Utilisation of Different Eucalyptus Species with Bark for Pulping and Papermaking

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Eucalyptus hybrid, Eucalyptus grandis and Eucalyptus citriodora of 12 years age were studied for their pulping and papermaking characteristics with and without bark. The proximate chemical analysis of these woods and their bark was carried out. The results, in general show, the high water and 1% NaOH solubilities, high ash content, less pentosans and lignin contents in case of barks than those of respective woods. Fairly large amount of fibres are also present in these barks. The average bark content in these three cases was about 10%.

The unbleached pulps obtained with the mixture of wood chips and bark chips in the proportion present in wood gave a pulp having higher Kappa Number (by 2—3 units), less pulp yield (by about 0.5%) than with corresponding wood, when the chemicals and pulping conditions were kept constant. E. citriodora required less chemicals and gave about 5% higher unbleached pulp yield than E-hybrid and E-grandis. The strength properties of the pulps obtained with and without bark for all practical purposes were comparable in all the three species.

Fibre length of wood pulp was higher than that of bark pulp in case of E-hybrid and E-citriodora, but was lower in case of E-grandis.

Thus, the laboratory results show, that E-hybrid, E-grandis and E-citriodora can be used along with bark for pulping and papermaking for better utilisation of the wood with the bark without adversely affecting the quality of paper.

Introduction

Shortage of fibrous raw materials is invaringly felt all over the world and attempts are being taken everywhere to optimise the utilisation of available resources. Whole tree pulping is one of the developments towards this. Though debarking of woods has become conventional way of preparing the woods for pulping, it is found that not all woods need debarking as some of the species (1—3) have soft and easily pulpable barks. Eucalyptus species are amongst such woods and this paper deals with the study and utilisation of Eucalyptus wood with bark.

Three species of Eucalyptus namely E. hybrid, E. grandis and E. citriodora are taken for this study.

Experimental

The unbarked wood samples of E. hybrid, E. grandis and E. citriodora were collected from the Forest Department of The West Coast Paper Mills Ltd. each having eight billets of about one metre length. All the three species were of 12 years age and grown in the mill nursery. The wood and bark characteristics are given in Table No. I. In each case, after removing the barks, the logs were chipped in the mill chipper. The chips were classified in the Williams chip classifier. The classification of chips acceptable for pulping is recorded in Table No. II.

The barks of all species were separately hand chipped and were used for this study.

Proximate Chemicals Analysis

The representative sample of wood portion and bark portion was taken separately in all cases and powdered in the Wiley Mill. The powder was made to pass through 40 mesh and this was analysed for different constituents. Tappi standard methods were used in all cases except

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TABLE IV

Pulping of chips

Particulars	*100% Wood chips*			*100% Bark chips*			*Mixed (wood+bark) chips*		
	Eh	*Eg*	*Ec*	*Eh*	*Eg*	*Ec*	*Eh*	*Eg*	*Ec*
Wood : Bark	100:0	100:0	100:0	0:100	0:100	0:100	89:11	91:9	89:11
Chemicals as Na_2O, %	17	17	17	17	17	17	17	17	17
Bath ratio									
Chips : Liquor	1:3	1:3	1:3	1:3	1:3	1:3	1:3	1:3	1:3
Time schedule, Min.									
70°C to 120°C.	45	45	45	45	45	45	45	45	45
At 120°C.	60	60	60	60	60	60	60	60	60
120°C to 170°C	90	90	90	90	90	90	90	90	90
At 170°C.	90	90	90	90	90	90	90	90	90
'H' Factor	1690	1690	1690	1690	1690	1690	1690	1690	1690
Unbleached yield,%	49.3	48.8	54.1	37.1	35.5	39.0	48.6	47.8	52.4
Kappa Number	16.0	15.7	13.2	41.3	43.8	40.8	20.5	18.0	15.9
Pulp brightness, % (Elrepho)	27.1	28.5	32.5	13.8	12.0	11.1	23.8	25.1	28.9

Eh=Eucalyptus hybrid
Eg=Eucalyptus grandis
Ec=Eucalyptus citriodora

TABLE V

Pulping of wood and wood+bark chips

Particulars	*Eucalyptus hybrid*		*Eucalyptus grandis*		*Eucalyptus citriodora*	
	100% wood chips	*89% Wood + 11% bark*	*100% wood chips*	*91% Wood + 9% bark*	*100% wood chips*	*89% Wood + 11% bark*
Chemicals as Na_2O, %	17.0	17.0	17.0	17.0	14.5	14.5
Bath ratio chips : liquor	1:3	1:3	1:3	1:3	1:3	1:3
Cooking schedule, Min.						
70°C to 120°C.	45	45	45	45	45	45
At 120°C.	60	60	60	60	60	60
120°C to 170°C	75	75	75	75	75	75
At 170°C.	40	40	40	40	40	40
'H' Factor	902	902	902	902	902	902
Screened yield, %	50.6	50.0	47.8	47.2	53.8	5.43
Rejects, %	0.4	0.5	0.5	0.5	1.3	1.0
Unbleached pulp brightness, % (Elrepho)	28.2	56.2	27.8	25.7	34.6	29.8
Kappa Number	22.3	24.5	21.6	24.7	19.6	22.8
Residual Active Alkali, gpl as Na_2O (17°Tw and at 80°C.)	7.0	6.8	8.7	8.1	7.4	7.1

Bleaching

The bleaching of unbleached pulps obtained from the above species with and without bark was done using CEHH sequence to get about 80% brightness (Elrepho). During the first stage of chlorination, chlorine was added as per the Kappa Number-chlorine demand relationship (4). The results of the bleaching experiments are recorded in Table No. VI.

Bauer McNett Fibre Classification

The Bauer McNett fibre classification of the unbleached pulps obtained from wood, x bark and their mixture in above three species was carried out. 10 gms. of pulps (oven dry basis) was taken in each case with 15 minutes classification time. The data are recorded in Table No. VII.

Strength Properties

The bleached pulps from all the cooks were beaten separately in the Laboratory Valley Beater to four different slowness levels. Standard handsheets (60 gms) were prepared on the British Sheetmaking machine and their strength properties were determined. For comparison, the properties at 30°SR (found by plotting the graphs) are given in Table No. VIII.

Fibre Dimensions

The fibre length, width and diameter were determined as per the TAPPI standard method. About 300 fibres in each case were counted for the fibre length determination. The results are recorded in Table No. IX.

Results & Discussion

As seen from Table No. I, the average bark content in all the three species of Eucalyptus is about 10%. The thickness of bark calculated from the girth difference is also almost same. Of the three species, E. citriodora has the higehst bulk density and the green volume density. Same is true in case of its bark.

From the proximate chemical analysis (Table No. III), it is observed that the ash is more in the bark than in corresponding wood and this difference is more pronounced in E. hybrid and E. grandis. All the solubilities are more in barks than in their woods. Holocellulose and pentosans are less in bark in all three cases. Same is the case with lignin content in E. hybrid and E. grandis. For E. citriodora, lignin in bark and wood are almost comparable, More Holocellulose content and less lignin content in E. citriodora than in E. hybrid or E. grandis will give higher pulp yield.

Table No- IV shows the data of autoclave pulping of these species classified in three different categories i.e. pulping of 100% wood, 100% bark and the mixture of wood and bark in the proportion present with wood. The results clearly show the different behaviour of wood and bark. In all the three species, bark has given lower pulp yield, darker shade, higher Kappa Number than with the respective woods. This behaviour can be linked with the proximate chemical analysis. The pulps from bark were much darker in shade which have affected the brightness of the pulp obtained from the mixture of wood and its bark, by 3.4 points than that from corresponding pulps. This finding has been proved even from the large scale pulping (Table No. V). when the bark was used with the wood, the Kappa Number was increased by 2-3 points than when only wood chips were used for pulping. Less lignin, higher amount of holocellulose in case of E. citriodora required less chemicals, gave higher pulp yield when compared to E. hybrid and E. grandis.

As the Kappa Number of the pulp obtained with mixture of wood and bark was higher by 2-3 points than with only wood pulp, correspondingly the bleach consumption was on the higher side. The bleached pulp viscosity was comparable. The dirt count was very little on the higher side in case where bark was used with wood (Table No. VI).

The Bauer McNett fibre classification and also the fibre morphology (Table No. VII and IX respectively) indicate the higher fibre length in case of E. citriodora than in E. hybrid or E. grandis. Pulps from only bark have more fines than from respective wood pulps. In some cases the fibre length of bark pulp has been found more than that from its wood pulp (5). Here, of the three Eucalyptus wood species studied, E. grandis bark fibres were longer than its wood. In case of E. hybrid and E. citriodora wood fibres were longer than bark fibres. No proper relationship between the fibre width, fibre diameter of wood and bark fibres was found.

The strength properties of the pulps obtained from mixture of

TABLE VI

Bleaching of unbleached pulps (with and without bark) using CEHH sequence

Particulars	*E. hybrid*		*E. grandls*		*E. citriodora*	
	100% Wood	*89% wood +11% Bark*	*100% Wood*	*91% Wood +9% Bark*	*100% Wood*	*89% Wood +11% Bark*
Chlorination (C)						
Cl_2 added on pulp, %	4.00	4.50	4.00	4.50	4.00	4.00
Cl_2 consumed,%	4.00	4.50	4.00	4.50	4.00	4.00
Alkali Extraction (E)						
NaOH added, %	1.0	1.0	1.0	1.0	1.0	1.0
Final pH	9.1	8.8	9.2	9.0	9.0	9.0
Hypo I Stage (H_1)						
Cl_2 added, %	2.00	2.00	2.00	2.00	2.00	2.00
Cl_2 consumed, %	1.40	1.40	1.35	1.40	1.40	1.40
Final pH	7.4	7.3	7.4	7.3	7.6	7.4
Hypo II Stage (H_2)						
Cl_2 added, %	0.75	0.75	0.75	0.75	0.40	0.40
Cl_2 consumed, %	0.40	0.40	0.40	0.40	0.20	0.20
Final pH	7.8	7.7	8.1	8.0	8.1	8.0
Total Cl_2 added, %	6.75	7.25	6.75	7.25	6.40	6.40
Total Cl_2 consumed, %	5.80	6.30	5.75	6.30	5.60	5.60
Shrinkage, %	6.1	6.3	5.0	5.2	5.0	5.7
Bleached pulp yield on raw material, %	47.4	47.1	45.3	44.9	51.3	50.7
Brightness, % (Elrepho)	80.1	79.9	80.8	80.7	80.2	80.5
Viscosity (CED), cp.	9.8	9.4	10.7	10.3	9.6	9.3
Dirt Count, ppm	13	18	8	14	12	13

Constant Conditions

	C	*E*	H_1	H_2
Temperature, °C.	29±1	55	45	45
Retention time, Min.	60	60	60	60
Consistency, %	3.0	5.0	5.0	5.0
Sulphamic acid on Cl_2 added, %	...	...	2.0	5.0

TABLE VII

Bauer McNett classification of pulps (unbleached)

Particulars	*Eucalyptus hybrid*			*Eucalyptus grandis*			*Eucalyptus citriodora*		
Mesh	*100% Wood*	*100% Bark*	*89% Wood + 11% Bark*	*100% Wood*	*100% Bark*	*91% Wood + 9% Bark*	*100% Wood*	*100% Bark*	*89% Wood + 11% Bark*
+35	25.5	14.6	24.2	22.2	12.7	21.4	30.6	15.8	27.9
−35 +50	16.2	16.2	15.1	25.9	27.8	26.3	24.7	14.8	22.8
−50 +100	18.0	20.3	18.5	13.6	12.2	14.5	15.6	30.4	17.1
−100+150	25.0	22.2	26.0	20.7	24.8	20.4	17.0	11.2	16.0
−150	15.3	26.7	16.2	17.6	22.5	17.4	12.1	27.8	16.2

TABLE VIII

Strength properties of bleached pulps at 30° SR

Particulars	*E. hybrid*		*E. grandis*		*E. citriodora*	
	100% Wood	*89% Wood+ 11% Bark*	*100% Wood*	*91% Wood+ 9% Bark*	*100% Wood*	*89% Wood+ 11% Bark*
Beating time, Min.	13	13	13	13	13	13
Drainage time, (BSM) Sec.	5.6	5.7	5.7	5.6	5.3	5.3
Bulk, cm^3/g	1.64	1.64	1.44	.1.47	1.87	1.81
Breaking length, km	6.30	5.60	6.90	5.97	5.78	5.88
Stretch, %	3.3	3.0	3.3	3.0	3.2	3.0
Tensile Energy Absorption, J/m^2	35	27	40	32	30	28
Tear factor	93	95	100	101	103	104
Burst factor	44.8	41.8	55.0	49.2	45.3	45.2
Double folds (MIT)	70	70	170	140	67	41
Air Porosity, (Bendtsen), ml/min.	700	600	300	400	1800	1600
Strength index	1970	1950	2300	2210	2040	1970

Strength Index=(Log Double Folds × Burst factor × Tear factor)^3 × 100

TABLE IX

Dimensions of wood and bark fibres

Particulars	*E. hybrid*		*E. grandis*		*E. citriodora*	
	Wood	*Bark*	*Wood*	*Bark*	*Wood*	*Bark*
Average fibre length, mm	0.80	0.73	0.83	0.95	0.97	0.76
Average fibre diameter, micron	13.0	12.7	14.3	10.7	11.3	13.5
Lumen width, micron	5.4	5.4	7.5	5.2	2.9	3.9
Wall thickness, micron	3.8	3.7	3.4	2.8	4.2	4.8

wood and bark were little on the lower side than those from the respective wood species (Table No. VIII). But for the practical purposes the strength properties are comparable. All the pulps required same beating time to get 30°SR. As far as the strength properties are concerned. E. grandis gave better properties than other two. E. hybrid and E. citriodora had comparable strength properties.

Conclusion

From the above study, it can be concluded that, E. hybrid, E. grandis and E. citriodora can easily be used with bark without affecting much the strength properties or the quality of the pulp.

More pulp yield per hectare of land could be obtained by using these woods along with the barks. E. hybrid is being used in our mills with bark for pulping.

Acknowledgement

The authors are thankful to the Management, The West Coast Paper Mills Ltd. for their kind permission to publish this paper, and to the Forest Department, The West Coast Paper Mills Ltd. for supplying the necessary raw material.

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