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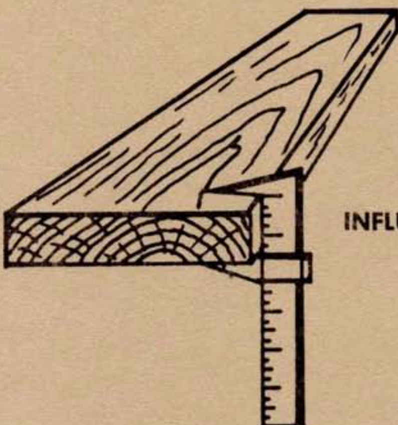

INFLUENCE OF VARIATION IN PHYSICAL AND CHEMICAL PROPERTIES OF SOUTHERN RED OAK LUMBER ON DECAY RESISTANCE

by

E. Richard Toole

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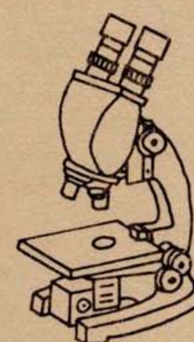

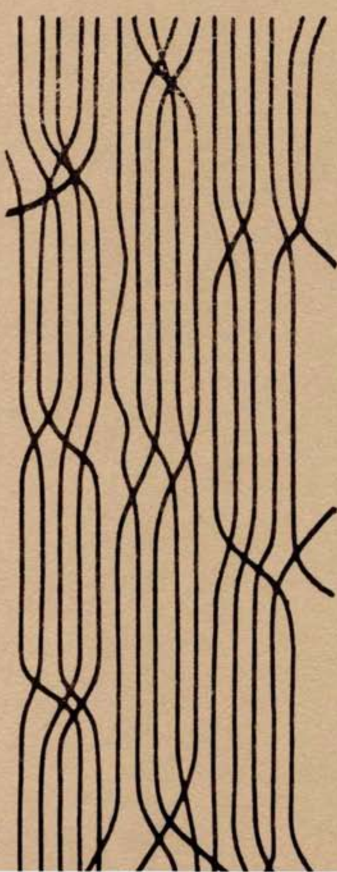

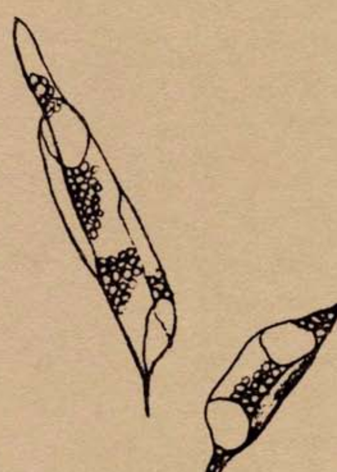

MISSISSIPPI STATE UNIVERSITY
FOREST PRODUCTS UTILIZATION
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INTRODUCTION

Although differences in decay resistance of the heartwood of various oak species have long been recognized, the effect of changes in physical and chemical wood properties on this decay resistance have not been well defined. Scheffer *et al* (5) studied the decay resistance of seven native oaks. They found that, within the species of the red oak group studied, there were no practical differences in resistance. However, they did find differences in decay resistance between individual trees of the same size in the same locality, and attribute this variability to genetic differences. Within a tree they found that as a rule resistance decreased from the outer heartwood toward the pith and from the butt to the top. They made no direct study of the effect of physical or chemical properties of oak wood on decay resistance, but found that resistance decreased as ring width decreased in the outer heartwood of white oak.

A number of investigators have studied decay resistance in relation to physical and chemical properties of the wood of other tree species. Extractives have been shown to be closely related to decay resistance (4, 8). Scheffer and Hopp (6), in their study of decay resistance of black locust heartwood, demonstrated the toxicity of hot-water extractives and concluded that the concentration of extractives accounted for a substantial part of the variability in decay resistance within any one tree, but that other factors must be considered in accounting for differences between trees.

In laboratory tests, assuming that air and moisture conditions are not limiting, it might be expected that within a tree species the higher the specific gravity the greater the decay resistance until such time as availability of food becomes a limiting factor. Southam and Ehrlich (7) in their discussion of specific gravity and decay resistance believe that this theory accounts for the contradictory conclusions arrived at by other workers (2, 3, 9).

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*Technologist, U.S. Forest Service, Southern Forest Experiment Station, Stoneville, Mississippi.

Garren (3) in his studies on the influence of specific gravity, percent summerwood, and moisture content on the rate of decay of loblolly pine sapwood by *Polyporus abientinus* concluded that wood of high specific gravity is more resistant to decay than that of low specific gravity. He was one of the early workers to apply regression analytical procedures to his data. Garren's data show that after his test blocks had been subjected to decay for seven months increased specific gravity resulted in increased decay resistance, but after eight months the reverse was true.

The present study seeks to determine by laboratory tests the effect of certain physical and chemical properties of southern red oak lumber on resistance to decay induced by a brown-rot and a white-rot decay fungus. Multiple regression analysis was used as an aid in interpreting the results obtained.

METHODS

Source of Test Specimens

The study trees were selected from two locations in Mississippi, two in Louisiana, two in Alabama, and one in Arkansas during the summer of 1967 (Table 1). At each location 12 trees either of water oak, cherrybark oak, or southern red oak were selected. The butt 16 foot log from each tree was hauled to a central location and sawn into 1 x 6 inch boards. From each log two boards from the outer heartwood and two from the inner heartwood were retained for laboratory study. Table 2 gives the distribution by tree species. All logs were obtained and prepared by the Southern Forest Experiment Station at Stoneville, Miss.

Test samples were removed from each board for the determination of the physical and chemical properties studied, and of the decay resistance.

Table 1. Study Areas by Species and Location

Location Number	Tree Species	State
1	Water Oak	West Central Mississippi
2	Water Oak	South East Louisiana
3	Cherrybark Oak	South West Alabama
4	Cherrybark Oak	South East Arkansas
5	Southern Red Oak	North West Mississippi
6	Southern Red Oak	South East Louisiana
7	Water Oak	South West Alabama

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Table 2. Number of Oak Boards, by Species and Location, Used in Evaluating Decay Resistance

Tree Species	Locations	Trees	Boards
	Number	Number	Number
Water Oak, *Quercus nigra* L.	3	36	141
Cherrybark Oak, *Q. falcata* Var. *pagodeofolia* Ell.	2	24	91
Southern Red Oak, *Q. falcata*, Michx.	2	24	92
Total	7	84	324

Testing Procedure

Decay resistance was determined using the ASTM standard soil-block method (1). The brown-rot test fungus used was *Lenzites trabea* Fr. (Madison 617), and the white-rot test fungus was *Polyporus versicolor* Fr. (Madison 697). From each sample board four specimens were cut for each fungus. These samples were incubated in the test bottles for ten weeks at 26.7° C and 70 percent relative humidity, and percent loss in weight was determined.

Using standard procedures the following were determined for each board:

green moisture content
specific gravity
fiber length
soluble extracts
summerwood percent
tyloses percent
number of rings per board
pH

In addition the following four determinations related to permeability were made:

moisture loss in grams between 4 and 6 hours after exposure
moisture loss in grams between 6 and 8 hours after exposure
each of the above expressed as percent of oven-dry weight.

The decay tests were prepared by the Mississippi Forest Products Utilization Laboratory, and all other tests by the Southern Forest Experiment Station at Stoneville, under the supervision of the junior author.

The data were prepared for stepwise regression analysis by the Southern Forest Experiment Station at Stoneville, Miss. under the supervision of Mr. R. M. Krinard.

RESULTS

Variation in Decay

Decay caused by the white-rot fungus varied from 0 to 62 percent in ten weeks, while that for the brown-rot fungus varied from 6 to 69 percent (Table 3). No clear difference was found between decay of the inner and outer heartwood, and therefore this separation was not made in subsequent analysis. Analysis of variance showed no difference in decay among locations for the white-rot fungus, but with the brown-rot fungus, location 2 (water oak in Louisiana) had less decay than the other locations (significant at the 5 percent level). Variation in decay for both white rot and brown rot was as great or greater among trees within location as among locations.

Effect of Wood Properties on Decay

The data for the 12 wood properties determined for each of the 324 boards were compared with loss in weight caused by the white-rot fungus, *Polyporus versicolor*, and the brown-rot fungus, *Lenzites trabea*, using the stepwise regression procedure. The ranges and averages for the variables are given in Table 3.

White Rot: The amount of decay caused by the white-rot fungus was significantly related to fiber length (Table 4). Decay decreased as fiber length increased. However, this relationship accounted for only 2 percent of the variation. The increase in R values due to each variable shows that for white rot all 12 independent variables accounted for only 4 percent of the variation (Table 4).

Brown Rot: The amount of decay caused by the brown-rot fungus was reduced as tyloses, specific gravity, and pH increased (significant at 1 percent level) (Table 4). The percent tyloses accounted for 24 percent of the variation in brown rot, tyloses plus specific gravity accounted for 29 percent, and all 12 variables accounted for 34 percent. The equation for brown rot and tyloses is plotted in Figure 1. Figure 2 gives the relationship between brown rot, tyloses, and specific gravity.

Table 3. Ranges and Averages of the Board Characters and Weight Loss Due to Decay for the Seven Locations

Board Characters	Location 1		Location 2		Location 3		Location 4		Location 5		Location 6		Location 7		All	
	Range	Ave.	Range	Ave.	Range	Ave.	Range	Ave.	Range	Ave.	Range	Ave.	Range	Ave.	Range	Ave.
Moisture Content (%)	65-121	87	72-104	86	76-107	89	75-101	85	74-109	91	71-110	82	72-113	95	65-121	88
Specific Gravity	.53-.67	.60	.58-.64	.63	.56-.66	.60	.58-.65	.61	.47-.66	.59	.58-.67	.60	.49-.66	.58	.47-.67	.60
Wt. loss 4-6 hrs. (gms)	17-46	30	21-45	33	21-52	37	18-46	30	22-121	34	17-55	30	20-42	31	17-55	32
Wt. loss 6-8 hrs. (gms)	20-63	30	21-47	30	21-56	35	23-47	34	20-75	34	18-50	31	20-131	35	18-131	33
Wt. loss 4-6 hrs. (%)	5-16	10	6-14	10	7-19	12	6-14	9	7-44	11	5-22	10	7-16	10	5-44	10
Wt. loss 6-8 hrs. (%)	6-21	10	6-16	9	8-18	11	7-15	11	6-17	11	6-17	10	7-42	11	6-42	11
Fiber Length (mm)	2-3	3	3-4	3	2-3	3	3-4	3	2-3	3	3-4	3	2-3	3	2-4	3
Soluble Extractives (%)	1-4	3	1-6	2	2-6	3	2-6	3	2-5	3	1-8	3	2-5	3	1-8	3
Summerwood (%)	10-44	23	15-50	22	15-58	25	23–50	29	24-57	37	13-50	27	12-42	24	10-57	27
Tyloses (%)	14-99	70	20-99	73	15-99	75	22-90	57	12-98	48	15-90	48	12-99	58	12-99	61
Rings per board (no.)	2-10	5	3-13	4	3-8	4	3-15	6	3-13	7	3-14	6	4-15	6	2-15	5
pH	3.8-4.5	4.1	3.8-5.5	4.1	3.7-4.6	3.9	3.8-4.5	4.1	3.7-4.2	3.9	3.7-4.3	3.9	3.7-4.2	3.9	3.7-5.5	4.1
Brown Rot wt. loss (%)	16-69	33	6-59	25	15-57	34	31-64	41	17-59	40	11-57	37	17-66	39	6-69	40
White Rot wt. loss (%)	1-58	18	0-56	18	0-53	21	0-49	24	0-53	16	0-50	16	0-62	21	0-62	22

Table 4. Correlations between Wood Characteristics and Decay Resistance

Statistical Comparisons			
Dependent Variable vs.	Independent Variable	r Value	Increase in r Value
% wt. loss, white-rot	Fiber length (mm)	.1419*	.1419
	pH	.1658	.0239
	Wt. loss 4 to 6 hours (gms)	.1733	.0075
	Summerwood (%)	.1780	.0047
	Tyloses (%)	.1849	.0069
	Specific gravity	.1894	.0045
	Green moisture content (%)	.1968	.0074
	Rings/bd. (no.)	.1974	.0006
	Wt. loss 6 to 8 hours (gms)	.1977	.0003
	Wt. loss 6 to 8 hours (%)	.2052	.0075
	Wt. loss 4 to 6 hours (%)	.2058	.0006
% wt. loss, brown-rot	Tyloses (%)	.4913**	.4913
	Specific gravity	.5426**	.0513
	pH	.5622**	.0196
	Green moisture content (%)	.5675	.0053
	Wt. loss 6 to 8 hours (%)	.5727	.0105
	Fiber length (mm)	.5749	.0022
	Wt. loss 6 to 8 hours (gm)	.5768	.0019
	Rings per board (no.)	.5781	.0019
	Soluble extracts (%)	.5786	.0005
	Wt. loss 4 to 6 hours (gm)	.5789	.0003
	Wt. loss 4 to 6 hours (%)	.5818	.0029
	Summerwood (%)	.5818	.0000

*Significant at the 5% level.
**Significant at the 1% level.

CONCLUSIONS

The great variation in decay resistance to both white rot and brown rot shown in the southern red oak population studied here probably should be attributed mostly to genetic differences rather than differences among species and locations (5).

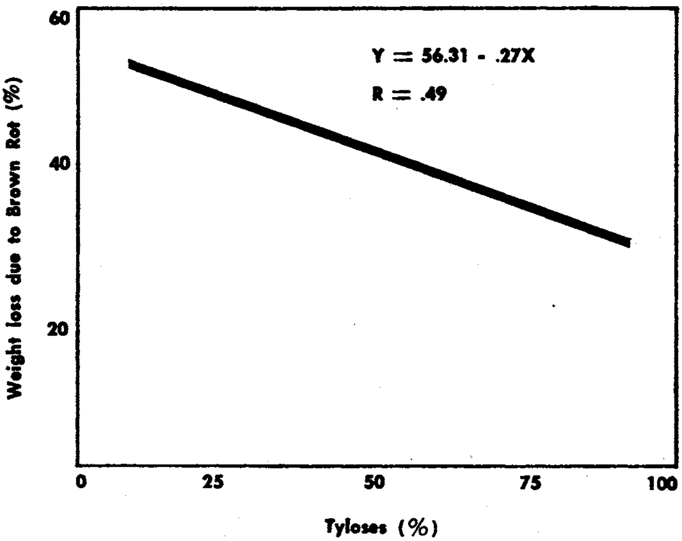

Figure 1. Relationship of loss in weight due to brown rot, and tyloses.

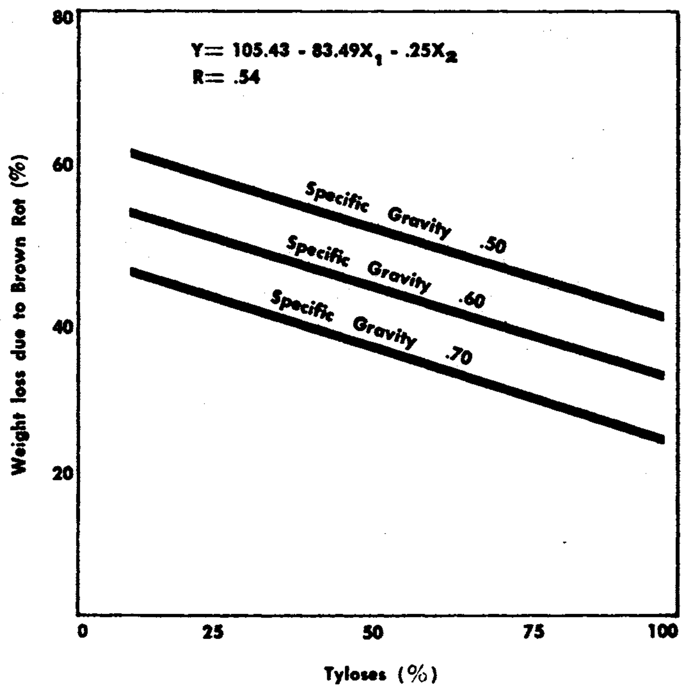

Figure 2. Relationship of loss in weight due to brown rot, specific gravity, and tyloses.

Although none of the independent variables studied were strongly enough correlated with decay resistance for precise prediction purposes, the frequency of occurence of tyloses, specific gravity, and pH were significantly related to weight loss by *Lenzites trabea* a brown-rot fungus. Fiber length was the only variable significantly correlated with white rot caused by *Polyporus versicolor*.

Soluble extractives, which had been shown to be highly correlated with decay resistance in other species (4, 6, 8), showed no relation to decay resistance in this study, possibly in part due to the narrow range in this value in our sample.

From the practical standpoint, decay resistance of southern red oak lumber within the species-area sampled is not sufficiently affected by variation in any of the wood properties studied to warrant separation in use.

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