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BIODEGRADATION OF THREE HARD WOODS BY SOME WHITE ROT FUNGI

BY

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Chemical changes in woods of *Albizia lebbeck*, *Mangifera indica* and *Terminalia arjuna* decayed by three white rot fungi, viz., *Polyporus occidentalis* Klotzsch,, *Trametes lactinea* Berk. and *Pycnoporus sanguineus* L. ex Fr. respectively were studied. Considerable loss of cell wall components of wood in respects of total lignin, cellulose and carbohydrate was recorded after 4 and 8 months of decay. Quantitative loss of the cell wall components indicated that the fungi consumed mainly the lignin and carbohydrate but cellulose to a much lesser extent. Different fungus-host combination exhibited differential loss of wood components which increased with time.

Key words : Biodegradation, Hard Woods, White rot fungi.

INTRODUCTION

White rot fungi cause wood damage primarily by decaying lignin, depolymerizing cellulose as well as hemicelluloses and carbohydrates (Kirk, 1973, 1975; Cowling, 1961; Santra and Nandi, 1980). Studies on the degradation of wood by white rot fungi show that lignin physically, serve as effective barrier to the enzymatic degradation of the polysaccharides (Cowling and Brown, 1969 ; Pew and Weyna, 1962). On the contrary, polysaccharides may not pose such a barrier as substantial part of the lignin in wood can be depleted disproportionately by some white rot fungi (Kawase, 1962 ; Kirk and Moore, 1972).

The present investigation was aimed to study the degrading ability of wood contituents of respective hosts of three white rot fungi.

MATERIALS AND METHODS

Wood samples and decay tests

Pure cultures were made from basidiocarps of three white rot species of family Polyporaceae, *Polyporus occidentalis* Klotzsch., *Trametes lactinea* Berk.. and *Pycnoporus sanguineus* L. ex Fr. growing luxuriantly on logs of *Albizia lebbeck*, *Mangifera indica* and *Terminalia arjuna* respectively in and around Burdwan. Blocks of 2 cm × 2 cm × 1 cm (in the small dimension in the fibre direction) were cut

from heartwood and sapwood of the host species. Small test blocks were used rather than large blocks because of more uniform decay likely to occur throughout, particularly in early stages. The blocks were numbered, sterilized, conditioned to constant weight at 27°C and 80% relative humidity and then weighed. These blocks were subjected to decay by mycelia of the three species by agar block method not only provided favourable conditions for decay but also prevented contamination of the blocks by foreign nutrient material and leaching of the degradation product from blocks. The test fungi were grown in Kolle flasks containing 2.5% nutrient agar medium. After the fungi covered the agar surface, 10 blocks were exposed to the mycelium for different lengths of time (4 and 8 months) to obtain wood samples at different stages of decay. Following incubation the blocks were taken out, surface mycelia carefully removed, reconditioned, weighed and their weight losses were calculated. Non-inoculated blocks served as control.

Analytical techniques

Sound and decayed wood blocks were ground to 40 mesh and the meal dried thoroughly at 45°C. The samples were analysed for lignin, carbohydrate, holocelluloses and nitrogen and losses of each due to decay were calculated therefrom.

For quantative estimation of lignin in wood, the method proposed by Saeman *et al.* (1954) was mainly followed The lignin was condensed to an insoluble residue by hydrolysis in H_2SO_4 and was then determined quantitatively.

Total carbohydrate was estimated quantitatively following the colorimetric method of Viles and Silverman (1949).

For the estimation of cellulose in wood Tappi standard (1954) and Cowling (1961) was mainly followed. Holocellulose was taken as the residue remaining upon successive preextraction of wood meal with ethanol benzene, ethanol and hot water to remove extraneous substances followed by a succession of chlorination and monoethanolamine extraction to remove lignin. The isolated holocellulose was treated with 1 .5% aqueous NaOH when hemicellulose was dissolved while alpha-cellulose fraction remained insoluble and was separated. The beta-cellulose was precipitated on acidification of the alkaline hemicellulose while gamma-cellulose remained in the acidified solution. The percentage of alpha- and beta cellulose was determined by dry weight method. The gamma-cellulose portion was determined by substracting the percentage of alpha- and beta-cellulose from the percentage of holocellulose in the original moisture free sample.

Total nitrogen was estimated colorimetrically following mainly the method of Vogel (1961).

RESULTS

Analytical values of lignin, total carbohydrate, holocellulose and fraction of cellulose in the decayed heart and sap wood have been graphically represented as loss expressed in percent of the original amount of each (Figs. 1 and 2). The amount of nitrogen in the decayed wood has been shown in Table 1.

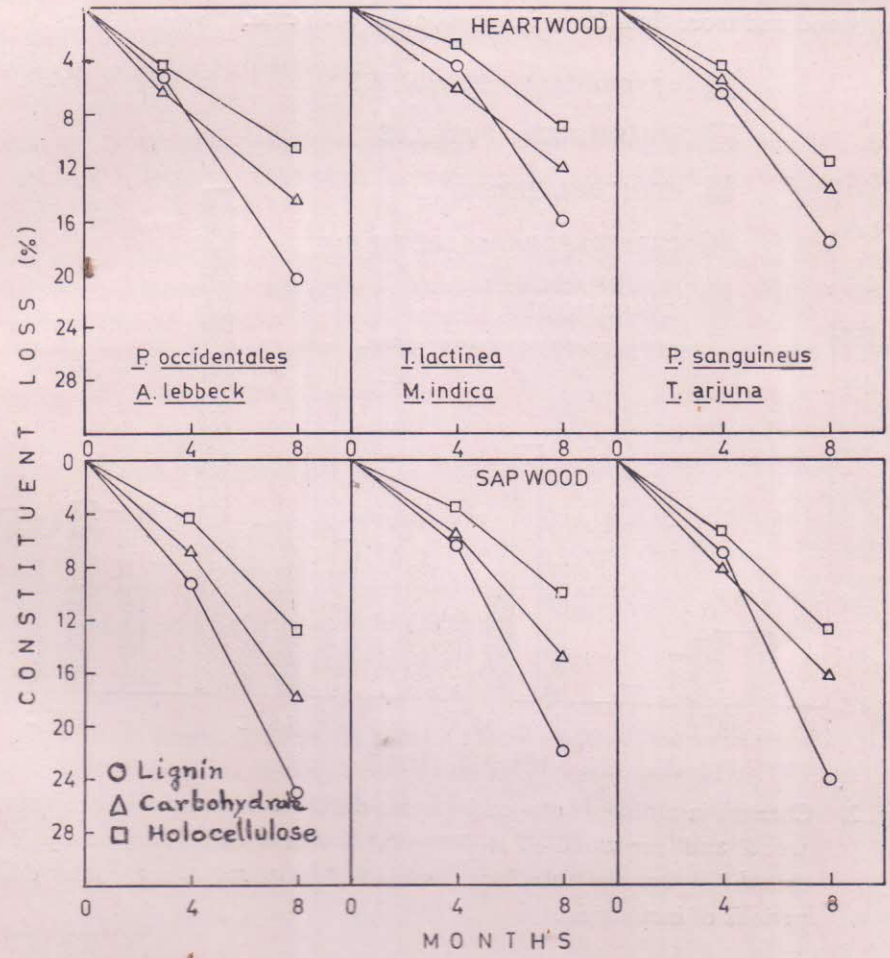

Fig. 1. Changes in total carbohydrate, lignin and holocellulose in decayed heart wood and sap wood of *Albizia lebbeck*, *Mangifera indica* and *Terminalia arjuna* by *Polyporus occidentalis*, *Tramates lactinea* and *Pycnoporus sanguineus* respectively after different periods of incubation.

The three white rotters were fairly efficient in removing the cell wall components of the wood. Distinct variations were, however, evident in the relative rates

of degradation of the components in both heart and sap wood of a wood species by the different fungi.

Typical of the white-rot decay, lignin was degraded by all the test fungi earlier than those of the carbohydrate and holocellulose. The extent of lignin degradation after 4 months of decay varied in different host fungus combinations which increased further with the longer treatment. It reached 16 to 20.5% in heart wood and more than 20 % in sap wood in each case.

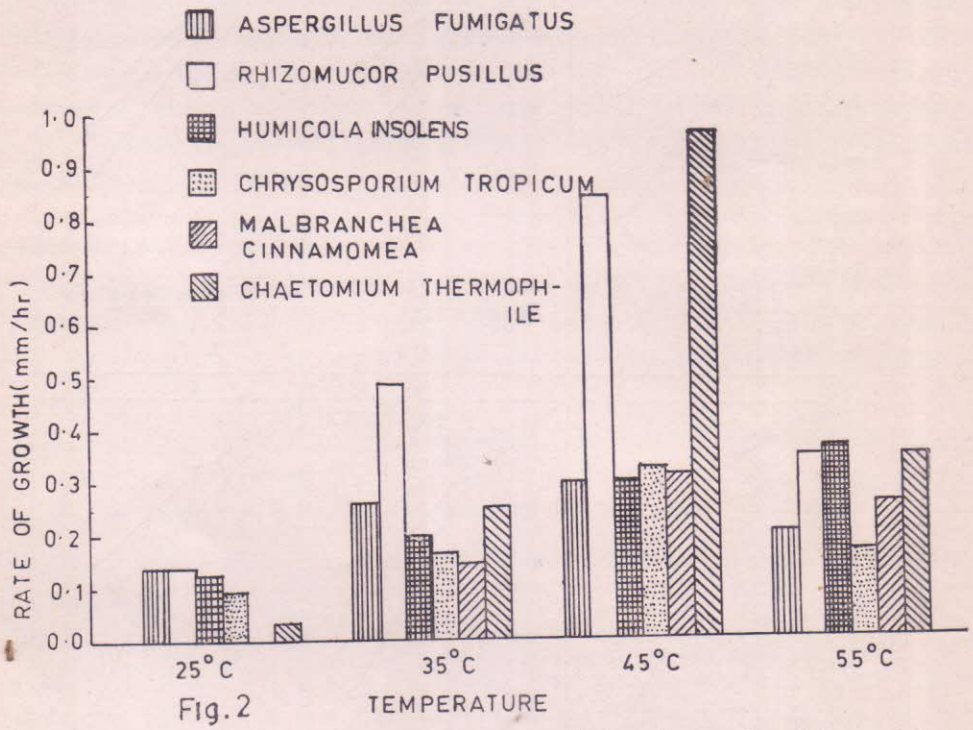

Fig. 2. Changes in alpha-, beta- and gamma-cellulose in sound and decayed heart wood and sap wood of *A. lebbeck*, *M. indica* and *T. arjuna* by *P. occidentalis T. lactinea* and *Pycnoporus sanguineus* respectively after different periods of incubation.

Carbohydrate utilization also increased with time and was between 12 to 14.5% in heart wood and 14 to 18 % in sap wood of the host species.

The three fungi also showed varied rates of degradation of hollocelulose after 4 months which increased further after 8 months. Holocellulose degradations were 9 to 11.5% in heart wood and 10 to 13.20% in sap wood after 8 months of decay. Different fractions of holocellulose which were considerably higher in sap wood, also showed higher losses in the former than the latter. Maximum

Table 1. *Changes in nitrogen content of sound and decayed wood of* A lebbeck, M. indica *and* T. arjuna *by* P. occidentalis, T. lactinea *and* P. sanguineus *respectively after different periods of incubation.*

Organisms	Hosts	Type of wood	Sound wood Mean* (%)	Decayed wood (4M)		Decayed wood (8M)	
				Mean* (%)	Increase (%)	Mean* (%)	Increase (%)
Polyporus occidentalis	*Albizia lebbeck*	Heart wood	0.96	1.30	35.41	2.24	133.33
		Sap wood	1.20	1.89	57.5	2.51	109.16
LSD (P=0.05)			0.04	0.04		0.04	
Trametes lactinea	*Mangifera indica*	Heart wood	1.01	1.32	30.69	2.20	117.82
		Sap wood	1.18	1.07	44.06	1.88	59.32
LSD (P=0.05)			0.11	0 11		0.11	
Pycnoporus sanquineus	*Terminalia arjuna*	Heart wood	1.03	1.28	24.27	2.10	103.88
		Sap wood	1.10	1.63	48.18	2 04	85.45
LDS (P=0.05)			0.06	0.06		0.06	

*Mean of 10 replicates.

loss of alpha fraction was recorded by *P. occidentalis*, while those beta- and gamma-fractions were recorded by *P. sanguineus* on their respective hosts.

Nitrogen content in wood increased with longer period of decay. It was 1.1 to 1.2 %in sound sap wood and 0.96 to 1.03 % in sound heart wood. It increased following decay of the wood and reached 1.8 to 2.5 % in sap wood and 2.1 to 2.25 %in heart wood after 8 months of decay.

DISCUSSIONS

Wood-rotting fungi possess differential ability to decay lignin, holocellulose and carbohydrates in sap wood and heart wood. The present study indicates that the test fungi were much more active in respective of heart wood. Higher resistance of heart wood could be attributed to its higher extrative contents than the sap wood, which inhibited the fungal attack (cf. Santra and Nandi, 1977).

The test-fungi proved to be capable of utilizing more efficiently substatial amount of lignin from the host woods They also showed variations in their relative rates of utilization depending on the fungus-wood combinatios. This was evidently due to differences in the production of extracelluar phenol-oxidizing enzymes, peroxidases and laccases which acted on the lignin through the oxidative process (cf. Kirk, 1975). Previous works showed that lignin in wood was removed more rapidly than polysaccharides by white-rot fungi (Kirk and Moore, 1972), indicating thereby that degradation of polysaccharides did not need simultaneous lignin degradation. Results of the present study suggest that

degradation of polysaccharides is not closely tied to lignin degradation and hence polysaccharides probably do not serve as a significant barrier to the degradation of much of the lignin in wood by white-rot fungi (Kirk, 1973). On the otherhand, lignin physically and perhaps to some extent chemically is known to serve as an effective barrier to the enzymatic degradation of the polysaccharides (Cowling and Brown, 1969 ; Pew and Weyna, 1962).

Proportionately, cellulose was removed much less than lignin by the fungi. Lowering in the yield of holocellulose or cellulose or both in wood as a result of decay reflects a general lowering of the degree of polymerization of the substances.

Results indicate that *P. occidentalis, T. lactinea* and *P. sanguineus* degrade, after 4 months, the polysaccharides in their respective hosts without showing any definite proportion to the lignin degradation. Thus,the fungi apparently behaved in contradiction to the general behavior of whiterot fungi and could not provide barrier to the polysaccharide degradation in wood as was evident from the simultaneously polysaccharide utilization. However, after 8 months, the expected higher proportional utilization of lignin was evident. Thus, the fungi proved to be very effective lignin degrader causing considerable degradation of the respective economic host woods.

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