Natural Durability Ratings in *Fagus orientalis* degraded by wood-rotting *Basidiomycetes, Coriolus versicolor*

A.M. Olfat

Department of Wood and Paper Science and Industries, Faculty of Natural Resources University of Tehran, Iran.P.O.Box.31585-4314

**ABSTRACT**

Decay is the most significant problems facing the wood products industry. One of the common fungi causing decay damage to trees is *Coriolus versicolor*. In this research, the stages of wood colonization and degradation by *Coriolus versicolor* have been investigated after 10 weeks and 16 weeks respectively. The highest weight loss occurred after 16 weeks (47.5%) in comparison with 10 weeks (13.2%). There were high correlation between mass loss and fibre-efficiency. Anatomical changes studied by the light microscopy following decay process. The ability to measure decay process in microstructure of *Fagus orientalis* is important for assessing degradation of wood for biotechnological applications using these wood-modifying microorganisms such as bio-pulping.

**INTRODUCTION**

Most fungal degradation patterns are distinctive and easily recognizable [1-4,18], the wood-inhabiting fungi as well as their colonization and damaging of wood are influenced by various physical/chemical and biological influences. Natural environment elements can also be a nutrient source for fungi, enhancing fungal capacity to degrade wood.[7,9-10]. They are inhibited as the cellular spaces of wood become fully saturated with water. The maximum wood moisture content allowing fungal growth is determined by the minimum air content within the wood cell. The tunnel within wood cell walls produced by hyphae of wood decay fungi [4,9] appears to be a unique form of fungal decay different from any of the well-known fungal decay types.

Investigations have shown that wood-decay fungi have many valuable biotechnological purposes in the pure and applied wood sciences [23]. Alterations in the cell wall structures are reflected in the plasticity of the wood degradation modes of different fungi[8-10]. The biotechnological process of bioincising is a promising approach for improving the uptake of preservatives and wood-modification substances by refractory wood due to the degradation of bordered pits by the white-rot fungi [12,14] Traditionally, wood decomposition by fungi is usually classified into three categories based on micro-morphological and chemical characteristics of decay resulting in different patterns of degradation of the cell wall: soft rot, brown rot and white rot [6,7,13-14].

The aim of the present study was to test the hypothesis that decay fungi can be applied under controlled conditions as analytic tools for the exposure of the annual ring border in diffuse porous wood. For this purpose, wood samples were selected and artificially incubated with white rot fungi.

**MATERIAL AND METHODS**

**wood samples- Systematic position:**

Beech wood(*Fagus orientalis*.Lipsky) belong to the family of *Fagaceae* The beech is most widespread in mixed woodlands and in low mountainous regions.

**Fungal specie:**

The white-rot fungus *Coriolus versicolor* was used for degradation of woods according EN-350-1.[5]

**Conditions necessary for decay of wood:**

Four conditions are necessary for the development of wood decay producing fungi.

1- An adequate supply of oxygen
2- A favorable temperature (25°C - 30°C)
3- Moisture in excess of the fiber saturation point (> 25-30%)
4- A suitable source of energy and nutrients (i.e. the wood)

The wood blocks were placed in distilled water for 1 h to get enough humidity and sterilized at 120°C, 15 psi for 15 minute in autoclave. The white -rot fungus *Coriolus versicolor* was used for degradation. First pure culture [13,14] was grown on a malt-agar nutrient medium in plate for 2 weeks, then inoculums disk (5 mm) prepared from edges of Petri dishes and carried into kolle flasks.

The wood samples were carried into Kolle flasks after growing fungi carried out during 2-3 weeks at 25-30°C completely.

The wooden blocks were then inoculated on a medium containing fungal culture and incubated for 10 weeks and 16 weeks at 25 -30 °C in darkness. After this period, mycelia were removed and the blocks were dried at 100±5 °C and weighed (m1 and m2) to determine the mass loss caused by the fungal attack after 10 and 16 weeks respectively, where m1 was the initial oven dried mass of wood block before attack. Blocks of sound wood and decayed wood was used for anatomical studies. Sections of 15–20 μ were taken on sledge microtome and double stained with Safranin - Fast green.

**Statistical Analysis:**

The ANOVA procedure used for quantity measurement of the decay characters.

(α = 0.05).

All Data were statistically analyzed using analysis of variance (ANOVA) according to the one-way repeated measures. Probability of significance among treatments and L.S.D. (p≤0.05) were used to compare means among treatments.

**RESULTS AND DISCUSSION**

**Comparison of weight loss:**

Degradation of Beech wood by white rot *Coriolus versicolor* under experimental conditions resulted in its marked mass loss [Table 1] and decrease in its density, lose its colour and appear whiter than normal and gradually lose its strength [Table 2] and become spongy to the touch proportional to time of fungal action [6,12,13].

Table 1: Mass loss of Fagus orientalis after 10 and 16 weeks incubation at 27° c in dark condition

<table>
<thead>
<tr>
<th>N</th>
<th>M1</th>
<th>M2</th>
<th>M1/M2</th>
<th>M1/M2/M1</th>
<th>M1/M1</th>
<th>M1/M1/M1</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.548</td>
<td>1.403</td>
<td>0.181</td>
<td>11.7</td>
<td>0.634</td>
<td>0.914</td>
<td>59%</td>
</tr>
<tr>
<td>2</td>
<td>1.444</td>
<td>1.326</td>
<td>0.118</td>
<td>8.2</td>
<td>1.082</td>
<td>0.362</td>
<td>25%</td>
</tr>
<tr>
<td>3</td>
<td>1.586</td>
<td>1.426</td>
<td>0.160</td>
<td>10.1</td>
<td>1.126</td>
<td>0.46</td>
<td>29%</td>
</tr>
<tr>
<td>4</td>
<td>1.490</td>
<td>1.302</td>
<td>0.188</td>
<td>12.6</td>
<td>0.466</td>
<td>1.024</td>
<td>69%</td>
</tr>
<tr>
<td>5</td>
<td>1.481</td>
<td>1.289</td>
<td>0.192</td>
<td>13</td>
<td>1.058</td>
<td>0.423</td>
<td>29%</td>
</tr>
<tr>
<td>6</td>
<td>1.510</td>
<td>1.202</td>
<td>0.308</td>
<td>20.4</td>
<td>0.920</td>
<td>0.59</td>
<td>39%</td>
</tr>
<tr>
<td>7</td>
<td>1.540</td>
<td>1.377</td>
<td>0.163</td>
<td>10.6</td>
<td>1.147</td>
<td>0.393</td>
<td>26%</td>
</tr>
<tr>
<td>8</td>
<td>1.523</td>
<td>1.421</td>
<td>0.102</td>
<td>6.7</td>
<td>0.581</td>
<td>0.942</td>
<td>62%</td>
</tr>
<tr>
<td>9</td>
<td>1.566</td>
<td>1.276</td>
<td>0.290</td>
<td>18.5</td>
<td>0.371</td>
<td>1.195</td>
<td>76%</td>
</tr>
</tbody>
</table>

where m0 =initial oven dry mass and m1= dry mass after 10 week, m2 = dry mass after 16 weeks incubation. significant difference at p≤0.05

**Physical properties:**
Table 2: overall changes in Fagus orientalis (comparison mass loss and fibre efficiency in control and treatment)

<table>
<thead>
<tr>
<th>Density Kg/m³</th>
<th>Color</th>
<th>Permeability</th>
<th>mass loss (10 week)</th>
<th>mass loss (16 week)</th>
<th>fibre efficiency (M₁) %</th>
<th>fibre efficiency (M₂) %</th>
<th>fibre efficiency (M₃) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>720</td>
<td>pale brown</td>
<td>good</td>
<td>13.2</td>
<td>47.5</td>
<td>66</td>
<td>60</td>
<td>48</td>
</tr>
</tbody>
</table>

Fagus data: before degradation: fibre efficiency $M₁: 0.342/0.518 = 66\%$ and after degradation (10 weeks) : fibre efficiency $M₂: 0.31/0.518 = 60\%$ then after 16 weeks: fibre efficiency $M₃: 0.249/0.518 = 48.5\%$

As natural durability is the inherent resistance of heartwood timber to decay, in this research it was (47.5\%) ([Table 1]) very low (non durable) according Findlay methods [13] that it accordance with experiments of Scheffer and Morrell in 1998 [16] and Van Acker et al in 2003 [27]. As beech wood has medium to heavy-weight [Table 2][9]. Therefore as compensation for its low durability it is well suited for impregnation.

Comparison mass loss and fibre efficiency showed decrease them after incubation periods showed that were positive correlation among them. Many physical properties of wood, such as strength are related to specific gravity. Therefore, this parameter is widely used as an indicator of wood quality [6,11,15,17,18].

Variation in specific gravity is closely and positively correlated with variation in cell wall percentage, which in turn proportions [6,15].

**Light microscopically studies:**

Growth and penetration of hyphae takes place in various directions within the cell. [fig 1-9].

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**Fig. 1-3:** transverse and tangential and radial section in non treatment beech wood (Fagus orientalis)

**Fig. 4-6:** sections of decayed beech wood after 9 weeks incubation. the middle lamellas were still present holding the fibers together. The strongest hyphal growth occurs in the xylem rays, without at first breaking them down. The ray cells were being highly colonized by the fungal hyphae.

**Fig. 7-9:** sections of decayed beech wood after 16 weeks incubation.
Nearly all the horizontal ray cells show colonization by thick walled hyphae which scarcely branch. In many regions evident of degradation of middle lamella is recognizable before complete degradation of ray cavities. Bore holes appeared in the adjacent fiber cells. The ray cells are penetrated by bore holes which fuse forming elongated cavities further gradually completely degrading the ray leaving behind a wide space.

The hyphae expands within the lumen of the cell [Fig 4-9]. Hyphae were also observed penetrating through the middle lamella of adjacent cells [Fig 5,6,8,9]. Hyphae traverse through pit apertures into the adjacent axial parenchyma cells degrading the wall causing elongated troughs indicating its pathway.

The fibre tracheids and ray cells are intact at this stage. Radial sections showed lumen of axial parenchyma and fiber tracheid cells filled with fungal hyphae [Fig 8,9]. At a later stage of decay the adjacent walls break off, because of the fungal hyphae degrading middle lamella and the walls of axial parenchyma become disfigured [Fig 9] breaking them completely [Fig 9] creating space between the cells.

The fungal hyphae begins to penetrate boring holes through the cellulosic wall breaking them and forming large cavities [Fig 9] degrading these cells completely. Further to decay, some of the hyphae start penetrating the xylem ray cells through the pit apertures according Schwarze and Shwarze et al. in 2000-2011. By this time the apotracheal and paratracheal axial parenchyma gets completely degraded forming holes close to xylem vessel elements (Fig 8). Of course the wall of fibers appear to be largely resistant to the enzymatic destruction and are present even at advanced stage of degradation.

At a later stage the fiber cells are broken down in the region of the middle lamella (Fig 7-9) of adjacent cells, separating them and wall begins to show discoloration finally breaking down forming large spaces as mentioned by Simon et al. [7-9,12,25]

Delignified and intact fibers were often found next to each other and clearly delimited along the middle lamella (Fig 7-9), which suggests that diffusion of the delignifying according Srebotnik and Messner investigates in 1994 [26] and Furh et al. [8] in 2011.

Variations in the cell wall structure and/or distribution of cell wall constituents are reflected in the plasticity of wood degradation modes by wood decay fungi. Middle lamella appeared unchanged in the early stages of decay. However, the Figure shows that the fungus could penetrate the whole wood cell wall in advanced stages (Fig. 9).

**Conclusion:**

The degree of decay of the cell wall at stages of degradation is variable. The ability to measure rot decay in wood and ligno-cellulosics is important for assessing degradation of wood in service and for biotechnological applications using these wood-modifying microorganisms such as bio-pulping.

### REFERENCES


