The protective effectiveness of dry heat treatment on Turkey oak against fugal decay*

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ABSTRACT

Dry heat treatment as a wood modification process is known to significantly improve the dimension stability and to decrease the mass loss caused by brown-, white rot fungi on wide range of wood species.

The primary aim of the presented study was to clear up the effect of dry thermal treatment on wood properties of Turkey oak (*Quercus cerris* L.), with special emphasis on wood resistance to fungal decay. The research work was organised by the Institute of Wood Sciences of the University of West Hungary in Sopron. The thermal treatments were carried out in an electric oven under atmospheric air conditions. The temperature of the treatments ranged between 180-200°C and was combined with a wide range of durations. In our project the most important physical and mechanical wood properties were analysed using the European Norms. In this paper we only publish the effect of dry heat treatment on the mass loss caused by Oak mazegill (*Daedalea quercina*) on Turkey oak. Based on our results, the fungal decay resistance can be enhanced by dry heat treatment not only in case of sapwood, but heartwood as well.

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INTRODUCTION

Turkey oak is an east-Mediterranean species, native to South-Eastern Europe, the southern part of Central Europe (south of the Brno-Zvolen-Sighetul-Marmartiei line) and Asia Minor. Turkey oak has a high industrial importance in Hungary. Unlike grand oaks, Turkey oak develops wide, light-grey (sometimes yellowish) sapwood, distinctly different from the dark reddish-brownish heartwood in colour (MOLNÁR AND BARISKA 2002).
Five natural durability ratings against wood-destroying fungi are defined in EN 350 European Standard. The classes relate to heartwood only are numbered 1-5 (1-very durable, 2- durable, 3-moderately durable, 4-slightly durable, 5-not durable). Sapwood must always be considered as "not durable" against wood degrading agents. Turkey oak with its wide sapwood is less durable than grand oaks. Therefore the effect of dry heat treatment had a special importance in our research work. This research was part of a GOP 3.1.1 project called "Chemical free wood protection". It has been set-up in co-operation with the Institute of Wood Sciences (University of West Hungary), Sokon Ltd. and Apostol és Társai Ltd. The objective of a part-study of our project was to determine the effect of the dry heat treatment on the most important wood properties of Turkey oak (*Quercus cerris* L.) with a special emphasis on the protective effectiveness against Oak mazegill (*Daedalea quercina*).
Heat treatments as alternative wood protection processes have been developed and optimized in various countries for a considerable time. STAMM ET AL. (1946) reported on the first systematic attempts to increase resistance to wood-destroying fungi in a hot metal bath. BURO (1954, 1955) studied the heat treatment of wood in different atmospheres. Investigation often focused on the drying characteristics (SCHNEIDER 1973) and the chemical aspects of heat-treated wood (SANDERMANN and AUGUSTIN 1963; KOLLMANN and FENGEL 1965; TOPF 1971; TJEERDSMA ET AL.1998) as well as changes in dimensional stability (KOLLMANN and SCHNEIDER 1963) and strength (SCHNEIDER 1971, RUSCHE 1973). The well known moisture / heat / pressure (FWD) process by BURMESTER (1973) was further developed by GIEBELER (1983). There have been continuing researches to improve wood properties by thermal treatment for some years some other European countries. The production of TMT (thermally modified timber) in Europe is more than 300.000 m^3 in 2012 (IHD 2012). According the findings of the last decades it could be summarized, that the heat treatment is able to increase the dimensional stability, the resistance to fungal decay, though also has negative effects on the wood's characteristics. Due to the degradation of wood components the brittleness and the formation of cracks in particular

could be increased. The heat-related brown hue has low UV resistance which could also be problematic during practical use.
In this paper we publish the effect of dry heat treatment on the mass loss of Turkey oak caused by Oak mazegill (*Daedalea quercina*).

EXPERIMENTAL METHODS

During our research were used logs from one certain production site. The so called juvenile wood was not totally removed, but it was minimized by removing the first 5-10 annual rings. The native and to be treated samples were cut out from the same board before the tests. According to the preliminary tests, the temperature of treatments was limited to 200°C and the heat transmitter agent was dry, normal atmospheric air, without blowing steam. The schedules were based on the Finnish ThermoWood-schedule combined with 5-, 10- and 15-hour-long treatment period after reaching the 180 °C and 200 °C reaction temperatures. From statistical aspect, the number of samples was 25 pcs and evaluation of data was made in SPSS program. During the analysis of variance (ANOVA) we used a level of significance of 0,05.
The resistance to fungal decay of the modified timbers was tested in laboratorial conditions according to the standard EN 113. The special aim of this method is to determining the protective effectiveness against wood destroying basidiomycetes. During our research the tests were completed according to this standard, but in some cases we had to depart from it. In case of Turkey oak, we grafted mycelia of oak mazegill (*Daedalea quercina*) to the soils. Though oak mazegill is not listed in the standard EN 113, but it can be also found in the class of Basidiomycetes, and causes brown rot on wood. It attacks not only stubs in the forest, but the heartwood of freshly felled logs as well. In turkey oak forests it is not so frequent, but it attacks often the built-in timber of turkey oak. We set the sizes of samples according to the volume of the project, so we had to decrease those as compared to the prescribed sizes of the standard's. So the dimensions of samples were 20×20×6 mm (tangential × radial × along the grain).

Figure 1: Placing samples into Kolle-flasks in grafting cabin

Samples were dried in an electrical oven at 103 ± 2 °C and their mass was measured with an accuracy of 0,01 g. Placing of samples has to be done in sterile environment (Fig.1.)
After placing of samples the Kolle-flasks closed by a sterilized paper cork were put in a thermostat, which assured constant 23 °C inner temperature for the growing of the fungi. The standard test lasts 16 weeks, which was also reduced due to the decrease of the sample size and the wood weight placed in one flask. So the test duration was 12 weeks, after which it was still able to measure the samples, without crumbling. The rate of fungal decay, practically the rate of oven dry mass loss was determined by comparing to the initial oven dry mass of the samples. After 12 weeks incubation the samples were measured with careful removal of mycelia and repeated oven drying. The rate of fungal decay can be calculated by the formula as Eq. 1 shows.

$$m_{ol} = \frac{m_{obefore} - m_{oafter}}{m_{obefore}} \cdot 100 \qquad (1)$$

where:

m_{ol}	mass loss, the rate of fungal decay, [%]
$m_{o\ before}$	oven dry initial mass, [g]
$m_{o\ after}$	oven dry mass after the incubation, [g]

The less the rate of decay, the more durable is the wood to the enzymatic decay of the fungus.

RESULTS AND DISCUSSION

In case of investigation of dry heat treatments at 180°C the average mass loss of untreated samples caused by oak mazegill was 24,76 %. It was established, that the longer schedule at 180°C we used, the lover mass loss was able to be reached. The Figure 2 shows the average mass loss of Turkey oak sapwood. After the schedule with 5-hour-long period at 180°C the samples showed significant decrease (data signed red) on mass loss compared to the native's. The 2nd schedule with 10 hours at 180°C had also significant effect on mass loss. In this case the average mass loss of the sapwood samples was less than half of the native's value. The schedule 3rd with 15 hours at 180°C didn't cause significant change compared to the 2nd schedule.

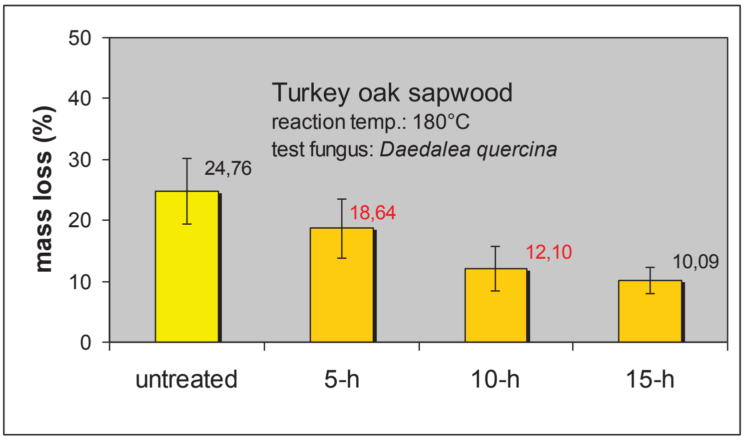

Figure 2: Average mass loss of heat treated (at 180°C) and native Turkey oak sapwood caused by oak mazegill after 12-week-long incubation

The results of investigation at 200°C can be seen on Figure 3. The average mass loss of untreated group was 26,72 %. After the 1st schedule with 5-hour-long period at 200°C the samples showed very significant decrease on mass loss compared to the native's value. The average mass loss after the 1st schedule was 5,5%. The 2nd schedule with 10 hours at 200°C had not significant effect on mass loss compared to the 1st one. In case of the 3rd schedule with 15-hour-long period at 200°C the samples showed 2,22% average mass loss, witch meant significant effect compared to the 1st schedule.

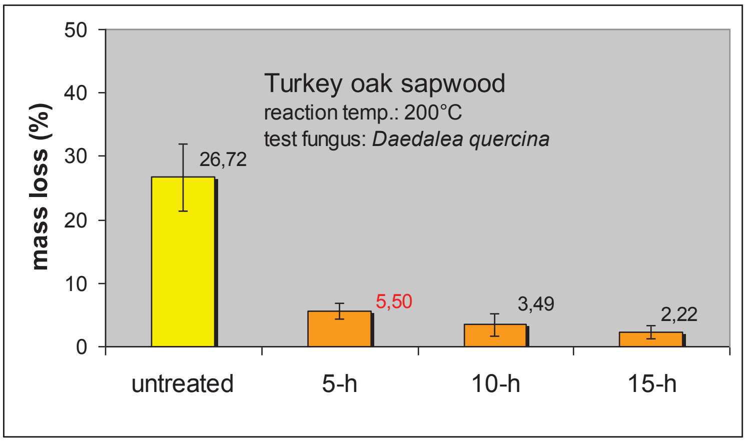

Figure 3: Average mass loss of heat treated (at 200°C) and native Turkey oak sapwood caused by oak mazegill

In group of treatments at 180 °C the native heartwood samples had an average mass loss of 11,60 %, witch was significantly lower than the sapwood's data (Fig. 4.). The same effect can be observed in case of native heartwood of group of treatments at 200°C on Fig. 5, witch could be explained by the different chemical ingredients of heartwood having more resistance against enzymatic decomposition caused by oak mazegill.
The samples treated by the schedule with 5-hour-long period at 180°C showed with their average mass loss of 9,95% no significant difference in comparison to the native's value. Increasing of the treating period of the 1st schedule had in all case significant effectiveness on decreasing the mass loss (Fig. 4.). The value (4,98%) reached by the schedule with 15 hours at 180°C was lower than the half of untreated heartwood's.

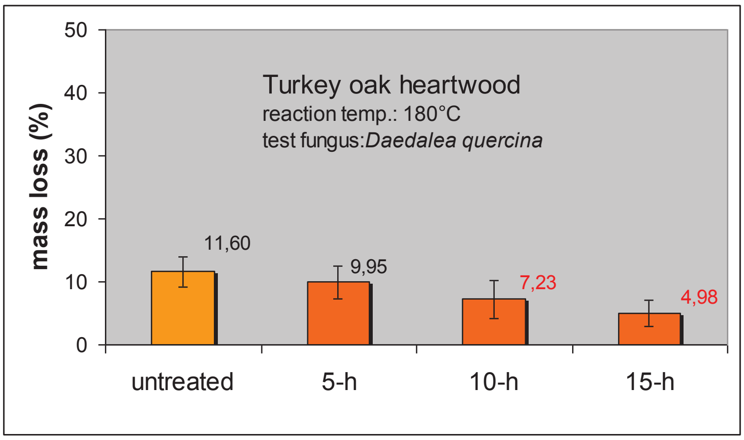

Figure 4: Average mass loss of heat treated (at 180°C) and native Turkey oak heartwood caused by oak mazegill

The effect of schedules including a treatment period at 200°C was found significant in all cases of our tests. The 1st treatment with a 5-hour-long period at 200°C was able to reach a value of mass loss of 2,19 %. Increasing of the treatment period was unnecessary in case of turkey oak heartwood.

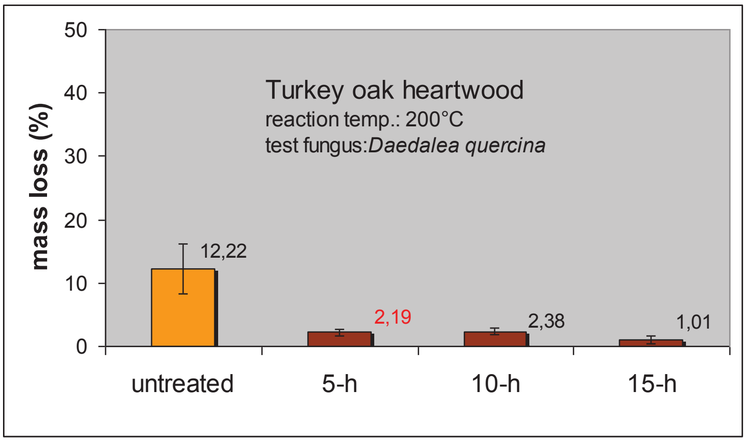

Figure 5: Average mass loss of heat treated (at 200°C) and native Turkey oak heartwood caused by oak mazegill

CONCLUSIONS

According to our investigations we can establish that the dry heat treatment is able to decrease the mass loss caused by enzymatic attack of oak mazegill on Turkey oak. The schedule including 10-hour-long period at 180°C was found suitable to reduce the mass loss of sapwood from 24,76 % to 12,1 %, although increasing of the treatment period to 15 hours didn’t show significant effect on mass loss. In case of the schedule with 15-hour-long period at 200°C the sapwood samples sowed 2,22 % average mass loss in opposite to the native’s 26,72 %. It was established that the native heartwood has a significant resistance against oak mazegill in comparison to native sapwood. The average mass loss of the untreated samples of heartwood was cca 12%. The schedule including 15-hour-long period at 180°C was found suitable to reduce the mass loss of heartwood from 11,06 % to 4,98 %. Because of a treatment with 5-hour-long period at 200°C was able to reach a value of mass loss of cca 2%, so the increasing of the treatment period was unnecessary in case of turkey oak heartwood.

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