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Influence of hemicelluloses content on the paper quality produced with *Eucalyptus globulus* fibres.

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Abstract
The raw-material composition and the cooking conditions determine the pulp composition and this affect the behaviour of the pulp in the beating process and the papermaking potential. However, at industrial scale the variability of the pulp composition, for a given raw material and a given process, is relatively low and usually it is difficult to quantify the impacts of pulp composition on beating and papermaking.

In the present study *E. globulus* bleached pulps were produced under different cooking conditions by the kraft process in order to obtain pulps with significant different hemicelluloses content (19% versus 14.5%). The behaviour of the pulps in beating and the papermaking potential were investigated under two beating intensities in the PFI mill and at four beating times. The pulp suspensions were characterised in terms of drainability, fibre morphology, wet fibre flexibility and relative bonded area. The paper produced was evaluated in terms of structural, superficial, mechanical and optical properties. The results showed the clear effect of the hemicelluloses content on the beating rate as well as on the paper properties.

Key words: Hemicelluloses content; *Eucalyptus globulus*; paper quality; fibres

Introduction
The behaviour of the fibres in the refining process depends on their physical and chemical characteristics. Lot of work has been done on the softwood fibres and some hardwood fibres[1,2], but *E. globulus* has received comparatively little attention. The data regarding the influence of refining intensity on the fibre performance are scarce[2]. On the other hand, the increased use of modified kraft cooking processes and the wood variability makes available in the market bleached kraft *E. globulus* pulps with different responses in refining. The different behaviours in refining are usually associated with the different hemicelluloses content. The objective of this paper is to investigate the behaviour of *E. globulus* pulps with very different hemicelluloses content in refining and evaluate their papermaking potential.

Materials and Methods
Eucalyptus globulus industrial wood chips (basic density=0.536 kg/L) were cooked at laboratory scale by the kraft process under markedly different reaction conditions in order to obtain two pulps with very different hemicelluloses content. One of the pulps was produced under conventional (CV) conditions while the other was produced by a modified kraft process (MOD) with 8/1 liquor/wood ratio and liquor replacement at the middle of the cooking cycle. The kappa number of both pulps was close to 15. The two pulps were bleached using a $D_0E_1D_1E_2D_2$ sequence. The hemicelluloses content of the pulps was determined by HPLC analysis of the neutral sugars after hydrolysis of the pulps with trifluoroacetic acid according to an optimised procedure adapted from the literature[3]. The papermaking potential of the pulps was evaluated in the PFI mill, using two refining intensities, 2N/mm and 5N/mm, and different refining revolutions. These were selected in order to obtain similar net specific energy consumption in refining for the two series. 30 g (o.d.) of air dry bleached pulp was refined at 10% consistency for each refining point. After beating, laboratory isotropic paper sheets were produced according to the Scan standards, using demineralised water. The biometrics characteristics of the fibre elements in the suspension were evaluated by the Morfi® and the wet fibre flexibility (WFF) index determined according to the procedure of Steadman and Luner[4], using a Cyberflex® equipment. The fine content of the suspension was determined in the Bauer-

McNett, as the material that flow throughout the 200 mesh. The paper hand-sheets were analysed in terms of structural, mechanical and optical properties according to the ISO standard.

Results and discussion

The hemicelluloses content of the CV and MOD pulps was 19% and 14.5%, respectively. These data are in good agreement with the pulp yields, which were 51% and 45% respectively. Regarding the biometrics properties of the fibres, the MOD pulp exhibits a lower coarseness and higher kink index and curl.

Drainage Resistance

Figure 1 shows the evolution of SR degree with the PFI revolutions, for the two pulps under investigation and for two refining intensities (2N/mm and 5N/mm). Considering, for example, the two series corresponding to the lower refining intensity (2N/mm), it is evident the effect of the pulp chemical composition. The refining rate increases clearly with the hemicelluloses content. According to the WRV and the fines data, this higher refining rate can be associated to both higher fines generation and higher hydration.

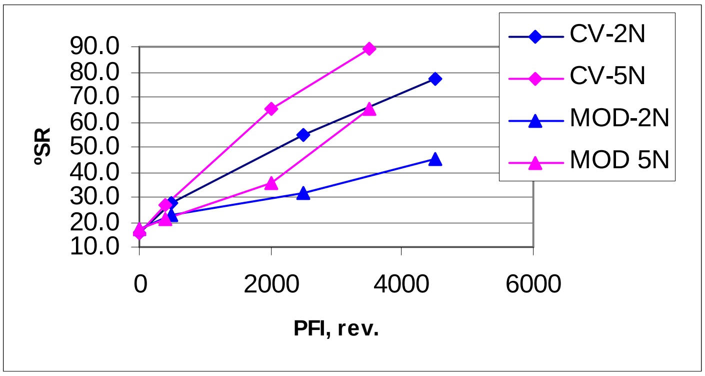

Figure 1: °SR vs PFI revolutions, for conventional (CV) and modified (MOD) pulps.

Structural Properties

Figure 2-a shows the evolution of the paper density with refining for the two pulps and for the two refining intensities, where it is evident the very positive role of the hemicelluloses content on paper consolidation. Moreover, the corresponding data for energy consumption (Fig. 2-b) suggest that higher refining intensity (5 N/mm) exhibits advantage over the lower refining intensity (2N/mm). On the other hand, at a given sheet density, the air permeability is similar for the four series, while the scattering coefficient is slightly higher for the modified pulp. Regarding to the paper smoothness, there are significant differences between the pulps when the independent variable is the PFI revolutions or the energy consumption. However, these differences become irrelevant when the paper density is used for comparison.

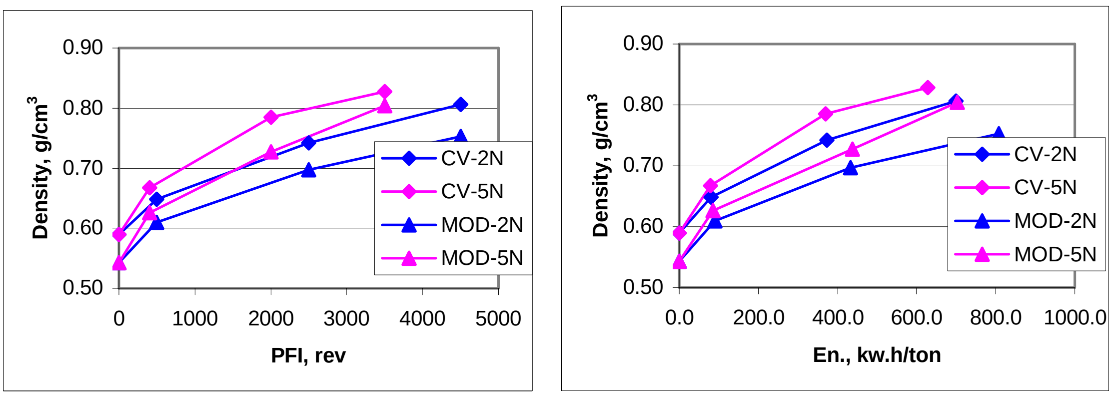

Figure 2: Density vs PFI revolutions (a-left) and density vs energy consumption (b-right).

Mechanical

The values of tensile strength (Fig. 3-a) reveal that the pulp with high hemicelluloses content is much more efficient in energy consumption than the corresponding pulp with low hemicelluloses content. However, the performance becomes similar when the data are represented as a function of paper density (Fig. 3-b). In opposition to tensile strength, the tear resistance of the pulps with 14.5% hemicelluloses content is similar or even higher than the corresponding values for the pulp with 19% hemicelluloses content (Fig. 4). The number of fibre per gram, which is higher for the first pulp, can be the most important reason behind this behaviour. On the other hand, the extremely low tear resistance exhibited by the CV pulp when refined under 5N/mm intensity can be related with the markedly decrease of the intrinsic fibre strength for these refining conditions. Despite the superior tensile strength of the pulp with higher hemicelluloses content, the representation of tear index as a function of the tensile strength shows similar behaviour as a consequence of the inferior tear resistance.

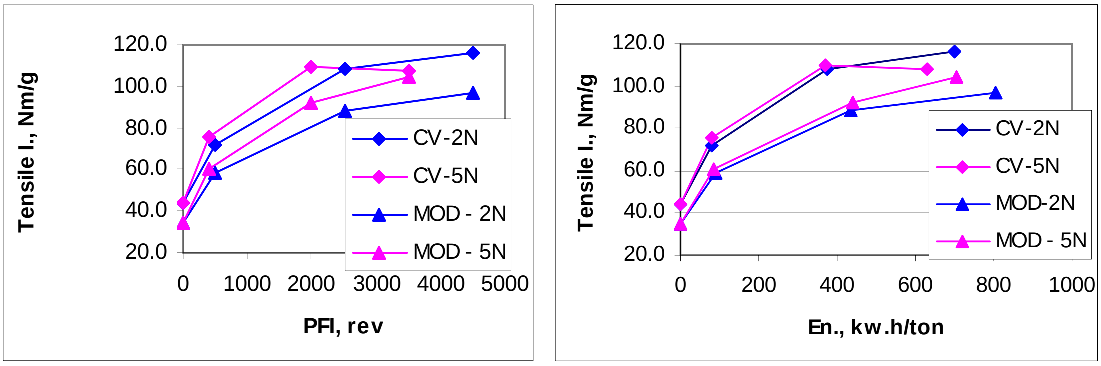

Figure 3: Tensile index vs PFI revolutions (a-left) and tensile index vs energy consumption (b-right).

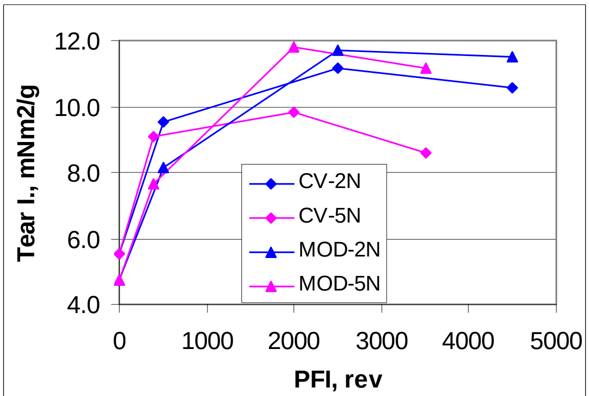

Figure 4: Tear index vs PFI revolutions.

Conclusions

The refining rate, measured as SR degree, sheet density and tensile strength, increases markedly with the hemicelluloses content (14.5% vs 19%). As a consequence, to produce paper with a given density, the pulp with lower hemicelluloses content requires much more energy in refining. However, the strength properties of the pulps are similar if the comparison is made at a given sheet density. The increase of the refining intensity from 2N/mm to 5N/mm has shown detrimental for the pulp strength (tear vs tensile) when the hemicelluloses content is high (19%). On the contrary, for the pulp with lower hemicelluloses content there is no effect.

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