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# Enhancing Softwood Mechanical Pulp Properties Through Chip Treatment with *Ophiostoma piliferum*

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## SUMMARY

Fungal treatment effects of *Ophiostoma piliferum* (*O.p.*) marketed as Cartapip 97® on handsheet strength properties were studied by producing refiner mechanical pulps from fungal treated chips for varying time periods. Cartapip 97® (Cp) treatment decreased extractive levels and increased fiber length, tear, tensile, and zero-span tensile strengths over and above growth with *O.p.* wild-types. Cp treated chips refined with greater fiber lengths, which may partly account for increased tear strength. The Cp pulps resemble chemimechanical pulps(1), where strength properties increase while freeness changes minimally. Fiber and/or extractive chemical compositional changes may explain strength differences.

## INTRODUCTION

The fungus, *Ophiostoma piliferum*, is used to control pitch problems in paper production. Natural pitch consists of low-molecular-weight oleophilic materials extracted from wood chips by neutral, nonpolar, organic solvents. Pitch contains triglycerides, fatty acids, diterpenoid resin acids, sterols, waxes, and other compounds, some of which are not well characterized(2).

Cartapip is a commercially available, albino strain of *O.p.* which does not stain wood, as do most blue stain fungi(3). In addition to controlling pitch problems and preventing blue stain, Cp chip treatment yields products with improved strength and runnability characteristics(4). The objectives of this work were to document any strength changes in mechanical pulps produced from loblolly pine (*Pinus taeda*) chips treated with Cp, and explore probable causes.

## MATERIALS AND METHODS

### Wood Source

Three half-sib, loblolly pine trees were obtained in Southeastern Georgia to use as the wood source for this project. Trees were cut into boards, the boards were sawn into blocks, and then uniformly cut into chips by hand with a band saw. To increase uniformity, care was taken to remove knots and associated compression wood. Chips were stored frozen until used. All experiments were conducted with random mixtures of chips from all trees, including early wood, late wood, juvenile, and mature wood.

### Inoculation and Fungal Growth Period

Cp master stocks were grown at IPST in shake flasks. Fungal suspensions were centrifuged after 36 hours. Pellets from centrifugation were homogenized and diluted before being pipetted into plastic bags containing about 1200 g. (wet weight) of wood. Chips were inoculated with 1.61 x $10^7$ c.f.u.s for every 100 g. of chips (wet weight), and incubated at 25°C for one-, three-, and five-week periods. Nontreated controls were also incubated and aged for the same time periods. Significant growth of *O.p.* wild-types occurred on all controls.

### Refining

A Sprout-Waldron atmospheric refiner equipped with 12 inch, D2B505 patterned, 440C stainless steel plates was used to refine the fungal treated and nontreated chips. Motor load was measured with a Hall Effect power transducer and recorded with a reporting integrator. Chips were refined with peripheral water flowing into the refiner casing. Consecutive passes were carried out at 30% consistency. Refining was executed in 5 to 7 refining passes. Pulp retained for latency removal, and handsheet production ranged in freeness from 250 to 30 mL CSF.

### Dichloromethane Extractions and Handsheet Production

Wood meal samples from chips used for refining were extracted with dichloromethane (dcm) according to TAPPI Test Method T-204 after grinding to 10 mesh size in a Wiley mill. Freeness testing, handsheet production, physical and optical property testing were carried out according to TAPPI Test Methods. Fines contents and fiber lengths were estimated from Bauer-McNett classification(5) .

### Data Analysis

Statistical analyses of the data were performed. Multiple regression analysis with Cp treatment, incubation time, and specific energy consumption designated as independent variables was performed, while freeness, fines content, tensile, density, tear, z-span, fiber length, and scattering coefficient were used as dependent variables.

## RESULTS AND DISCUSSION

### Extractive Results

Cp treatment reduced extractive content from 25-45% more than non-aged, non-treated control chips and 7-16.5% more than wild-type fungi on non-treated, nonsterile wood chips aged for one-, three-, and five-week time periods (Fig.1).

### Strength Results

The multiple regresssion equations were all significant and yielded strong multiple coefficients of correlation (Table 1). Equivalent refining energy input to treated and nontreated chips and resulting pulps did not produce pulps with meaningfully different freeness levels. Fungal treatment did not reduce energy usage to produce these pulps. Strength and power relationships given in Figures 2, 4, and 5 represent upper and lower limits for the multiple regression equations. (Lower limit - no Cp/incubation time equals zero; upper limit - Cp is present/incubation time equals five weeks ).

**Figure 1. Extractive Content vs. Cartapip Residence Time in Extracted Wood Meal**

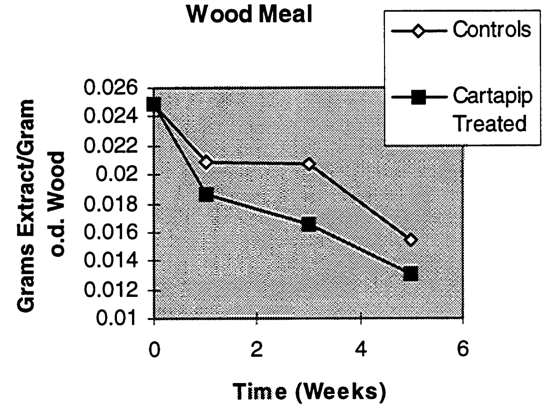
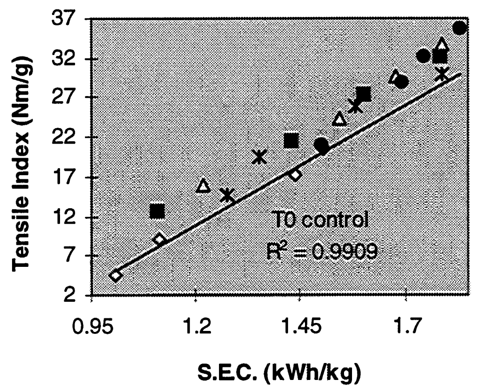


**Figure 2. Change in Tensile Strength with S.E.C.**



The same amount of energy input in the fungal treated pulps produced greater tensile strengths (Fig. 2).[1] Generally, tensile, tear, and zero-span tensile strengths all increased with *O.p.* treatment. Tear strength dramatically increased from 18 to 35% over three- and five- week control pulps, respectively (Fig. 3). As shown in Figure 3, tear at a given tensile strength increased indicating a probable increase in individual fiber strength, supported by zero-span data (Fig. 4). In addition, fungal treatment yielded pulps with fiber lengths longer than those in untreated pulps (Fig. 5). Increased fiber length also contributes to increased tear strength. Cp treatment yielded concurrent significant decreases in fines content.

**Figure 3. Tensile-Tear Relationship**

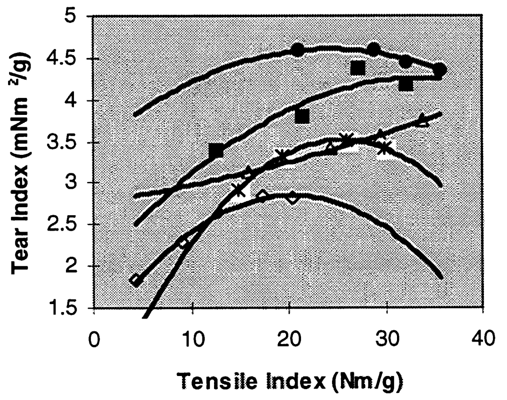
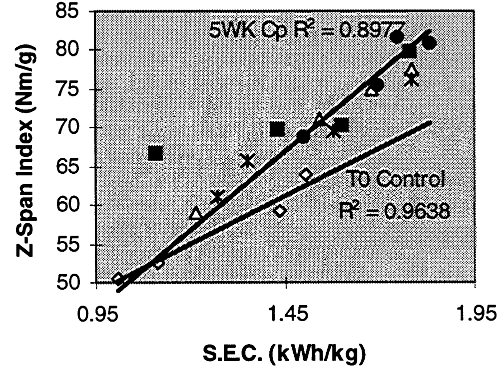


**Figure 4. Zero-Span Tensile-Specific Energy Consumption Relationship**



[1] Symbols used in the figures are: ◊ Diamonds are nonsterile, time-zero controls;
△ Triangles are nonsterile controls aged three weeks;
* Stars are nonsterile controls aged five weeks;
■ Squares are three-week Cp treatments;
● Circles are five-week Cp treatments.

The wild-type *O.p.* affected the same parameters as did Cp. However, Cp gave a much greater effect most likely as a result of its aggressive colonization.

**Figure 5. Change in Fiber Length with Specific Energy Consumption**

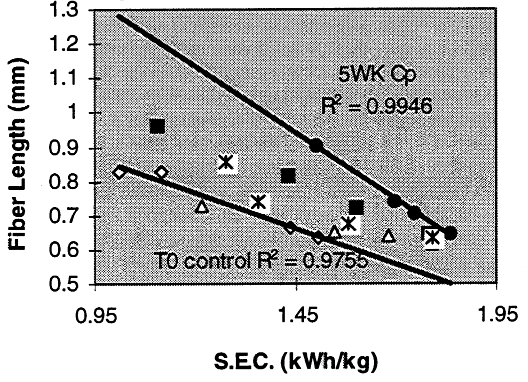


**Table 1. Mult. Reg. Equations and $R^2$ for Dependent Variables (95% Confidence Level)**

| Dependent Variable, y | Regression Equation, where: $x_1$=SEC, $x_2$=Incubation Time, $x_3$=Cartapip Presence | $R^2$ |
|---|---|---|
| CSF | $y=-2.986x_1- + .24x_3 + 8.629$ | 0.962 |
| Fines | $y=21.85x_1-1.212x_2-3.527x_3+16.827$ | 0.9034 |
| Tensile Index | $y=31.54x_1 + .83x_2 +26.147$ | 0.969 |
| Density | $y=161.15x_1 - 19.33x_3 + 56.29$ | 0.9226 |
| Tear Index | $y=1.327x_1+.1182x_2+.7973x_3+.8403$ | 0.9214 |
| Z-Span Tensile Index | $y=26.87x_1+.939x_2+3.895x_3+23.918$ | 0.9179 |

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## REFERENCES

(1) Gummerus, M., Virkola, N.E. 1979. Paperi ja Puu. 4a:203-214.
(2) Mutton, D.B. 1962. In: Hillis, W.E. (ed) Wood Extractives and Their Significance to the Pulp and Paper Industries, Chap. 10, Academic Press, New York.
(3) Blanchette, R.A., Farrell, R.L., Burnes, T.A., Wendler, P.A., Zimmerman, W., Brush, T.S. and Snyder, R.A. 1992. Tappi 75(12):102.
(4) Hoffmann, G.C., Brush, T.S., and Farrell, R.L. 1992. Naval Stores Rev. 102(3):10.
(5) Tasman, J.E. 1972. Tappi 55(1):136.