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Antifungal properties of some plant extracts used as wood preservatives

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ABSTRACT

This study evaluated antifungal resistance of some commercial and environmentally friendly plant extracts. Four different concentrations of mimosa (*Acacia mollissima*), quebracho (*Schinopsis lorentzii*) and pine (*Pinus brutia*) bark extracts known with their high condense tannin amounts were used to impregnate Scotch pine (*Pinus sylvestris* L.), beech (*Fagus orientalis* L.) and poplar (*Populus tremula*) wood specimens. Extract treated wood specimens were tested against two types of white rot fungi (*Trametes versicolor* and *Pleurotus ostreatus*) and two types of brown rot fungi (*Fomitopsis palustris* and *Gloeophyllum trabeum*) for 16 weeks. The lowest mass loss rates were recorded for mimosa and quebracho extract treated wood blocks at the 9% and 12% concentration levels against both white and brown rot fungi. Pine bark extract, on the other hand, seemed to be ineffective against all fungi species tested even at the highest concentration level (12%). The current study suggests that commercial mimosa and quebracho extracts can be utilized as alternative wood preservative chemicals against common wood decay fungi in indoor applications.

1. Introduction

Various chemicals and methods have been developed in wood preservation industry to protect and extend service life of wood material. In some cases, wood preservation chemicals developed for outdoor applications are avoided to be used in indoor applications due to their volatile compounds which reduce air quality. Therefore alternative wood preservative chemicals are needed to be developed and tested for indoor use. Natural plant extracts and tannins are well known alternatives for intended purposes in wood preservation industry. Extractives obtained from naturally durable species can be used to treat non-durable wood species (Turner and Conradie, 1995; Mortinez-Inigo et al., 1999; Dorado et al., 2001; Harju et al., 2003).

Tannins, flavanoids, lignans, stilbens, terpenes and terpinoids can be listed as major extractive chemicals and are well known with their protective properties against biological degradation of wood (Toshiaki, 2001; Windeisen et al., 2002).

Various natural plant extracts were tested, such as *Pterocarpus soyauxii* heartwood extract (Nzokou and Kamdem, 2002), *Robinia pseudoacacia* heartwood extract (Smith et al., 1989), heartwood extracts of western red and eastern white cedars (Stirling et al., 2007), *Zelkova carpinifolia*, *Quercus castanifolia* and *Moris alba* wood extracts (Kazemi et al., 2006), *Acacia nilotica* leave extract (Khan et al., 1996), and essential oils from *Cinnamomum osmophloem* (Lin et al., 2007) found effective against wood decay fungi at certain concentration levels.

Three different natural extracts, mimosa, quebracho and pine bark, were used this study. Mimosa extract was derived from bark of some *Accacia* spp. from Leguminosae family which includes *Acacia mearnsii*, *Acacia mollissima*, *A. pycnantha*, *Acacia decurrens*, and *Acacia dealbata*. The mimosa extract has high purity and tannen conten and low acidity and salinity. The quebracho extract is obtained from wood of *Schinopsis balansae* and *Schinopsis lorentzii* and it is known with high tannen content (20%). Pine bark extract is produced from *Pinus brutia* bark and has around 10% tannen content which increases with tree age (Hus, 1969).

The focus of this study to compare the effectiveness of natural wood and bark extracts previously utilized in leather industry against common wood decay fungi in indoor applications since no leaching performed prior to decay tests.

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2. Materials and methods

2.1. Wood material

Specimens were prepared from randomly selected first grade Scotch pine (*Pinus sylvestris* L.), beech (*Fagus orientalis* L.) and poplar (*Populus tremula* L.) according to the TS 5563 EN 113, 1996 standards with minor modifications in sample size (30 × 15 × 5 mm [longitudinal × radial × tangential directions]). The mean oven-dried densities of wood species were 0.43 g/cm^3 (±0.03), 0.48 g/cm^3 (±0.04) and 0.74 g/cm^3 (±0.09) for poplar, Scotch pine and beech, respectively. A total of 468 specimens (156 from each species) were prepared. All specimens were conditioned at 20 ± 2 °C and 65 ± 3% RH for 3 weeks before the subsequent treatments.

2.2. Extractive solutions

Pure mimosa bark and quebracho heartwood were purchased as fine powder from nearby leather plants. Pine barks were obtained from nearby forest in Duzce province and oven-dried at 100 °C before coarse grinding. A laboratory scale Wiley mill was utilized to grind the coarse particles further until they pass through a 60-mesh screen for the subsequent hot water extraction process. Four different concentration levels (3%, 6%, 9% and 12% by weight) were prepared from all fine powders with distilled water and extracted on a hot plate with magnetic stirrer at 100 °C for 20 min. To prevent chemical structure and effectiveness of the extracts the extraction process was limited with 20 min. All extracted solutions were filtrated after cooling for subsequent treatments.

2.3. Treatment

Previously conditioned and weighed wood blocks were placed into glass containers according to their intended treatments. An only vacuum treatment at 6.10^{-3} MPa level was applied using glass desiccators for 20 min. When the desiccators returned to the ambient atmospheric pressure, the treated blocks were immediately removed and weighed to determine gross solution uptake. Retention of each extractive solution on wood blocks (kg/m^3) was calculated based on the following equation (TS 5723, 1988).

$$R = \frac{(M_1 - M_0) \times C}{V} \times 10\text{kg/m}^3$$

In this equation, M_0: weight before treatment (g), M_1: weight after treatment (g), C: Concentration of solutions, V: volume of wood blocks (m^3).

The treated wood blocks were stored in a conditioning room at 20 ± 2 °C and 65 ± 3 °C relative humidity until they reach stable weight before the decay resistance tests.

2.4. Decay resistance test

Decay resistance tests were conducted in Forest Biology and Wood Preservation Laboratory of Duzce University. Untreated and treated wood specimens were exposed four different Basidomycetes fungi according to EN 113 (TS 5563) standard. Two white rot fungi, *Trametes versicolor* (L: Fr.) Pilat. (FFPRI 1030) and *Pleurotus ostreatus* and two brown rot fungi *Fomitopsis palustris* (Berk. Et Curt) Gilbn. & Ryv. (FFRPI 0507) and *Gloeophyllum trabeum* (Pers.) Murrill (Mad-617-R) were used in this experiment. *T. versicolor* and *F. palustris* were obtained from RISH, Kyoto University, Japan. *G. trabeum* was kindly provided by Forest Products Laboratory, Madison, Wisconsin, USA. *P. ostreatus* was purchased from Agromar™ Denizli, Turkey. *F. palustris*, *G. trabeum*, and *P. ostreatus* were maintained on 3.9% potato dextrose agar (PDA) medium, while *T. versicolor* was grown on 3.7% malt extract agar (MEA) medium. The media than steam-sterilized at 110 °C and 1.1 A for 30 min before transferred to pre-sterilized petri dishes. After inoculation, the dishes were kept at 26 ± 2 °C and 70 ± 2% relative humidity until the media surfaces were completely colonized by the test fungi. The treated and untreated wood blocks were sterilized at 110 °C for 20 min after their oven-dried reference weights (at 60 °C for 48 h) were determined 6 specimens per retention group were placed in pre-inoculated petri dishes on solid maple feeder strips to minimize direct contact with nutritional media surfaces. Following fungal exposure for 16 weeks at 26 ± 2 °C and 70 ± 2% relative humidity in an incubator, the exposed wood specimens were weighed immediately after the surface mycelium was cleaned. Percent mass losses were calculated from the difference in the 60 °C oven-dried weights of each specimen before and after the decay test.

2.5. GC–MS (Gas chromatograph–Mass Spectrometry) analysis

GC–MS analysis were performed in TUBITAK-MAM Research Center in Gebze, Turkey. Fine powder extracts were dissolved in methanol and filtered through a 25 mm polypropylene disposable syringe filter with nylon filter before injecting the GS-MS (Thermo Trace DSQ). An Agilent HP 5MS (60m × 0.25mm × 0.25 μm) column was used. The injection amount was 1 μL and carried into the column with helium gas (He) at the rate of 1 m/min. The oven temperature was 225 °C at the time of the injections.

2.6. Statistical analyses

The SPSS software (SPSS 19, 2010) was utilized as statistical tool. As a result of multiple analyses of variation (ANOVA) tests, the wood species, extract species and concentration levels and their interactions on mass losses were evaluated. In addition, a Duncan test was used to compare values.

3. Results and discussions

3.1. Retentions

Mean extract retentions, calculated based on gross solution uptake data and concentrations, of treated wood specimens were given in Table 1. As expected, the retention values increased as solution concentration increased from 3% to 12%. When wood

Table 1
Mean extract retentions (kg/m^3) of wood species treated with different extracts and concentrations (Mean of 24 replicates, numbers in parenthesis are standard deviations).

Extracts species	Retention (kg/m^3)[a]						
	Concentration (%)	Scotch pine		Beech		Poplar	
Mimosa	3	19.6 (3.9)	*a*	19.4 (2.3)	*a*	20.5 (3.4)	*a*
	6	40.0 (7.3)	*d*	36.5 (3.5)	*cd*	38.6 (8.4)	*d*
	9	59.3 (9.2)	*gh*	54.7 (7.9)	*efg*	57.0 (12.0)	*fgh*
	12	74.8 (15.0)	*ijk*	74.4 (6.1)	*ijk*	80.2 (11.1)	*l*
Quebracho	3	18.1 (3.2)	*a*	18.9 (3.1)	*a*	19.9 (4.2)	*a*
	6	37.9 (7.9)	*cd*	36.5 (3.3)	*cd*	37.6 (8.4)	*cd*
	9	59.4 (13.2)	*gh*	55.1 (5.6)	*efg*	61.2 (9.8)	*h*
	12	72.7 (14.5)	*ij*	74.3 (9.2)	*ijk*	77.6 (12.3)	*jkl*
Pine bark	3	16.2 (3.8)	*a*	16.3 (1.9)	*a*	18.2 (3.6)	*a*
	6	31.0 (6.5)	*b*	33.2 (4.8)	*bc*	36.8 (6.7)	*cd*
	9	50.9 (11.3)	*e*	52.9 (6.5)	*ef*	54.3 (10.7)	*efg*
	12	70.7 (9.6)	*ı*	72.2 (6.2)	*ı*	78.8 (7.2)	*kl*

[a] Means within each column and factor followed by the same letter are not significantly different ($p < 0.50$).