LOSS OF LIGNIN AND CELLULOSE COMPONENTS OF WOOD OF *SWIETENIA MAHAGONI* AND *SHOREA ROBUSTA* DUE TO DECAY BY *TRAMETES SCABROSA* (PERS.) G. H. CUNN, *PHELLINUS BADIUS* (BERK.) G. H. CUNN, AND *DAEDALEA FLAVIDA* LÉV.

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ABSTRACT

The decay of wood of mahagony (*Swietenia mahagoni*) and sal (*Shorea robusta*) caused by *Trametes scabrosa, Phellinus badius,* and *Daedalea flavida* was investigated on the basis of quantitative estimation of lignin and cellulose. The lignin and cellulose contents of sound wood of both host species were above 30% and 60%, respectively, of the extractive-free dry weight of wood. Percentage of lignin in decayed wood became much less than that in sound wood, particularly in sapwood, whereas the precentage of cellulose decreased only slightly during the process of decay. Results revealed that the test fungi primarily utilized the lignin portion and only a small amount of cellulose and proved to be "white rot" fungi. From wood of S. *mahagoni*, maximum amount of lignin was removed by *T. scabrosa* and cellulose by *D. flavida,* whereas with S. *robusta* maximum amount of lignin was utilized by *D. flavida* and maximum cellulose by *P. badius.*

Keywords: *Swietenia mahagoni, Shorea robusta,* white rot, lignin, cellulose, chemical analysis, decay, biodegradation, fungi, *Trametes scabrosa, Phellinus badius, Daedalea flavida.*

INTRODUCTION

The process of wood deterioration by basidiomycetes is receiving increased attention not only for their well-known destructiveness but also for the recently realized enormous importance of bioconversion of lignin and cellulose of wood into simpler substances to make them available for ultimate utilization by growing plants. Many of the wood-destroying basidiomycetes are known to be very efficient in utilizing cellulose (Siu 1951; Scheffer and Cowling 1966) and lignin (Pelczar et al. 1950; Van Vliet 1954) of wood, but they vary considerably in their capacities to decompose lignin and cellulose of wood in storage, in service or in living trees (Lindeberg 1946; Kirk 1971, 1975). On the basis of the chemical nature of degradation, "white rot" fungi attack both lignin and cellulosic constitutents of wood, whereas for "brown rot" type, only the cellulose and its associated pentosans are attacked, leaving the lignin more or less unchanged.

In India, general information about deterioration of economic timbers by wood-destroying fungi is known, but quantitative data on the capacities of such organisms to degrade wood constituents are still very limited. With this in mind, the present investigation has been undertaken to estimate the quantitative changes in lignin and cellulose contents of two very important economic timbers, mahagony (*Swietenia mahagoni* Linn.) and sal (*Shorea robusta* Gaertn. f.) decayed by three common wood-destroying fungi, *Trametes scabrosa* (Pers.) G. H. Cunn, *Phellinus badius* (Berk.) G. H. Cunn, and *Daedalea flavida* Lév. under controlled laboratory conditions.

MATERIALS AND METHODS

Cultures from tissues of fresh fructifications of the test fungi grown on Difco malt

TABLE 1. *Percentage of lignin loss*[a] *from decayed wood of* Swietenia mahagoni *and* Shorea robusta *by* Trametes scabrosa, Phellinus badius, *and* Daedalea flavida

Nature of wood	Period of incubation	Loss in dry weight			Lignin in sound wood	Loss in lignin from wood decayed by[b]		
		Trametes scabrosa	*Phellinus badius*	*Daedalea flavida*		*Trametes scabrosa*	*Phellinus badius*	*Daedalea flavida*
	(months)	(percent)			(percent)	(percent)		
Swietenia mahagoni								
Sapwood	4	14.5	10.0	8.1	30.0	23.3	15.0	12.0
	8	30.5	20.1	16.6		48.3	30.5	25.5
Heartwood	4	6.1	3.4	2.8	34.5	4.8	2.3	2.0
	8	12.4	6.8	5.9		9.4	4.5	4.5
Shorea robusta								
Sapwood	4	8.4	9.3	11.3	31.0	8.3	10.9	17.0
	8	17.7	18.6	22.9		18.7	22.5	34.8
Heartwood	4	3.1	2.9	5.3	37.0	1.5	1.9	3.2
	8	6.5	6.0	10.6		3.2	3.7	6.5

[a] Expressed as percentages of the original lignin content

[b] Mean of three replicates

agar (2%) were used. Sapwood and heartwood blocks (2″ × 1″ × ½″) of *S. mahagoni* and *S. robusta* were exposed to mycelia of *T. scabrosa*, *P. badius*, and *D. flavida* in Kolle flasks for a period of eight months under controlled laboratory conditions (Banerjee 1955). The test blocks were taken out in two installments after 4 and 8 months of incubation. After removing the superficial mycelia, the extractive-free wood blocks were dried, weighed, ground into fine 40-mesh powder, and used for quantitative estimation of lignin and cellulose.

Since lignin analysis based on sulphuric acid method is still considered to be largely satisfactory (Kirk 1971), the present estimation was made following mainly Saeman et al. (1954). Carbohydrates were removed by hydrolysis with sulphuric acid; and lignin, condensed and thoroughly washed to an insoluble residue, was determined gravimetrically.

Different cellulose components were estimated following the Tappi Standard (1954) and Cowling (1961). Percentages of alpha and beta cellulose were determined by dry weight. The gamma cellulose portion was determined by subtracting the percentage of alpha and beta portions from the total holocellulose of the wood samples.

RESULTS

It is evident from Table 1 that in both host woods the lignin contents of sound wood are more than 30% of the extractive-free dry weight of wood and slightly higher in *S. robusta* than *S. mahagoni*. Heartwood has higher lignin content than the respective sapwood in both species. Percentage of lignin in decayed wood decreases increasingly during the process of decay. In all treatments, the loss of lignin in sapwood is much higher, sometimes more than five times that obtained with heartwood subjected to attack by the same fungus. These values are more or less proportional to the corresponding losses in dry weight of particular wood subjected to a particular fungus species. Lignin degradation in *S. mahagoni* is maximum in presence of *T. scabrosa* followed in descending order by *P. badius* and *D. flavida*, whereas in *S. robusta* maximum degradation is caused by *D. flavida* followed by *P. badius* and *T. scabrosa*.

TABLE 2. *Percentages of different components of cellulose in sound wood of* Swietenia mahagoni *and* Shorea robusta

Nature of wood	Cellulose components (%)[a]			
	Holo	Alpha	Beta	Gamma
Swietenia mahagoni				
Sapwood	70.0	40.0	20.0	10.0
Heartwood	65.5	37.0	19.5	9.0
Shorea robusta				
Sapwood	69.0	42.5	17.0	9.5
Heartwood	63.0	40.0	15.5	7.5

[a] Mean of three replicates

Cellulose contents (Table 2) in sound wood are between 60–70% of the extractive-free dry weight of wood, being slightly higher in *S. mahagoni* than *S. robusta*. Heartwood has comparatively lower cellulose content than the respective sapwood. Percentage of cellulose in decayed wood (Table 3) is much lower than in sound wood, the loss being less prominent in heartwood than in sapwood and increasing with time of incubation. *T. scabrosa* causes maximum degradation of cellulose from *S. mahagoni* followed by *P. badius* and *D. flavida* in decreasing order. *D. flavida*, however, is most active against *S. robusta* heartwood followed by *T. scabrosa* and *P. badius*. Wide differences are evident in the utilization of different components of cellulose by the fungus species.

DISCUSSION

Lignin and cellulose contents in sound wood of both hosts are between 30–40% and 60–70%, respectively. These values are fairly in accordance with our earlier observations (Nandi 1970; Santra and Nandi 1975). In laboratory decay tests of some commercial species of mahagony, Moses (1955) observed that true mahagony possesses a higher level of decay resistance than others although most types show fairly good resistance. In the present study, the test fungi prove to be capable of utilizing quite substantial amounts of lignin from the tested host woods. The fungi, however, show variations in their relative rates of utilization depending on wood species and

TABLE 3. *Loss of different cellulose components*[a] *of wood of* Swietenia mahagoni *and* Shorea robusta *decayed by* Trametes scabrosa, Phellinus badius, *and* Daedalea flavida

Nature of wood	Period of incubation (months)	Loss of cellulose components of wood decayed by[b]											
		Trametes scabrosa				*Phellinus badius*				*Daedalea flavida*			
		Holo	Alpha	Beta	Gamma	Holo	Alpha	Beta	Gamma	Holo	Alpha	Beta	Gamma
		(percent)				(percent)				(percent)			
Swietenia mahagoni													
Sapwood	4	4.9	6.2	3.5	5.0	3.8	2.5	3.4	10.0	3.2	3.7	1.2	5.0
Heartwood	4	4.1	4.0	3.6	5.5	2.3	1.5	3.6	2.2	1.8	1.3	1.1	5.5
Sapwood	8	10.7	12.5	7.3	10.0	7.8	5.0	7.3	20.0	6.4	7.5	2.4	10.0
Heartwood	8	8.3	8.1	7.6	11.1	4.5	2.7	7.6	5.5	3.8	2.7	2.5	11.0
Shorea robusta													
Sapwood	4	4.6	4.0	5.6	5.2	3.2	2.8	1.4	7.3	4.3	4.0	2.9	1.0
Heartwood	4	2.3	1.2	3.2	3.3	1.9	0.5	4.5	3.3	3.5	2.5	4.5	0.6
Sapwood	8	9.1	8.2	11.1	10.5	6.5	5.8	2.3	15.7	8.6	8.2	5.8	2.1
Heartwood	8	4.7	2.5	6.4	6.6	3.9	1.2	9.6	6.6	7.1	5.0	9.6	1.3

[a] Expressed as percentages of the original cellulose content

[b] Mean of three replicates

fungus species. In all cases, the fungi are much more active in sapwood than in respective heartwood. The higher resistance of heartwood usually can be attributed to higher extractive contents of this type of wood than sapwood, which inhibits in fungal growth. Although the three fungi show considerable differences in the relative rates at which they attack the lignin of a particular host wood, there seems to be no reason to suspect that they affect lignin differently in a qualitative way. Such differences may be due to differences in production of extracellular phenol-oxidising enzymes, which act on the lignin through the oxidative process.

Proportionately less cellulose than lignin is removed by the fungi. The relatively small amounts of cellulose utilized simultaneously with lignin proves the 'white rot' nature of the test fungi. Although the cellulose contents of the two woods are fairly high, the activities of cellulolytic enzymes seem to be quite low.

The authors frequently have observed the test fungi to attack living trees of the host species in nature. Results of laboratory experiments show both S. *mahagoni* and S. *robusta* to be quite severely affected with the test fungi. Thus, from the point of view of chemical degradation of wood, the test fungi prove to be very important and play very active roles in the bioconversion of complex lignin in nature.

CONCLUSION

The three test fungi utilized lignin from woods of two host species much more effectively than the cellulose proving their 'white rot' nature. The fungi showed variations in their relative rates of utilization of these two structural components, depending on the wood species and fungus species. Utilization of the compounds was progressive with time of incubation and in most cases more or less proportional to the loss of dry weight of wood.

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