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Research Article

Decay Resistance of Carbonized Wood Surfaces

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ABSTRACT

In this study, decay resistance of carbonized wood surfaces by combustion with blow torch method was examined. In this context either single or five geometrical surfaces of Scots pine and beech wood specimens were carbonized and exposed to *Coniophora puteana* (brown rot) and *Pleurotus ostreatus* (white rot) decay fungi for 12 weeks. According to the results single or five surface carbonized Scots pine specimen showed reduced weight loses when compared to un-carbonized controls. Beech wood specimens, on the other hand, resulted significantly low weight losses only for five surface carbonized specimens. A statically significant difference was found between the control samples of both wood species. In terms of weight loss, no statistically significant difference was found between beech control samples and samples exposed to white rot fungi. These results showed that the combustion process provides efficacy against brown rot in both wood species and white rot only in Scots pine.

Keywords: *Carbonized wood, decay fungi, Scots pine, beech, Coniophora puteana, Pleurotus ostreatus*

Yüzeyleri Karbonlaştırılmış Odunların Çürüklüğe Karşı Direnci

ÖZET

Bu çalışmada pürmüz ile yakma metodu uygulanarak yüzeyleri karbonlaştırılan sarıçam ve kayın odun örneklerinin çürüklük mantarlarına karşı dayanımı araştırılmıştır. Bu kapsamda tek ve beş yüzeyi karbonlaştırılan örnekler ağaç malzemede esmer ve beyaz çürüklük meydana getiren *Coniophora puteana* ve *Pleurotus ostreatus* mantarlarına karşı 12 haftalık süreyle maruz bırakılmıştır. Çalışma sonucunda esmer çürüklük mantarına maruz bırakılan sarıçam odun örneklerinde tek ve beş yüzeyi karbonlaştırılan örneklerde, kayın odununda ise beş yüzeyi karbonlaştırılan örneklerin ağırlık kayıplarında azalma olmuştur. Her iki ağaç türünün kontrol örnekleri ile aralarında istatistiki olarak da anlamlı fark bulunmuştur. Beyaz çürüklük mantarına maruz bırakılan kayın örnekleri ve kontrol örnekleri arasında ağırlık kayıpları bakımından istatistiki olarak fark bulunmamıştır. Bu sonuçlar yakma işleminin esmer çürüklüğe karşı her iki odun türünde, beyaz çürüklükte ise yalnızca sarıçam odununda etkinlik sağladığını ortaya koymuştur

Anahtar Kelimeler: *Karbonlaştırılmış odun, çürüklük mantarı, sarıçam, kayın, Coniophora puteana, Pleurotus ostreatus*

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I. INTRODUCTION

Carbonization is the transformation of the flammable type of materials in nature from the raw state to the carbonization by the process of passing through high temperatures and almost oxygen free in the environment [1].

The necessity of protecting the wood material at the place of use was accepted at even centuries ago and various measures have been taken. After the examination of the wood materials used in archaeological excavations and sunken ships in many years ago, it was understood that wood was carbonized by partially. Carbonization is the first precaution to protect the wood material used 4000 years ago. For example; The Temple of Diana in Ephesus was located on charcoal poles [2].

Combustion is the chemical coupling of flaming wood fiber with oxygen. The ignition point is considered between 225-260 °C. It is the first flare of wood gas at this temperature. Between 260-290 °C is known as combustion point where flame is complete. If the temperature is increased to 750 °C the wood turns to ash. As the carbonization occurs during the burning, a charcoal layer (carbon) is formed on the upper surface of the wood. The purpose of the carbonization of wood surface is the reduction of sensitive sapwood layer amount by carbonizing, drying outer layer and protection against fungi with the tar and tar oil which is occurred during the combustion.

The carbonization has a great value in protecting the fence and posts. This situation was also demonstrated in tests conducted by the US Forest Products Laboratory. The carbonized fence and post have proven to be resistant to fungi when contact with the soil. In addition, the burning of the surface of the wood is also made for decorative purposes. After the surface is burned, the surface is brushed and abraded with a steel wire brush. Various decorative surfaces are created. Example carbonized wood surfaces were shown in figure 1.

Figure 1. *Carbonized wood surfaces*

In wood protection industry, many wood preservatives have been used. Especially, CCA (copper, chromium, arsenic) wood preservative was frequently used due to its toxic effect to fungi [3,4]. However, CCA was banned in some applications in 2003 because it contains heavy metals and has negative environmental impacts [5]. Therefore, researches developed new alternative preservatives and method against CCA [6]. Acetylation [7] thermal modification [8] and hydro-thermolytical Plato process [9] have been tried by researchers to protect wood. Generally, these methods are still required very high cost. In this study, the effectiveness of a traditional method (carbonization of wood surfaces was examined for two wood species against white and brown rot.

II. MATERIAL AND METHOD

A. *PREPARATION OF WOOD SPECIMENS AND CARBONIZATION OF WOOD SURFACES*

Scots pine (*Pinus sylvestris*) and beech (*Fagus orientalis*) samples were taken from the sapwood parts of two tree species and 2x1x1 cm (six for control and nine for carbonization) samples were prepared according to JIS K 1571 [10]. Samples were carbonized at 275±25 °C by means using a blow torch operated with LPG [11]. For the test, two difference types of specimens were prepared. The first group only single surface was carbonized leaving the other five surfaces untreated. The second group specimens, five geometrical surfaces were carbonized while a single surface left un-carbonized. Carbonization process was applied about 0.5 mm in depth for both wood species (Figure 2).

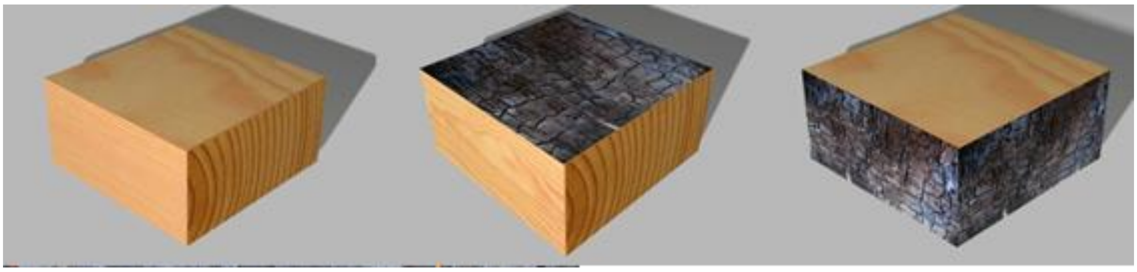


Figure 2. *Non-carbonized and carbonized wood surfaces in the study*

The prepared samples were dried at 60 °C temperature in the oven until their weights were constant. The first weights of the samples were then measured on an electronic scale of 0.01 g.

B. DECAY TEST

3.7 g Malt-Extract-Agar was used in 100 ml of water to prepare the medium in an Erlenmeyer. The media and all wood samples were sterilized in an autoclave at 121 ± 2 °C 'in a pressure of 1.1 A for 20 minutes.

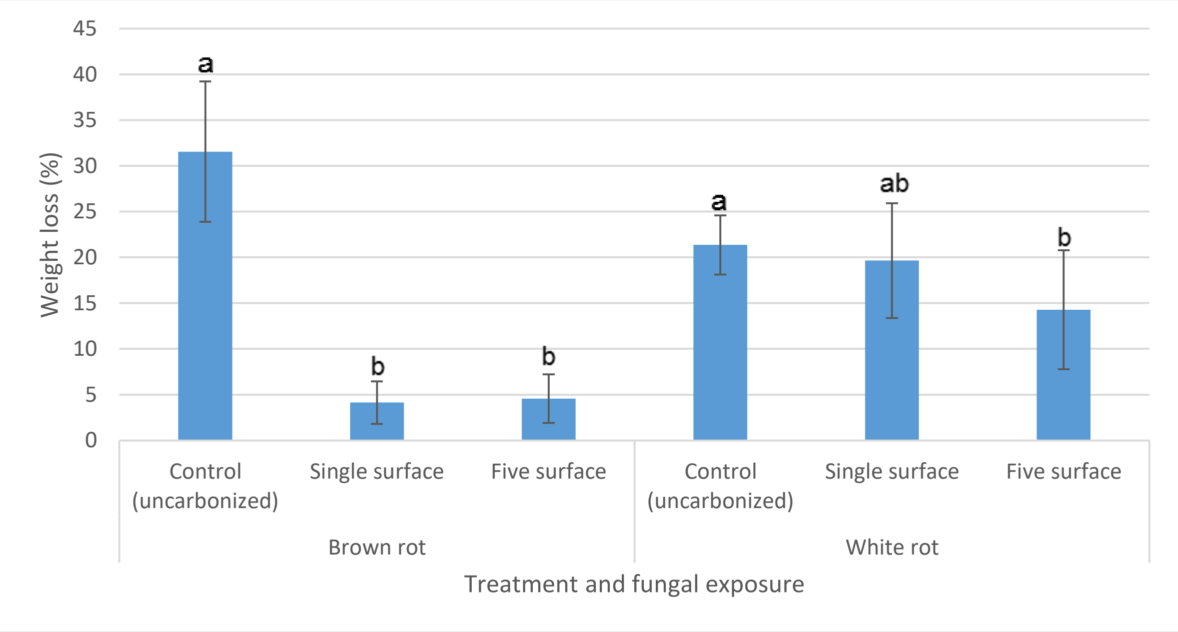
The malt-agar mixture prepared in sterilized environment (15 ml) was transferred to the 8 cm diameter petri dishes. *Pleurotus ostreatus* and *Coniophora puteana* fungi cultures were then inoculated to the petri dishes in the bio safety cabinet (Biohazard Safety Cabinet). For 10 days, the growing of mycelium in an incubation room was provided at temperature of 28 °C and a relative humidity of 75-80%. After the micelles were developed, control samples and carbonized samples were placed in petri dishes. At the end of the experiment (12 weeks), mycelium on the wood samples was removed and the samples were dried at 60 °C temperature in the oven until their weights were constant, all samples were reweighted, then percentage of mass losses caused fungi was calculated according to the following formula.

$$WL\ (\%) = \frac{W0 - W1}{W0} x100 \qquad 1$$

Here, WL Weight loss, W0 full dry weight before decay test, W1 full dry weight after decay test

III. RESULTS AND DISCUSSION

A. SCOTS PINE WOOD WEIGHT LOSSES



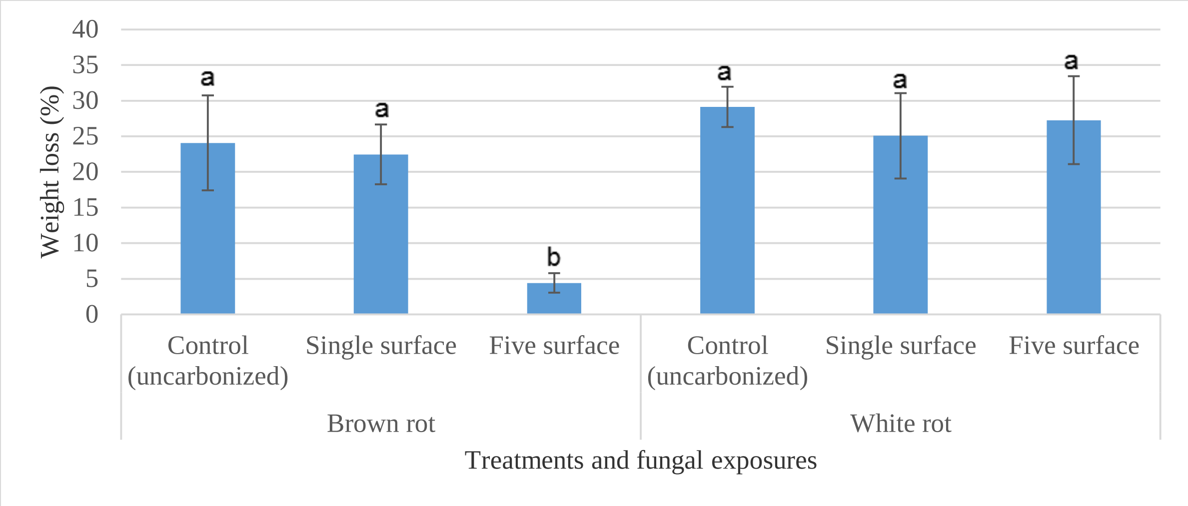
Note: Statistical homogeneity grouping is different for brown and white rot. There is no statistical difference between the same letters shown on the columns (p<0.05). Error bars indicate standard deviation.

Figure 3. *Weight loss in Scots pine based on carbonized surfaces*

B. BEECH WOOD WEIGHT LOSSES

As it is shown in Figure 4, the mean weight loss in the beech control groups exposed to the brown rot fungi was 24.07% while the mean weight losses in the single and five surface carbonized were 22.42% and 4.36%, respectively. A significant difference was found between the weight loss of the control and five surfaces carbonized samples ($p \leq 0.05$). The mean weight loss in beech control groups exposed to white rot was 29.13%, and the mean weight loss in the one-five directions carbonized samples was 25.07% and 27.28%, respectively. There was no statistically significant difference between weight loss of carbonized samples and control samples in white rot fungi results ($p \geq 0.05$).

Figure 5 clearly shows, un-carbonized Scots pine and beech control samples were covered with a very dense fungal mycelium. However, it was shown that the propagation of the fungal hypea on wood samples is quite weak compared to the control samples especially for the five surface carbonized specimens.



Note: Statistical homogeneity grouping is different for brown and white rot. There is no statistical difference between the same letters shown on the columns ($p<0.05$). Error bars indicate standard deviation.

Figure 4. *Weight loss in beech based on carbonized surfaces*

When the weight loss of the control samples of the wood species were examined, the weight losses were found higher in pine wood exposed brown rot than beech wood exposed white rot. This is due to the differences in the enzyme systems of fungi [12].

In general, it was shown that single and five surface combustion processes gave better results in Scots pine when compared to beech specimens. The reason for better protection in Scots pine might be explained with the resin content of wood. It was observed that during charring process, the surfaces of Scots pine specimens were covered with tar oil emitted from wood due to combusting temperature [13].

The higher weight losses in beech wood specimens surfaces occurred during charring process. Such cracks clearly help to fungal mycelium to penetrate into internal section of the specimens [13]. Beech wood’s tendency to crack was also mentioned in previous study [14].

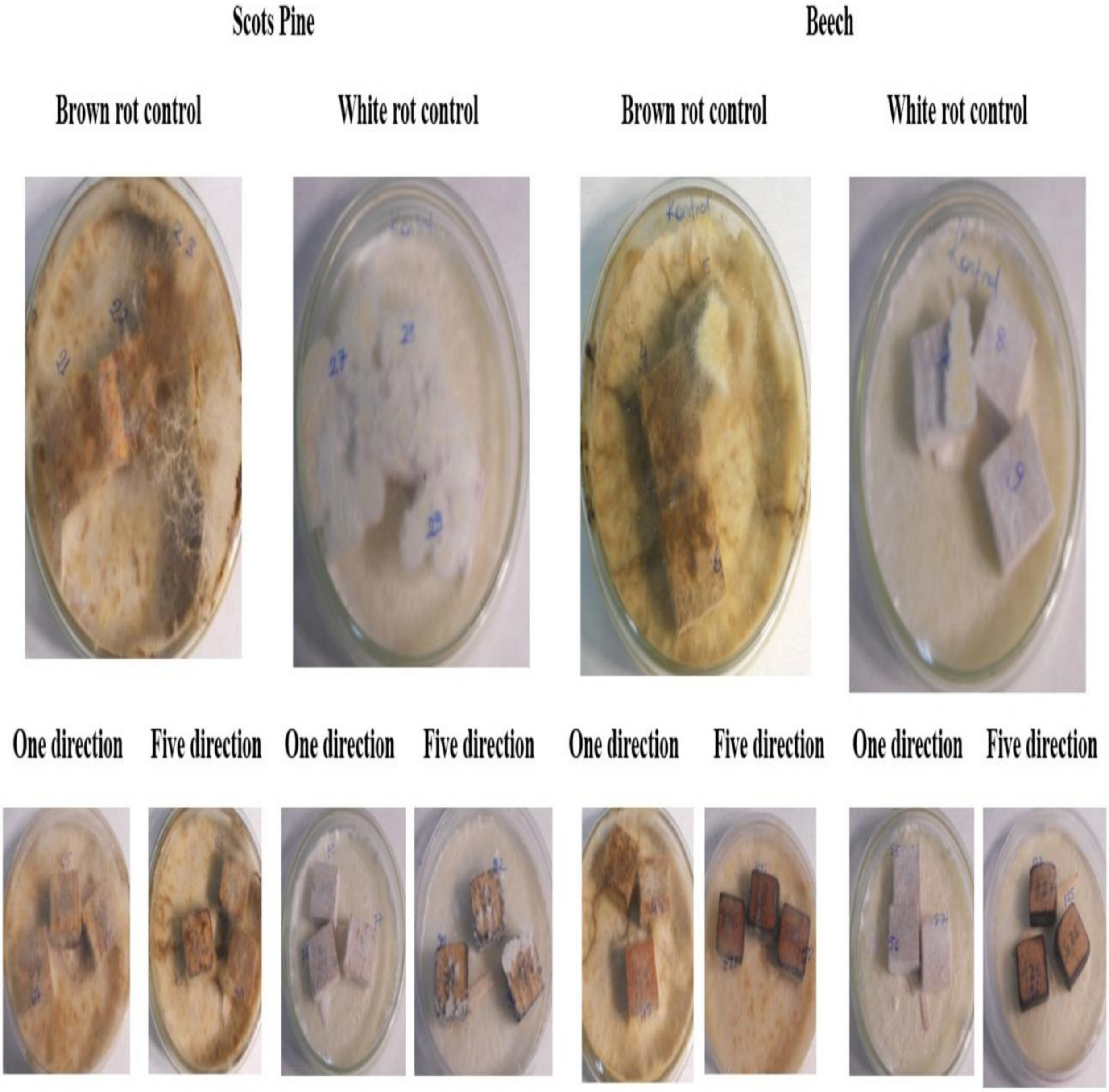


Figure 5. *Images of decay tests*

IV. CONCLUSION

In this study, the resistance of single and five surface carbonized Scots pine and beech samples were investigated against white (*P. ostreatus*) and brown (*C. puteana*) rot fungi. According to the results obtained from the study, there were statistically significant differences in weight losses of Scots pine control specimens and single and five surfaces carbonized when exposed to brown rot fungi when the white rot data fungi examined for the same wood species.

There was no statistically significant difference between mean weight loss of control specimens and single surface carbonized beech specimens. When five surface carbonized samples exposed to brown rot, the difference in mean weight loss between direction beech specimens were concerned, their weight loss were recorded as statistically significant when compared to their control. The white rot data, on the other hand, shows no statically difference among the beech specimen's regardless of treatments. The current study indicates that surface carbonization could be successful to protect wood against decay fungi.

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