

Laboratory results of TMP and CTMP trials with *Pinus patula*, *P. tecunumanii*, and *P. caribaea* var. *hondurensis*

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ABSTRACT: Wood from CAMCORE trials of tropical pines was evaluated at eight years of age from Colombia, Venezuela, and South Africa. Laboratory results at Andritz Sprout-Bauer for *Pinus patula*, *P. tecunumanii*, and *P. caribaea* var. *hondurensis* indicated that, generally, CTMP was superior to TMP for ISO brightness, physical sheet brightness and lower freeness using less total energy. The TMP process gave higher values for tensile index and stretch (%) in most cases. The paper strength properties were generally higher for *P. patula* than for *P. tecunumanii*. The ISO brightness and physical sheet brightness were often considerably higher for *P. patula* than for *P. tecunumanii*. There appears to be considerable potential for printing and writing applications of mechanical pulp from juvenile pines grown in the tropics.

KEYWORDS: Chemithermomechanical pulping, Colombia, juvenile wood, mechanical properties, *Pinus*, South Africa, thermomechanical pulping, tropical plants, Venezuela.

Plantation development should be considered with specific end product objectives clearly defined in the early planning stages of each project. Many tropical pine species have the advantage of multiple uses including restoration of heavily eroded soils, lumber production as

well as pulp and paper from both chemical and mechanical methods. However, for many pine species planted in the tropics, wood properties have not been intensively studied. Therefore, the most viable uses financially may be determined only in these instances once the trees in

trials or plantations are old enough to assess the production potential of pulp, paper, and lumber.

Trials of fast-growing pine species have been established in a number of countries by members of the Central America and Mexico Coniferous Resources Cooperative (CAMCORE) based at North Carolina State University, USA. Since 1980, CAMCORE has collected and distributed seed from 25 conifer and broadleaf species in Central America (1). These trials, many of which are over ten years old, can now be used to assess pulp and paper properties.

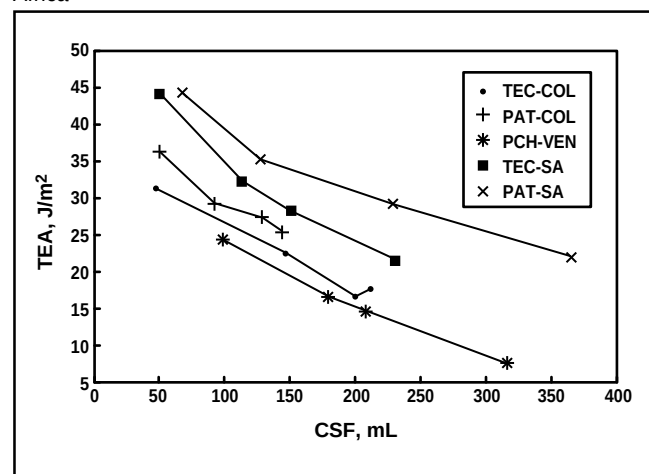
Andritz Sprout-Bauer offered CAMCORE members the opportunity of comparing TMP and CTMP properties from CAMCORE trials in Colombia, Venezuela, and South Africa. This was the first time that three promising species, *Pinus caribaea* var. *hondurensis*, *P. tecunumanii* and *P. patula*, could be compared as mechanical pulp from wood of similar age. The species *P. patula* is the most frequently used wood for mechanical pulping in South Africa (2).

Extensive plantings of *P. caribaea* var. *hondurensis* in Venezuela, Brazil, and Queensland, Australia, have been established for kraft pulp, lumber, and treated posts. CAMCORE trials of *P. tecunumanii* in Brazil, Colombia, and South Africa have indicated very rapid growth rates. However, neither *P. caribaea* var.

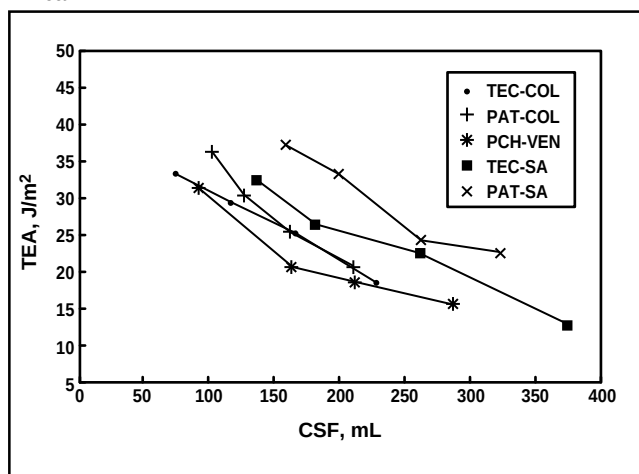
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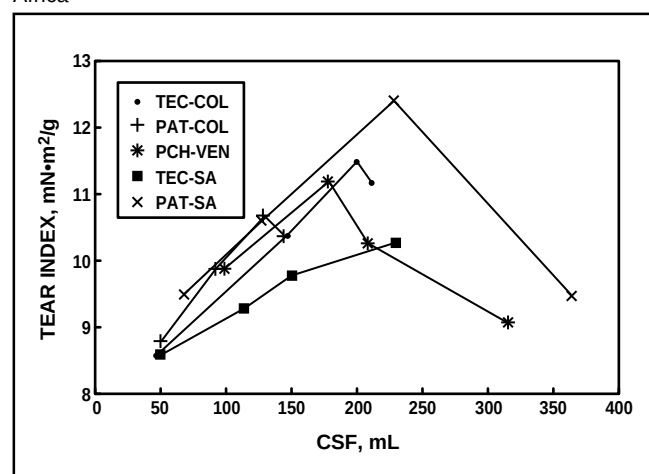
1. Comparison of TMP pulp from Colombia, Venezuela, and South Africa



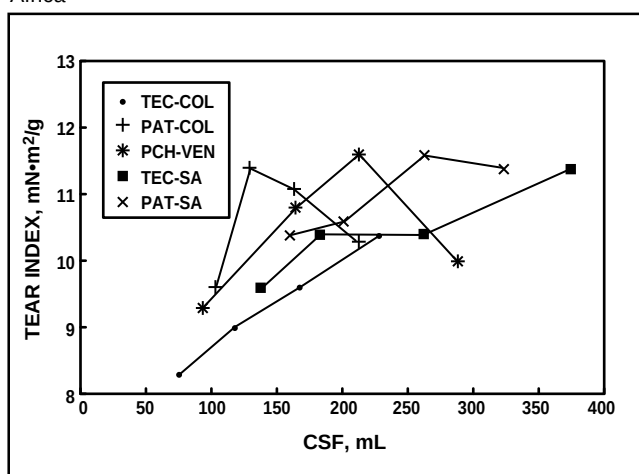
2. Comparison of CTMP pulp from Colombia, Venezuela, and South Africa



3. Comparison of TMP pulp from Colombia, Venezuela, and South Africa



4. Comparison of CTMP pulp from Colombia, Venezuela, and South Africa



hondurensis nor *P. tecunumanii* has been extensively tested for TMP or CTMP.

Wood preparation and laboratory procedures

The wood was derived from CAMCORE trials that were approximately eight years of age (Table I). The wood sample was therefore considered to be 100% juvenile wood with a very low proportion of summerwood. Thirty trees were chosen at random in the trials. From each tree, a single log of 1.3 m length cut at 1.0 m height from the ground was sent

I. Wood dispatched from CAMCORE trials to Andritz Sprout-Bauer

Country	Species
Colombia	<i>P. patula</i> , <i>P. tecunumanii</i>
Venezuela	<i>P. caribaea</i> var. <i>hondurensis</i>
South Africa	<i>P. patula</i> , <i>P. tecunumanii</i>

to Andritz Sprout-Bauer by air freight following debarking.

Upon arrival at Andritz Sprout-Bauer, the logs were chipped and screened. The chips were kept separate by country and by species and were treated in a similar manner. Thermomechanical refining was carried out at 2.1 bar steaming pressure

with a 3-min retention time in the horizontal steaming vessel. Pressurized refining was followed by two-stage atmospheric refining. Three secondary refiner runs were produced at targeted energy levels of 1000, 1200, and 1400 kW·h/ovendry metric ton (o.d.mt). A tertiary run was made on the 1400 kW·h pulp

II. TMP and CTMP results from CAMCORE trials in Colombia

<i>P. tecunumanii</i>	TMP					CTMP (3% Na ₂ SO ₃ applied)				
kW·h/o.d.mt	1298	1179	1350	1476	1009	1267	818	1007	1285	1473
Total		2477	2648	2774	3783		2085	2274	2552	2740
CSF, mL	680	210	199	146	47	621	227	166	117	75
Burst index, kPa·m ² /g	^a	1.0	1.1	1.4	2.0	^a	1.0	1.4	1.6	2.0
Tear index, mN·m ² /g	^a	11.2	11.5	10.4	8.6	^a	10.4	9.6	9.0	8.3
Tensile index, N·m/g	^a	26.0	28.6	31.5	41.2	^a	26.4	31.8	36.5	40.5
Stretch, %	^a	1.80	1.66	1.90	2.06	^a	1.82	2.01	2.09	2.15
TEA, J/m ²	^a	17.7	16.7	22.6	31.4	^a	18.6	25.5	29.4	33.3
Brightness (phys. sheet)	^a	48.3	49.1	45.9	47.6	^a	52.1	52.5	52.6	51.8
Opacity, %	^a	90.1	89.7	94.6	96.7	^a	85.2	88.3	89.9	93.2
Scat. coef., m ² /kg	^a	41.7	43.9	46.6	53.4	^a	37.9	41.8	45.9	50.6
ISO Brightness	48.2	53.2	54.1	54.5	55.3	51.3	56.8	57.2	58.3	63.0
Shives, % (Pulmac-0.10 mm)	8.90	1.18	1.16	0.74	0.40	9.32	1.40	1.10	0.80	0.66
<i>P. patula</i>	TMP					CTMP (3% Na ₂ SO ₃ applied)				
kW·h/o.d.mt	1310	1056	1324	1572	904	1246	936	1225	1301	1429
Total		2366	2634	2882	3786		2182	2471	2547	2675
CSF, mL	600	144	128	92	50	642	210	162	128	103
Burst index, kPa·m ² /g	^a	1.5	1.6	1.9	2.3	^a	1.3	1.5	1.7	1.9
Tear index, mN·m ² /g	^a	10.4	10.7	9.9	8.8	^a	10.3	11.1	11.4	9.6
Tensile index, N·m/g	^a	34.1	36.6	40.1	43.6	^a	31.0	35.0	39.7	44.4
Stretch, %	^a	1.96	1.97	1.95	2.17	^a	1.80	1.92	2.01	2.14
TEA, J/m ²	^a	25.5	27.5	29.4	36.3	^a	20.6	25.5	30.4	36.3
Brightness (phys. sheet)	^a	54.0	53.0	54.3	52.2	^a	58.2	56.9	57.6	57.9
Opacity, %	^a	88.9	89.0	89.3	95.7	^a	84.5	86.4	87.7	87.2
Scat. coef., m ² /kg	^a	46.8	44.7	48.8	58.8	^a	43.7	42.5	45.6	47.2
ISO Brightness	53.1	58.3	58.8	59.6	61.1	58.2	62.7	63.3	63.5	64.0
Shives, % (Pulmac-0.10 mm)	9.30	2.72	0.88	0.40	0.16	8.88	0.64	0.60	0.58	0.38

^aCould not make handsheets.

with additional refining with an energy input of approximately 800 kW·h/o.d.mt.

A CTMP series was also produced from each of the tree species supplied in this study (Table I). A sodium sulfite liquor was added in the eye of the Model 418 pressurized double disc refiner. Approximately

3% Na₂SO₃ (ovendry basis) was applied. Refining was carried out at 1.38 bar steaming pressure with a 3-min retention time. Four secondary refiner runs were produced on each series at targeted energy levels of 800, 1000, 1200 and 1400 kW·h/o.d.m.t.

All pulps were tested in accordance with TAPPI Methods for Canadian Standard Freeness (CSF) and physical and optical properties (T 425, T 218, T 494, T 414 and T 403). The laboratory results for TMP and CTMP pulps are given for Colombia (**Table II**), Venezuela (**Table III**), and South Africa (**Table IV**).

III. TMP and CTMP results from a CAMCORE trial in Venezuela

<i>P. caribaea</i> var. <i>hondurensis</i>	TMP					CTMP (3% Na ₂ SO ₃ applied)				
kW·h/o.d.mt	1202	1152	1275	1409	881	1102	878	1039	1409	1622
Total		2354	2477	2611	3492	1908	2141	2511	2724	2724
CSF, mL	700	315	207	178	99	728	287	211	163	93
Burst index, kPa·m ² /g	^a	0.8	0.9	1.4	1.8	^a	0.8	1.2	1.5	2.0
Tear index, mN·m ² /g	^a	9.1	10.3	11.2	9.9	^a	10.0	11.6	10.8	9.3
Tensile index, N·m/g	^a	18.9	23.8	24.3	33.1	^a	22.7	25.8	28.7	37.9
Stretch, %	^a	1.32	1.44	2.11	1.74	^a	1.91	2.06	2.07	2.41
TEA, J/m ²	^a	7.85	14.7	16.7	24.5	^a	15.7	18.6	20.6	31.4
Brightness (phys. sheet)	^a	49.2	50.4	50.8	51.9	^a	53.0	53.7	55.3	56.3
Opacity, %	^a	86.4	87.7	88.3	90.2	^a	84.6	85.9	88.1	90.8
Scat. coef., m ² /kg	^a	39.2	40.1	43.7	47.5	^a	36.9	39.6	45.0	52.1
ISO										
Brightness	47.3	53.5	54.8	55.6	56.8	51.9	58.0	59.8	59.5	59.4
Shives, % (Pulmac-0.10 mm)	8.44	7.11	2.07	1.86	0.99	12.3	3.95	3.24	2.47	0.95

^aCould not make handsheets.

Comparison of TMP and CTMP

Compared to TMP, CTMP gave higher ISO brightness as well as higher physical sheet brightness. Generally, the freeness was developed with less total energy using the CTMP process. The TMP process gave higher values for tensile index and stretch (%) in most cases. In *P. tecunumanii* from South Af-

rica, CTMP had more long fibers and fewer fines than TMP.

The pulping of a given species using TMP or CTMP methods will depend on the desired end product. As this trial was an evaluation of 100% juvenile wood, it is to be expected that certain properties of TMP and CTMP will be better when wood from mature trees can be used. However, the results from this trial indicate that acceptable properties for

both TMP and CTMP from trees considerably younger than are commercially utilized for softwood plantations in North America or Scandinavia are feasible. Several studies have demonstrated satisfactory pulp quality from juvenile pine species (3, 4). Pulps with superior light scattering coefficient and reduced coarseness are available using juvenile pine (4-6).

IV. TMP and CTMP results from CAMCORE trials in South Africa

<i>P. tecunumanii</i>	TMP					CTMP (3% Na ₂ SO ₃ applied)				
kW·h/o.d.mt	1255	1184	1419	1602	891	1249	819	1046	1281	1481
Total		2439	2674	2857	3748		2068	2295	2530	2730
CSF, mL	719	229	150	113	50	726	374	261	182	137
Burst index, kPa·m ² /g	^a	0.9	1.5	1.6	2.2	^a	0.6	1.2	1.5	1.8
Tear index, mN·m ² /g	^a	10.3	9.8	9.3	8.6	^a	11.4	10.4	10.4	9.6
Tensile index, N·m/g	^a	25.9	32.3	35.8	44.1	^a	21.0	28.3	32.3	37.8
Stretch, %	^a	1.91	2.09	2.15	2.40	^a	1.47	1.90	1.96	2.04
TEA, J/m ²	^a	21.6	28.4	32.4	44.1	^a	12.8	22.6	26.5	32.4
Brightness (phys. sheet)	^a	45.8	46.8	47.2	45.7	^a	50.2	50.6	51.1	51.1
Opacity, %	^a	92.8	93.2	93.3	96.7	^a	84.6	87.4	88.3	91.0
Scat. coef., m ² /kg	^a	42.0	44.1	44.5	55.8	^a	33.9	38.2	40.1	44.1
ISO										
Brightness	46.4	52.0	53.1	54.4	55.3	52.0	55.8	56.1	58.4	58.7
Shives, % (Pulmac-0.10 mm)	8.52	3.70	1.08	0.81	0.37	11.36	3.55	1.39	0.96	0.70
<i>P. patula</i>	TMP					CTMP (3% Na ₂ SO ₃ applied)				
kW·h/o.d.mt	1249	1107	1351	1645	884	1366	910	1151	1452	1569
Total		2356	2600	2894	3778		2276	2517	2818	2935
CSF, mL	730	364	227	127	68	698	322	262	199	159
Burst index, kPa·m ² /g	^a	0.8	1.4	1.8	2.4	^a	1.2	1.4	1.8	2.0
Tear index, mN·m ² /g	^a	9.5	12.4	10.6	9.5	^a	11.4	11.6	10.6	10.4
Tensile index, N·m/g	^a	22.2	29.3	35.4	44.2	^a	28.3	30.6	36.6	38.7
Stretch, %	^a	1.86	2.28	2.44	2.65	^a	1.87	1.92	2.11	2.33
TEA, J/m ²	^a	15.7	26.5	34.3	47.1	^a	22.6	24.5	33.3	37.3
Brightness (phys. sheet)	^a	51.6	52.1	52.5	52.7	^a	54.3	53.8	55.3	54.2
Opacity, %	^a	86.6	88.5	91.2	94.1	^a	84.5	86.4	88.3	89.8
Scat. coef., m ² /kg	^a	38.0	41.5	47.0	54.2	^a	37.6	40.0	43.2	45.2
ISO										
Brightness	50.6	54.5	56.2	56.4	58.3	55.9	61.4	62.3	61.5	62.0
Shives, % (Pulmac-0.10 mm)	13.9	2.61	1.32	0.83	0.26	11.8	2.07	0.78	0.61	0.58

^aCould not make handsheets.

Comparison of *P. patula* and *P. tecunumanii*

For both TMP and CTMP from South Africa, the tensile energy absorption (TEA) was higher with *P. patula* relative to *P. tecunumanii* (Figs. 1 and 2) and a similar trend was observed for the tear factor (Fig. 3 and 4). The *P. patula* had superior scattering coefficient using the CTMP process, but the two species

were almost equivalent when compared using TMP. Thermomechanical pulping with *P. Patula* had fewer fines than did *P. tecunumanii*.

The CTMP *P. tecunumanii* developed lower freeness with lower total energy input. The *P. patula*, however, demonstrated improved tear index, ISO brightness, and physical sheet brightness when compared to *P. tecunumanii*. The higher brightness of TMP and CTMP from

P. patula would imply lower bleaching inputs to achieve target brightness levels.

The comparison from Colombia is more difficult since the *P. patula* TMP achieved low freeness with a low level of total energy input. The *P. patula* TMP demonstrated superior burst and tensile indices, TEA, ISO brightness, and physical sheet brightness compared to the *P. tecunumanii* TMP. Comparing the

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CTMP pulps, *P. patula* had higher tear and tensile indices, TEA, and physical sheet brightness. The *P. tecunumanii* CTMP had a higher handsheet opacity. This was reflected by a higher P200 fines content. The *P. patula* CTMP had more long fibers at low freeness than did *P. tecunumanii*.

TMP and CTMP from *P. caribaea* var. *hondurensis*

The CTMP pulps from *P. caribaea* var. *hondurensis* demonstrated superior tear and tensile indices, TEA, physical sheet brightness, and ISO brightness compared to the TMP pulps. Compared to *P. patula* and *P. tecunumanii*, the TMP and CTMP pulps of *P. caribaea* var. *hondurensis* were generally weaker and

had a higher shive content. It should be noted, however, that *P. patula* and *P. tecunumanii* will not grow in areas of Venezuela where plantations of *P. caribaea* var. *hondurensis* are being established.

Conclusions

TMP and CTMP pulps produced from tropical pines at eight years of age demonstrated good potential for use in a range of newsprint, printing, and writing grades. Although mature pines tend to produce TMP of higher tensile and tear strength properties, the juvenile pulps produced in this study meet pulp quality criteria for industrial application. The availability and harvesting frequencies of tropical juvenile pines further improves the differential in

softwood costs when compared to producers in North America and Scandinavia. ■

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