

Laboratory kraft pulping of juvenile tropical pines: *Pinus patula*, *P. tecunumanii*, *P. maximinoi*, and *P. chiapensis*

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THE VAST MAJORITY OF CONIFER plantations in the tropics and subtropics are *Pinus patula* Schiede and Deppe (1) or *P. caribaea* var. *hondurensis*. Both species have been planted because of their acceptable wood properties and their relatively well-known silvicultural requirements. However, a large number of other pine species are being tested by members of CAMCORE (Central America and Mexico Coniferous Resources Cooperative). In particular, *P. maximinoi*, *P. tecunumanii*, *P. chiapensis*, and *P. patula* have demonstrated potential as plantation species in South Africa, Brazil, and Colombia (2).

Efforts at tree improvement through testing of various pine species have been underway at Smurfit Carton de Colombia (SCC) for more than 20 years (3). So far, 24 pine species have been tested, and many of these tests have been at the provenance or individual family level (4–6). Once a species has shown promise in trials, small pilot plantations of 50–100 hectares are established. This allows for larger-scale evaluation of nursery and silvicultural characteristics. In addition to trials and pilot plantations, it is imperative to test the pulp and papermaking properties of promising species.

Pulp and papermaking with wood of *P. patula* is common in Colombia, Swaziland, and South

Africa (1, 7). However, many other promising pine species have not been intensively utilized. Laboratory-scale pulp evaluations have been undertaken in South Africa for *P. maximinoi* (8, 9) as well as for *P. tecunumanii* (10). SCC decided that before initiating further tree-improvement activities with new pine species, it would be prudent to conduct laboratory evaluations of the pulp and papermaking properties of *P. maximinoi*, *P. tecunumanii*, *P. chiapensis*, and *P. patula*.

MATERIALS AND METHODS

Pinus chiapensis, *P. maximinoi*, and *P. tecunumanii* were chosen for kraft pulping studies, with *P. patula* as the control. *Pinus chiapensis* is a soft pine with wood very similar in density to *P. strobus* in the United States and Canada. *Pinus maximinoi* and *P. tecunumanii* are hard pines that grow in more-tropical climates than does *P. patula*.

Trees from adjacent, unthinned CAMCORE trials of *P. maximinoi*, *P. tecunumanii*, *P. chiapensis*, and *P. patula* were sampled at eight years of age. Soil properties and climatic effects were consistent among the four trials. The annual rainfall was 2000 mm, with a mean annual temperature of 18°C. The trial sites were at a latitude of 2.5°N and an elevation of 1850 m. The trees grow year round in this area and do not experience drought or frost. For eight-year-old trees, total height growth will be

ABSTRACT

Laboratory-scale kraft pulping was carried out using wood chips from 8-year-old trees of *Pinus patula*, *P. tecunumanii*, *P. maximinoi*, and *P. chiapensis*. Samples were pulped to target kappa nos. 50, 38, and 28. A portion of the kappa-no.-28 pulps was bleached to 85% brightness (ISO) using an OCOH sequence. Pulps were refined using a Valley beater at four levels, and handsheets were evaluated for burst and tear. *Pinus chiapensis* required the highest active alkali to achieve a given kappa number, while *P. patula* required the least. With refining, tear index for the four pine species reached similar levels. For wood from juvenile tropical pines, the results are within accepted international standards for pulp.

almost 16 m. Total volume production at eight years of age will be on the order of 120 m³, excluding bark.

For each species, 30 trees without defects of forking, excessive branching, or fox tailing were felled. At an above-ground height of 1.5 m, a log of 2.4-m length was sampled. As pruning to a tree height of 2 m had been done at age four years, the log represented both pruned and unpruned wood. The logs of a species were kept separated and chipped at the SCC mill on the same day they were cut. This was done to prevent blue stain, which is very common in pines in Colombia.

The chips were air-freighted to the Dept. of Wood and Paper Science, North Carolina State University, for laboratory kraft pulping. Pulping conditions for the 700 g (ovendry basis) of chips were an *H*-factor of 1000, 30% sulfidity, and a 4:1 liquor-to-wood ratio. The active alkali concentration varied from 16.75% to 24.0% (as Na₂O, percent on ovendry wood) in order to reach target kappa numbers of 28, 38, and 50. Part of the pulp from the cook to

kappa no. 28 was bleached using an OCOH sequence to 85% brightness (ISO). Bleached and unbleached pulps were refined at four levels using a Valley beater.

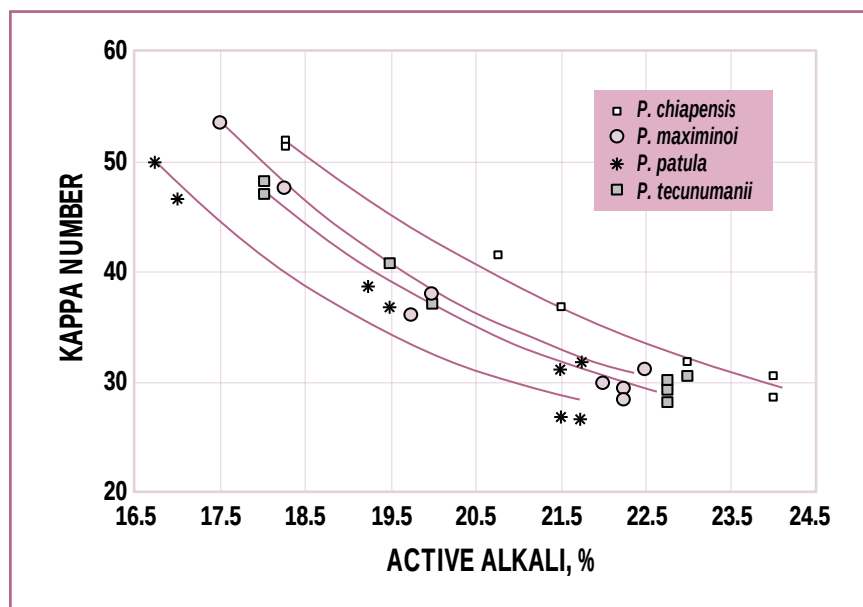
Pulp kappa number was determined according to TAPPI T 236 om-85. Brightness was measured using an Elrepho 2000 ISO. Handsheets were made in accordance with TAPPI T 205 om-88 and conditioned prior to testing. Sheet strength properties were tested using TAPPI test methods.

RESULTS AND DISCUSSION

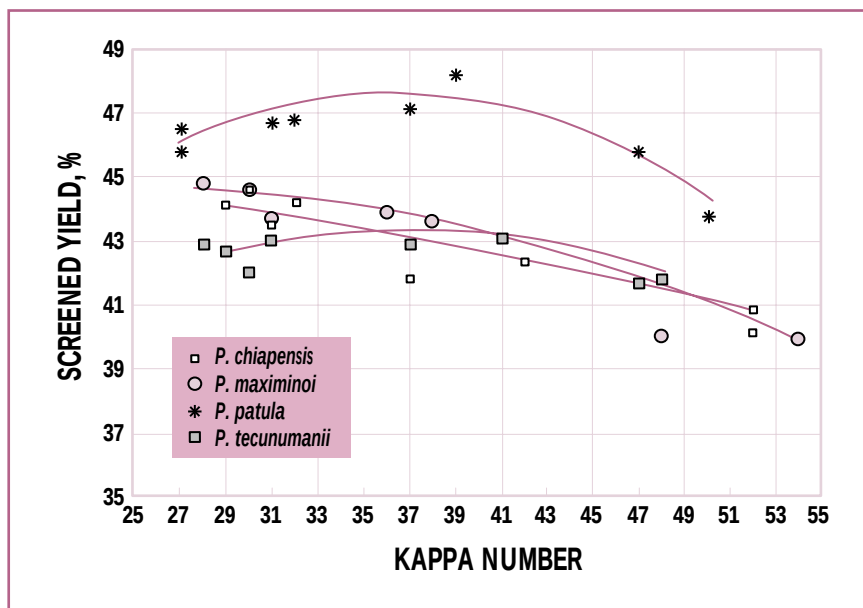
Figure 1 shows the percent active alkali required to pulp to various kappa numbers for the four pine species. Wood of *P. chiapensis* required higher active-alkali charges to achieve a given kappa number. The opposite trend was observed for *P. patula*, which required the lowest active-alkali charges to reach a given kappa number. The relationship of kappa number to screened yield in Fig. 2 and unscreened yield in Fig. 3 reveals some differences among the four pine species. *Pinus patula* clearly had the highest screened pulp yield, while *P. chiapensis* had the lowest unscreened pulp yield.

Figures 4 and 5 show burst index and tear index, respectively, as functions of tensile energy absorption (TEA) for the four pulps at kappa no. 50. Similarly, Figs. 6 and 7 show the same properties at kappa no. 38, while Figs. 8 and 9 show the results at kappa no. 28, and Figs. 10 and 11 show the results for the bleached pulp samples (kappa no. 28).

Burst index became increasingly variable as kappa number decreased from 50 (Fig. 4) to 38 (Fig. 6) to 28 (Fig. 8) to the bleached pulp samples (Fig. 10). In the three unbleached samples (kappa nos. 50, 38, 28), *P. tecunumanii* did not reach the burst-index levels of the other



1. Kappa number as a function of active alkali for kraft pulps produced from four pine species

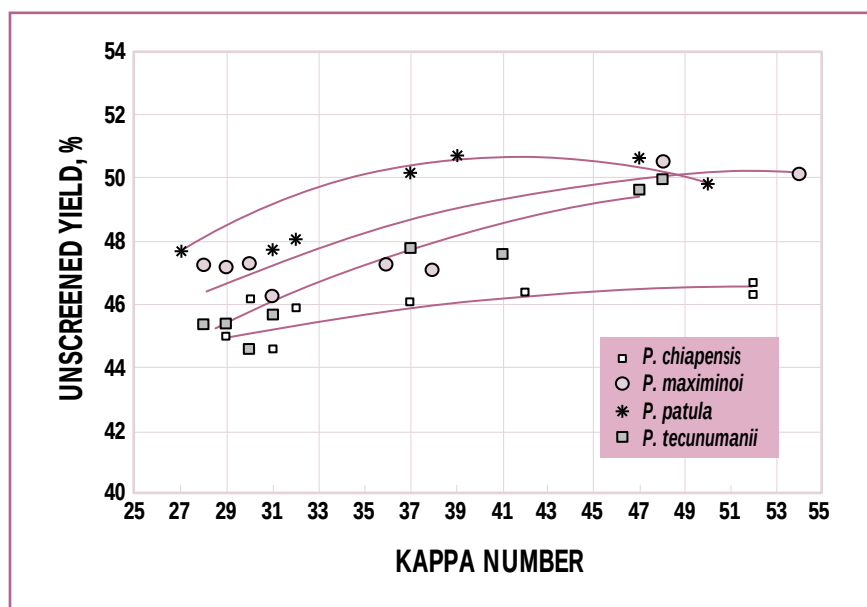


2. Screened pulp yield as a function of kappa number for kraft pulps produced from four pine species

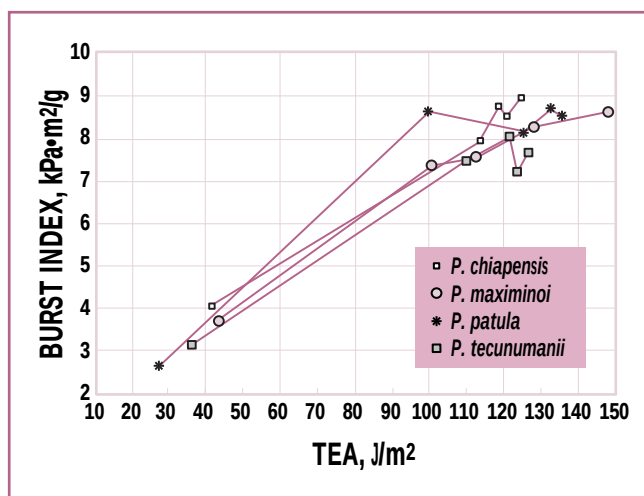
species as TEA increased with refining. However, the burst index of *P. tecunumanii* and the other three species are within the normal range of values (6.0–9.0 kPa·m²/g) for

unbleached kraft pulp. The lowest TEA values represent the unbeaten pulp.

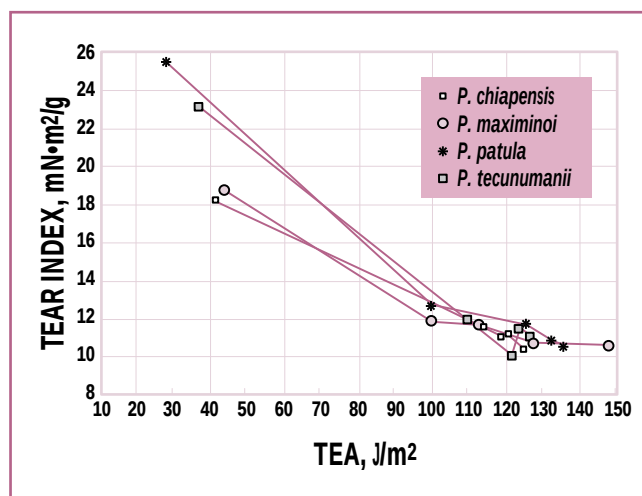
Tear index (Figs. 5, 7, 9, 11) for the unbeaten pulps were scattered.



3. Unscreened pulp yield as a function of kappa number for kraft pulps produced from four pine species



4. Burst index as a function of tensile energy absorption for kraft pulps (kappa no. 50) produced from four pine species. The lowest TEA values represent unbeaten pulp.



5. Tear index as a function of tensile energy absorption for kraft pulps (kappa no. 50) produced from four pine species. The lowest TEA values represent unbeaten pulp.

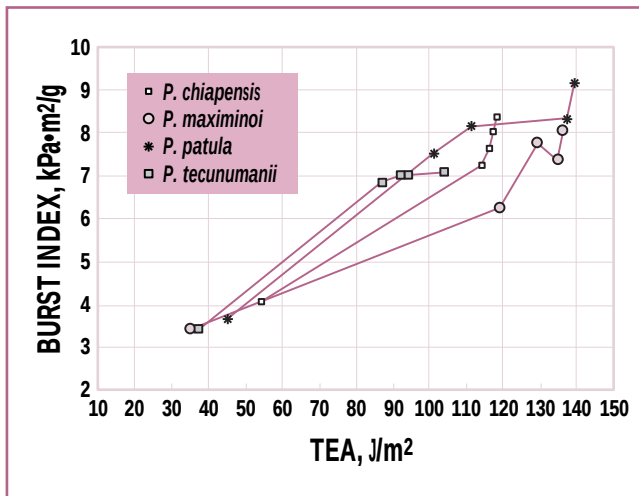
However, with refining, the tear index values for the four pine species reached similar levels. The actual tear index values (10.0–12.0 mN·m²/g) are low by international standards for unbleached kraft pulp. However, for eight-year-old trees, the values are not significantly below that of juvenile pine from other parts of the world.

For *P. tecunumanii*, maximum values for burst and tear indexes are achieved quickly at low levels of refining. This implies that further refining would not be required to reach target levels of burst and tear index. The operational consequences of this would need to be evaluated further at the pilot-plant scale.

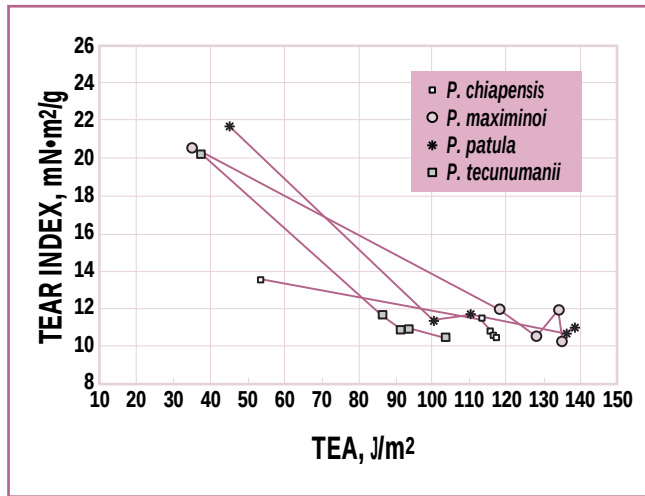
CONCLUSION

The results presented here should be considered preliminary, especially for *P. chiapensis*. This soft pine has considerable potential for rapid growth rates in a number of countries, and new methods of utilization for pulp and paper need to be developed.

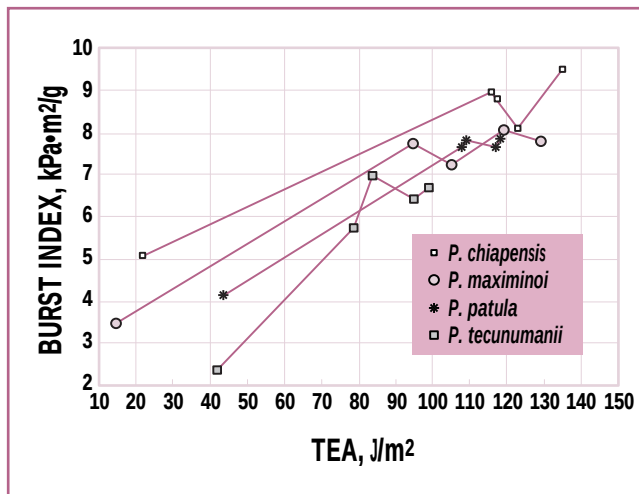
Softwood plantations in the Andes region of Colombia can be



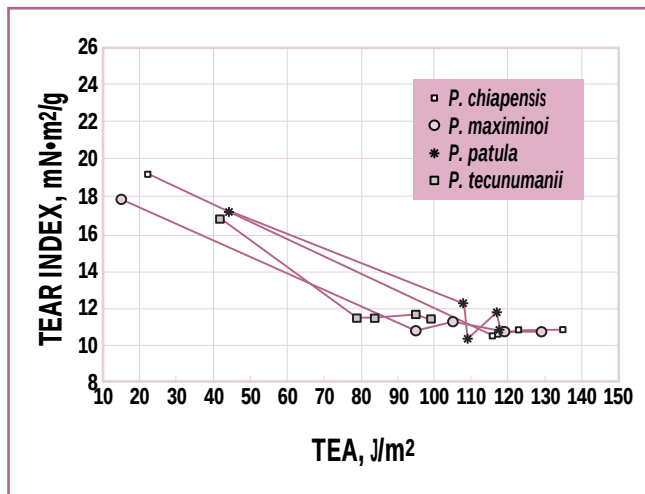
6. Burst index as a function of tensile energy absorption for kraft pulps (kappa no. 38) produced from four pine species. The lowest TEA values represent unbeaten pulp.



7. Tear index as a function of tensile energy absorption for kraft pulps (kappa no. 38) produced from four pine species. The lowest TEA values represent unbeaten pulp.



8. Burst index as a function of tensile energy absorption for kraft pulps (kappa no. 28) produced from four pine species. The lowest TEA values represent unbeaten pulp.



9. Tear index as a function of tensile energy absorption for kraft pulps (kappa no. 28) produced from four pine species. The lowest TEA values represent unbeaten pulp.

KEYWORDS

Chips, Colombia, kappa number, kraft pulping, pinus, test methods, tropics.

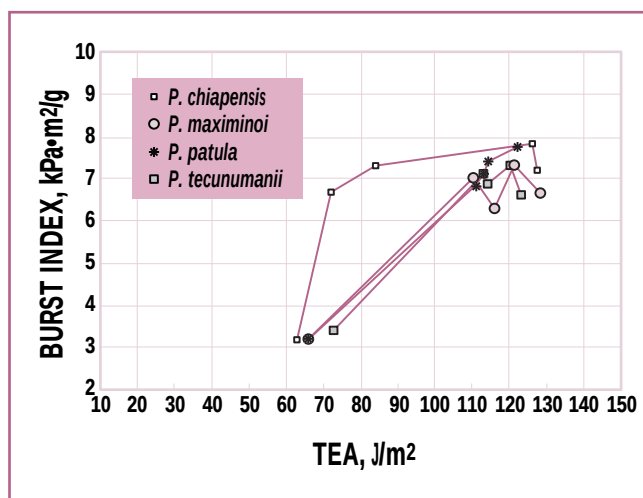
thinned after eight years for pulp production. The furnish from these thinnings would provide only a small proportion of pulpwood needs

in any given period. Thus, the relatively low values for tear index are not of major concern, since wood from final rotations of 15–18 years would provide the majority of the furnish. Wood quality does increase with age in the tropical pines for the majority of pulp and paper characteristics. TJ

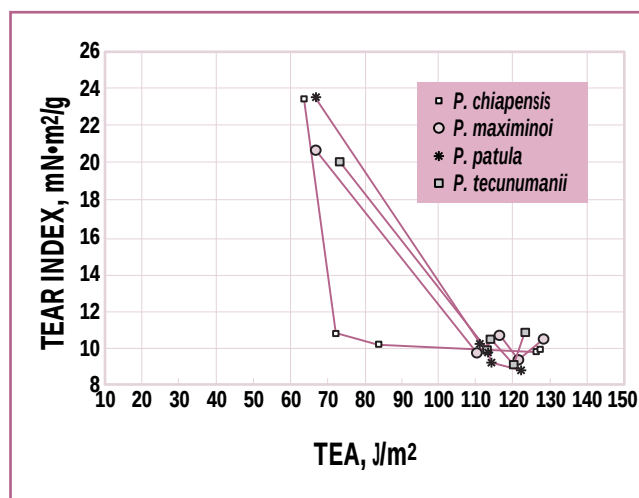
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10. Burst index as a function of tensile energy absorption for kraft pulps (kappa no. 28) produced from four pine species after bleaching to brightness of 85% (ISO). The lowest TEA values represent unbeaten pulp.



11. Tear index as a function of tensile energy absorption for kraft pulps (kappa no. 28) produced from four pine species after bleaching to brightness of 85% (ISO). The lowest TEA values represent unbeaten pulp.

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