Gmelina Arborea (Gamari) Pulping Alone And Mixed With Bamboo

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SUMMARY

This paper deals with the pulping studies of *Gmelina arborea* stem from *Gmelina arborea* tree planted nine years ago on experimental basis in the nursery. The growth was poor when we compare with the growth of *Gmelina arborea* at Brazil due to suitability of soil and favourable climatic conditions.

Aspects covered are chips classification, physical & chemical properties, fibre morphology, pulping and bleaching studies. *Gmelina arborea* is a medium density wood, gives no trouble during chipping operation. The chemical requirement of this wood for pulping was not high. The pulping conditions, utilised for mixed bamboo pulping were also used for *Gmelina arborea*. The yield and strength properties of unbleached *Gmelina arborea* pulps and mixed bamboo pulps were quite satisfactory. The unbleached pulps were bleached under optimum Chlorine demand. The bleach consumption of bamboo was found higher than *Gmelina arborea* pulps. The strength properties of unbleached pulps increased after bleaching.

INTRODUCTION

The conventional raw materials for pulp and paper industry in India is chiefly Bamboo, belonging to grass family. As the paper industry progressed more and more the shortage of this important raw material was felt. Naturally the paper industry had to go for other raw materials like hard woods, agricultural residues i.e. straws, bagasse etc. along with bamboo to make up the shortages. There are certain mills which use agricultural residues, but for a large paper mill which is mainly based on bamboo, the agricultural residues can not be a solution because of the process difficulties. The solution was to use the local hardwoods to the maximum possible extent.

A few paper mills in India have tried to raise own plantations on experimental basis. Orient Paper Mills, Amlai is one of the leading paper mills in India to have raised *Eucalyptus hybrid*, *Acacia auticuliformis*, *Sesbania grandiflora* and *Dendro calmus strictus* plantations over an area of about 600 acres at Amlai. Birla Institute of Scientific Research, Amlai has also raised Eucalyptus hybrid plantations along with indegenous as well as exotic tropical pines over an area of 1100 acres in Amarkantak region. *Gmelina arborea* (Gamari) was planted in the Orient Paper Mill's nursery on a trial basis in July 1971. Three *Gmelina arborea* trees which had attained average girth 18-20 inches and a height of 8 meters were felled during the month of October 1979 for carrying out laboratory pulping studies.

Gmelina arborea is a native tree of Burma and India but is not a particularly strong species in the native region, it occurs sparsely due to competition from other local species. This tree has been planted in several African countries but most successfully in Amazon Basin of Brazil where *Gmelina arborea* and pine are the two main species in the man made forest of 90,000 hectares for bleached kraft pulp. The growth rate of *Gmelina arborea* as estimated in Brazil was 25-30 solid m^3/ha/year was quite surprising. In India *Gmelina arborea* plantations were raised in West Bengal and Assam but the growth rate is not as good as in Amazon Basin due to climatic conditions.

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EXPERIMENTAL

Three *Gmelina arborea* trees were cut from the mill nursery. The tops and lops were removed. The debarking of the stems was carried out manually. The debarked logs were cut into two pieces and then chipped in K.M.W. mill chipper. The chips were classified on a William's chips classifier. The specific gravity and bulk density of the chips were carried out. The results are recorded in Table-1.

TABLE—1 CHIPS CLASSIFICATION OF G. arborea

Mesh size	=	% chips retained
+ 29 m.m.	=	12.0
— 29 + 22 m.m.	=	12.0
— 22 + 16 m.m.	=	18.9
— 16 + 10 m.m.	=	30.5
— 10 + 5 m.m.	=	21.5
— 5 m.m.	=	3.1
Bulk density of chips Kg/m³ (OD basis)	=	172.21
Specific gravity g/c.c.	=	0.42

PROXIMATE CHEMICAL ANALYSIS 150 g *Gmelina arborea* chips of +5 m.m. size were powdered in a Raymond mini mill. The dust retained on —40, +60 mesh was taken for proximate chemical analysis. The analysis of the dust was carried out by Tappi Standard methods. The results are given in Table-2.

TABLE—2 PROXIMATE CHEMICAL ANALYSIS OF G. arborea

1. Cold water solubility (%)	=	4.390
2. Hot water solubility (%)	=	5.994
3. 1% NaOH solubility (%)	=	17.830
4. Alc/Benzene solubility (%)	=	5.057
5. Holocellulose (%)	=	69.618
6. Pentosan content (%)	=	15.615
7. Lignin content (%)	=	26.59
8. Ash (%)	=	3.601
9. Silica (%)	=	1.57

PULPING : Pulping experiments were conducted in a pilot digester with *G. arborea* chips using 15% and 17% active alkali as Na_2O under idential cooking conditions, pulping experiments with 50%, 75% and 100% bamboo were also carried out using 15% chemicals as Na_2O. Cooking conditions and results are given in Table-3.

BLEACHING OF PULPS : Optimum chlorine demand for each unbleached pulp was found out (i.e. about 96% chlorine consumption) in chlorination stage. The chlorinated pulps were alkali extracted in the second stage and K.Nos (40 ml) were determined (Table-5) Finally the unbleached pulps were bleached under optimum conditions using C-E-H sequence to get 77-78% P.V. brightness. The results of bleaching experiments are given in Table-6.

FIBRE MORPHOLOGY:—The fibre characteristics of *G. arborea* pulp were studied under a laboratory microscope. The results are given as follows :

Fibre length (m.m.)	Gmelina arborea (Gamari)
(i) Maximum	1.430
(ii) Average	0.976
(iii) Minimum	0.585
Fibre diameter (m.m.)	
(i) Maximum	0.0318
(ii) Average	0.0224
(iii) Minimum	0.0144

Tfie average slenderness ratio (L/D) of G. Arborea is 43.5.

PHYSICAL STRENGTH PROPERTIES OF PULPS:—The physical strength characteristics of unbleached and bleached pulps were determined after beating the pulps to different slowness (SR°) levels in a laboratory valley beater and making standard sheets (60±2 g.s.m.) on a British Sheet Making Machine. The sheets were pressed, dried and air conditioned (temp=25°C and relative humidity 60%) before determining the strength properties. The unbleached and bleached pulp strength properties are given in Table-4 and 7 respectively.

RESULTS & DISCUSSIONS

Gmelina arborea has manifold uses[2]. It regrows from stumps like Eucalyptus. The growth rate of G. Arborea[2] is fast i.e. 4 rings per inch of radius. So more trees should be planted in Assam and Bengal where climatic conditions are comparatively favourable.

G. arborea logs were chipped in a K.M.W. chipper. The logs do not give trouble during the chipping operation.

The chips were classified in a laboratory William Chips classifier. The chips +22 m.m. and above fraction and —5 m m. fraction were taken as rejected (29.0%). The acceptable chips taken for pulping studies were 70.9% (Table-1). The oversized chips percentage was high and will require severe

pulping conditions. The more surface area of chips is exposed to the pulping conditions the better would be the quality of the pulp.

The bulk density of chips was 172.21 Kg/m^3 and specific gravity 0.42 g/c.c. shows that *G. arborea* is a medium density wood.

The proximate chemical analysis of *G. arborea* shows that the ash and silica percentage were 3.601 and 157% respectively, which are on a higher side.

Screened *Gmelina arborea* chips (–22, +5 mm) were cooked separately with 15 and 17% active alkali (as Na_2O) under constant conditions of bath ratio 1:2.7 and cooking cycle 3½ hours. With 15% chemicals the total yield obtained was 50.55%, rejects 2.79% and Kappa No. 38.3. When 17% active alkali was used the total yield has come down 47.15% rejects (1.32%) and Kappa No. 24.59. The residual alkali in the former case was 10.55 g/L and in the latter 17.05 g/L.

Mixed pulping of *G. arborea* chips with 50 and 75% Bamboo were carried out using 15% active alkali (as Na_2O), bath ratio 1:2.7 and cooking cycle 3½ hours. With 50% bomboo the gross yield obtained was 49.34%, rejects (3.3%) and Kappa No. 40.5. *Gmelina arborea* chips when cooked with 75% bamboo the gross yield (48.71%), rejects (2.91%) and Kappa No 37.04 has come down. The rejects percentage in the mixed cooking was higher as compared to cook No. 1 (Table-3).

Screened Bamboo chips were cooked with 15% active alkali (as Na_2O), keeping bath ratio 1:2.7 and cooking cycle 3½ hours. The total

TABLE—3 COOKING CONDITIONS FOR *G. arborea* AND BAMBOO CHIPS

S. No.	Process Detail	Cook No. 1 (100% *G. arborea*)	Cook No. 2 (100% *G. arborea*)	Cook No. 3 (*G. arborea* Bamboo) 1 : 1	Cook No 4 *G. arborea* +Bamboo) 1 : 3	Cook No. 5 Bamboo
1.	(i) Alkali used as Na_2O (on OD chips)	15	17	15	15	15
	(ii) White liquor Conc T.A.A. g/l	77.5	81.22	76.88	77.88	81.22
	(iii)Sulphidity (%)	17.6	16.7	16.7	16.7	16.7
2.	Bath ratio	1 : 2.7	1 : 2.7	1 : 2.7	1 : 2.7	1 : 2.7
3.	Weight of chips taken(kgs) (on OD basis)	10	10	10	10	10
4.	Treatment in Pilot Digester					
	(i) Time to reach 135°C (mts)	60	60	60	60	60
	(ii) Time at 135°C (mts)	30	30	30	30	30
	(iii)from 135-165°C (mts)	60	60	60	60	60
	(iv) at 155°C (mts)	60	60	60	60	60
5.	Residual alkali (g/l)	10.95	17.05	10.95	10.95	13.95
6.	Yield (%) rejects free	47.76	45.83	46.04	45.8	47.21
7.	Rejects (%)	2.79	1.32	3.30	2.91	2.73
8.	Gross Yield (%)	50.55	47.15	49.34	48.71	49.94
9.	K.No. (40 ml)	23.5	16.5	24.1	23.8	24.3
10.	Kappa No	38.3	24.59	40.5	37.04	40.92

TABLE—4 PHYSICAL STRENGTH PROPERTIES OF UNBLEACHED PULPS

S. No.	Pulp No.	No. 1 (100% *G. arborea*)			No. 2 (100% *G. arborea*)			No. 3 (*G. arborea*+ Bamboo) 1 : 1			No. 4 (*G. arborea*+ Bamboo) 1 : 3			Bamboo		
1.	Initial Freeness (SR°)	13			15			14			14			19		
2.	Pulp beaten at Freeness (SR°)	30	40	50	30	40	50	30	40	50	30	40	50	30	40	50
3.	Beating time (minutes)	45	60	70	30	42	50	40	58	65	33	43	52	33	39	48
4.	Basis weight (g.s.m.)	58.5	59	59	61.5	60	62	60	60	63	60.5	61	60	59	60	59
5.	Caliper (microns)	89	90	90	92	90	95	90	90	95	91	92	90	89	90	90
6.	Breaking length (k.m.)	4.467	5.141	5.276	4.899	5.489	6.075	4.744	5.577	5.788	4.903	5.300	5.800	5.350	5.611	6.345
7.	Burst Factor	30.2	39.3	44.0	40.6	42.5	47.58	37.8	42 3	46.8	32.2	34.7	35.8	28.8	34.16	37.6
8.	Tear Factor	54.6	61.0	69	52	66 6	67.7	66.6	71.6	74.6	80.9	81 9	86.6	84 6	86.9	99.7
9.	Double fold	294	414	625	405	498	566	262	336	376	250	284	298	160	180	210

TABLE—5 OPTIMUM CHLORINE DEMAND FOR THE FIRST STATE BLEACHING UNDER C E H SEQUENCE OF G. ARBOREA & BAMBOO PULP

Pulp No. Bleaching Conditions	No. 1 *G. arborea* (100%)			No. 2 *G. arborea* (100%)			No. 3 *G. arborea*+Bamboo 1 : 1			No. 4 *G. arborea*+Bamboo 1 : 3			No 5. (Bamboo)		
Set No.	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3
Chlorination Stage (C) Constant Conditions: Cy=3%, temp=room temp retention time=60 mts															
(i) Chlorine added (%) (on O.D. pulp Basis)	7	8	9	4	5	6	7	8	9	7	7.5	8	7	8	9
(ii) Chlorine consumed (%) on added basis.	99.1	97.5	94.3	98.66	95.03	85.8	98.66	97.3	94.4	97.3	95.5	93.2	98.9	94.8	92.1
Caustic Extraction (E) Constant conditions cy=5%, temp 55±1°C retention time (60mts)															
(i) NaOH (%) applied on O.D. pulp basis.	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
(ii) End pH	10.4	10.5	10.5	10.5	10.6	10.6	10.4	10.5	10.5	10 5	10.5	10.5	10.5	10.5	10.5
(ii) K. No. (40 ml)	8.8	8.1	6.7	7.04	6.04	4.8	9.04	8.58	7.8	8.64	8 4	7.7	9.5	8.8	7.6

unbleached yield obtained was 49.94% rejects 2 73% and Kappa No. 40.92. The Kappa No. was high but rejec s percentage was lower than the mixed pulping. The average fibre length of G. Arborea was 0.976 and fibre diameter 0.0224. The slenderness ratio L/D of *G. arborea* pulp was 43.

Adding the optimum amount of Chlorine is one of the prerequisites for efficient bleaching both for economic and quality considerations. Pulps treated with insufficient amount of chlorine in chlorination stage consume more chlorine as hypochlorite[3] for a certain brightness level which is both detrimental from the stand-point of quality and economics of the process as the cost of available chlorine as hypochlorite is much above than that of elemental chlorine.

The unbleached pulps were bleached under optimum chlorine demand in chlorination and hypochlorite stages. *G. arborea* unbleached pulp No. 1 (Kappa No. 38.3) and No 2 (Kappa No 24 59) have 10.15% and 7.13% net chlorine consumption respectively. The bleached pulp No. 1 has brightness 77.5% P.V., viscosity (11.4) cps and shrinkage (9.2%). Pulp No. 2 has brightness 78 5% P.V., viscosity (9.42) cps and shrinkage (6.5%). The shrinkage of pulp No. 1 was higher than No. 2 and pulp viscosity has little come down. Bamboo mixed pulp No. 2 (50% Bamboo; Kappa No. 40.5) and No. 4 (75% Bamboo; Kappa No. 37.04) have total chlorine consumption 11.5% and 11% respectively. Pulp No 3 has brightness 78% P.V., viscosity 11.38 cps and shrinkage 9.4%. Pulp No. 4 has brightness 77.5% P.V., viscosity (13.3) cps and shirnkage (8.8%). Bamboo pulp No. 5 (Kappa No. 40.92) has

TABLE – 6 BLEACHING OF G. ARBOREA, BAMBOO AND MIXED G. ARBOREA—BAMBOO PULPS UNDER C-E-H SEQUENCE

S. No.	Pulp No. Particulars	No. 1 *G. araorea* (100%)	No. 2 *G. arborea* (100%)	No. 3 *G. arborea*+ Bamboo (1.1)	No. 4 *G. arborea*+ Bamboo (1:3)	No. 5 Bamboo
1.	**Chlorination Stage**					
	i Cl_2 added on pulp (%)	8.5	5	8.5	7.5	8
	ii Cl_2 consumed on pulp %	8.2	4.75	8.15	7.18	7.73
	iii Cl_2 consumed on added basis.	96.4	95.0	95.9	95.7	96.7
2.	**Alkali Extraction Stage**					
	i NaOH added on pulp (%)	2 5	2.5	2.5	2.5	2.5
	ii Final PH	10.5	10.6	10.5	10.5	10.5
3.	**Hypo Stage.**					
	i Hypo added (%)	2.0	2.5	3.0	3.5	4.0
	ii Hypo consumed (%)	1.95	2.30	2.86	3.3	3.8
	iii Hypo consumed on added basis (%)	97 5	92.0	95.3	94.3	95.0
	iv End PH	7.5	7.3	7.5	7.6	7.6
4.	**Results.**					
	i Brightness (%)	77.5	78.5	78.0	77.5	77.5
	ii CED viscosity of pulp (0.5%) cps	11 4	9.42	11.38	13.3	14.4
	iii Copper No	1.121	1.301	1.18	1.08	1.03
	iv Total Cl_2 consumed (%)	10.15	7.13	10.95	10.48	11.53
	v Total Cl_2 added (%)	10.50	7.50	11.5	11.0	12.0
	vi Shrinkage of pulp (%)	9.2	6.5	9.4	8.8	9.5

Constant conditions for bleaching

	C	E	H
Temperature °C	20±2	55±1	40±1
Retention time (minutes	60	60	120
Consistency (%)	3	5	5

TABLE—7 PHYSICAL STRENGTH PROPERTIES OF BLEACHED PULPS

S. No.	Pulp No. Particulars	No. 1 (100% *G. arborea*)			No. 2 (100% *G. arborea*)			No. 3 (*G arborea* + Bamboo) 1 : 1			No. 4 (*G. arborea* + Bamboo) 1 : 3			No. 5 Bamboo		
1.	Initial Freeness (SR°)		13			15			14			14			13	
2.	Pulp beaten at Freeness (SR°)	30	40	50	30	40	50	30	40	50	30	40	50	30	40	50
3.	Beating time (mts)	30	41	50	28	35	45	25	35	44	28	40	46	25	35	44
4.	Basis weight (g.s.m.)	60	59	61.5	60	60	60.5	60	59	62	60	61	61.5	58.5	59	61.5
5.	Caliper (microns)	89	90	92	88	88	90	88	86	92	90	92	95	88	90	92
6.	Breaking length (km)	4.744	5.288	6.118	5.577	5.706	6.883	5.388	5.762	6.433	5.233	5.983	6.633	6.022	6 185	6.927
7.	Burst Factor	35.0	43.3	51.2	43.7	49.15	52.6	43.66	45.76	50.80	45.9	52.4	57.2	40.17	43.2	47.9
8.	Tear Factor	66.6	73.3	79.3	72.8	78.3	84.5	73.3	77.9	80.6	81.9	95.0	99.2	97.4	101.7	107.3
9.	Double fold	244	366	492	340	770	1228	384	576	650	274	390	698	246	364	500

net chlorine consumption 11.53, brightness 77.5% P.V., viscosity (14.4) cps and shrinkage 9.5% P.V. Bamboo pulp has certainly higher chlorine consumption than with Gmelia Arborea pulp for a brightness 77.5% P.V. (Table-6).

Beatability is one of the important characteristics of pulp and has a bearing on energy requirement and power economics. This is also an index of the response of pulp to beating action and subsequent strength development[4].

Unbleached pulps beaten to 30, 40 and 50 SR° freeness shows that *G. arborea* pulp takes 70 minutes to beat the pulp to reach 50° SR freeness whereas bamboo pulp takes 50 minutes to arrive at the same freeness. In pulp No. 3 and No. 4 the beating time of pulp decreased with increase in bamboo percentage (Table-4). Similarly bleached *G arborea* pulp also takes higher beating time than bamboo pulp either beaten alone or mixed with *G arborea* (Table-7). The strength properties of *G. arborea* unbleached pulps were quite good. The strength properties were found to increase with increase in bamboo percentage (Table-4). Bleached pulps when beaten also showed a similar trend. The strength properties were found to increase with bamboo percentage (Table-7). The strength properties of unbleached pulps increased after bleaching.

The pulping and bleaching data shows that it gives no problem during these studies. This can be successfully mixed with bamboo for mixed pulping for writing and printing paper.

ACKNOWLEDGEMENTS

The authors wish to express their deepest gratitude to Shri I.M. Bhandari, Executive Vice President for giving permission to publish this paper. The authors are also grateful to Shri S.S. Kaul, Deputy Director of Research and Shri N.R. Jangalgi, Chief Chemist for their keen interest and useful suggestions. Thanks are also due to our forest officer Shri S.L. Arora for procuring the material.

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