WOOD AND PULP PROPERTIES OF TWO *EUCALYPTUS GLOBULUS* WOOD SAMPLES

António Santos[1], Ofélia Anjos[2] and Rogério Simões[1]

[1]Unidade de Materiais Têxteis e Papeleiros, Universidade da Beira Interior, 6201-001 Covilhã, Portugal
[2]Escola Superior Agrária de Castelo Branco, Quinta da Senhora de Mércules, Apartado 119, 6001 –909 Castelo Branco, Portugal (ofelia@esa.ipcb.pt)

ABSTRACT

This paper reports experimental data about wood chemical composition (extractives and lignin content), fibre characteristics, kraft cooking behaviour and papermaking potential of two wood samples of *Eucalyptus globulus* (one industrial chip sample and another obtained from a clone tree). The samples were submitted to the kraft cooking and bleaching processes in order to evaluate its pulping potential. The experimental results showed that the clone tree requires milder cooking conditions and exhibits higher pulp yield. The pulp fibres obtained from the clone have higher fibre length and fibre width and lower coarseness, which give higher fibre flexibility and collapsibility. In consequence, structural, mechanical and optical properties of paper are significantly different. In addition, we observed that the fibres from the clone tree are weaker than the corresponding fibres from the industrial sample.

Keywords: *Eucalyptus globulus*, clone, chemical composition, fibres, pulp and paper properties.

INTRODUCTION

Annual growth of a tree is a complex function of some factors like genetic factors, climate conditions, silviculture practices, soil nutrients, water availability, and their interactions, what it prints great natural variability of wood properties. The variability within the tree and between trees is very well documented (Zobel and Buijtenen, 1989;Kibblewhite *et al*., 2003). With the genetic manipulation it is possible to minimize the variability between the trees and improve some wood characteristics. In Portugal, *Eucalyptus globulus* is the most important species for the pulp and paper industry. Despite this relevance, the published data about the wood variability and the corresponding impacts on the pulping and paper making potential are scarce. However, lot of work has been published for other hardwood species (O'Neill *et al*., 1999; Seth *et al*., 1997). The aim of the present work is to investigate the behaviour of two wood samples in the kraft process, evaluate the fibre characteristics and their influences on the paper properties.

MATERIALS AND METHODS

Wood chips from a pulp mill (IND) working with Eucalyptus globulus and produced in a laboratory chipper from a clone (CLON) Eucalyptus globulus (basic density of 536 g/cm3 and 527 g/cm3, respectively) were cooked at laboratory scale by the kraft process. The cooking conditions were: active alkali charge = 20.6% (IND) and 18.5% (CLON) (as NaOH); sulfidity index = 25%; liquor/wood ratio = 4/1; time to temperature = 90 min; time at temperature (160 ºC) = 90 min for the industrial wood and 60 min for the clone wood. The cooked chips were disintegrated, screened and washed. The screened and total yields, kappa number and pulp viscosity were determined according to the standard methods. The pulps were bleached using a D0E1D1E2D2 sequence. The papermaking potential of the pulps was evaluated in the PFI mill, with refining intensities of 2N/mm, and 4 refining revolutions (0, 500, 2500 and 4500). After beating, isotropic paper sheets were produced according to the Scan standards. The fibre biometrics characteristics as elements in the suspension were evaluated by Morfi® equipment. The paper hand-sheets were analysed in terms of structural, mechanical and optical properties according to the ISO standard.

RESULTS AND DISCUSSION

Regarding the cooking process, Table 1 shows the clone requires both significantly lower alkali consumption and lower time at temperature, than the industrial chips. Despite the milder reaction conditions, the residual lignin content of the clone pulp is even lower. Moreover, the clone exhibits both higher pulp yield and pulp viscosity. These markedly different results can be explained by the chemical composition of the wood samples. The total extractive content of the clone and industrial chips is 2.98% and 3.62%, respectively. The Klason lignin content of the industrial sample is (22.9), while the clone exhibits (20.4).

In Borralho, N., *et al.* (2004). Eucalyptus in a Changing World. Proc. of IUFRO Conf., Aveiro 11-15 October 2004

Table 1 - Cooking parameters for *Eucalyptus globulus* wood samples

	IND	CLON
Residual alkali [AE] as NaOH (g/l)	5.1	6.9
Effective alkali consumption as NaOH (%)	16.0	13.5
Time at temperature (160ºC), min	90	60
Pulp Yield, %	50.1	54.8
Rejects (%)	1.7	0.8
Kappa number	17	12
Unbleached pulp viscosity (cm^3/g)	993	1103
Bleached pulp viscosity (cm^3/g)	800	900

The fibres from the clone tree exhibit higher fibre width and fibre length and lower coarseness (Table 2). These experimental data suggest the lumens of the clone fibres are relatively width and the cell wall relatively thin. The microscopic observation of the transverse section of the wood confirms this hypothesis. The microscopic observation of the transverse section of the wood confirms this hypothesis. Experimental data regarding to the refining, measured by the ºSR, suggest the industrial chips, with higher coarseness, exhibits a slightly higher refining rate (Table 3); in agreement with this data, the fines content is also higher for the industrial chips.

Table 2 - Fibre characteristics to 2N/mm refining intensity

		PFI (number of revolutions)			
		0	500	2500	4500
Fibre width (μm)	IND	15.6	15.6	15.8	15.8
	CLON	17.4	17.0	17.5	17.3
Length weighted in length (mm)	IND	0.70	0.72	0.70	0.69
	CLON	0.76	0.75	0.76	0.73
Coarseness (Mg/ 100 m)	IND	9.5	8.9	9.2	9.3
	CLON	8.6	8.7	8.4	8.6
Curl (%)	IND	6.6	5.4	5.3	6.5
	CLON	5.7	5.5	6.6	7.5

Despite of this, the clone fibres, with lower coarseness and higher fibre width, develop denser paper, which highlight the role of the fibre properties. The mechanical resistance (tensile and burst strength) of the paper is lower for the clone, even when the comparison is made using paper density as reference. These results can be attributed to the lower zero-span tensile strength in dry or wet state. This important result can't be attributed to the chemical degradation of the clone fibres because the milder cooking conditions and the higher pulp viscosity. Based on microscopic observations, we suspected this lower strength could be attributed to the higher number of weak points in the fibres. Whatever the explanation, these experimental results must be considered in the global evaluation of the pulp and paper potential of different raw materials.

Table 3 – Paper properties for *Eucalyptus globulus* wood sample to 2N/mm refining intensity

		PFI (number of revolutions)			
		0	500	2500	4500
SR degree	IND	16	28	55	77
	CLON	19	22	38	73
Density (g/cm^3)	IND	0.59	0.65	0.74	0.81
	CLON	0.59	0.61	0.76	0.86
Tensile index (Nm/g)	IND	44.5	72.1	108.4	115.9
	CLON	38.3	48.5	82.2	97.2
Tear index (mNm^2/g)	IND	5.6	9.5	11.2	10.6
	CLON	3.8	5.5	11.1	12.2
Zero-span tensile index, (Nm/g)	IND	198	199	213	211
	CLON	185	185	192	194
Light scattering coefficient (m^2/kg)	IND	40.2	34.8	25.8	21.2
	CLON	38.6	37.0	27.5	19.9

Respecting the tear index, this property is higher for the paper produced with the industrial wood sample for unrefined pulp and pulp with lower refining. For 2500 and 4500 levels of refining the tear index values of both clone and industrial chips are similar, despite the higher fibre length of the clone. Regarding to the light scattering coefficient, for intermediate paper densities the clone can be superior due to the higher number of fibres per gram. However, this better performance is cancelled when the strength is also considered.

CONCLUSIONS

This work put in evidence the fundamental importance of the chemical composition of the wood and the characteristics of the fibres for the pulp and paper potential. The wood from the clone tree has much lower lignin content, which has a very positive impact on the pulping process, namely in the pulping yield and alkali consumption. On the other hand, the fibres are width and with thin wall, which give higher paper density. Despite of this, the mechanical strength of the paper is lower than the corresponding for industrial wood. The results suggest that zero-span tensile strength is the key factor behind this behaviour and we suspect that the weak points of the fibres are the reason behind these results. However, for intermediate paper densities good relationships between mechanical strength and scattering ability can be achieve.

REFERENCES

Zobel, B.J., Buijtenen, J.P. (1989) «Wood variation: its causes and control» Springer-Verlag, Berlin, Germany.

Kibblewhite, R.P., Evans, R., Riddell, M.J.C., Shelbourne, C.J.A. (2003). *Proc. 57th Appita Ann. Conf.* p: 111.

O'Neill, P., Mohiddin, S., Michell, A. (1999). *Appita J.* 52(5): 358.

Seth, R.S., Jang, H.F., Chan, B. K., Wu, C. B. (1997). *Proc. 11th Fundamental Research Symposium*, Cambridge: 473