a) These data were taken from the Forest Dept., W.C.P.M. Ltd., Dandeli.

(b) *Bambusa vulgaris* (2 years old) was obtained from Nursery. Relevant data were not available.

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The above three varieties of bamboo were collected in sound (fresh) condition from the mill yard. A fourth variety *Bambusa vulgaris* (Golden bamboo or Decorative bamboo), was collected from nursery of the West Coast Paper Mills for this project. Although this variety is not found significantly in North Kanara, it is reported to be the most widely grown bamboo in Orient[2].

Experimental

The bamboos were chipped separately in the mill chippers. The chips size classification was done on Williams laboratory chips classifier. Green volume density and bulk density of chips were carried out. The results are recorded in Table No. II.

Water absorption capacity of chips

For studying the water absorption capacity of chips, the chips were soaked in water individually. The amount of water absorbed by the chips was determined after 8 hours, 16 hours and then 1 to 7 days, by determining the increase in weight. A graph of percent increase in weight was plotted against time in (days) of soaking. (Fig. No. 1).

Proximate Chemical Analysis

Representative chip samples, of all bamboos were powdered individually, in laboratory Willey Mill, to pass through 60 mesh. These powders were taken for proximate chemical analysis. The analysis were carried out by 'TAPPI Standard Methods'. The results are recorded in Table No. III.

TABLE II.

Chips	% Chips retained			
Mesh size, mm	Medar	Dowga	Chiva	Vulgaris
+32	3.5	5 5	1.5	7.4
—32+25	11.4	12.2	9.6	15.5
—25+22	7.4	7.8	10 5	9.3
—22+19	11.9	11.5	17.5	12.8
—19+16	18 6	16.2	18.5	16.6
—16+13	22.3	16.9	16.5	15.5
—13+ 6	22.5	23.6	21.0	20.2
— 6+ 3	1.3	4.0	2.8	1.9
— 3	1.1	2.3	2.1	0.8
Bulk density of chips at 10% moisture, Kg/m³	250	205	238	248
Green volume density, g/cc.	0.59	0.45	0.47	0.52

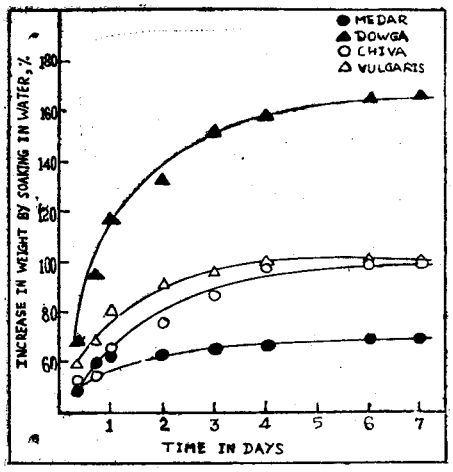

Fig. No. 1

TABLE III

Proximate Chemical Analysis of Different Bamboos

Sample details Particulars	Medar	Dowga	Chiva	Vulgaris
1 Cold water solubility,	10.5	6.3	4.0	7.6
2 Hot water solubility	13.7	6.5	4.9	8.5
3 1.0 % NaOH solubility,	31.0	24.9	25.4	26 8
4 Alcohol–Benzene solubility,	4.7	5.5	2.9	3.4
5 Holocellulose*	64.5	68.8	72.0	71.5
6 Alpha–cellulase,	41 1	43.5	45.6	43.5
7 Beta–cellulose,	6.8	11.3	8.9	9.9
8 Gamma–cellulose,	11.4	10.2	14.2	14.0
9 Pentosans,	15.2	17.2	17.5	18.3
10 Lignin Klason,	25.0	24.6	27.5	24.3
11 Ash contents,	3.2	2.7	3.9	2.1

*Holocellulose determined by 5 treatments of sodium chlorite and uncorrected for ash and residual lignin.

All results are reported on 100 g O.D. Bamboo basis.

TABLE-IV

PULPING OF DIFFERENT BAMBOOS

Particulars	Sample / COOK No.						
	Medar	Dowga	Chiva	Vulgaris	Dowga	Chiva	Vulgaris
Chemical as such* on pulp, %	19.0	19.0	19.0	19.0	17.5	18.0	16.0
Bath ratio (Liquor : Chip)	2.5:1	2.5:1	2.5:1	2.5:1	2.5:1	2.5:1	2.5:1
Black Liquor :							
pH	10.5	11.1	10.5	10.5	10.6	10.7	10.6
T.D.S., gpl	245	200	226	239	190	217	219
R.A.A. as Na_2O, gpl	8.8	9.3	10.1	10.8	7.3	9.6	7.0
A.A. consumed on chips, %	16.1	16.2	15.7	15.6	15.2	14.9	13.3
Pulp :							
Screened yield on chips, %	49.3	53.5	51.2	49.5	53.3	52.2	50.0
Rejects on chips, %	1.4	0.9	1.1	0.9	1.3	1.3	2.1
Kappa No.	34.7	24.6	27.3	21.1	33.5	34.6	32.2

Cooking schedule for all cooks :

70°C to 12°C., Min. = 45

At 120°C., Min. = 45

120°C to 165°C., Min. = 45

At 165°C., Min. = 45

'H' Factor = 590

*White liquor sulphidity, % =18.5

Pulping

Laboratory pulping experiments were carried out in a digester, with 19.0% active alkali as such on chips (14.6% as Na_2O). For subsequent pulping active alkali was varied to get Kappa Number in range of 34 ± 2, under constant pulping conditions of 'H' factor etc. The pulping data are recorded in Table No. IV.

Bleaching of pulps

All the unbleached pulps (Kappa No. 34 ± 2) were individually bleached by using CEHH sequence to get final brightness of about 80% (Elrepho). The results of bleaching experiments are recorded in Table No. V.

Fibre Morphology

The fibre morphology of the bamboo varieties was studied. The morphological data are recorded in Table No. VI.

Physical strength properties of pulps

The physical strength characteristics of unbleached and bleached pulps were determined after beating. The pulps to different slowness levels in Laboratory Valley Beater and making standard sheets (60 ± 1 gsm) on British Sheetmaking Machine. The results are recorded in Table Nos. VII to X.

OBSERVATION AND DISCUSSION

Forestry data on various bamboos

Table No. I shows that although the acrage of *Dowga* bamboo in the region is only 30% which is

Table No. V

Bleaching of Bamboo Pulps With CEHH Sequence

Particulars	Medar	Dowga	Chiva	Vulgaris
Kappa No. of unbleached pulp	34.7	33.5	34.6	32.0
Chlorination Stage				
Cl_2 added on pulp, %	9.50	9.50	9.50	9.00
Cl_2 consumed on pulp, %	8.60	8.30	8.60	7.80
Final pH	1.5	1.7	2.1	2.5
Alkali Extraction Stage				
NaOH added on pulp, %	2.2	2.2	2.2	1.9
Final pH	9.8	10.6	10.6	9.8
Hypo I Stage				
Cl_2 added on pulp as hypo, %	2.50	2.50	2.50	2.50
Cl_2 consumed on pulp, %	1.99	1.66	1.67	2.09
Final pH	7.6	7.8	7.7	7.6
Hypo II Stage				
Cl_2 added on pulp as hypo, %	0.75	0.75	1.00	0.50
Cl_2 consumed on pulp, %	0.31	0.24	0.39	0.36
Final pH	7.0	7.1	7.1	7.0
Total Cl_2 added on pulp, %	12.75	12.75	13.00	12.00
Total Cl_2 consumed on pulp, %	10.90	10.20	10.66	10.25
Brightness, %	79.3	79.1	79.2	81.4
Shrinkage, %	11.0	10.0	8.8	10.0
Viscosity, cp (CED)	14.2	15.1	16.6	16.3

Constant Conditions For Bleaching

	C	E	H	H
Temperature, °C. ± 1	30	55	45	45
Retention time, Min.	60	60	60	90
Consistency, %	3	5	5	5
Sulfamic acid on Cl_2 added, %	—	—	2.0	5.0

Table No. VI

Fibre Morphology of Different Bamboos

Bleached pulp of Bamboos	Average fibre length, mm	Average fibre diameter,/μ
Medar	1.60	16.0
Dowga	1.72	15.4
Chiva	1.62	16.4
Vulgaris	1.75	17.3

half of *Medar* bamboo, the yield per acre per year is 0.6 tonne which is highest and twice that from *Medar*. Also the number of *Dowga* of 10 ft. length per tonne is only 200–300, which is lowest as compared to 600–800 of *Medar*. The tonnage per truck is maximum, in case of *Dowga* which has important bearing on transport costs. The flowering period of *Dowga* is 40–45 years, which is significant, as compared to other varieties. The problem of gregarious flowering of bamboos in North Kanara area and the steps to counter it have been disscussed in a paper[3].

Physical characteristics

Table No. 11 shows that, the bulk density of *Dowga* was found to be comparatively lighter. *Dowga* variety was found to possess the highest water absorption capacity while *Medar* had the lowest absorption capacity. Water absorption capacity of the chips has an important bearing on liquor penetration. The difference in liquor penetration in chips of different raw materials are due to the differences in anatomical structure of the raw materials[4]. Ideally for a uniformly cooked pulp, each fibre should receive the same chemical treatment for the same length of time at the same temperature[5].

Proximate chemical analysis

Cold water, hot water and 1% NaOH solubilities in case of *Medar* were found to be maximum. Holocellulose contents in case of *Medar* was found to be

Table No. VII

Strength Characteristics of Unbleached and Bleached Medar Pulp

Particulars	Unbleached				Bleached			
Beating time, Min.	0	5	12	18	0	5	12	18
Slowness, °SR	17	21	30	41	16	21	34	42
Drainage time (SR), Sec.	4	8	20	36	4	9	29	41
Bulk, cc/g.	2.37	2.11	2.00	1.89	2.01	1.80	1.63	1.50
Breaking length, km.	3.30	4.60	6.00	6.60	3.92	5.84	7.14	8.13
Stretch, %	1.3	1.9	3.2	3.4	2.0	2.6	3.0	3.5
T.E.A., J/m²	16	29	60	70	29	50	76	100
Double folds, MIT	8	142	500	570	16	187	490	685
Tear factor	206	239	190	202	278	207	161	141
Burst factor	15.4	24.8	41.0	47.3	19.6	36.7	47.0	55.0
Bendtsen Porosity, ml/min.	>3000	>3000	2600	1000	>3000	2700	530	130
Wet web strength, metres	—	—	32.5	45.8	—	—	44.3	61.0

Table No. VIII

Strength Characteristics of Unbleached and Bleached Dowga Pulp

Particulars	Unbleached				Bleached			
Beating time, Min.	0	5	12	18	0	5	12	16
Slowness, °SR	16	21	34	48	17	24	38	46
Drainage time (SR), Sec.	4	9	26	48	5	13	33	45
Bulk, cc/g.	2.36	2.11	1.88	1.70	2.05	1.79	1.61	1.51
Breaking length, km	4.00	6.00	7.00	7.50	4.37	6.48	7.00	8.05
Stretch, %	1.6	2.2	3.0	3.5	2.0	2.7	3.0	3.4
T.E.A., J/m²	19	46	70	78	28	57	70	85
Double folds, MIT	21	220	550	700	28	210	430	560
Tear factor	173	198	180	157	228	158	124	117
Burst factor	17.0	35.0	44.0	50.0	21.8	41.7	56.6	62.0
Bendtsen Porosity, ml/min.	>3000	>3000	1300	330	>3000	2100	350	95
Wet web strength, metres	—	—	35.8	49.5	—	—	47.5	54.5

minimum i e., 64.5%. Lignin content was nearly same in all the varieties, except in case of chiva which was little higher. Ash content in the case of *chiva* which was a little higher. Ash conten in the case of *chiva* was found to be maximum.

Pulping characteristics

Under the constant pulping condition of 19.0% (as such). Active alkali (14.61% as Na_2O), 1 : 2.5 bath ratio and 'H' factor of 590, the screened pulp yield from the four varieties of bamboo in the descending order was—*Dowga* (53.5%), *Chiva* (51.2%), *Vulgaris* (49.5%) and *Medar* (49.3%) while rejects were— *Medar* (1.4%), *Chiva* (1.1%), *Dowga* (0.9%) and *Vulgaris* (0.9%). Kappa Number obtained were—*Medar* (34.7), *Chiva* (27.8), *Dowga* (24.6) and *Vulgaris* (21.1).

These data indicate that *Medar* while giving lowest pulp yield has highest chemical demand as it gives high Kappa Number pulp and *Dowga* while giving highest pulp yield has the lowest chemical demand. The other two varities fall in between *Medar* and *Dowga. Chiva* is perferable for pulp yield and *Vulgaris* for lower chemical demand.

Bleaching of the pulps

The chlorine demand for getting about 80% brightness was found to be nearly the same except for *Dowga* where it was lowest. The viscosities of the bleached pulps were in the range of 14–16 cp (CED). The pulp shrinkage for

Table No. IX

Strength Characteristics of Unbleached & Bleached Chiva Pulp

Particulars	Unbleached				Bleached			
Beating time, Min.	0	6	15	19	0	5	11	15
Slowness, °SR	16	20	36	45	17	24	36	46
Drainage time (SR), Sec.	4	7	26	47	5	11	28	48
Bulk, cc/g.	2.61	2.26	1.92	1.87	2.20	1.86	1.73	1.60
Breaking length Km.	2.40	4.12	5.70	6.07	2.71	4.50	5.71	6.25
Stretch, %	1.2	2.1	3.1	3.5	1.6	2.7	3.2	3.6
T.E.A., J/m^2	10	33	74	83	20	45	70	87
Double folds, MIT	8	35	354	1052	17	112	609	1475
Tear factor	189	252	227	211	204	218	173	153
Burst factor	13.1	22.4	38.4	44.0	18.8	35.2	48.0	54 5
Bendtsen Porosity, ml/min.	>3000	>3000	1800	650	>3000	2750	650	175
Wet web strength, metres	—	—	37.0	43.0	—	—	44.5	58 5

Table No. X

Strength Characteristics of Unbleached & Bleached Vulgaris Pulp

Particulars	Unbleached				Bleached			
Beating time, Min.	0	5	11	15	0	5	11	15
Slowness, °SR	17	23	35	46	17	24	37	50
Drainage time, (SR) Sec.	5	9	26	45	5	11	29	56
Bulk, cc/g.	2.44	2.19	2.00	1.88	2.09	1.84	1.70	1.60
Breaking length km.	2.34	3.72	4.77	5.17	2.58	4.54	5.20	5.95
Stretch, %	1.2	1.8	2.4	3.0	1.5	2.3	2.9	3.4
T.E A., J/m^2	10	24	40	48	13	38	53	71
Double folds, MIT	14	69	440	1000	16	192	709	1145
Tear factor	206	224	215	203	242	204	160	153
Burst factor	15.0	26.0	38.0	42.0	16.8	32.0	44.2	52.1
Bendtsen Porosity, ml/min.	>3000	>3000	2000	870	>3000	2700	760	200
Wet web strength, metres	—	—	32.6	40.5	—	—	41.0	49.5

Medar pulp was found to be maximum i.e. 11.0% while that for *Chiva* was found to be minimum i.e. 8.8%.

Fibre morphology

Average fibre length was maximum in the case of *Vulgaris* (1.5 mm) next in descending order were *Dowga* (1.72 mm), *Chiva* (1.62 mm) and *Medar* (1.60 mm). Maximum fibre diameter was found in *Vulgaris* 17.3 μ) while in *Chiva* (16.5 μ), *Medar* (16.0 μ) and *Dowga* (15.4 μ) has lower fibre diameter.

Strength properties of unbleached and bleached pulps

Beatability is one of the important characteristics of pulp and has a bearing on the energy requirement and power economics. This is also an index of the response of pulp to the beating action and subsequent strength development[6].

From Table No. XI it is seen that to obtain 35° SR freeness *Chiva* has required highest beating time (14 min.) followed by *Medar* (13 min.), *Dowga* (12 min.) and *Vulgaris* (11 min.), which indicates that *Chiva* requires more power and is slow in response to beating compared to other varieties of bamboo.

Bulk is another important fundamental properties of paper. *Vulgaris* has highest bulk followed by *Chiva*, *Medar* and *Dowga* at 35° SR. Bulk has a direct bearing on some of the properties of paper such as compressibility, porosity, etc. The porosity of *Vulgaris* with high bulk was 2000 ml/min. as against 1100 ml/min. per *Dowga* with low bulk with reference to burst factor, *Dowga* has highest value (45.0) followed by *Medar* (44.0), *Vulgaris* (38.0) and *Chiva* (37 5). In respect to folding endurance the same order as burst is seen.

The beating time required by the bleached pulps for getting 35°SR are—*Medar* (13 min.), *Dowga* (11 min.), *Chiva* and *Vulgaris* (10 min. each).

The bulk of handsheets of bleached pulp at 35°SR are in descending order—*Chiva* (1.76). *Vulgaris* (1.75), *Dowga* (1.67) and *Medar* (1.61). Porosity of *Vulgaris* pulpsheet is highest (800 ml/min.) and lowest for *Dowga* (420 ml/min.). *Dowga* has highest burst factor (53) followed by *Medar* (48), *Chiva* (46) and *Vulgaris* (42). *Medar* and *Dowga* have higher breaking length than *Chiva* and *Vulgaris*. For all these pulps tear factor reduces on beating which is the characteristics of long fibred pulps[7].

Conclusions :

From forestry data it is observed that--

(a) The yield of *Dowga* per acre per year is 0.6 Tonne which is highest and twice of *Medar*.

(b) The flowering period of *Dowga* is 40–45 years which is significant from the point of availability.

Table No. XI

Strength Properties of Unbleached and Bleached Pulps At 35° SR

Particulars	Unbleached				Bleached			
	Medar	Dowga	Chiva	Vulgaris	Medar	Dowga	Chiva	Vulgaris
Beating time, Min.	13	12	14	11	13	11	10	10
Drainage time, Sec.	26	28	26	26	30	29	27	27
Bulk, cc/g.	1.94	1.87	1.95	2.00	1.61	1.67	1.76	1.75
Breaking length, km	6.30	6.90	5.60	4.77	7.20	7.00	5.70	5.10
Stretch, %	3.2	3.0	3.0	2.4	3.0	3.0	3.2	2.8
T.E.A., J/m²	60	68	70	40	76	65	70	47
Double folds, MIT	500	550	325	440	520	390	580	650
Tear factor	195	175	232	215	155	135	178	170
Burst factor	44.0	45.0	37.5	38.0	48.0	53.0	46.5	42.0
Bendtsen Porosity, ml/min.	2000	1100	1900	2000	500	420	700	800

The study on the pulping and papermaking properties of these bamboos reveals that—

Dowga has the highest water absorption capacity while *Medar* has the lowest and that indicates its easy pulping.

Medar is found to have lowest holocellulose content while *Chiva* has the maximum.

With the same pulping conditions, the pulp yield of *Dowga* is the maximum while that of *Medar* is lowest. Medar pulp also has highest Kappa Number, indicating higher alkali demand. For getting the pulp in the Kappa Number range of 32–34, the *Vulgaris* required comparatively minimum chemical next to that *Dowga*.

Dowga unbleached and bleached pulps were found to possess comparatively higher breaking length. burst factor and wet web strength.

From the above study, it is indicated that *Bambusa arundinacea* (Dowga) is the best variety among these bamboos and therefore efforts should be made to develop more areas under this variety. However, under the situation obtained for best utilisation of the two major varieties i.e. Dowga and Medar; a 50 : 50 blend is rccommended

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