DECAY OF BIRDSEYE SUGAR MAPLE (*ACER SACCHARUM*) AND CURLY RED MAPLE (*ACER RUBRUM*) FIGURED WOODS

*Tara L. Bal**

Research Assistant Professor
Wood Protection Group
E-mail: tlbal@mtu.edu

Katherine E. Schneider

Research Assistant
E-mail: keschne1@mtu.edu

Dana L. Richter

Research Scientist
Wood Protection Group
College of Forest Resources and Environmental Science
Michigan Technological University
Houghton, MI 49931
E-mail: dlrichte@mtu.edu

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Abstract. Two figured woods, commonly known as birdseye maple (*Acer saccharum*, sugar maple) and curly maple (*Acer rubrum*, red maple), were exposed to brown rot and white rot fungi in a standard laboratory decay test and compared with unfigured wood of each species, respectively. For the birdseye maple, two levels of figure intensity were used: wood with heavy figure and wood with light figure. Heavily figured birdseye maple wood was decayed significantly less by the brown rot fungus *Rhodonia placenta* than unfigured maple wood or lightly figured maple wood. However, heavily figured birdseye maple wood was decayed significantly more by two white rot fungi, *Trametes versicolor* and *Irpex lacteus*, than unfigured maple wood but was not decayed significantly more than lightly figured wood. For both brown rot and white rot fungi, lightly figured birdseye maple wood did not decay significantly differently compared with unfigured wood. Likewise, there was no significant difference in decay between curly red maple wood and unfigured red maple wood for either brown rot or white rot fungi. Results suggest chemical or anatomical differences in the heavily figured birdseye sugar maple wood affect decay by brown rot and white rot fungi. These findings may be useful to hobbyists and woodworkers needing to protect wood or who partially decay wood to produce spalted wood for decorative purposes.

Keywords: *Acer saccharum*, *Acer rubrum*, figured wood, biodeterioration, wood preservation, spalting.

INTRODUCTION

Maple (*Acer* spp.) wood is regarded as a highly valuable timber species for either their hardness and durability (such as sugar maple, *Acer saccharum* Marsh.) or softness and workability (*Acer rubrum* L.). Maple wood, like many other tree species, is sometimes found with specialty figured grain appearance, which differs from normal figure, or pigment figure, which is a color variation (Hoadley 1990). Specialty figured wood is the result of a disfiguration or nonalignment in normal growth rings of a tree in the form of indentations, such as birdseye, or waves, such as curly or striped figures (Beals and Davis 1977; Bragg 1999). Birdseye figure is defined as localized conical elevations of the growth ring in which the grain swirls, as seen on tangential surface, each sectioned swirl appears as a tiny bird's eye (Hoadley 1990). Curly figure (also called wavy figure) is defined as undulations of the grain direction creating horizontal corrugations on radially, and sometimes tangentially, cut surfaces (Hoadley 1990). These figures are seen as decorative in

* Corresponding author

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wood products and are, therefore, more valuable than their nonfigured counterparts when it occurs consistently throughout a log; for example, the heavy distribution of birdseye figure in quality wood can increase the value of a sawlog by 5-15 times the value of its nonfigured counterparts (Rioux et al 2003). Specialty figures and other character-marked woods are often marketed at a premium price (Donovan and Nicholls 2003).

The causes of figured wood in trees are not fully known, but differences in cellular anatomy and histochemistry for birdseye maple compared with normal maple wood have been investigated (Rioux et al 2003). It was found that the abnormal xylem in birdseye maple cells is less lignified than adjacent normal xylem cells (Rioux et al 2003). Differences in the histochemistry between curly maple and normal maple have not been reported, although figured curly birch wood (*Betula pendula* Roth) is associated with higher sucrose content in the wood during its formation (Novitskaya et al 2016). Discussions of figured wood formation and anatomy are complicated because of the rarity of the wood. For example, birdseye figure in sugar maple is estimated to occur in less than 1% of trees (Bragg et al 1997; Bragg 1999).

Furthermore, there is overlap in the terminology for descriptions of figure in the wood products industry. For example, "curly maple" generally is referring to a wavy grain pattern (Bailey 1948; Hoadley 1990), but "curly birch" may either be referring to a wide, shallow, wavy grain pattern or more of a flower or marbled pattern with abundant protuberances and depressions (Velling et al 2000; Novitskaya et al 2016). There are many variations in the anatomical layering of wood grain, leading to other figure types such as blister, quilted, fiddleback, tiger, and bee's wing (Beals and Davis 1977) which may occur in multiple species but have different names in different regions for different species. Adding further to this, the degree or intensity of figure appearance can vary, leading to additional naming of figure types within a theme such as fingernail, round eye or cat's paw, all being further names describing birdseye figure variations (Bragg 1999).

Differences in cell chemistry and structure between figured wood and unfigured wood may affect decay properties of the wood. Brown rot decay fungi act on the cellulose component of wood, leaving a brown residue, consisting mostly of lignin (Rayner and Boddy 1988; Schmidt 2006). White rot decay fungi act on both the lignin and cellulose components of wood (sometimes called simultaneous rot), leaving a primarily white residue (Rayner and Boddy 1988; Schmidt 2006). Woodworkers sometimes partially decay wood using various fungi to produce a streaked and mottled appearance in the wood, called "spalted wood" (Lindquist 1977).

Wood decay by fungi is typically caused by the actions of Basidiomycotina, which are broadly categorized into groups of white rot and brown rot fungi (Rayner and Boddy 1988; Schmidt 2006). Both decay types are commonly used in decay-resistance testing (ASTM 1995; AWPA 2016). Lower concentrations of lignin in figured wood would, therefore, suggest that figured wood should decay differently or at different rates than nonfigured wood.

Knowledge of the differential decay resistance or susceptibility between birdseye maple and curly maple may have application among hobbyists and woodworkers who partially decay wood to produce decorative spalted wood or may use highly figured wood in decorative pieces and are concerned with potential decay. To shed light on the decay properties of figured vs normal-grained wood, we tested birdseye sugar maple wood that had a high concentration of the birdseye figure (heavy birdseye) and sugar maple that had a low concentration of the birdseye figure (light birdseye), along with unfigured, normal sugar maple wood. In addition, curly red maple wood was compared with normal red maple wood in the decay testing. Because hardwoods are commonly decayed by white rot fungi (Rayner and Boddy 1988; Schmidt 2006), all wood types were exposed to two white rot fungi and one brown rot fungus in a standard laboratory decay test (AWPA 2016).

MATERIALS AND METHODS

Freshly harvested logs of red maple (*A. rubrum* L.) and sugar maple (*A. saccharum* Marsh.) were obtained during the winter of 2018 in Keweenaw County, MI (approximately 47.288151, −88.401587). Samples came from five different logs with diameters ranging from 30 to 40 cm. Sugar maple logs contained either normal grain, heavy birdseye figure, or light birdseye figure. Birdseye figured wood was divided into heavily figured wood, having a birdseye pattern within approximately 1 cm, or lightly figured wood, having a birdseye pattern averaging greater than 1 cm apart. Red maple logs contained either normal grain or curly figure grain with patterns throughout. Boards of 30-cm-length logs were kept frozen until cutting into small blocks of 19 mm^3 using only sapwood.

Blocks were selected by weight to be within ±0.5 g within each wood type category, with 10 replicate blocks of each wood type exposed to decay fungi in the method described as follows. Individual blocks were labeled, dried at 40°C for 24 h, and weighed. Before inoculation and insertion into individual jars, blocks were steam sterilized for 30 min.

Individual wood blocks were exposed to pure cultures of Basidiomycetes fungi under sterile conditions. The brown rot fungus used for this experiment was *Rhodonia placenta* (Fr.) (Niemelä, K. H. Larss. & Schigel) (syn. *Postia placenta*) MAD 698. White rot fungi used were *Trametes versicolor* (L.) Lloyd MAD 697 and *Irpex lacteus* (Fr.) Fr. ATCC 11245.

The AWPA E-10, Laboratory Method for Evaluating the Decay Resistance of Wood-Based Materials against Pure Basidiomycete Cultures: Soil/Block Test was followed for conducting the wood decay tests (AWPA 2016). In summary, 30 ± 1 mL of distilled water was added to a square glass jar (5 × 5 × 13.5 cm) so that 100 ± 1 g of air-dried forest topsoil (pH 5.8) that was combined with water would have approximately a 90-100% water holding capacity. A plastic lid with a centered 5-mm diameter hole covered by a strip of adhesive first-aid tape was used as a covering for the jar that would allow for air exchange. Jars for the brown rot fungi contained a pine feeder strip (0.5 × 3.2 × 2.0 cm) which was placed on the soil before autoclaving. An autoclaved birch feeder strip was added after inoculation for white rot fungi. All jars were autoclaved (15 ψ, 120°C) for 45 min.

A 2% malt extract agar was used for the growth medium of the fungus inocula in 100-mm petri dishes for 2 wk at 22-24°C, long enough for mycelium to cover the surface of the agar. After autoclaving and cooling the jars, the process for the brown rot fungus was to place a piece of colonized agar (approximately 1 × 2 × 0.5 cm) on the pine feeder strip, and a single wood block was then placed firmly on the agar on top of the feeder strip. For white rot fungi, the labeled, oven-dried (40°C), preweighed, and sterilized maple blocks were placed in a partially dug out section of the soil of the sterilized and cooled jars. This allowed the white rot fungi more contact with the moist soil. A piece of colonized agar was then placed on top of the block with a birch feeder strip placed firmly on top of the inoculum. Plastic lids were tightly placed on all jars preceding incubation at 27 ± 1°C and 80 ± 4% RH for 12 wk (AWPA 2016). After incubation was complete, blocks were removed from jars and brushed to remove soil or mycelium. They were dried at 40°C for 24 h and reweighed to determine total weight loss from decay.

Mean % weight loss of replicate sets of blocks by wood type and fungus exposure was calculated. Statistical analysis of the red maple blocks within decay type was compared with a paired *t*-test ($\alpha = 0.05$), and sugar maple blocks within decay type were compared with a one-way analysis of variance followed by Tukey's pairwise comparisons ($\alpha = 0.05$) using Statistix 9.0 (Statistix 9.0, Analytical Software 2008).

RESULTS AND DISCUSSION

At the end of the 12-wk incubation period, jars and blocks were visually examined for colonization by fungi to note the coverage by mycelium. All jars and blocks were thoroughly colonized by decay fungi, and no contaminating fungi were present.

In general, the variability in decay among blocks for sugar maple and red maple was higher in the figured wood than that in the unfigured wood (Fig 1). Heavily figured birdseye maple wood was decayed significantly less (40.3%) by the brown rot fungus *R. placenta* than unfigured maple wood (49.1%) or lightly figured maple wood

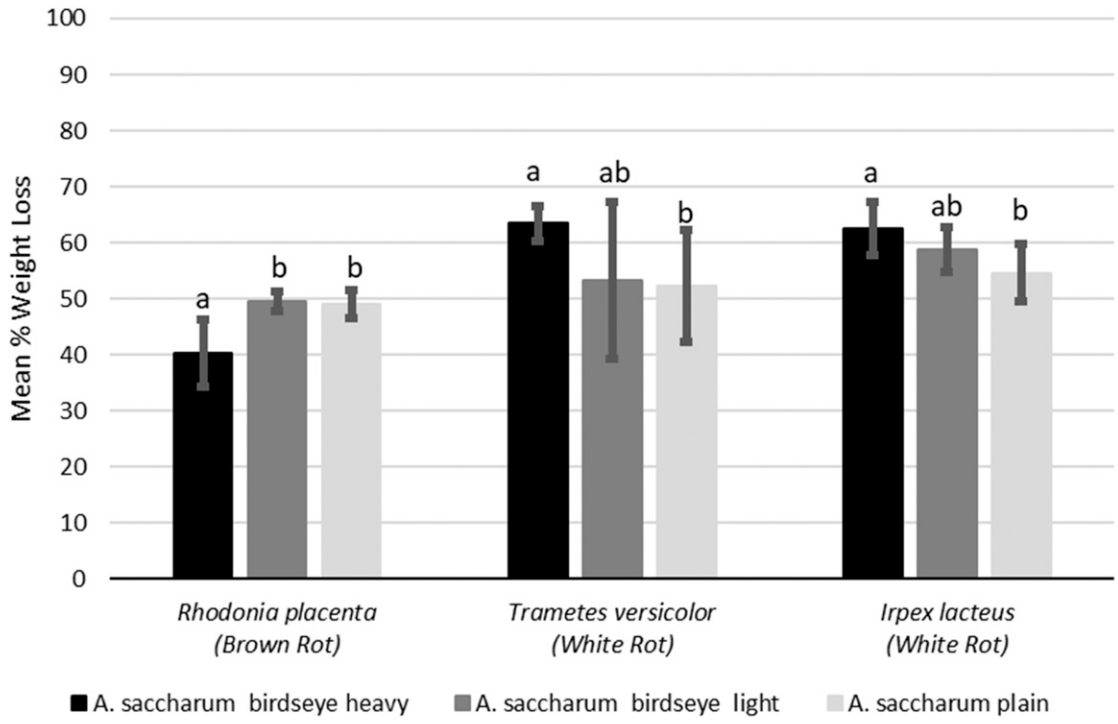

Figure 1. Figured sugar maple blocks (*Acer saccharum*, $N = 10$), exposed to three wood decay fungi and compared with unfigured wood. Lines on bars represent standard deviation. Letters indicate significant differences by wood type within fungus ($p \leq 0.05$).

(49.5%) (Fig 1). However, the presence of birdseye figure in heavily figured maple wood increased decay significantly by the two white rot fungi, *T. versicolor* (63.4%) and *I. lacteus* (62.5%), compared with unfigured maple wood (52.2% and 54.6%, respectively), but was not decayed significantly greater than lightly figured wood by these fungi (53.3% and 58.9%, respectively). For both brown rot and white rot fungi, there was no significant difference in decay between lightly figured maple wood and unfigured wood, but the amount of decay varied by fungus (Fig 1).

There was no significant difference in mean % weight loss for the curly figured or plain red maple for any fungus (Fig 2). It appears that this type of figuring pattern of the wood is not the result of wood chemical changes that would affect decay by fungi. Curly red maple does not have the variation in anatomy or the variable lignin content as does the birdseye sugar maple but is rather more of a simple distortion of the grain.

Previously, plain, unfigured sugar maple and red maple were compared along with other wood species against *P. placenta* and *T. versicolor* using a similar standard decay test (ASTM 1995; De Groot et al 1998). In that test, average weight loss with 12-wk incubation resulted in a mean % weight loss of 42.1% and 45.9% (sugar maple and red maple, respectively) for *P. placenta* and 71.8% and 82.8% (sugar maple and red maple, respectively) for *T. versicolor* (De Groot et al 1998). These higher weight losses compared with our tests with unfigured maple may be due to different fungal strains used. Also, red maple usually undergoes greater weight loss because of decay than sugar maple. This is consistent with red maple being a softer wood, with a lower average specific density than sugar maple,

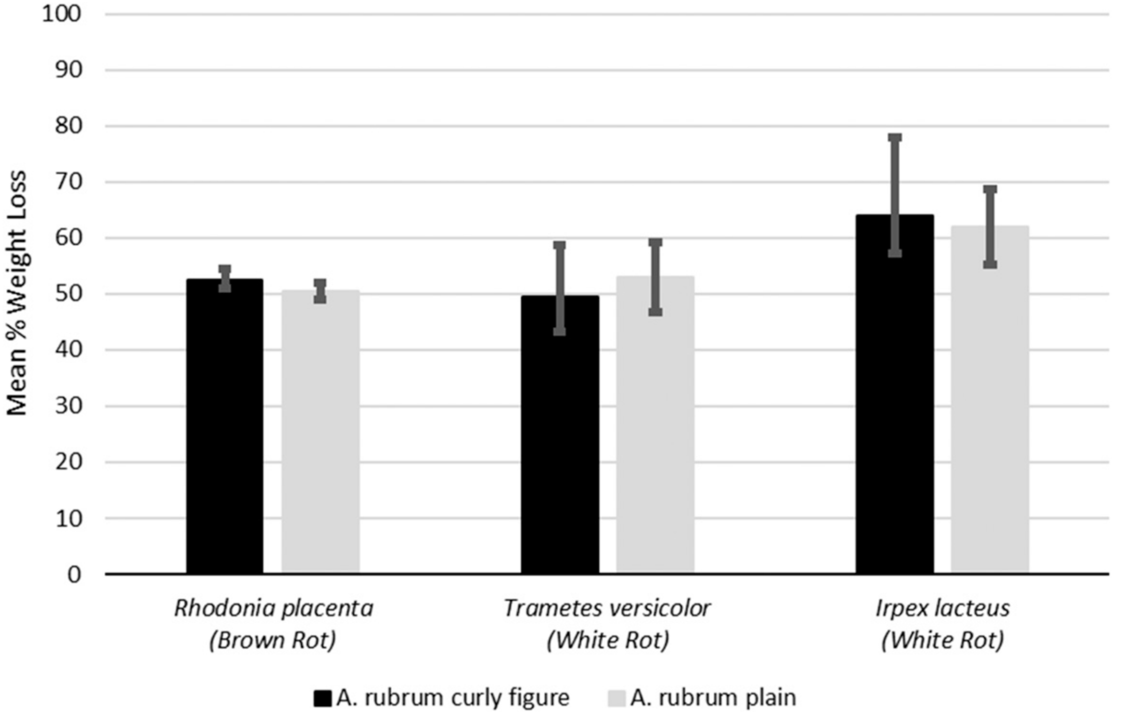

Figure 2. Figured red maple blocks (*Acer rubrum*, $N = 10$), exposed to three wood decay fungi and compared with unfigured wood. Lines on bars represent standard deviation. No significant differences ($p \leq 0.05$) were found between wood types within fungus for all fungi.

making it easier to be colonized and decayed by fungi.

Results suggest wood chemical differences in the heavily figured birdseye sugar maple wood affect decay by brown rot and white rot fungi, although in the opposite way. Differences in wood chemistry, lignin composition, density, and possibly cellular structural features between figured and normal wood may result in the way fungi decay the wood. Rioux et al (2003) reported that cells comprising the birdseye figure were less lignified than adjacent normal xylem cells, thus possibly affecting fungal metabolism.

In decay tests and in natural systems, white rot fungi tend to favor and attack woods with less total lignin, typically hardwood or broadleaved tree species, and most fungi that decay maple are white rots (Gilbertson and Ryvarden 1994). The less lignified birdseye figure was less decayed than the unfigured wood by both of the white rots in this study (Fig 1). In regular decay tests, brown rots tend to have higher rates of decay in woods with higher percentages of lignin. It is possible that the amount of lignin has less effect on the decay fungi than the abnormal cell structures themselves, with birdseye tissues having more gaps, abnormal thickening of vessel walls, and collapsed and hypertrophied parenchyma cells (Rioux et al 2003).

Heavy birdseye figure appeared to inhibit cellulose degradation by the brown rot fungi; thus, other factors appear to be causing the effect observed. Similarly, heavily figured birdseye maple wood stimulated decay by both white rot fungi possibly because of the lower lignin content and wood chemistry, but other factors such as wood morphology are likely to be affecting observations.

Knowledge of the differential decay resistance and/or susceptibility of figured maple wood may be useful among woodworkers and hobbyists who partially decay wood to produce decorative spalted wood. Moreover, considering the value of birdseye figured wood and its susceptibility to decay by white rot fungi, precautions should be taken to protect the wood from decay fungi. Future work on wood cell structure, lignin and cellulose chemistry, and relationships with other decay fungi will further elucidate the interactions of figured wood and its decay.

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