

Wood potential use of *Acacia melanoxylon* growing in pure or mixed stands with *Pinus pinaster* by the Portuguese forest industry

Utilização potencial do lenho de *Acacia melanoxylon* a crescer em povoamentos puros ou mistos com *Pinus pinaster* pela indústria florestal portuguesa

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Projecto AGRO
283 – Medida 8



Universidade da
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Laboratório
Nacional de
Engenharia
Civil

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR Portugal

Projecto AGR/42594/2001 – Programa POCTI

Objective

Acacia potential analysis as a raw material source for Portuguese industry (solid wood and pulp and paper), using information from **forest management**, **wood properties** and **fiber quality** for paper.

Wood growth of

Pinus pinaster
Eucalyptus globulus
Acacia melanoxylon

Mechanical Properties

Pinus pinaster
Acacia melanoxylon

Papermaking evaluation

Eucalyptus globulus
Acacia melanoxylon

Acacia sampling (similar for pine in Macão; different for the others)

North & Center Regions of Portugal

(pré-selection)

22 sites Pure *austrália* or mixed dominants stands with *P. pinaster*

Installation of diameter growth study

- Edaphic and silvicultural characteristics of sites.
- Diametric range evaluation (selection of *dbh* classes);

(Selection of 4 sites)

2 sites – dune sandy soils

National Forest of Camarido – **MNC**
Forest Perimeter of Ovar - **PFDO**

2 sites – granite soils

Forest Perimeter of Rebordões/Sta. Maria, Ponte de Lima – **PFRSM**

Forest Perimeter of Serra do Crasto, Viseu - **PFC**

Sampling (cont.)

For the 4 sites

(pré-selection)

200 trees - 10 trees per *dbh* classes of 10, 20, 30, 40, e 50 cm

5 trees - 40 cm *dbh* class per site

Base, 5, 15, 35, 65% total height and top

Papermaking evaluation

discs

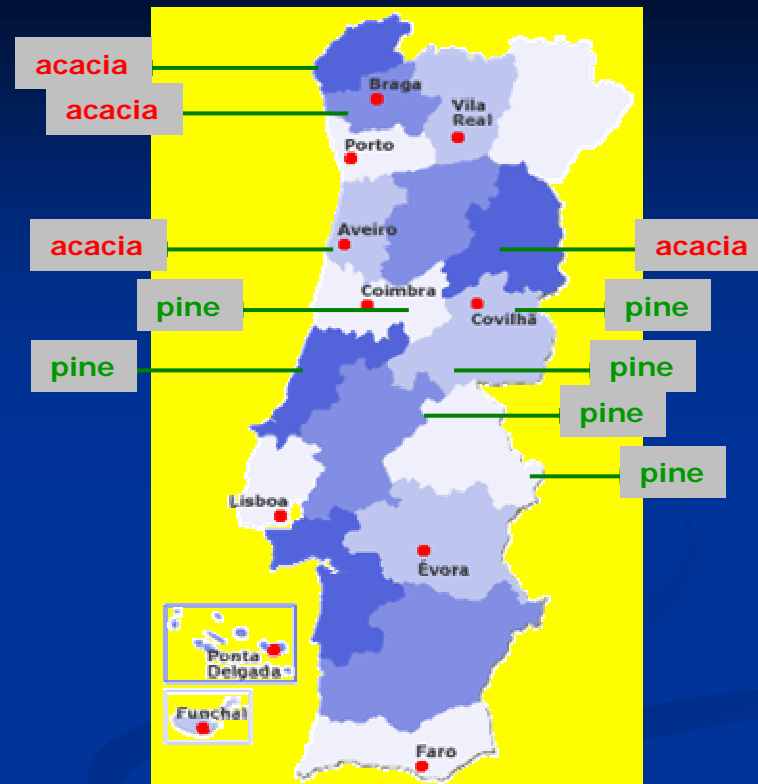
Solid wood study

logs

100 trees - 5 trees per *dbh* classes

Diameter growth study

trees



Material and methods

Wood growth

(origin of dendrometric information)



Model GLOBULUS 2.1
(Tomé *et al.*, 2001)



(previous outlined)

Center/north pine forest

Pine forest of center of Country - Municipality of Mação



Estação
Florestal
Nacional

Results and discussion

Mean values of *dbh* growth (**maritime pine** – main stand) from littoral to interior of Portugal

Site	Soil/ region	t (years)	dg (cm)	ami dg (cm.year ⁻¹)	cmi dg (cm.year ⁻¹)
M. Nacional Valado Frades, Nazaré	Sand littoral	22	12.8	0.58	0.50
Vila Velha de Ródão	Sandstone center	29	22.9	0.79	0.85
Serra Lousã, Castanheira de Pêra	Schist center	25	21.8	0.87	0.90
Serra S. Mamede, Portalegre	Schist interior	24	17.5	0.73	1.05
Serra da Estrela, Covilhã	Granite interior	30	20.7	0.69	0.65

t – age; dg – mean dbh; ami – annual mean increment; cmi – current mean increment. *In*: Tavares *et al.*, 2004.



Results and discussion (cont.)

Mean values of *dbh* growth (maritime pine – main stand) in Municipality of Mação, center of Portugal

Cl. dbh	t (years) start of study	Study duration (years)	t (years) final study	dg(cm) initial	dg (cm) final	ami dg (cm.year ⁻¹)	cmi dg (cm.year ⁻¹)
5	22.4	1.9	24.3	5.6	6.3	0.26	0.34
10	24.4	1.9	26.3	10.2	10.5	0.40	0.17
15	30.6	1.9	32.5	15.0	16.0	0.49	0.49
20	30.6	1.9	32.5	19.8	20.8	0.64	0.49
25	32.6	1.9	34.5	25.5	26.6	0.77	0.61
30	32.6	1.9	34.5	29.5	30.6	0.89	0.56

Cl.dbh – dbh class; t – age; dg – mean dbh; ami – annual mean increment; cmi – current mean increment.



Results and discussion (cont.)

Estimated values for *E. globulus* in Portugal by Model GLOGULUS 2.1 (Tomé *et al.*, 2001)

Region (N.ha ⁻¹ = 1250, 4x2m)	Mean SI III (m)	N.ha ⁻¹ at 12 years old	dg (cm)	ami dg (cm.ano ⁻¹)	G (m ² .ha ⁻¹)	ami G (m ² .ha ⁻¹ .ano ⁻¹)	ami V (m ³ .ha ⁻¹ .ano ⁻¹)
N / C Littoral	22, 20, 19, 14	1090	11.6	0.96	18.78	1.57	13.73
N/C Interior	17. 16	1061	10.7	0.89	15.24	1.27	9.54
S Littoral	18	1093	11.2	0.93	17.35	1.45	11.87
S Interior	15	850	10.1	0.84	10.97	0.91	6.20

N/ha – stand density; ami – annual mean increment in dg (mean dbh), in G (basal area per hectare) and in V (total volume)



Results and discussion (cont.)

Mean values of *dbh* growth of *acacia* in sands and granites in Portugal

Site	dbh class	t estimated at the beginning of study (years)	duration of study (years)	t estimate d at the end of study (years)	dg (cm) initial	dg (cm) final	ami dg cm.ano ⁻¹	cmi dg cm.ano ⁻¹
<i>Mean values for North Region</i>	10	11.3	2.6	13.9	10.6	11.5	0.83	0.36
	20	22.6	2.6	25.2	21.3	22.4	0.89	0.44
	30	33.9	2.6	36.5	29.1	30.5	0.83	0.52
	40	45.3	2.6	47.9	41.0	42.5	0.89	0.60
	50	56.6	2.6	59.2	49.9	51.4	0.87	0.56

t – age; dg – mean dbh; ami – annual mean increment; cmi – current mean increment.



Material and methods

Mechanical properties

Mechanical experiments were done at 3 levels (15, 35 and 65% of stem total high).

From each level were collected 3 cores from 3 different positions on stem cross section, defined by the relative distance to pith (10, 50 and 90% of radius length).

Mechanical experiments			
Mechanical experiment	Standard	Cores size (width x thickness x length) (mm)	Number of cores
Static bending (3 points)	ISO3133	20x20x340	223
Modulus of elasticity in bending	ISO3133	20x20x340	198
Compression parallel to the fibers	ISO3787	20x20x60	254
Tension perpendicular to the fibers	ISO3346	20x20x60	246



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Results and discussion

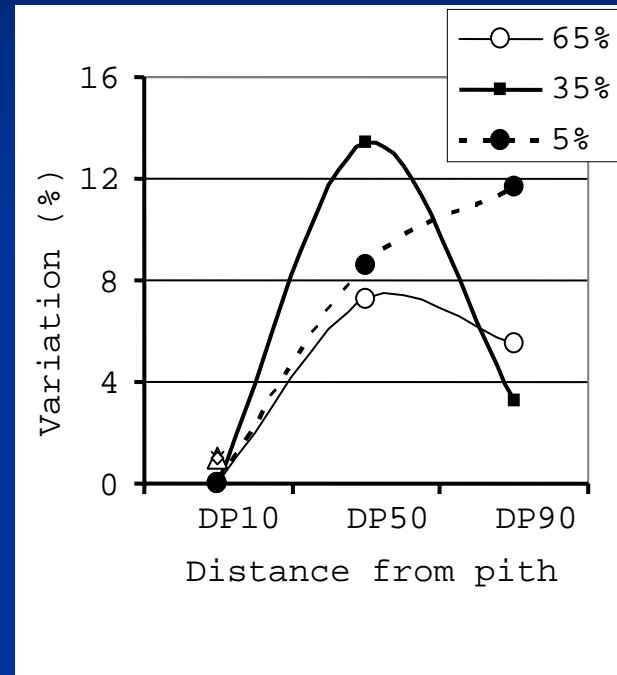
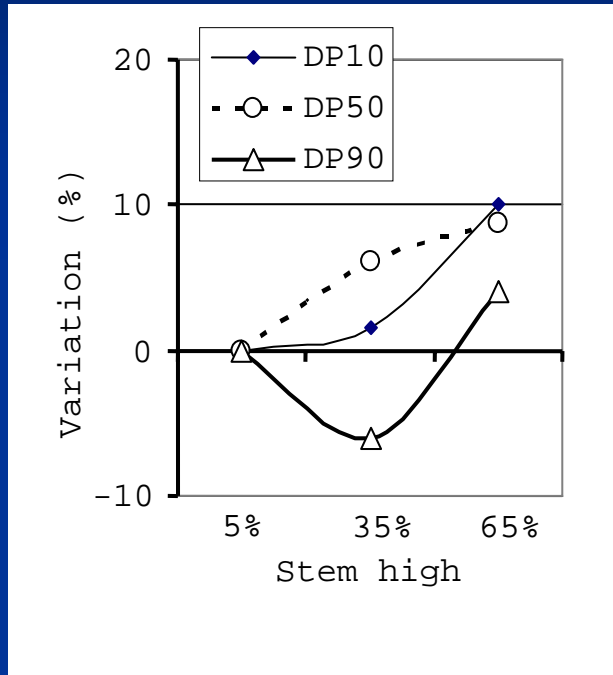
Mean physical-mechanical properties of defects clean wood of maritime pine and acacia-austrália

Species/ origin	Average density (kg.m ⁻³)	Average bending strength (N.mm ⁻²)	Average modulus of elasticity (N.mm ⁻²)	Average axial compression strength (N.mm ⁻²)
Maritime pine / Different regions ^{a)}	530	-	-	46
Maritime pine / Leiria National Forest ^{a)}	600	96	13500	52
Maritime pine / Leiria National Forest ^{b)}	630	130	10500	47
Acacia/ Different regions ^{c)}	650	146	14200	61
Acacia/ Different regions ^{d)}	614	142	9800	-

^{a)} Mateus (1961)
^{b)} Machado e Cruz (2005)
^{c)} Preliminary data from project *Upgrading of Portuguese wattle wood. Potential uses*
^{d)} Tavares *et al.* (1999)



Results and discussion (cont.)

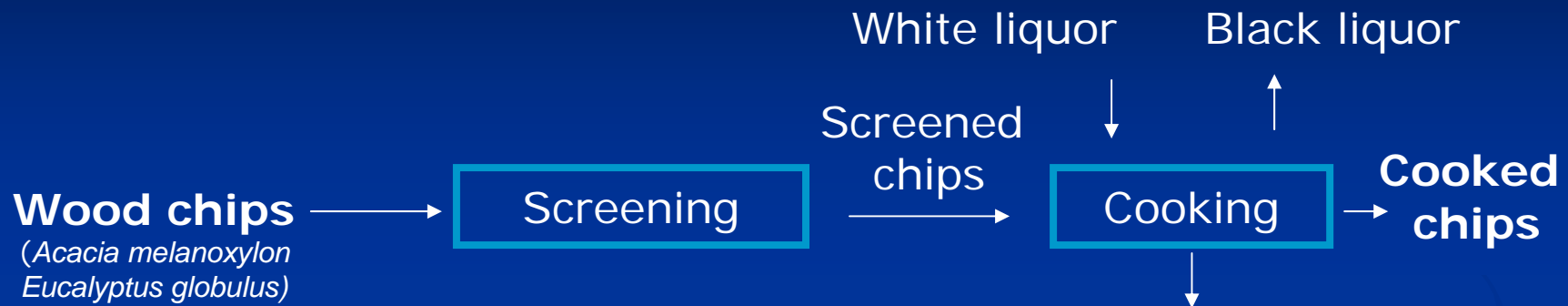


Variation (in median) vertical (referring to 5% stem total high) and horizontal (referring to distance to pith of 10% of radius) of density in the tree.



Material and methods

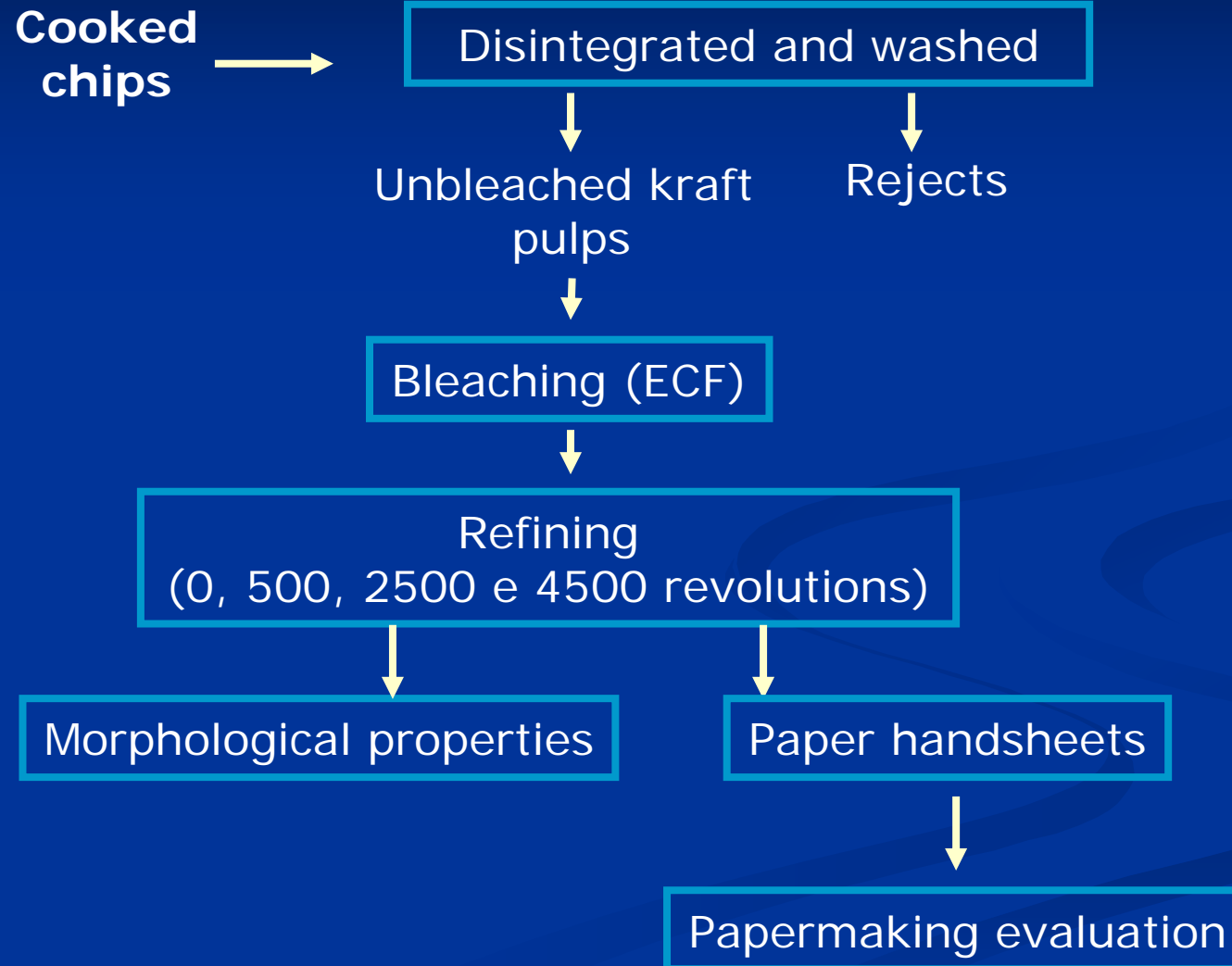
Papermaking evaluation



6 + 2 samples	<i>Acacia melanoxylon</i>	<i>Eucalyptus globulus</i>
Effective alkali NaOH (%)	19.6 - 21.3	16.2 - 18.1
Sulfidity index (%)	30	25
Liquor/wood ratio	4:1	4:1
Time to temperature (min.)	90	90
Time at temperature (min.)	80 - 90	70 - 90
Temperature (°C)	160	158 - 160



Material and methods (cont.)



Material and methods

Papermaking evaluation

Wood chips
(*Acacia melanoxylon*
Eucalyptus globulus)

Screening

Screened chips

White liquor

Black liquor

Cooking

Cooked chips

6 + 2 samples

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Effective alkali NaOH (%)

19.6 - 21.3

16.2 - 18.1

Sulfidity index (%)

30

25

Liquor/wood ratio

4:1

4:1

Time to temperature (min.)

90

90

Time at temperature (min.)

80 - 90

70 - 90

Temperature (°C)

160

158 - 160

Disintegrated and washed

Unbleached kraft pulps

Rejects

Bleaching (ECF)

Refining
(0, 500, 2500 e 4500 revolutions)

Morphological properties

Paper handsheets

Papermaking evaluation



Results and discussion

Cooking results

	<i>A. melanoxylon</i> (n=6)	<i>E. globulus</i> (n=2)
Pulp yield (%)	52.3 ± 3.6	52.5 ± 3.3
Rejects (%)	1.1 ± 0.6	1.3 ± 0.6
Effective alkali consumption (as NaOH) (%)	17.0 ± 1.1	14.8 ± 1.8
Kappa number	15.1 ± 1.3	14.4 ± 3.7
Pulp viscosity - unbleached (cm ³ /g)	882 ± 127	1002 ± 144
Pulp viscosity - bleached (cm ³ /g)	783 ± 71	897 ± 136



R.D. – Morphological properties

Papermaking evaluation

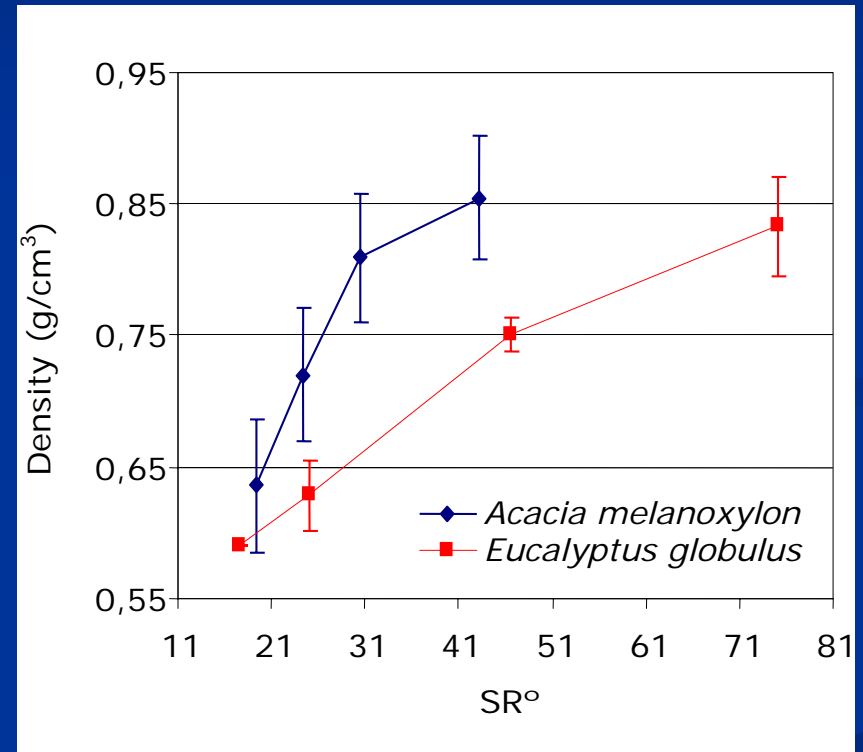
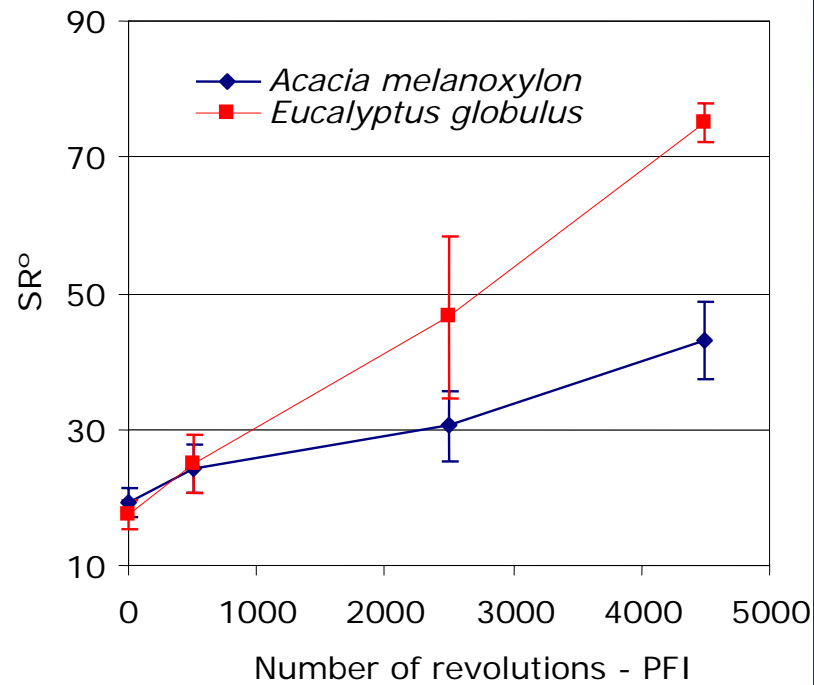
	Refining (revolutions)	Fiber width (μm)	Length weighted in length (mm)	Coarseness (mg/m)
<i>Acacia melanoxylon</i>	0	18.6	0.85	0.055
	500	18.6	0.86	0.055
	2500	18.6	0.85	0.055
	4500	18.8	0.85	0.056
<i>Eucalyptus globulus</i>	0	16.5	0.73	0.091
	500	16.4	0.73	0.088
	2500	16.7	0.73	0.088
	4500	16.6	0.71	0.090

A. melanoxylon versus *E. globulus*

- ⇒ Fibers with higher width
- ⇒ Fibers with higher length
- ⇒ Lower coarseness



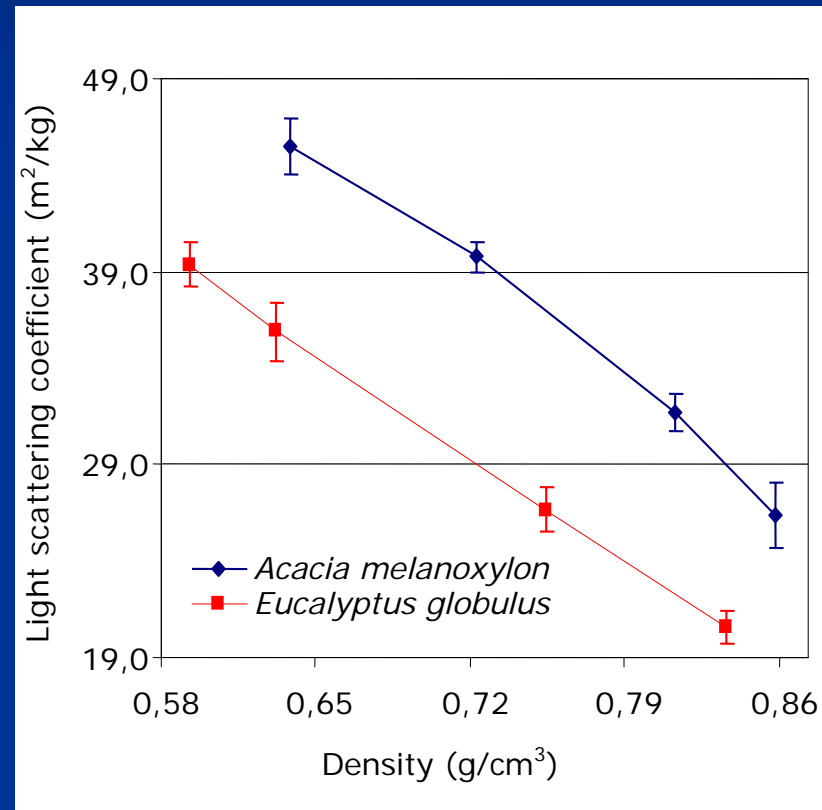
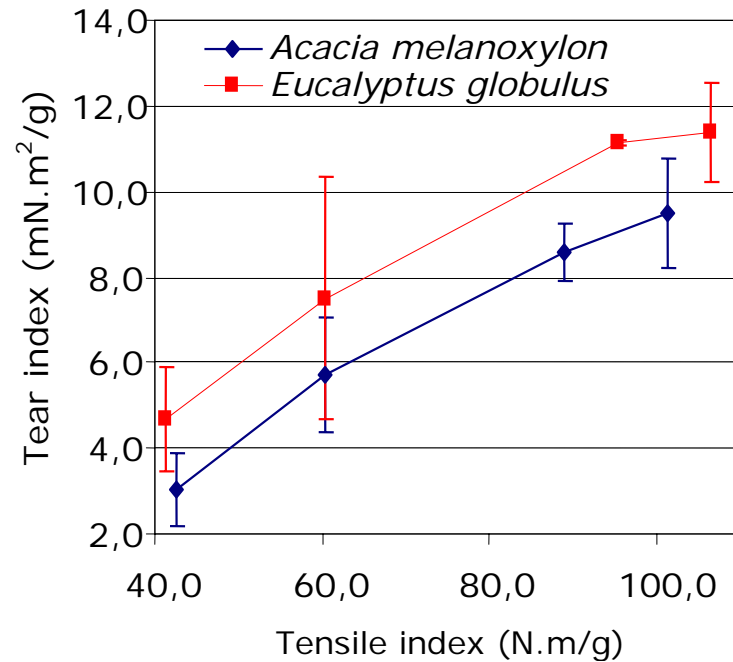
R.D. - Suspension - properties



R.D - Structural properties



R.D. – Mechanical properties



R.D. – Optical properties



Conclusions

Growth pattern of acacia is higher (ami $dg=0.89$ cm.year⁻¹) than **m. pine** (0.71) and just a little lower than **blue gum** (0.90). It can be an alternative wood producer.

Mechanical properties (determined in small cores without defects) allows to qualify the wood of australia as a source of wood for **sawing** and **construction** national industry.

Concerning **resistance** and **stiffness**, must be noticed a considerable **variability** *intra* and *inter* trees.

Acacia australia versus Eucalypt

- Bigger smoothness of papers.
- Less resistance to tear and tensile.
- Bigger light scattering coefficient.

Acacia fiber presents real potential to be combined with eucalypt in writing & printing paper.

... the end