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A study of natural durability of wood in selected tropical wood species from South America and Africa affected by the fungus *Serpula lacrymans* (Wulf., Fr.) Schroet.

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Abstract: *This paper presents the results of a study on natural durability of selected tropical wood species from South America and Africa affected by Serpula lacrymans (Wulf., Fr.) Schroet. Tabebuia* sp. and *Autranella congolensis* (De Wild.) A.Chev. wood displayed the highest class of natural durability. They were ranked to first class in terms of natural durability. *Apuleia leiocarpa (Vogel)* J.F.Macbr. exhibited the lowest resistance to fungal activity. It was classified third class in terms of natural durability presented in European standards.

Keywords: natural durability, *Tabebuia*, *Autranella congolensis, Apuleia leiocarpa*, *Serpula lacrymans*

INTRODUCTION

The use of wood in construction has a long tradition and the demand for the material is constant. With the increase of our knowledge about the material, its structure and characteristics have become better recognized. Additionally, knowledge about ways of protecting wood against numerous biotic and abiotic factors has grown as well [Kollmann and Fengel 1965, Zaman et al. 2000, Yildiz 2002, Hill 2007]. Apart from looking for new solutions aimed at increasing the natural resistance of domestic wood, a search was undertaken for wood with more favourable technical properties than the ones we find in domestic species. This enhanced interest in tropical wood. In Poland trade of tropical wood has been developing for over 40 years. Wood imported from Africa, Asia and South America has higher prices owing to importation-related costs. Hence the need for the most economical use of the material. Due to reports in literature regarding the resistance to domestic pathogens information related to it is necessary.

The aim of the present paper was to study the influence of fungi on the natural durability of exotic wood. The knowledge that has been gained is indispensable for rational wood management, which is particularly essential from both the ecological and economical points of view. In the present paper we have used selected species of wood form South America: ipe (*Tabebuia* sp.), mukulungu (*Autranella congolensis* (De Wild.) A. Chev) and garapa (*Apuleia leiocarpa* (Vogel) J.F.Macbr.).

MATERIAL AND METHODS

The wood selected for our research is a material that has already been partially known and described in literature [Jankowska et al. 2012], as well as wood with incomplete technical properties. The wood of the studied species is very heavy, according to classification given by Krzysik [1978], and has high potential for different uses in the form of various elements in external architecture. Ipe (*Tabebuia* sp.) is acquired from Brazil, Columbia and Venezuela. Depending on the country of origin the wood bears different names, Brazilian walnut and lapacho (Brazil and Bolivia), Acapro (Venezuela), Lapacho negro (Paraguay) [Jankowska et al.

2012]. The wood is valued for its density, which reaches up to 1300 kg×m^{-3} as well as its high mechanical properties.

Mukulungu (*Autranella congolensis* (De Wild.) A. Chev) is a species coming from Central Africa, mainly from Cameroon [Richter and Dallwitz 2000]. Mukulungu wood exhibits very high resistance to biodegradable factors such as fungi, termites and other wood boring insects. According to the European norm EN-350-2:2000 mukulungu wood has been classified as having first class resistance to fungi and insects. The resistance to fungi is quoted in the norm in the context of durability when exposed to the activity of the fungus *Coniophora puteana* (Schumach.) P. Karst. Polish literature does not, however, describe the resistance of mukulungu wood to other fungi which decompose wood in buildings.

Garapa (*Apuleia leiocarpa* (Vog.) Macbr.) comes from South America from certain areas in the Amazon basin, including some in the forests of south Brazil and the coast of the Atlantic Ocean. Garapa wood varies slightly in terms of colour depending on its place of origin [Richter and Dallwitz 2000].

For our study we have used the heartwood part of ipe, mukulungu and garapa wood. In accordance with the PN-EN 113:2000 norm samples, sized 50 × 25 × 15 mm preserving the basic anatomical crosssection, were prepared. Samples with similar density were chosen in a way to prevent them from having any visible deffects such as cracks or knots. The samples, with moisture content at around 12%, have been weighed to the nearest 0.01 g. Next, the samples were moistened for 48 hours until they reached at least 20 % of moisture content. 40 samples of each wood species have been used for the study. To examine the pace of decay of the fungus *Serpula lacrymans* (Wulf., Fr.) Schroet. domestic beechwood (*Fagus sylvatica* L.) was used according to PN-EN 350-1:2000. 15 samples for each exotic wood species examined were used for comparison. Pure cultures of the fungus *Serpula lacrymans* (Wulf., Fr.) Schroet. were used for the study.

The species has been selected owing to the fact that is constitutes a real threat for various types of constructions. The fungal strains were taken from the collection of the Wood Protection Department of Faculty of Wood Technology (Warsaw University of Life Sciences). The grafting lasted 16 weeks.

The equilibrium moisture content of samples was determined according to PN-D-04100:1977 and ISO 3130:1975. The wood density of samples was determined according to PN-D-04101:1977 and ISO 3131:1975.

RESULTS AND DISCUSSION

The density of the wood is connected with a whole range of physical and mechanical wood properties. Studies conducted up to the mid-20th century confirmed that wood density is at the same time an indicator of its durability [Nördlinger 1860, Vorreiter 1949, Wanin 1953]. This is explained by Kamiński and Laurow [1974] through the fact that high-density wood is considered to be very resistant to factors causing its gradual degradation, which in turn is connected with relatively low levels of air or water inside wood cells as well as with considerable cell wall thickness, which can constitute a natural barrier e.g. against fungal spread in wood. In the present study density loss in individual species before the fungal activity and after the period of 16 weeks from the graft have been used and compared. The density was established for wood at 0% moisture. The obtained results were complied below in Table 1.

Table 1. Change of wood density under the influence of the *Serpula lacrymans* (Wulf., Fr.) Schroet

Wood species	Period of fungal activity [weeks]	Density at 0% moisture [kg×m^{-3}]	Δ [kg×m^{-3}]
Mukulungu	0	842	4,5
	16	795	2,1
Garapa	0	841	4,5
	16	737	3,8
Ipe	0	993	3,4
	16	941	2,4
Beechwood	0	582	3,7
	16	433	5,0

The obtained results allow us to state that the household fungus *Sperpula lacrymans* (Wulfen) J. Schröt causes decay of examined wood (Table 1). The change in density occurred in all examined tropical wood species, at the same time the drop in density was visibly smaller than in control samples made of domestic wood. The biggest difference in density was recorded for garapa wood – it was twice as big as that of mukulungu wood. The results for mukulungu wood were similar to those of ipe wood. Beechwood turned out to be the least resistant as its density after 16 weeks of fungal activity decreased twice as much compared with garapa wood. The calculated coefficients of variability and the standard deviation show little dispersion for all wood species, both exotic and domestic. In order to better illustrate the already mentioned loss in density, a graph is presented below, which illustrates the percentage decrease of wood density (Figure 1).

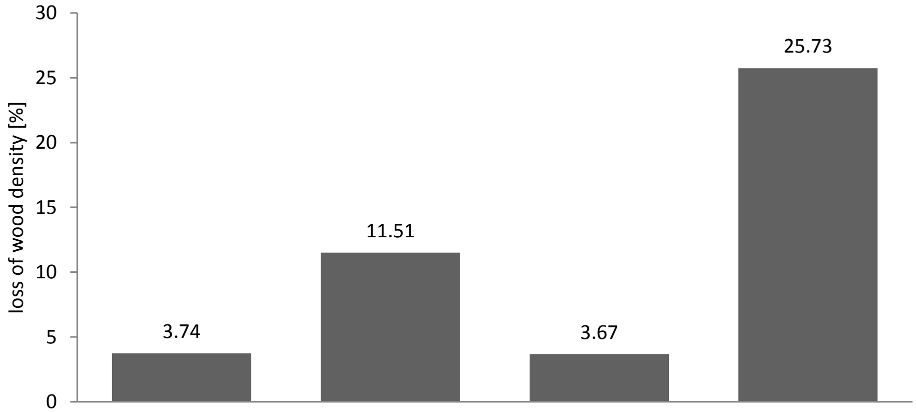

Figure 1. Change in wood density as a result of the activity of *Serpula lacrymans* (Wulf., Fr.) Schroet.

The main criterion for evaluating the natural resistance of wood to fungal activity is the loss of wood mass over the period of its contact with the fungi. The mass loss informs us directly of the level of wood degradation by the given household fungus. The results are presented in Table 2.

Table 2. Change in wood mass under the influence of *Serpula lacrymans* (Wulf., Fr.) Schroet.

Wood species	Wood mass at 0% moisture		Mass loss			Correction factor	Average corrected mass loss	δ
	Beginning	End	Min.	Avg.	Max.			
	[g]		[%]			[%]		
Mukulungu	15,15	14,83	0,20	3,82	8,94	0,08	3,74	0,74
Garapa	15,06	13,3	0,60	11,67	16,9	0,16	11,51	0,4
Ipe	17,7	16,92	0,46	3,81	8,55	0,14	3,67	2,38
Beechwood	9,69	6,43	26,2	37,73	52,0	12,00	25,73	0,11

* δ – standard deviation

On the basis of analysis of data obtained during the study we find a substantial difference in resistance to *Serpula lacrymans* (Wulf., Fr.) Schroet. between domestic and tropical wood. Ipe wood obtained the best results, with a mass loss of only 3.67%. This proves that this wood species is highly resistant to the activity of this particular fungus. Mukulungu wood achieved similar results. A three-times bigger mass loss was registered for garapa wood. The loss of mass observed in beechwood was 7 times bigger than ipe wood. A comparison of mass loss in all examined species is presented in Figure 2.

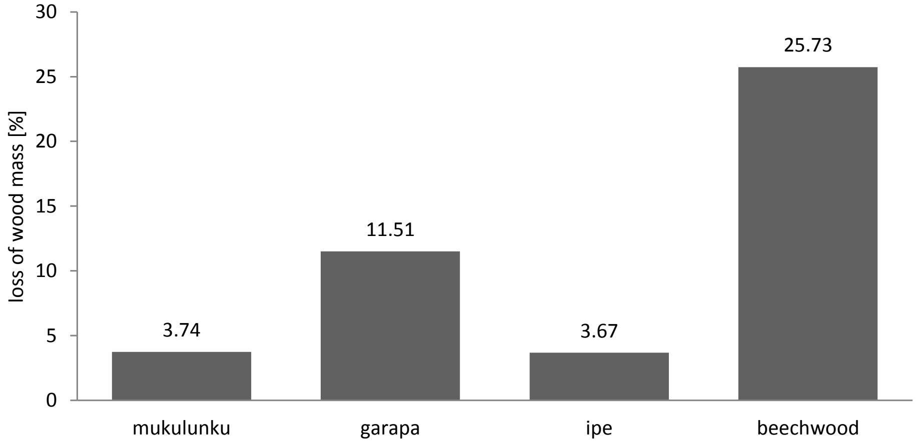

Figure 2. Loss of wood mass as a result of the activity of *Serpula lacrymans* (Wulf., Fr.) Schroet.

According to Carthwright and Findley [1951] in case of softwoods the mass loss can reach up to 30%. Hardwood species are characterized by a mere 5% loss of mass. To sum up, only ipe and mukulungu wood can be counted among hardwoods according to this classification. Garapa wood, ranging from 5 to 30%, can be considered medium durable wood.

The durability of the selected exotic species is caused by the presence of non-structural substances which may toxically affect the attacking fungi. Moreover, the high density of all selected species hinders the hyphae penetration into the wood structure as the wood is less porous. In the case of ipe wood, with a mass loss of merely 3.67%, the lapachol and fatty substances content considerably inhibit fungus growth and the high wood density prevents it from penetrating the structure [Jankowska et al. 2012].

The reason why tropical wood has decayed to such a small extent is probably its anatomical structure influencing the high density of the material. Another factor is likely to be the difference in chemical structure. Probably the difference between European beechwood and tropical wood is caused by the amount of extractives in wood structure which can act hydrophobic. This surmise finds confirmation in literature. Former research points to the influence of extractives on many properties of wood. However, studies in this area are incomplete and knowledge in this field of expertise should be expanded. European beech is a non-heartwood species and other tested wood was derived from heartwood zone. The differences between durability of European beech and tropical wood seem obvious, but differences between tropical wood species require verification.

The PN-EN 113:2000 norm (Appendix E) informs about the minimal percentage mass loss in beechwood. It is specified, however, only for the fungi *Trametes versicolor* (L.) Lloyd (25 %) and *Lentinus cyathiformis* (Schaeff.) Bres. (20 %). The PN-EN 350-1:2000 norm in Appendix C specifies the percentage mass loss in beechwood for *Serpula lacrymans* at 30.1%, which gives similar results to those obtained in the conducted studies.

Comparing the results of studies carried out on beechwood, we see the similarity of the obtained results. According to the studies of Ważny [1959] conducted with the use of the *Merulius lacrymans* (Wulf.) Fr. (current name *Serpula lacrymans*), the loss of specific weight was 24.4%. However, when comparing the results of the above mentioned research one has to stress that the samples were of different size (20 × 20 × 20 mm) and that they were completely dried before the research started.

Additional research concerned confirming the research activity on the basis of observation of fungal growth on wood surface. Fungus developed in all samples of all species, which according to the Polish norm PN-EN 113+A2:1993 ought to take place in case of all properly conducted studies. In the case of tropical wood fungal growth was limited compared with domestic species. This resulted from the high density of tropical wood. This suggests using this wood in places with high humidity or where it touches the ground.

CONLUSION

The research conducted on selected tropical wood species: ipe (*Tabebuia* sp.), mukulungu (*Autranella congolensis* (De Wild.) A.Chev)) and garapa (*Apuleia leiocarpa* (Vog.) Macbr.) allowed to determine their natural durability. On the bases of obtained results the following conclusions were made:

1. The highest class of natural durability from among the studied tropical wood species in the face of the activity of the fungus *Serpula lacrymans* (Wulf., Fr.) Schroet. was exhibited by ipe wood (*Tabebuia* sp.). Based on the results this species has been classified first class in terms of durability.
2. Mukulungu wood (*Autranella congolensis* (De Wild.) A.Chev.) was ranked first class in terms of natural durability.
3. The lowest resistance to the activity of *Serpula lacrymans* (Wulf., Fr.) Schroet. was exhibited by garapa wood (*Apuleia leiocarpa* (Vog.) Macbr.). It was classified third class in terms of natural durability.
4. The activity of *Serpula lacrymans* (Wulf., Fr.) Schroet., determined on the basis of mass loss of beechwood (*Fagus sylvatica* L.), was correct.

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Streszczenie: *Badanie naturalnej trwałości wybranych gatunków drewna egzotycznego wykorzystywanego w budownictwie na działanie grzyba Serpula lacrymans* (Wulf., Fr.) Schroet. W pracy przedstawiono wyniki badania naturalnej trwałości wybranych gatunków drewna egzotycznego z Ameryki Południowej na działanie grzyba *Serpula lacrymans*. Najwyższą klasą naturalnej trwałości wykazało drewno *Tabebuia sp*. i *Autranella congolensis* Najniższą odporność na działanie grzyba wykazało drewno *Apuleia leiocarpa*.

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