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Determining Loss of Wood Substance After Fungal Attack

A Comparison of Two Methods

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Abstract: Loss of wood substance after fungal attack was determined on the same sample by the two following methods: Direct weighing and specific gravity loss determinations before and after fungal attack. The two methods gave almost equivalent results after water-soluble extractives produced by the fungi were removed from the decayed wood by water-soaking. After fungal attack, little green volume change occurred even up to 40% weight loss. The specific gravity method reliably determined losses in wood substance caused by fungal degradation such as occur in pulpwood chips stored for long periods in large piles.

Keywords: Chip storage · Decay · Fungi · Losses · Weight measurement · Density measurement · Quaking aspen · Pinus resinosa

WOOD stored outdoors is subject to microbial attack that causes losses in wood substance. These losses can vary considerably; hence it is economically important that the methods to determine these losses be accurate.

In most of the investigations on the storage of wood chips, specific gravity measurements are used to determine losses in wood substance (1). Some investigators, who have used both direct weighing and specific gravity measurements to assess wood substance loss, have obtained conflicting results *(2, 3)*. It has been reported that decay has little effect on the volume of pulpwood; thus the decrease in specific gravity of the wood should be an accurate measure of the extent of loss of wood substance (4). Until now, this assumption has not been validated.

The purpose here was to determine if the loss in wood substance after fungal attack obtained by measuring loss in specific gravity correlates with that obtained by direct weighing.

EXPERIMENTAL

Blocks, 3.5 (tangential) by 1.5 (radial) by 0.25 in. (longitudinal) were cut consecutively from green logs of quaking aspen (*Populus tremuloides* Michx.) and red pine (*Pinus resinosa* Ait.), and numbered. Sixty-six blocks were used, 42 aspen and 24 red pine.

Specific gravity was determined for each block by TAPPI procedure T 18 m-53. The samples were waterlogged, soaked in water for 5–6 hr, and their volumes (V_1) determined by water displacement. They were then ovendried at 110°C for 16 hr, weighed (o.d.$_1$), and their specific gravities calculated (Sp. gr.$_1$).

The ovendried blocks were then conditioned at 27°C and 80% RH, after which half of the aspen blocks were subjected to decay by the brown rot fungus (*Poria monticola* Murr.) and the other half to decay by the white rot fungus (*Polyporus versicolor* L. ex Fr.). Peniophora "G,"[1] a pine chip-degrading Basidiomycete, was used to decay all of the test pine blocks. The method used to decay all blocks was similar to the ASTM D-2017-62T, "Tentative Method for Accelerated Laboratory Test of Natural Decay Resistance of Woods," except that larger test blocks and larger bottles (2 qt) were used for this study, and the incubation periods varied to produce blocks with ranges of weight losses from 3 to 40%.

Specific gravities of the decayed blocks (Sp. gr.$_2$) were determined, by the method described, on the basis of waterlogged volumes (V_2) and ovendry weights (o.d.$_2$). The percentage loss in specific gravity is determined from

$$\frac{\text{Sp. gr.}_1 - \text{Sp. gr.}_2}{\text{Sp. gr.}_1} \times 100$$

The percentage loss by direct weighing is determined from

$$\frac{\text{o.d.}_1 - \text{o.d.}_2}{\text{o.d.}_1} \times 100$$

Table 1. Range in Losses in Weight and in Specific Gravity of Woods Decayed by Three Fungi after Water Extraction

Species	Weight loss,[a] %	Specific gravity loss, %	Weight loss minus specific gravity loss, %	Volume change,[b] %
		Poria monticola (brown rot)		
Quaking aspen	8.3	7.7	0.6	−0.7
	22.8	22.6	0.2	−0.2
	27.9	27.5	0.4	−0.5
Control[c]	0.9	0.7	0.2	−0.2
		Polyporus versicolor (white rot)		
Quaking aspen	4.8	4.9	−0.1	+0.2
	9.8	10.3	−0.5	+0.5
	16.8	17.3	−0.5	+0.6
	40.5	40.8	−0.3	+0.4
Control[c]	0.9	.7	0.2	−0.2
		Peniophora "G"		
Red pine	2.8	2.9	−0.1	+0.1
	9.6	9.0	0.6	−0.7
	13.4	12.8	0.6	−0.6
Control[c]	1.0	0.9	0.1	−0.04

[a] Difference between initial ovendry weight and final ovendry weight after removal of water extractives.
[b] Determined by water-displacement method before and after fungal attack.
[c] Samples not subjected to decay by a fungus.

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[1] This fungus was identified to genus (*Peniophora*) by members of the Forest Disease Laboratory, U.S. Department of Agriculture, Forest Service, Laurel, Md., then with similar cultures, assigned the identifying letter, "G." Identification of the fungus to species awaits the possibility of obtaining an identical culture from a known *Peniophora* sporophore.

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Volume changes were determined from

$$\frac{V_2 - V_1}{V_1} \times 100$$

Weight losses were determined on some of the decayed samples that had been ovendried but not waterlogged and water-soaked. To determine if appreciable leaching, hence, weight loss, occurred during soaking, these samples were subsequently waterlogged, soaked, and specific gravities and ovendry weights determined as described. Water-soluble extractives are then defined as any material leached out during the 5–6 hr soaking period.

Control samples that were not subjected to decay by fungi were carried through the test to determine any effects of ovendrying and rewetting on the specific gravities and weight losses. Approximately 1% weight loss and 1% specific gravity loss occurred in the controls.

RESULTS AND DISCUSSION

In Table I, losses in weight are compared with losses in specific gravity for the two wood species after exposure to fungal decay. In Table II, percentages of water-soluble extractives produced during fungal attack are listed. Values in both tables represent the range of results for all the samples. The data for all of the samples are plotted in Fig. 1.

The data in Table I show a direct relationship between losses in wood substance by the direct-weighing method and those by the specific gravity method if the direct weighing is on wood that has been waterlogged and soaked. The specific gravity measurement is always based on water-soaked wood because the volume is determined by water displacement. The two methods gave differences in values up to ±0.6%.

The relationship in Fig. 1 shows clearly that losses in specific gravity are approximately equal to losses in weight on water-soaked samples even for values as large as 40% loss in wood substance. The standard error of estimate of the linear regression line where the intercept was chosen as zero and the slope of the line was chosen as one (specific gravity loss = direct weighing weight loss) was 0.4%. Performing a linear regression analysis on the data without forcing the intercept to zero or the slope of the line to one gave a value of the intercept of 0.093 (theoretical = 0), a slope of the line of 0.992 (theoretical = 1), and the same standard error of estimate. A direct relationship thus exists between the two methods.

The solid points in Fig. 1 are those obtained from samples for which weight losses were determined before water-soaking and removal of water soluble extractives and the specific gravity losses after removal. It is seen that the correlation is not as good as in the water-soaked samples. Linear regression analysis of these data gave an intercept of 1.717 (theoretical = 0), a slope of the line of 1.039 (theoretical = 1), and a standard error of estimate of 1.5%. When the data were forced through the origin, the slope of the line became 1.196, whereas the slope of the line for the water-soaked samples was 0.996. This shows a highly significant relationship between loss in weight and loss in specific gravity for water-soaked samples, but a poorer relationship for loss of weight in samples that had not been soaked.

Water-soluble extractives are produced during decay of wood by fungi (Table 11). The presence of these extractives explains why a 1:1 relationship was not found between losses in unextracted samples by direct weighing and those in specific gravity samples because the specific gravities are determined on water-soaked samples. The brown rot

Table II. Water Extractives Produced During Fungal Attack

Species	Weight loss: Before wafer extraction (A), %	Weight loss: After water extraction (B), %	Water extractives produced (B – A) %	Specific gravity loss, %
	Poria monticola (brown rot)			
Quaking aspen	3.9	7.9	4.0	6.8
	11.6	15.9	4.3	13.8
	23.5.	29.7	6.2	26.9
	Polyporus versicolor (white rot)			
Quaking aspen	4.3	6.6	2.3	6.5
	4.9	7.7	2.8	8.0
	Peniophora "G"			
Red pine	1.9	2.5	0.6	2.7
	6.0	7.4	1.4	6.6
	11.7	13.4	1.7	12.3

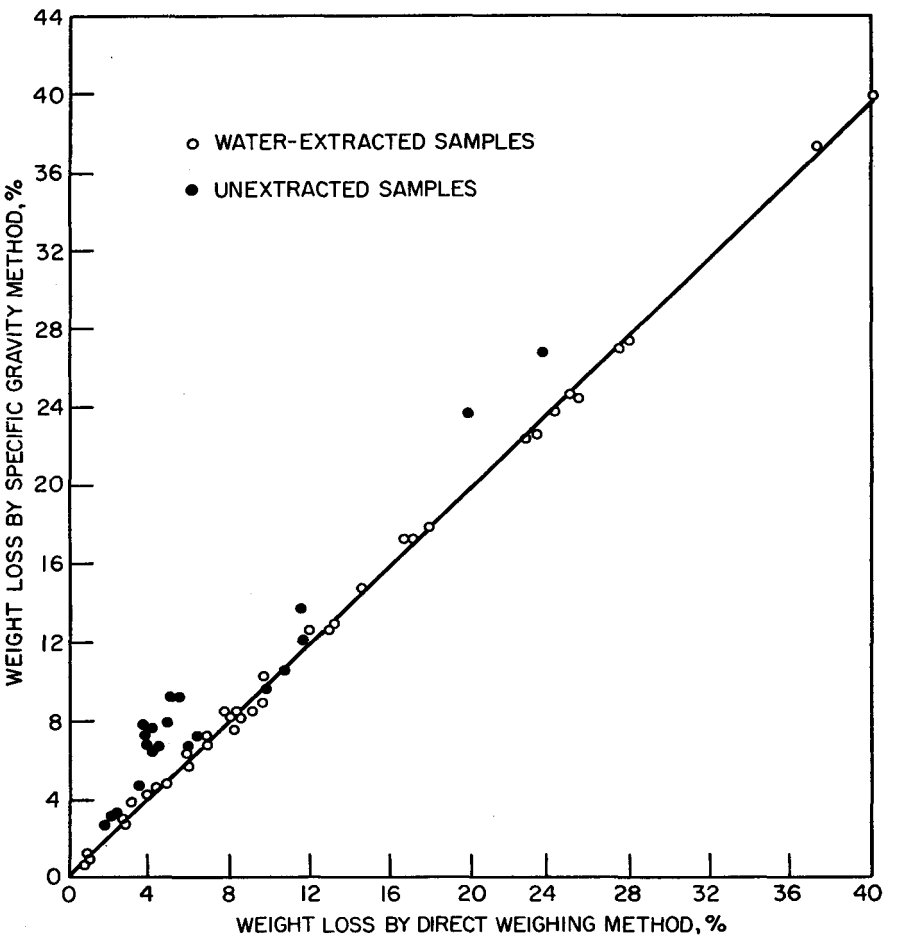

Fig. 1. Relationship between weight loss and specific gravity loss for water-soaked and hence water-extracted and unextracted wood samples after fungal attack.

fungus produced greater amounts of water-soluble extractives than did either the white rot fungus or *Peniophora* "G" (Table 11); consequently, for this fungus the correlation between losses determined by weighing and by specific gravity is poorest.

Losses in weight and in the amount of water-soluble extractives were determined for samples of aspen chips stored 6 months in small piles (10 × 10 × 4 ft. high). In this case the samples were exhaustively extracted with water at room temperature. At losses (determined by direct weighing) of 14--15%, the water-soluble extractives amounted to 1.5-2%. Thus, total weight losses were 16—17%. Both the white rotter and the *Peniophora* "G" produced 1.5–3% water-soluble extractives, similar to values found from the wood that had been attacked in storage.

Determining loss of specific gravity requires measurement of sample volume both before and after fungal attack. Measurement is by water displacement of waterlogged samples; therefore, the green volume is obtained. The change in volume of samples before and after fungal attack is shown in Table I. A negative value indicates that the green volume of the sample decreased after fungal attack; a positive, that the green volume increased (swelling occurred). It is seen that the green volume changes were generally not of practical significance (±0.7%). It is interesting that little apparent green volume change occurs even when weight losses as high as 40% are found. The differences between the losses determined by the direct weight method and the specific gravity method are reflected remarkably well in the small changes in volume.

CONCLUSIONS

After wood had been subjected to fungal attack, losses in wood substance were determined by measuring both loss in weight and in specific gravity on the same wood sample. The results show that the losses of wood determined by these two methods will be equivalent only if the samples have been water-soaked and hence extracted. The need for water extraction is caused by the presence of water-soluble material produced by the fungus as it decays the wood. A brown-rot fungus (*Poria monticola*) on aspen wood produced from 5 to 6% water-soluble extractives, whereas a white rot fungus (*Polyporus versicolor*) on aspen wood and Peniophora "G" on red pine wood produced from 1 to 3% water-soluble extractives. These water-soluble extractives should be considered when determining weight losses by direct-weighing methods.

The assumption that little volume change occurs when wood substance is degraded by fungal attack has been validated. Green volume changes of only ±0.7% were found even up to weight losses (water extracted) as high as 40%.

The conclusion from the results here is that the method for determining loss in specific gravity accurately assesses losses in wood substance caused by fungal degradation.

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