WOOD RESEARCH
60 (6): 2015
865-872

NATURAL DURABILITY OF *TETRACLINIS ARTICULATA* (VAHL) MASTERS WOODS AGAINST WOOD DECAY FUNGI: LABORATORY TEST

Fidah Abdelwahed, Rahouti Mohamed
Laboratoire De Botanique, Mycologie Et Environnement, Faculte Des Sciences, Universite Mohammed V, Rabat, Morocco

Kabouchi Bousselham
Equipe De Spectronomie Moleculaire, Optique Et Instrumentation Laser, Faculte Des Sciences, Universite Mohammed V, Rabat, Morocco

Ziani Mohsine
Institut National Des Sciences De L'archeologie Et Du Patrimoine, Rabat, Morocco

El Bouhtoury-Charrier Fatima
Universite De Pau Et Des Pays De L'adour Institute of Science and Analytical Chemistry Physical Environment and Materials
Mont De Marsan, France

Fidah Abdelwahed, Famiri Abderrahim
Laboratoire De Durabilite Et D'anatomie, Service De Technologie De Bois Et De Valorisation Des Produits Forestiers, Centre De Recherche Forestiere
Rabat, Morocco

(Received May 2015)

ABSTRACT

The coniferous tree, *Tetraclinis articulata* (Vahl) Masters, commonly known as Barbary thuya is endemic to the western Mediterranean areas. Its root burl wood is very appreciated for its natural beauty, homogeneity and quality for marquetry and furniture. The natural durability of both thuya trunk and root burl woods against three wood decay fungi, *Gloeophyllum trabeum*, *Poria placenta* and *Coniophora puteana*, according to the methods described in the CEN/TS 15083-1 (2005) and NF EN 350-1 (1994) European standards, was assessed. Mass losses obtained after 16 weeks of exposure to these fungi, in laboratory test, showed that both thuya woods can be included in the very durable to durable classes against fungi. Such natural durability allows these woods to access to the risk classes of biological attacks 4 and 5 (high-risk), but only regarding fungi, for end-use without preservative treatment.

KEYWORDS: *Tetraclinis articulata*, trunk wood, root burl wood, durability, wood decay fungi, laboratory test.

INTRODUCTION

The thuya, *Tetraclinis articulata* (Vahl) Masters, belonging to the order of Pinales and family of Cupressaceae, is endemic to the western Mediterranean areas and it is par excellence a tree of the semi-arid temperate and hot bioclimate. In North Africa, natural stands of *Tetraclinis articulata* cover a total area of 1 million hectares and grow to heights ranged from sea level up to 1800 m altitude (Fennane 1984). It is found in Morocco, Algeria, Tunisia, and more rarely in Spain and Malta (M'Hirit et Blerot 1999). Recently, conservation and rehabilitation of this species in the Iberian Peninsula began to regain more interest (Esteve-Selma et al. 2010).

In Morocco, the thuya populations occupy an area of approximately 566.000 ha and play an important socio-economic role in the satisfaction of the needs of the human riparian populations in terms of rangelands (for livestock), wood products (timber, fuelwood, wood of service and burl wood for crafts), sandarac gum, tannins and vegetal tar. However, in recent decades, this forest undergoes a significant degradation especially due to its overexploitation by the craft sector following a strong demand (Dakak 2002). Effectively, thuya is mainly famous for its root burl wood, which is an outgrowth of the tree at the level of the crown and the root. It is a good quality material (hard, homogeneous and fine grained) and has a remarkable fleck, an aesthetic aspect very appreciated by the cabinetmakers and marquetry in layers.

Previous works were focused on the physic and mechanic characterization of thuya woods, especially the identification of material symmetries of burl wood in relation with its internal structure. It have shown that burl wood is a material exhibiting a transverse isotropic behavior and does not present the same natural symmetries as the wood of the trunk (El Bouhtoury-Charrier et al. 2009, El Mouridi et al. 2011a, b, El Alami et al. 2013).

The thuya woods are assumed durable by artisans, but their natural durability against wood decay fungi has not yet been experimentally tested. The objective of the present work is to assess, in a laboratory experiment, the natural durability of both thuya wood and root burl against three wood decay fungi (*Coniophora puteana*, *Gloeophyllum trabeum* and *Poria placenta*) according to the CEN/TS 15083-1 (2005) and EN 350-1 (1994) European standards.

MATERIALS AND METHODS

Plant material used

In this study, both thuya trunk and root burl woods, originated from Khemisset region (North-West, Morocco), were tested and compared to Scots pine, *Pinus sylvestris* L., sapwood used as reference. Thuya trunk wood specimens of (2.5 cm width, in radial direction × 1.5 cm thick, in tangential direction × 5 cm length, in longitudinal direction) were randomly carried from plates cut in three trees aged about 45 years, without distinguishing sapwood and heartwood. Since that the complex internal structure of thuya root burl, axis of symmetry (radial, tangential and longitudinal) were difficult to find, it was supposed that they were similar to those of thuya heartwood according to the assumptions formulated by previous works (El Mouridi et al. 2011a, b, El Alami et al. 2013). Root burl specimens were then taken from plates of three root burls cut following the same longitudinal axis of tree (reference axis). The wood reference specimens were carried from commercial Scots pine sapwood. All specimens were free of cracks, discoloration, biological attack, insect holes and other defects. The distribution of wood specimens, by type of test and by fungus, is given in Tab. 1.

Tab. 1: Numbers of wood specimens by fungus and type of wood.

Type of wood	Biological test specimens			Conditioning specimens
	C. puteana	*G. trabeum*	*P. placenta*	
Thuya root burl wood	30	30	30	10
Thuya trunk wood	30	30	30	10
Scots pine sapwood	10	10	10	10

Before the test, all specimens were put into a climatic chamber (20 ± 2°C and 65 ± 5 % relative humidity) in order to reach the equilibrium of 12 % wood moisture content. Ten conditioning specimens of each wood species were oven dried to 103°C for 24 hours in order to determine the moisture content as well as the "K" coefficient used for the calculation of theoretical anhydrous mass of biological test specimens.

The three brown rot fungi used in this study were *Gloeophyllum trabeum* BAM Ebw. 109, *Poria placenta* FPRL. 280 and *Coniophora puteana* BAM Ebw. 15., conserved in the mycological collection of the Laboratory of Botany, Mycology and Environment, Faculty of Sciences, Rabat, Morocco.

Methodology

The assessment of the natural durability of thuya woods was determined according to the French and European standards: NF EN 350-1 (1994), CEN/TS 15083-1 (2005), NF EN 335-2 (2013) and NF EN 460 (1994). The determination of the resistance of woods specimens to fungal decay is based on their mass loss value after fungi exposition in laboratory test. Scots pine sapwood, used as reference wood, is recognized non- durable against the wood decay fungi.

The standard CEN/TS 15083-1 previews, before fungi exposition, the calculation of the theoretical oven-dry mass (M_{to}) of test specimens and the K coefficient of moisture correction, obtained from the measurement of the moisture content on another series of ten oven dried test and reference specimens at 103°C for 24 hours, as indicate:

$$U = \frac{M_h - M_o}{M_o} * 100 \text{ and } K = \frac{100}{100 + U_{moy}} \quad (\%) \qquad (1)$$

where: M_h - initial mass at 12 %,
M_o - anhydrous mass (%),
U - moisture content of each specimen (%),
U_{moy} - mean of moisture content of ten specimens of each type of wood.

The theoretical anhydrous mass (M_{to}) of specimens intended for biological tests, was then determined as follows:

$$M_{to} = M_h * K \qquad (2)$$

Fungal strains used in this study were grown in Petri dishes on 4 % malt extract and 3 % agar in distilled water and then transferred after 10 to 15 days on the same medium in 500 ml square section bottles. Each bottle, containing 30 ml of the medium, was plugged with cotton. Wood specimens test were at first sterilized by autoclaving at 121°C for 20 minutes and were subjected to fungal decay in bottles (inoculation) after about 20 days of mycelium culture, at the rate of two specimens per bottle. A small round pellets stainless steel of 2 mm thick, used as holders, were placed between the mycelium surface and wood specimens bottom surface. Wood moisture must be above 20 % for suitable wood colonization by fungi. Specimens exposed to mycelia were then incubated in a dark climatic chamber (RH= 70 ± 5 % and T= 22 ± 2°C) during 16 weeks. At the end of incubation period, the woods specimens were removed from the culture bottles, carefully brushed and immediately weighed to determine their final moisture content before oven dried at 103°C for 24 hours and weighed again to determine their final anhydrous mass (M_f). Then, the mass loss of all the inoculated specimens and the average mass loss for each fungus were deducted.

The mass loss, in percentage, of each test specimen was calculated as indicate:

$$P = \frac{M_{to} - M_f}{M_{to}} \cdot 100 \tag{3}$$

M_{to} and M_f were respectively initial theoretical anhydrous mass and final anhydrous mass of wood specimens, and the means of mass loss of the biological test specimens (thuya trunk and root burl woods, P_e) and the mean of reference wood (Scots pine sapwood, P_r) were calculated respectively as follows:

$$P_{e,r} = \frac{\sum M_{to} - \sum M_f}{\sum M_{to}} \cdot 100 \tag{4}$$

The durability index "X" of each type of thuya wood was therefore: $X = \frac{P_e}{P_r}$.

Durability classes of test woods were then deducted from the Tab. 2.

Tab. 2: Classes of wood durability to brown-rot fungi according to standard NF EN 350.

Durability class (DC)	Description	Results expressed in X* value
1	Very durable	X ≤ 0.15
2	Durable	0.15 < X ≤ 0.30
3	Moderately durable	0.30 < X ≤ 0.60
4	Less durable	0.60 < X ≤ 0.90
5	Non-durable	X > 0.90

* X is the durability index expressed as mass loss of the test specimens / mass loss of the reference specimens.

RESULTS AND DISCUSSION

Means of mass loss of test and reference specimens are presented in Tab. 3. These results, as well as the observations of the woods specimens show that the most noticeable damage is caused by *G. trabeum* on Scots pine sapwood. Average mass loss reached approximately 41 %. Both thuya trunk and root burl specimens showed no apparent decay by the three tested wood decay fungi and mass loss was below 5.5 % (Tab. 3).

According to our results, the root burl wood is therefore very durable against two fungi, *G. trabeum* and *P. placenta* (durability class, DC1) and durable against *C. puteana* (DC 2), while the trunk wood is very durable against *G. trabeum* and *C. puteana* (DC 1) and durable against *P. placenta* (DC 2).

Tab. 3: Mass loss of the test specimens of thuya trunk (above the line) and root burl woods (below the line) and durability classes (DC) according to EN 350-1 in brown-rot test (SD standard deviation, n=30, for reference, specimens n=10)*

	Basic statistical parameters				X**	DC***
	Min	Max	Mean	S D		
	(%)					
P. placenta	<u>3.335</u> 4.116	<u>6.827</u> 5.529	<u>5.436</u> 4.765	<u>1.088</u> 0.287	<u>0.165</u> 0.144	<u>2</u> 1
C. puteana	<u>2.866</u> 4.380	<u>4.704</u> 5.200	<u>3.525</u> 4.810	<u>0.663</u> 0.839	<u>0.148</u> 0.194	<u>1</u> 2
G. trabeum	<u>1.623</u> 3.892	<u>4.122</u> 7.678	<u>3.193</u> 5.160	<u>0.773</u> 1.654	<u>0.079</u> 0.127	<u>1</u> 1

* Means of mass loss of reference specimens (Scots pine sapwood) were respectively 33 % for P. placenta, 25 for C. puteana and 41 % for G. trabeum.
** Durability index.
*** Durability classes.

The definition of biological risks, according to the standard EN 335-2 (2013), is generally taken as a reference in the elaboration of the conditions of end-use of a given wood. A correspondence is then established between natural durability classes and the risk of biological attacks classes (EN 460, 1994). Taking into account this correspondence, natural durability classes (DC 1 and 2) of thuya trunk and root burl woods against decay fungi, allows these woods to access high-risk classes of biological attacks 4 and 5 for an end-use without preservative treatment, but only regarding wood decay fungi.

Compared to other coniferous woods in Morocco, natural durability of these woods is similar to that of the Atlas cedar heartwood, considered as very durable to durable against wood decay fungi (DC 1 and 2) (Brunetti et al. 2001) and is better than the Aleppo pine timber considered as less durable (DC 4) (Thevenon et al. 2012).

The natural durability of thuya woods would be linked to its richness in tropolones (Haluk et Roussel 2000) and phenols which are recognized as antimicrobial (Satrani et al. 2006, El Hanbali et al. 2007, El Moussaouiti et al. 2010). The essential oil of *T. articulata* burl wood, containing phenols such as thymol, 3-tert-butyl-4-methoxyphenol and cedrenol, has shown a very significant antibacterial activity at concentrations below 1.25 µl/ml (El Moussaouiti et al. 2010). On the other hand, the incorporation of 1 to 2 % of thuya burl wood sawdust in the culture medium has limited the development of the wood decay fungus, *Coriolus versicolor* (El Bouhtouri-Charrier et al. 2009). This could allow us in future studies to consider the recovery of waste from thuya woods processing for extracting essential oils and used them in the preservative treatment tests of less durable woods.

CONCLUSIONS

The assessment of natural durability of thuya woods against three wood decay fungi, according to the methods described in the CEN/TS 15083-1 (2005) and EN 350-1 (1994) European standards, has shown that the thuya root burl is very durable against *G. trabeum* and

P. placenta (DC 1) and durable against *C. puteana* (DC 2), while the thuya trunk wood is very durable against *G. trabeum* and *C. puteana* (DC 1) and durable against *P. placenta* (DC 2). Such natural durability allows these woods to access high-risk classes of biological attacks 4 and 5 for an end-use without preservative treatment, but only regarding wood decay fungi.

ACKNOWLEDGMENT

This manuscript is prepared from the outcome of the project titled "Characterization of local wood and derivatives", one of four projected conducted by the wood technology and utilization of forest products office, Forest Research Centre, Rabat. This project is supported by Moroccan High Commission for Water and Forests and the Fight against Desertification.

REFERENCES

1. Brunetti, M., De Capua, E., Macchioni, N., Monachello, S., 2001: Natural durability, physical and mechanical properties of Atlas cedar (*Cedrus atlantica* Manetti) wood from Southern Italy. Ann. For. Sci. 58(6): 607-613. INRA EDP Sciences.
2. CEN/TS 15083-1, 2005: Durability of wood and wood-based products – Determination of the natural durability of solid wood against wood-destroying fungi- Test methods. Part 1: *Basidiomycetes*.
3. Dakak, J., 2002: Wood quality of Thuya of the Maghreb (*Tetraclinis articulata*) and its development conditions under its main phytoecological sites in the southern Moroccan block. (La qualité du bois de Thuya de Maghreb (*Tetraclinis articulata*) et ses conditions de développement sur ses principaux sites phytoécologiques de son bloc méridional au Maroc). PhD Thesis: Ecole Nationale du Génie Rural, des Eaux et des Forêts. Nancy, France (in French).
4. El Alami , S., El Mouridi, M., Laurent, T., Calchéra, G., Famiri, A., Hakam, A., Kabouchi, B., Gril, J., 2013: Fracture energy of wood and root burl wood of Thuya (*Tetraclinis articulata* (Vahl) Masters). Journal of Tropical Forest Science 25(2): 166-174.
5. El Bouhtoury-Charrier, F., Hakam, A., Famiri, A., Ziani, M., Charrier, B., 2009: Wood characterization of *Tetraclinas articulata* and evaluation of its resistance against ligninolytic fungi. IRG/WP 09-10697, Beijing, China, 24-28 May 2009.
6. El Hanbali, F., Amusant, N., Mellouki, F., Akssira, M., Baudasse, C., 2007: Potentiality of use extracts from *Tetraclinis articulata* like biocide against wood destroying organisms *Reticulitermes santonensis*. IRG/WP 07-30418, Jackson Lake Lodge, Wyoming, USA 20-24 May 2007.
7. El Mouridi, M., Laurent, T., Brancheriau, L., Arnould, O., Famiri, A., Hakam, A., Gril, J., 2011a: Searching for material symmetries in the burl wood of thuja by a direct contact ultrasonic method on spherical samples. Maderas Ciencia y tecnología 13(3): 285-296.
8. El Mouridi, M., Laurent, T., Famiri, A., Kabouchi, B., Almeras, T., Calchera, G., El Abid, A., Ziani, M., Gril, J., Hakam, A., 2011b: Physical characterization of root burl wood of Thuya (*Tetraclinis articulata* (Vahl) Masters). Phys. Chem. News 59: 57-64.
9. El Moussaouiti, M., Talbaoui, A., Gmouh, S., Aberchane, M., Benjouad, A., Bakri, Y., Kamdem, D.P., 2010: Chemical composition and bactericidal evaluation of essential oil of *Tetraclinis articulata* burl wood from Morocco. J. Indian Acad Wood Sci. 7(1-2): 14-18.

10. Esteve-Selma, M., A., Martínez-Fernández, J., Hernández, I., Montávez, J. P., Lopez, J. J., Calvo, J.F., Robledano, F., 2010: Effects of climatic change on the distribution and conservation of Mediterranean forests: The case of *Tetraclinis articulata* in the Iberian Peninsula. Biodiversity and Conservation 19(13): 3809-3825.
11. Fennane, M., 1984: Phytogéographical and phytoecological analysis of Moroccan *Tetraclinis articulata* stands. (Analyse phytogéographique et phytoécologique des tétraclinaies marocaines). Bulletin de L'institut Scientifique du Maroc 8: 115-134. Le thuya de Berberie au Maroc: Apergu phytoécologique et ecologique (in French).
12. Haluk, J.P., Roussel, C., 2000: Characterization and origin of tropolones involved in natural durability of *Cupressaceae* woods. Potential application as wood preservatives. Ann. For. Sci. 57(8): 819-829.
13. M'Hirit, O., Blerot, P., 1999: Great book of Moroccan forests. (Le grand livre de la forêt marocaine). Editions Mardaga, 280 pp (in French).
14. NF EN 350-1, 1994: Durability of wood and wood-based products –Natural durability of solid wood. Part 1: Guide to the principles of testing and classification of the natural durability of wood.
15. NF EN 335-2, 2013: Durability of wood and wood-based products – Definition of use classes of biological attack –Part 2: Application to solid wood.
16. NF EN 460, 1994: Durability of wood and wood-based products. Natural durability of solid wood, Guide of the the durability requirements for wood to be used in hazard classes.
17. Satrani, B., Aberchane, M., Farah, A., Chaouch, A., Talbi, M., 2006: Composition chimique et activité antimicrobienne des huiles essentielles extraites par hydrodistillation fractionnée du bois de *Cedrus atlantica* Manetti. Acta Bot. Gallica 153(1): 97-104.
18. Thevenon, M-F., Janah, T., Rahouti, M., Langbour, P., Gerard, J., 2012: Investigations on the durability of two secondary Pine species (*Pinus halepensis, Pinus uncinata*) within the scope of the European natural durability standards revision. IUFRO conference, Division 5 « Forest Products ». 8-13 July 2012, Lisbon, Portugal.

*Fidah Abdelwahed, Rahouti Mohamed
Universite Mohammed V
Faculte Des Sciences
Laboratoire De Botanique, Mycologie Et Environnement
Rabat
Morocco
Corresponding author : fidah.abdelwahed@gmail.com

Kabouchi Bousselham
Universite Mohammed V
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