Assessment of fungus and termite resistance in four Eucalyptus species cultivated in Tunisia

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Context and objectives

Eucalyptus trees have been adapted to the Tunisian climate. Now, they need to be economically valued. Tunisian Eucalyptus have great technological properties allowing us to use them as wooden material. However, there is large variability in the natural durability between heartwood Eucalyptus spp. (Taylor et al. 2006). The wood sustainability assessment provides reliable parameters to predict the service life of wood-based products. This study aimed to evaluate the wood deterioration of four North Tunisian fast-growing Eucalyptus spp. exposed to basidiomycetes and termites. Then, these natural durability results were put in perspective with the extractive content and analysis.

Material and methods

Eucalyptus maidenii, *E. saligna*, *E. camaldulensis* and *E. gomphocephala* trees were collected from the arboretum of Souiniet, which is located in Ain Draham, region of Kroumirie, Tunisia (35°54′ N; 8° 48′ E). 5 trees/Eucalyptus genus without defects (cracks, biotic and abiotic alterations, etc.), with a good rectitude and with a great visual quality were picked for each studied Eucalyptus spp. The selected trees were 55–60 years old and their diameters [at 1.30 m at breast height (DBH)] comprised between 30 and 40 cm.

To perform durability tests, a wooden disk, 50 mm in thickness, was cut at tree DBH, for each selected tree. From each disk, 15 samples with surrounding dimensions of 30 × 10 × 5 mm^3 (L × R × T) were randomly selected among the heartwood part: 12 samples to examine the fungal resistance and three samples to evaluate the termite resistance. For each of the Eucalyptus spp., 60 samples were submitted to fungal exposure [30 samples (12 × 5 wooden disk) for each tested fungus] and 15 samples to termite attacks.

Decay resistance was tested, against one brown rot [*Coniophora puteana* (CP)] and one white rot [*Trametes versicolor* (CV)], according to the main criteria of the EN 113-2 (2020), despite the fact that such an estimate is not very accurate for screening tests of 6 weeks.

Termite resistance non-choice tests were carried out against Eastern subterranean termites (*Reticulitermes. flavipes*), according to the main criteria of the EN 117 (2013), except for the sample sizes and test duration (4 weeks).

Finally, all raw Eucalyptus wood sawdusts were extracted by Soxhlet apparatus, using a sequential extraction with dichloromethane (DCM) and acetone. The extractive yields were determined and their chemical compositions were analysed by GC-MS (Gas Chromatography coupled with Mass Spectrometry).

Results and discussion

Among the four Eucalyptus woods, *Eucalyptus gomphocephala* presents the highest decay and termite resistance. The four Eucalyptus wood species are classified as very durable against fungal degradation (Tab. 1) and durable against termite attacks, expect for *Eucalyptus saligna* which is classified as sensible against termites.

Tab. 1: Durability classes of E. saligna, E. maidenii, E. camaldulensis and E. gomphocephala according to the XP CEN/TS 15083–1 (2006) and EN 117 (2013).

	Fungal resistance (according to the EN XP CEN/TS 15083-1)			Termite resistance (according to the EN 117)		
Species	*Coniophora puteana* (Brown rot)	*Trametes versicolor* (White rot)	Durability class	*Reticulitermes flavipes* (Eastern subterranean termites)		Durability class
	Average value of WL (%)	Average value of WL (%)		Survival rate (%)	Visual quotation	
E. saligna	0.65 ± 1.05	2.04 ± 2.60	1	34.7 ± 12.03	3	Sensible
E. maidenii	0.17 ± 0.15	0.45 ± 0.27	1	13.33 ± 7.02	1	Durable
E. camaldulensis	0.23 ± 0.63	0.28 ± 0.25	1	14.00 ± 6.93	1	Durable
E. gomphocephala	0.06 ± 0.06	0.27 ± 0.21	1	12.67 ± 5.03	1	Durable

The natural durability of Eucalyptus is mainly caused by extractives, and a lot of compounds are involved (Gominho et al. 2001, Boa 2014). Antifungal and anti-termite properties of these compounds were put in perspective with the natural durability of wood. Gas chromatography-mass spectrometry (GC-MS) analyses highlighted that Eucalyptus durability is mostly governed by gallic acid, fatty acid glycerides, fatty acid esters, phenolic compounds, sitosterol, catechin and ellagic acid (Tab. 2).

Tab. 2: Qualitative evaluation of the presence of chemical compounds with antifungal activities in the *E. saligna*, *E. maidenii*, *E. camaldulensis* and *E. gomphocephala* extracts.

Species	Solvent used for extraction	Extractive contents (%, w /w)	Presence of chemical compounds with anti-fungal and anti-termite activities				
			Gallic acid	Fatty acid glycerides and fatty acid esters	Sitost erol	Catechin	Ellagic acid
E. saligna	DCM	1.20	0	+++	++	0	0
	Acetone	2.60	++	++	0	-	0
E. maidenii	DCM	0.80	0	++	-	0	0
	Acetone	8.50	+++	+	0	0	+
E. camaldulensis	DCM	0.30	0	+++	++	0	0
	Acetone	5.80	++	-	+	++	0
E. gomphocephala	DCM	1.10	0	+++	++	0	0
	Acetone	12.30	+++	-	0	++	++

The high contents of gallic acid, fatty acid glycerides, fatty acid esters and phenolic compounds in the extractives conferred a high level of decay resistance (Durability class 1) to the four Eucalyptus wood. It is well known as the polyphenols protect the tree against microbiological, fungal and insect attacks (Metsämuuronen and Siren 2014). In addition, the tenors in sitosterol, catechin and ellagic acid of these extracts allowed to classify the four Eucalyptus spp. in the following order of durability (fungi and termites): *E. gomphocephala* > *E. camaldulensis* > *E. maidenii* > *E. saligna.*

Conclusion and perspectives

The results obtained through this study bring many new information about the relationships between extractive contents and compositions and decay and termite resistance levels of the four most common Tunisian Eucalyptus spp. The contents in total extractives of the studied Tunisian Eucalyptus seem to be correlated with their respective wood durability levels. While the literature gives us many results concerning the chemical composition of some Eucalyptus extractives, often closely related only to the paper industry, the present study identified several extractive compounds playing a role in wood durability (anti-fungal and anti-termite activities) and highlights their effects relating to the wood natural durability level. GC-MS analyses highlighted that the high contents of gallic acid, fatty acid glycerides, fatty acid esters and phenolic compounds in the four Eucalyptus extractives provided to the wood a high level of decay resistance (Durability class 1). In addition, the tenor's variations in sitosterol, catechin and ellagic acid, which also have anti-termite activities, allowed to classify the four Eucalyptus spp. These decay and termite-resistant of Tunisian Eucalyptus wood could be extensively used in some industrial processes such as pulp, paper, chipboard, plywood manufacturing and also wooden material and building structure, improving the economy of the wood sector in Tunisia.

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References

Boa AC (2014) Wood characterization of the upper half of the trunk of Eucalyptus grandis 3 *Eucalyptus urophylla* of 13 years trees for pulpwood. MS thesis. Federal University of Esp´ırito Santo, Brazil. 92 pp. (In Portuguese with English abstract.)

EN 113-2 (2020) Durability of wood and wood-based materials - Test method against basidiomycetes - Part 2: Determination of inherent or enhanced durability. European Committee for Standardization (CEN), Brussels, Belgium, p. 20.

EN 117 (2013) Wood preservatives – Determination of toxic values against *Reticulitermes* species (European termites) (laboratory method). European committee for standardization. https:// www.cen.eu.

Gominho J, Figueira J, Rodrigues JC, Pereira H (2001) Within-tree variation of heartwood, extractives and wood density in the eucalypt hybrid *urograndis* (*E. grandis* x *E. urophylla*). Wood and Fiber Science, 33(1): 3-8.

Metsämuuronen S, Siren H (2014) Antibacterial compounds in predominant trees in Finland: review. Journal of Bioprocessing and Biotechniques, 4: 167, 13 pages.

Taylor AM., Gartner B., Morrell JJ (2006) Effects of heartwood extractive fractions of T*huja plicata* and *Chamaecyparis nootkatensis* on wood degradation by termites or fungi. Journal of Wood Science, 52: 147–153.