

## VESSEL MORPHOLOGICAL CHARACTERIZATION OF *ACACIA MELANOXYLON* WOOD

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### ABSTRACT

In this paper we analyze the transversal variation of *Acacia melanoxylon* R. Br. wood porosity, using five trees with 40cm *dbh* collected in the Ponte de Lima region, in northwestern Portugal. Variation of porosity, vessel area, width and density were used to evaluate tree vessel variation, in order to relate it with other wood properties. Each value of these variables represents a mean of 60 vessels measurement. We collected five wood disks at the bottom, 5, 15, 35 and 65% of total height, and commercial top of those five trees, in order to acquire three radial cores at 10, 50 and 90% near the pith, and in north and south directions.

We found great variability along the tree concerning the axial and radial positions. Porosity is higher near the bottom and lower at the top; vessel number varies inversely. Vessels width and density are similar at the different height levels. Radial variation show that porosity, vessel area and vessel width all increase, and density decreases, with distance to the pith.

Principal components analysis was used to investigate the differences in vessel characteristics and levels in the trees, as well as their interaction. This methodology allowed us to determine how close, or how independent, the study variables were. We conclude there is a group of vessel morphologic characteristics which depend strongly on each other – porosity and vessel area and vessel number are negatively correlated with the other. The variation between North and south direction is not significant, because the values are very similar and the trees don't present a higher eccentricity.

**Keywords:** *Acacia melanoxylon*, wood morphology, Vessel.

### 1. INTRODUCTION

*Acacia melanoxylon* R. Br. (Blackwood) grows well in Portugal, in pure or mixed stands with *Pinus pinaster* Aiton though it faces strong ecological and legal constraints. It was introduced in Portugal as an ornamental species (Franco, 1971) and for soil enrichment (Humphries *et al.*, 2005). There are many spontaneous stands of *Acacia*, namely *Acacia dealbata* and *A. melanoxylon* because Portuguese climate conditions are favourable to it. While *A. dealbata* species is considered a (ecological) problem, *A. melanoxylon* is well adapted to Portuguese conditions. Therefore, it should be considered as an alternative raw material for sawmills and pulp industry and its use can avoid large monoculture areas and high risk of fire.

Blackwood timber is used for furniture and craft wood products due mainly to its texture and dark colour. It can also be used for pulp; it is planted in many countries for that purpose along with *Acacia mangium* and *A. dealbata*. For all these uses it's very important to know the anatomic characteristics of wood and correlate them with other properties. For pulp and paper uses *A. melanoxylon* has been well studied (Clark *et al.*, 1991; Guigan *et al.*, 1991; Furtado, 1994; Gil *et al.*, 1999; Paavilainen, 2000; Santos *et al.*, 2002; Santos *et al.*, 2006). For the sawmill industry the wood is much appreciated for its high sapwood proportion and dark colour (Pinkard, 2003).

On the other hand, it is very well documented that there is a quite high variability of the fibre morphology within trees, between trees within a stand, and between trees from different

stands (Evans *et al.*, 1999; Downes *et al.*, 2003), but no studies were carried out about this subject for *A. melanoxylon*.

This study aimed to evaluate the difference in vessel characteristics of *A. melanoxylon* wood, within trees and between trees, and correlate it with other wood properties and other Acacia species.

## 2. MATERIAL AND METHODS

In this work we studied the transversal variation of *Acacia melanoxylon* R. Br. wood characteristics, using five trees with 40cm *dbh* collected in Ponte de Lima region, in northwestern Portugal. The wood samples were used to evaluate tree vessels characteristics variation, in order to relate them with other wood properties. Each value of these variables represents a mean of 60 vessels measured.

At the bottom, 5, 15, 35 and 65% of total height and commercial top of those five trees, were collected seven wood disks in order to acquire three radial cuts at 10, 50 and 90% near pith, over north and south direction.

To determine radial and axial variation of wood vessel biometric characteristics we determined vessel number (N/mm<sup>2</sup>), width vessel (µm), Vessel area (mm<sup>2</sup>) and porosity (%). Table 1 summarizes the dendrometric characteristics of the trees samples.

**Table 1.** Dendrometric characteristics of samples tree.

	1	2	3	4	5
<i>Trees age</i>	42	50	41	43	48
<i>DBH (cm)</i>	36.5	39.0	41.0	44.0	45.0
<i>Total height (m)</i>	29.6	27.5	26.6	32.8	27.2
<i>Top commercial height (m)</i>	22.4	21.2	19.6	28.1	24.0

Vessel biometric characteristics were determined by image analysis on histological cuts with 16 mm of thickness. The image was acquired at a 10X magnification using a colour video camera and analyzed with the Qwin 500 Leica software. The porosity was reported as a coefficient of porosity (%), calculated as the area of pores divided by the total area measured in each sample.

Each value of these variables represents a mean of 60 measured vessels in three different cuts.

## 3. RESULTS AND DISCUSSION

Table 2 shows the results of porosity, vessel number, area and width, for *A. melanoxylon* according to tree radial position. Each value represents the mean of 5 trees. Fig. 1 and Fig. 2 illustrate this variation.

**Table 2.** Vessel parameters for *A. melanoxyton* wood samples ( $\bar{x}$  - mean;  $\sigma$  - standard deviation)

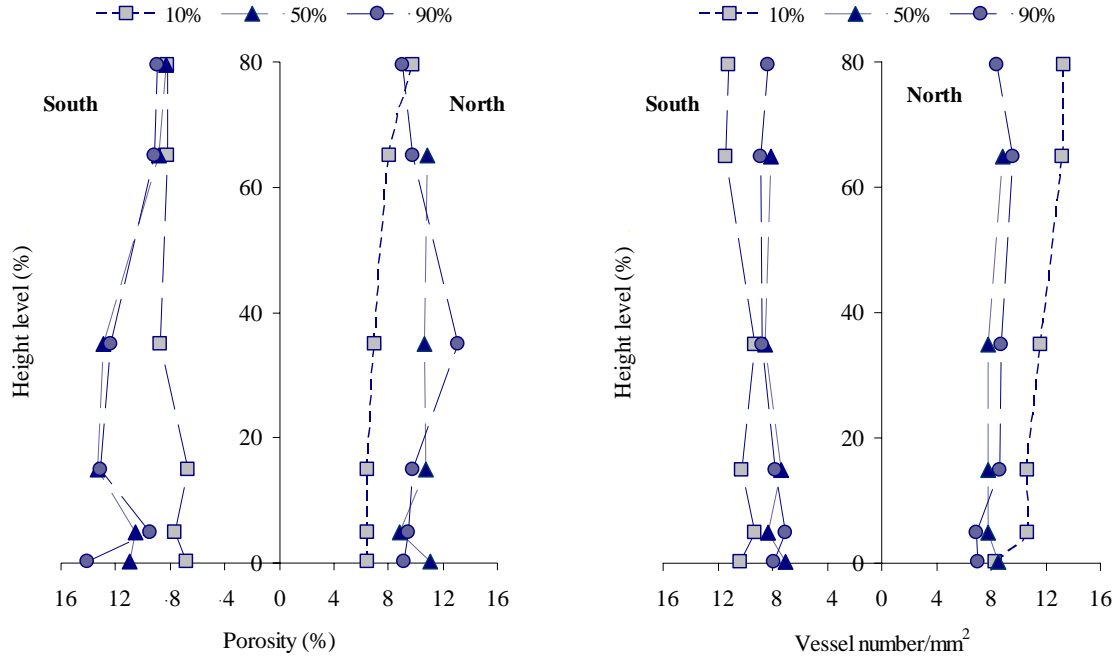
		North						South						
		Base	5%	15%	35%	65%	Topo	Base	5%	15%	35%	65%	Topo	
Porosity	A1	$\bar{x}$	6.5	6.5	6.5	7.1	8.0	9.8	6.7	7.6	6.7	7.9	8.6	8.9
		$\sigma$	1.10	0.54	0.55	0.56	0.99	1.05	0.49	0.51	0.64	0.39	0.61	0.46
	A2	$\bar{x}$	11.1	8.8	10.7	11.6	8.7		9.9	11.5	9.8	12.3		
		$\sigma$	0.64	0.83	1.37	0.50	0.76		0.70	0.83	1.06	0.84		
	A3	$\bar{x}$	11.0	10.5	14.0	12.2	11.5	8.3	16.5	9.4	13.1	12.3	10.8	9.4
		$\sigma$	0.73	0.98	1.32	0.90	0.31	0.73	0.21	1.50	0.53	0.47	0.96	0.69
Vessel number	A1	$\bar{x}$	8.3	10.7	10.6	11.6	13.3	13.8	10.3	9.3	10.3	9.3	11.4	12.2
		$\sigma$	1.11	0.54	0.81	0.40	0.57	1.01	1.29	0.74	0.78	1.03	0.37	0.83
	A2	$\bar{x}$	8.5	7.8	7.7	7.8	8.7		7.0	8.3	7.4	8.8		
		$\sigma$	0.68	0.38	0.87	0.23	0.61		0.85	0.77	0.38	0.32		
	A3	$\bar{x}$	7.0	6.9	8.7	8.7	10.7	9.0	7.9	7.0	7.8	8.4	8.3	8.3
		$\sigma$	0.38	0.70	0.61	0.49	0.00	0.47	0.55	0.41	0.53	0.33	0.74	0.30
Vessel area	A1	$\bar{x}$	0.008	0.006	0.006	0.006	0.006	0.007	0.007	0.009	0.007	0.009	0.008	0.007
		$\sigma$	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001
	A2	$\bar{x}$	0.013	0.011	0.014	0.015	0.010		0.014	0.013	0.013	0.015		
		$\sigma$	0.001	0.001	0.001	0.001	0.001		0.000	0.002	0.001	0.001		
	A3	$\bar{x}$	0.016	0.015	0.016	0.014	0.011	0.009	0.020	0.013	0.017	0.015	0.014	0.008
		$\sigma$	0.002	0.001	0.002	0.001	0.001	0.002	0.003	0.001	0.002	0.001	0.001	0.002
Vessel width	A1	$\bar{x}$	79	81	92	79	79	82	75	87	76	89	87	80
		$\sigma$	22.0	20.8	22.4	18.6	20.2	21.1	20.9	21.9	20.6	23.5	19.2	18.3
	A2	$\bar{x}$	105	106	119	118	96		105	110	109	120		
		$\sigma$	27.6	22.2	27.2	26.0	26.0		28.9	26.2	24.2	27.9		
	A3	$\bar{x}$	120	130	104	125	121	90	136	116	127	112	112	53
		$\sigma$	24.1	27.5	26.6	24.8	22.6	22.3	31.8	23.4	27.2	22.5	28.7	18.7

The experimental results clearly show a great variability between trees and in the same tree, for all parameters measured. In fact wood is a natural material characterized by this type of variability.

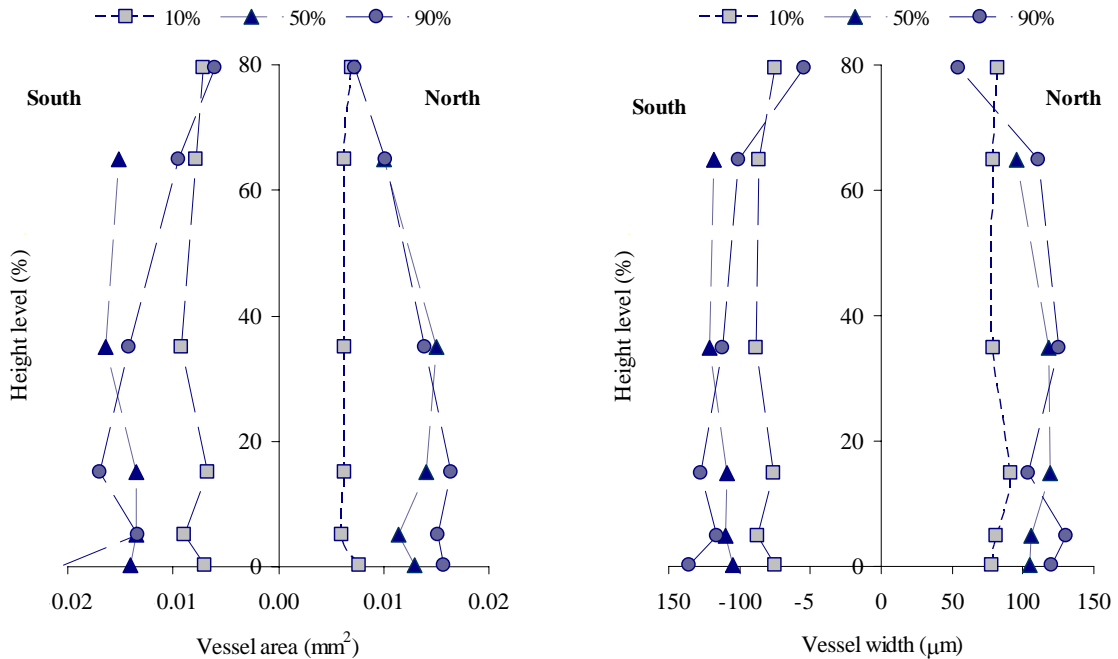
The porosity is lower near the tree pith (10% of radial direction) compared with samples collected near the bark (90% of radial direction). This could be explained by the presence of juvenile wood near the pith, which is characterized by different cell sizes and characteristics. In fact juvenile wood contained smaller vessel than mature wood. The same pattern was observed for the vessel area and vessel width. So the lower porosity observed near the pith is caused by a higher vessel number with a lower size. These results agree with those obtained by other authors for other species (Sharma, 2005; Adamopoulos and Voulgaridis, 2002; Silva 1987).

Vessel number was found to be lower near the bark, which is in accordance with our porosity results; low porosity corresponds to low pores (vessel) number. This variation could also be explained by the distribution of juvenile wood (Ferreirinha 1958).

In that samples tree the variation found at lower height levels is different, which could be explained by tree age and the presence of reaction wood in the bottom of the trees that present different anatomical characteristics when compared with the normal wood. In fact, those trees present a total height between 26m and 38m and *dbh* between 36.5 and 45 cm.



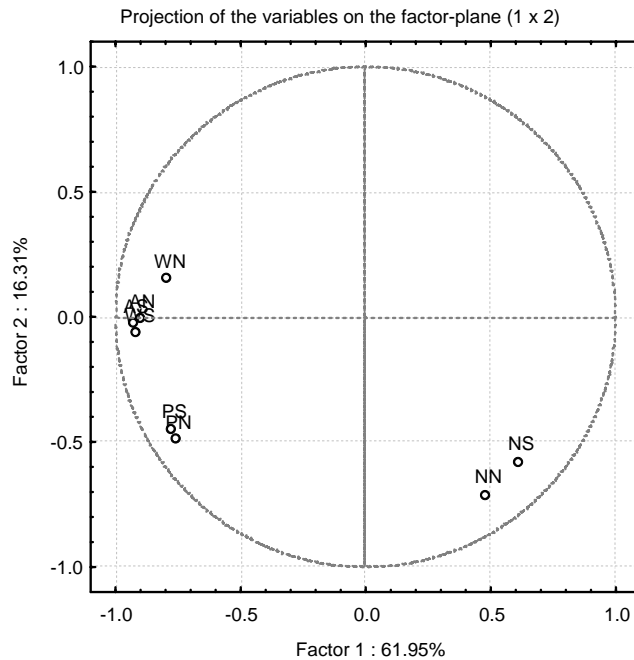
**Fig.1.** Variation of porosity and Vessel number of *A. melanoxylon* wood sample for North and south positions with the height level for tree radial positions.



**Fig.2.** Variation of Vessel area and Vessel width of *A. melanoxylon* wood sample for North and south position with the height level for tree radial positions.

The variation between North and South position isn't significant for all evaluated parameters. In fact, the trees don't present a higher eccentricity and the variability observed in different samples was higher than that observed for the North and South position.

We used principal components analysis to investigate the differences in anatomical vessel characteristics of *A. melanoxylon* wood. Each value of these variables represents a mean of 5 trees. This methodology allowed us to determine how close, or how independent, the study variables were. We chose two factors because they explained 78.3% of the total variation. The analysis results are presented in Table 3 and Fig. 3. In this figure each point represents the mean of a given property, for the five wood characteristics for all radial position. The first component explains 62% of the total variation and the second explains 16.3%.



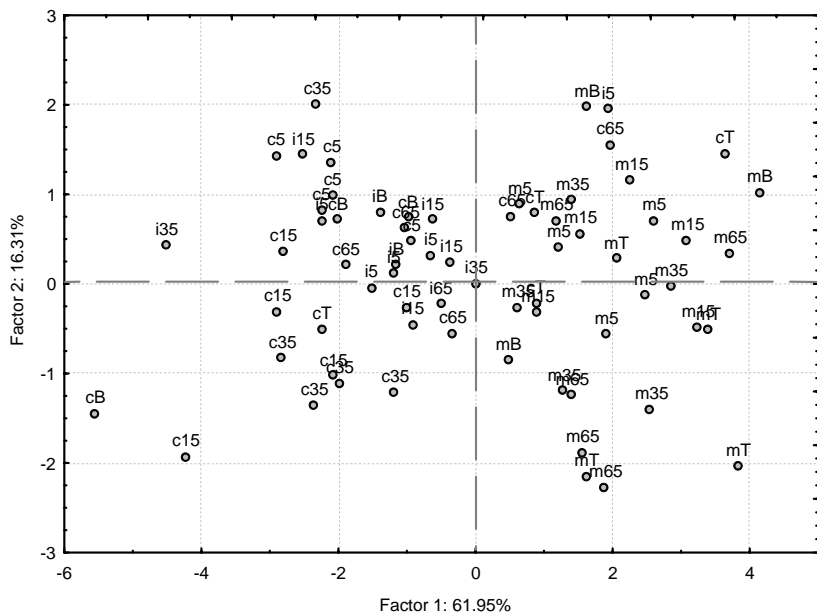
**Fig. 3.** Relative distribution of vessel characteristics according to the factors plane, resulting from multi-varied component analysis.

**Table 3 :** Factor analysis results F1 vs F2. of principal components determined by the anatomical wood parameters of *A. melanoxylon*.

<i>Variables</i>	<i>Codes</i>	<i>Factor 1</i>	<i>Factor 2</i>
Porosity – North	<b>PN</b>	<b>-0.7604</b>	-0.4904
Vessel width – North	<b>LN</b>	<b>-0.7955</b>	0.1527
Vessel area – North	<b>AN</b>	<b>-0.9054</b>	-0.007
Vessel number/mm <sup>2</sup> – North	<b>NN</b>	0.4806	<b>-0.7090</b>
Porosity, – South	<b>PS</b>	<b>-0.7802</b>	-0.4483
Vessel width – South	<b>LS</b>	<b>-0.9193</b>	-0.0643
Vessel area – South	<b>AS</b>	<b>-0.9322</b>	-0.0270
Vessel number/mm <sup>2</sup> – South	<b>NS</b>	<b>0.6097</b>	<b>-0.5763</b>

The factor 1 can be identified as vessel area. The values for vessel area (North and South positions) are well correlated amongst themselves and strongly correlated with vessel width. North and South porosity are well correlated themselves too and well correlated with the variable mentioned. The second factor can be considered to be vessel number, which is well correlated for the North size and south size, and negatively correlated with the previous parameters.

We projected the cases onto the same system of vectors; Figure 4 shows how the values of different variables for each *A. melanoxylon* anatomical wood parameter are highly correlated amongst themselves. Figure 4 shows that the anatomical characteristics studied are different for a size near the dark. Moreover, for the height level we can't see a clear difference due to the height variability observed for different samples.



**Fig. 4** – Projection diagram of the cases on the factor plane (three radial positions: c-90%; i-50%; m-10; height level: B-bottom, 5, 15, 35, 65% and T-total height)

#### 4. CONCLUSION

In general terms, we found great variability of *A. melanoxylon* R. Br.. vessel morphology, both between trees and within the same tree. This is true for all four parameters we studied: porosity (%); vessel number/mm<sup>2</sup>; vessel area (mm<sup>2</sup>) and vessel width (µm)).

In all the trees we studied, and at all height levels (base, 5%, 15%, 35%, 65% and top) porosity is lower near the pith (10% of radius) than near the bark (90% of radius), with the exception of the higher levels where porosity near the pith is similar to that near the bark. In all the trees and at all height levels the number of pores per unit of area is lower near the bark, an opposite tendency to that of porosity, but for this parameter we found very different vessel densities at higher tree levels. Vessel area and width are both lower near the pith for all height

levels, and these parameters (south and north positions) are highly correlated with each other. We can thus conclude that the lower porosity found near the pith is due to the presence of more vessels of lower size.

The variation between North and south directions is not significant, because the values are very similar and the trees don't present a higher eccentricity.

We conclude there is a group of vessel morphologic characteristics which depend strongly on each other – porosity and vessel area and vessel number are negatively correlated with the other.

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