

Utilization of Lops and Tops (With and without bark) of *Populus Deltoides* "G-3" of Six and Eight Years for Paper Making

Rai A.K., Bhandari S.S. and Singh S.V.

ABSTRACT

The pulping and papermaking characteristics of Populus deltoides "G-3" of six and eight years old with and without bark and mixture of 50% bolewood chips and 50% lops and tops have been discussed. P. deltoides "G-3" eight years old with and without bark gave higher unbleached and bleached pulp yield as compared to six years old P. deltoides "G-3". In preparation of bleached grade pulps from wood with bark and its mixture with lops and tops with bark required much higher H-factor for delignification as compared to wood without bark. The chlorine demand was also higher for the pulps obtained from bolewood chips with bark and mixture of 50% bole wood chips and 50% lops and tops with bark.

The unbleached pulps from six and eight years old P.deltoides "G-3" with bark gave almost same tensile index 110.71 (± 0.19) Nm/g, burst index 7.59 (± 0.06) kPam²/g and tear index 7.49 (± 0.18) mNm²/g. The pulps from the mixture of 50% bole wood chips and 50% lops and tops with bark also gave almost equal tensile index 109.84 (± 0.52), burst index 7.35 and tear index (± 0.30) 7.21 (± 0.45). It was observed that the physical strength properties of unbleached and bleached pulps from bolewood and mixture of bolewood chips and lops and tops were much higher as compared to pulps obtained from wood with bark. But from bolewood chips with bark and its mixture with 50% lops and tops with bark, pulp of satisfactory yield and strength properties could be prepared for the manufacture of packaging papers, corrugating medium and liner without much problem of pulp processing and will help in conserving valuable fast depleting forest resources, by saving due to bark and utilization of lops and tops.

INTRODUCTION

In recent years complete tree utilization involving the conversion and use of the total tree unmerchantable tops, branches, stumps, roots and bole has been studied as a possible route to provide additional wood fibres for pulp and papermaking. It has been estimated that such practices could increase the world wood fibre supply by as much as 35% , of which 10% may be

attributed to the pulping of branches. Pulping of logging residues, as well as specific components of trees has been investigated by numerous workers (1-5).

Cellulose and Paper Division,
Forest Research Institute,
P.O. New Forest DehraDun-248006 (U.P.)

The general conclusion of these studies was that kraft pulp of acceptable quality could be produced at reasonable yields from virtually all components of a tree excepting leaves.

The pulping of bark has also been studied separately as a way to increase pulp yield per acre of wood land. Eskilsson and Hartler (6) found that the consumption of cooking chemicals in the pulping of bark was considerably higher for a given kappa number of pulp.

The idea of chipping the round wood as received and pulping the bark and wood together has received much attention in recent past (5, 6, 7). Brown reported that there was no serious decrease of strength of kraft pulp produced from a northern oak mixture containing as much as 16% bark (8). After appropriate cleaning such pulp could be bleached to the same quality as that of pulp produced from bark free chips. In the production of linerboard type kraft pulp Samuels and Glennie (9) found that wood containing upto 20% bark could be used with little or no loss of pulp strength. Yield and cleanliness were, however, reduced as bark content was increased. Therefore, improved mechanical cleaning to limit the dirt level in the pulp was strongly recommended in case wood chips with bark is to be used for pulp and paper manufacture.

Keeping the above facts in view pulping and papermaking characteristics of six and eight years old Populus deltoides "G-3" with and without bark and of the mixture of 50% bole wood chips with 50% lops and tops of six and eight years P.deltoides "G-3", respectively, have been discussed.

EXPERIMENTAL

WOOD PREPARATION

Foliage of several trees of six and eight years old Populus deltoides "G-3" after felling from New Forest, F.R.I., Dehra Dun plantation alongwith branches and tops were removed separately in the two groups. After air drying the material the bole wood, lops and tops with and without bark of six and eight years age populus deltoides "G-3" were chipped in a pilot plant four knife Waterous chipper and chips were screened in waterous chip screen to get a uniform chips size about 2-3 cm long, 2.25 cm wide and 4-5 mm thick). All the wood samples were chipped and screened separately and stored in plastic bags. The P.deltoides "G-3" of 6 years age bole wood contained 18.5% bark and 8 years age had a bark content of 16.8% on oven dry basis.

PULPING

All the wood samples of P.deltoides "G-3" six, eight years with and without bark, mixture of 50% bole wood chips and 50% lops and tops with bark and without bark and bark of P.deltoides were delignified separately using kraft process in a "haato" air heated multidigester, equipped with six auto claves of 2.5 litres capacity. The digester is equipped with two temperature sensors. One is intended for sensing the temp. of the heating chamber. The second sensor is inserted into one of the autoclaves for accurate measurement of autoclave temperature. There are two digital panel meters to indicate the temperature and heating device was set as per the cooking conditions given below for all the wood samples.

(i) Total active alkali as Na ₂ O	14%, 16%
(ii) Sulphidity	25%
(iii) Material to liquor ratio	1:3
(iv) Cooking schedule from 100°C	90 min.
to 165°C at 165°C	90 min.

The rise in temperatures were recorded every ten minutes for the calculation of H-factor.

PULP BLEACHING

The kappa number of all the pulps were determined according to TAPPI standard method (T-23S-OS-76). The bleaching of pulps were carried out using CEHH sequence to get the pulps of brightness around 76-78% ISO. The conditions used in each stage of bleaching sequence were as under:

(i) Chlorination (C)	
Chlorine applied, %	8.0 - 8.7
Consistency, %	3.0
Temperature, °C	ambient
Time in min.	30
(ii) Alkali extraction (E)	
NaOH applied	2.0
Consistency, %	8.0
Temperature, °C	60
Time in min.	60

(iii) Calcium hypochlorite (H₁ & H₂)

Hypo as available chlorine applied, %	1.0 & 0.5
Consistency, %	8.0
Temperature, °C	40
Time in min.	120
pH	Over 10.0

ANALYSIS OF UNBLEACHED AND BLEACHED PULPS

All the pulp samples were beaten separately in a lampen mill under standard conditions to 250 ± 25 ml CSF. Handsheets 60 ± 2g/m² were prepared as per ISO standard (R-187).

The physical strength properties of the standard handsheets were determined according to ISO standard (DP 5269). The optical properties were determined by Elrepho Data color-2000.

RESULTS AND DISCUSSION

Unbleached kraft pulps : The pulping and papermaking properties of *P.deltoides* with and without bark for the preparation of unbleached pulps are recorded in Table-1, 2.

Pulp yield of unbleached pulp: *P.deltoides* "G-3" 8 years old with bark bole wood chips gave 2.73% higher yield than 6 years bole wood chips with bark, while the 6 and 8 years bole woods chips without bark gave about 55% pulp yield. Similarly 6 years old 1:1 mixture of bole wood chips, lops and tops without bark as well as 8 years old mixture of same composition without bark gave pulp yield around 53% (Table-1).

The 6 years old with bark, mixture of 50% bole wood chips and 50% lops and tops gave pulp yield 45.97% and 8 years old mixture of same composition gave 5.49% higher pulp yield than 6 years old mixture. All the cooking experiments were carried out at same H factor 1056. The kappa number of pulps obtained from woods with bark was around 68-69 whereas kappa number of all the pulps from wood without bark was lower; the range being 45.80-48.50 (Table-1).

PAPERMAKING CHARACTERISTICS

UNBLEACHED KRAFT PULP

In *P.deltoides* "G-3" bole wood with bark of 6 and 8 years age, and in mixture of 50% bole wood chips and 50% lops and tops with bark, there was not much difference in tensile, burst and tear indices (Table-1); the tensile index, burst and tear index ranged from 109.32 -110.90 Nm/g, 7.05-7.65 kPam²/g and 6.89-7.68 mNm²/g, respectively.

Table-1

Pulping characteristics of *Populus deltoides* "G-3" for the preparation of Unbleached kraft pulps

Particulars	6 years with bark		8 years with bark		6 years without bark		8 years without bark	
	Bole wood chips	50% bole wood chips +50 lops and tops	Bole wood chips	50% bole wood chips +50% lops and tops	Bole wood chips	50% bole chips+50% lops & tops	Bole wood chips	50% bole wood chips+50% lops & tops
Total chemicals as Na ₂ O%	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
H factor	1056	1056	1056	1056	1056	1056	1056	1056
Screened pulp yield* (%)	47.83	45.97	50.56	51.46	55.16	53.23	54.60	53.40
Screen rejects (%)*	1.07	1.3	2.33	1.68	0.34	0.48	0.40	0.57
Kappa number	68.20	69.10	69.10	68.60	48.50	46.90	46.60	45.80

* % based on o.d. raw material chips to liquor ratio 1:3, Sulphidity 25%

Table-2
Papermaking characteristics of Populus deltoides "G-3" for kraft paper

Particulars	6 years with bark		8 years with bark		6 years without bark		8 years without bark	
	Bole wood chips	50% bole wood chips +50 lops and tops	Bole wood chips	50% bole wood chips +50% lops and tops	Bole wood chips	50% bole chips+50% lops & tops	Bole wood chips	50% bole wood chips+50% lops & tops
Tensile index (Nm/g)	110.52	109.32	110.90	110.36	114.37	112.90	116.03	115.89
Stretch (%)	2.5	2.5	3.7	2.6	3.6	2.9	3.8	2.9
Tear index (mNm ² /g)	7.31	6.89	7.68	7.52	6.81	5.81	6.89	5.72
Burst index, (kPam ² /g)	7.53	7.65	7.65	7.05	9.15	8.68	10.09	8.75
Fold (Kohler Molin) (log)	2.13	2.55	2.18	2.57	2.16	2.58	2.46	2.60

P. deltoides "G-3" 6 years age bole wood chips (without bark) pulp gave tensile index 114.37, tear index 6.81 and burst index 9.15. The pulp from 50% bole wood and 50% lops and tops mixture of 6 years old without bark gave tensile index 112.90, tear index 5.81 and burst index 8.68. Further from the perusal of the data given in Table-2, it was observed that tensile, burst and tear indices of pulp from 8 years

Table-3
Pulping characteristics of Populus deltoides "G-3" for the preparation of Unbleached grade kraft pulps

Particulars	6 years with bark		8 years with bark		6 years without bark		8 years without bark	
	Bole wood chips	50% bole wood chips +50 lops and tops	Bole wood chips	50% bole wood chips +50% lops and tops	Bole wood chips	50% bole chips+50% lops & tops	Bole wood chips	50% bole wood chips +50% lops & tops
Total chemicals as Na ₂ O, %	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
H factor	1360	1360	1360	1360	1056	1056	1056	1056
Screened pulp yield* (%)	44.30	43.58	45.15	44.26	53.43	52.25	54.60	53.15
Rejects (%)*	1.76	0.81	1.13	0.92	1.06	0.38	0.38	0.27
Kappa number	30.15	30.6	30.18	30.19	28.50	27.60	28.50	27.35
Total chlorine** applied (%)	8.6	8.7	8.6	8.6	8.3	8.1	8.3	8.0
Bleached pulp* yield, (%)	38.70	37.58	39.35	38.36	47.63	46.25	49.00	47.50
Brightness (%) ISO	77.80	76.90	77.60	76.95	78.96	78.21	79.21	79.35

* % on o.d. raw material, ** % on o.d. pulp, chips to liquor ratio 1:3, Sulphidity 25%

bole wood chips without bark were 116.03, 6.89 and 10.09, respectively, and slightly lower physical strength properties of the pulp produced from its 8 years age mixture of 50% bole wood chips and 50% lops and tops without bark.

BLEACHED KRAFT PULPS

The pulping and papermaking characteristics of bleached grade pulps from *P.deltoides* "G-3" are recorded in Table-3 and 4.

To get the target kappa number of pulp around 25-30, bole wood chips and their 50% mixture with 50% lops and tops with bark in case of both the age of *P.deltoides* "G-3" pulping was carried out at H-factor 1360; while bole wood chips without bark and their mixture with lops and tops without bark were cooked at a lower H-factor 1056.

PULP YIELD

It could be seen from the data recorded in Table-3 that *P.deltoides* "G-3" bole wood chips (with bark) of 6 years gave the unbleached pulp yield of 44.30%, where as 8 years old with bark gave 45.15%. The unbleached pulp yield from the mixture of 50% bole wood chips and 50% lops and tops (with bark) of 6 and 8 years old *P.deltoides* "G-3" were 43.58% and 44.26%, respectively. Similarly the unbleached pulp yield ranged from 52.53-53 43% in case of 6 years old *P.deltoides* "G-3" bole wood chips and for its mixture with lops and tops and 53.15- 54.60 for

8 years old *P.deltoides* "G-3" and its mixture, respectively (Table-3).

The total chlorine applied in CEHH bleaching ranged from 8.0-8.7% for the pulps of both the age and its mixture under study as mentioned earlier. The bleached pulp yield was 38.70% and 39.35% in case of 6 and 8 years age bole wood chips with bark, respectively. The bleached pulp yield obtained for the mixture of 50% bole wood chips and 50% lops and tops with bark of 6 and 8 years old *P. deltoides* "G-3" was 37.58% and 38.36%, respectively.

The bleached pulp yield from 6 years age bole wood chips without bark was 47.63%. The 8 years age bole wood chips without bark gave 1.37% higher pulp yield than six years age bole wood chips without bark. the mixture of 6 years bole wood chips and its lops and tops without bark gave bleached pulp yield of 46.25% while similar mixture of 8 years age gave 1.25% higher bleached pulp yield (Table-3).

BRIGHTNESS OF BLEACHED PULPS

The data recorded in Table-3 showed that the bleached pulps brightness varied from 77.60-77.80% ISO in case of 6 and 8 years age bole wood chips with bark and its respective mixture with bark. In case of bole wood chips without bark and its mixture of both the age, the brightness of the bleached pulps was in the range of 78.81-79.35% ISO (Table-3).

The data recorded in Table-4 revealed that the

Table-4

Papermaking characteristics of *Populus deltoides* "G-3" for bleached grade pulps

Particulars	6 years with bark		8 years with bark		6 years without bark		8 years without bark	
	Bole wood chips	50% bole wood chips +50 lops and tops	Bole wood chips	50% bole wood chips +50% lops and tops	Bole wood chips	50% bole chips+50% lops & tops	Bole wood chips	50% bole wood chips +50% lops & tops
Tensile index (Nm/g)	108.62	106.48	109.51	108.48	116.65	111.32	117.45	116.34
Stretch (%)	4.85	4.80	4.60	4.35	5.77	5.20	5.83	5.60
Tear index mNm ² /g	7.85	7.62	7.98	7.61	6.51	5.75	6.63	5.85
Brust index, kPam ² /g	8.21	7.31	7.31	7.98	7.43	7.26	8.37	7.71
Fold (Kohler Molin) (log)	2.0	2.45	2.16	2.56	2.12	2.47	2.41	2.59

tensile, burst and tear indices were in the range of 108.62-109.51 Nm/g, 7.31-8.21 kPam²/g and 7.85-7.98 mNm²/g, respectively for 6 and 8 years P.deltoides "G-3" bole wood chips with bark.

The tensile, burst and tear indices of the pulps obtained from mixture of 50% bole wood chips and 50% lops and tops with bark from 6 and 8 years age P.deltoides "G-3" are in range of 106.48 -108.48 Nm/g, 7.31-7.98 kPam²/g and 7.61-7.62 mNm²/g respectively (Table-4). Further it could be seen from the data given in Table-4 that tensile index of pulp obtained from P.deltoides "G-3" 6 and 8 years age bole woodchips was in range of 116.65-117.45 Nm/g. This indicates that slight increase in tensile index is obtained in case of 8 years as compared to 6 and 8 years age. Similarly, tear index was in range of 6.51-6.63 mNm²/g i.e. almost same tear index in case of both the ages of bole wood chips obtained. Burst index of 6 years age bole wood chips pulp was 7.43 kPam²/g for 8 years, it was 8.37 kPam²/g, a little higher than 6 years age. The mixture of 50% bole wood chips and 50% lops and tops chips from 6 and 8 age without bark gave tensile index in the range 111.32-116.34 Nm/g, tear index 5.75-5.85 mNm²/g and burst index 7.26-7.77 kPam²/g. The data showed that physical strength properties of 8 years bole wood chips and pulp from mixture of 50% bole wood chips

and 50% lops and tops gave better results than 6 years age bole wood chips pulp and pulp from its similar mixture.

PULPING OF LOPS AND TOPS

The lops and tops of 6 and 8 years age P.deltoides "G-3" were separately delignified at a same H factor 1056 as in case of bole wood chips with and without bark (Table-5)

The unbleached pulp yield from P.deltoides "G-3" of 6 years age lops and tops with bark was 43.10% whereas 8 years age lops and tops with bark gave 3.16% higher pulp yield as compared to 6 years age. The 6 years age lops and tops without bark gave pulp yield of 44.30% and 4.05% higher pulp yield was obtained with 8 years old lops and tops of P.deltoides "G-3". The kappa numbers of the pulps from 6 and 8 years P. deltooides "G-3" lops and tops with bark were in range of 69-70, while for without bark it was in the range of 46.60-50.20, whe delignified at a same H factor 1056 (Table -5).

PAPERMAKING PROPERTIES OF PULPS FROM LOPS AND TOPS

The 6 years age lops and tops with bark gave tensile index 77.0 Nm/g, burst index 5.30 kPam²/g

Table-5

Pulping and Papermaking characteristics of P. deltooides "G-3" lops, tops and twigs of 6 and 8 years old with and without bark for the preparation of kraft unbleached pulps

Particulars	6 years with bark	8 years with bark	6 years without bark	8 years without bark
Total chemicals as Na ₂ O,%	14.0	14.0	14.0	14.0
H factor	1056	1056	1056	1056
Screened pulp yield* (%)	43.10	46.26	44.30	48.35
Rejects (%)*	1.28	1.16	0.38	0.25
Kappa number	69.1	70.0	50.20	46.60
Apparent density, g/m ³	0.79	0.79	0.83	0.84
Tensile index, Nm/g	77.0	79.6	91.00	93.50
Stretch, %	3.0	3.1	2.8	3.6
Burst index, kPam ² /g	5.30	5.81	5.7	6.31
Tear index, mNm ² /g	4.90	5.15	5.75	5.86
Fold Kohler Molin (Log)	2.11	2.50	2.41	2.47

* % on o.d. raw material, Chips to liquor ratio 1:3, Sulphidity 25%

and tear index 4.90 mNm²/g. Whereas 8 years age gave slightly higher tensile index (79.6 mNm²/g) burst index (5.81 kPam²/g) and tear index (5.15 mNm²/g).

Pulps from lops and tops from P.deltooides "G-3" without bark of 6 years age gave tensile index 91.0 Nm/g, burst index 5.7 kPam²/g and tear index 5.75 mNm²/g. The pulps from 8 years lops and tops without bark gave again better results as in case of with bark samples. The tensile index 93.50 Nm/g, burst index 6.31 kPam²/g and tear index 5.86 mNm²/g was obtained in case of 8 years without (Table-5).

PULPING OF P.DELTOIDES "G-3" BARK

The pulping conditions of 6 and 8 years P.deltooides "G-3" bark and physical strength properties of its pulps are recorded in Table-6. It could be seen from the data given in Table-6 that pulp yield obtained from 6 and 8 years old P.deltooides "G-3" bark was 20.35% and 18.96%, respectively. The tensile index tear index and burst index for 6 year and 8 years P.deltooides bark were 28.65 Nm/g, 29.10 Nm/g; 5.26 mNm²/g, 4.68 mNm²/g, 1.20 kPam²/g and 0.86 kPam²/g, respectively.

CONCLUSION

P. deltooides "G-3" 8 years old with and without bark gave higher unbleached and bleached pulp yields. In preparation of bleached grade pulps, the wood and

its mixture (with bark) required much higher H-factor for delignification. To achieve a pulp brightness around 77-78% the chlorine demand is also higher for the pulps obtained from P.deltooides "G-3" bole wood chips with bark and mixture of 50% bole wood chips and 50% lops and tops with bark. The physical strength properties of unbleached pulps from 6 and 8 years age P.deltooides "G-3" with bark and mixture of 50% bole wood chips and 50% lops and tops are almost comparable but in case of without bark the physical strength properties were much higher as compared to that of 6 and 8 years with bark. It was also observed that strength properties of unbleached and bleached pulps prepared from 8 years age P.deltooides "G-3" bole wood chips without bark and mixture of 50% bole wood chips and 50% lops and tops of 8 years age were better as compared to bole wood chips of 6 years age without bark and its mixture with lops and tops. The physical strength properties of the pulps obtained from mixture 50% of bole wood chips and 50% lops and tops were inferior than that of bole wood chips of 6 and 8 years P.deltooides "G-3". Although from bole wood chips with bark and its mixture of 50% bole wood chips and 50% lops and tops with bark, pulp of satisfactory yield and strength properties could be prepared but it would be better to manufacture unbleached grade pulp and paper. This will help in utilizing the whole tree for the production of packaging papers, corrugating medium and liner without much problem of pulp processing and will help in conserving valuable fast depleting forest resources.

Table-6
Pulping of poplar bark and physical strength properties of its pulps

Particulars	P. deltooides 6 years	Pdeltooides 8 years
Total chemicals as Na ₂ O,%	14.0	14.0
Chips to liquor ratio	1:3	1:3
Sulphidity, %	25	25
H factor	1056	1056
Screened pulp yield, %*	20.35	18.96
Tensile index, Nm/g	28.65	29.10
Stretch, %	2.4	2.3
Tear index, mNm ² /g	5.26	4.68
Burst index, kPam ² /g	1.20	0.86

* % on o.d. raw material

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