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The Penetration of CCA Preservative on Four Under-utilized Malaysian Hardwood Species

MOHD. HAMAMI SAHRI, LING KWONG HUNG, JALALUDDIN HARUN and FAUJAN B.H. AHMAD[1]
Department of Forest Production
Faculty of Forestry , Universiti Pertanian Malaysia
[1]Department of Chemistry
Faculty of Science and Environmental Studies
Universiti Pertanian Malaysia,
43400 UPM Serdang, Selangor Darul Ehsan, Malaysia.

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ABSTRAK

*Kajian kebolehrawatan telah dijalankan ke atas empat jenis kayu kurang digunakan di Malaysia iaitu Mempening (*Lithocarpus spp.*), Nyatoh Nangka Kuning (*Pouteria malaccensis *(Clarke) Baehni), Pauh Kijang (*Irvingia malayana*)(*Oliv.*) dan Petai (*Parkia speciosa *Hassk). Dua species kayu terkenal iaitu Jelutong (*Dyera costulata *Hk.*f) *dan Merbau (*Intsia palembanica *Miq.) digunakan sebagai kawalan. Semua spesimen kering diawet secara tekanan-vakum menggunakan larutan pengawet kuprum arsenat berkromat (CCA) berkepekatan 3%. Kandungan lembapan dan ketumpatan kayu-kayu berkenaan ditentukan dahulu sebelum diawet. Kajian menunjukkan terdapat korelasi umum di antara ketumpatan kayu dengan penembusan pengawet CCA. Petai memberikan penembusan sisi paling dalam (5) diikuti oleh Jelutong (4.9), Nyatoh Nangka Kuning (3.6), Mempening* (1.75), *Pauh Kijang (1.5) dan Merbau (0). Spesies berketumpatan rendah seperti Jelutong, Nyatoh Nangka Kuning dan Petai memperlihatkan penembusan pengawet lebih dalam dibanding dengan spesies yang mempunyai ketumpatan tinggi* (Merbau, Mempening dan Pauh Kijang). *Penembusan sisi di antara enam spesies yang dikaji memberikan perbezaan yang bererti. Kajian menunjukkan keempat-empat jenis kayu yang kurang digunakan ini dapat diawet menggunakan pengawet CCA.*

ABSTRACT

*Four under-utilized Malaysian hardwood species, namely Mempening (*Lithocarpus *spp.), Nyatoh Nangka Kuning (*Pouteria malaccensis *(Clarke) Baehni), Pauh Kijang (*Irvingia malayana Oliv.*) and Petai* (Parkia speciosa *Hassk.) were selected for the treatability study. Two popular timber species, namely Jelutong (*Dyera costulata *Hk.* f.) *and Merbau (*Intsia palembanica *Miq.) were included as controls. The moisture content and density of all the selected timbers were determined prior to the treatment. All the seasoned specimens were vacuum-pressure treated with three per cent copper-chrome-arsenate (CCA) preservative (Celcure "A") solution. There is a general correlation between the density (specific gravity) of wood and the penetration of CCA-preservative. Petai exhibited the deepest side penetration (5.0) followed by Jelutong (4.9), Nyatoh Nangka Kuning (3.6), Mempening (1.75), Pauh Kijang (1.5) and Merbau (0). Lower density timber species (Jelutong, Nyatoh Nangka Kuning and Petai) attained deeper penetration when compared to higher density timber species (*Mempening, Merbau and Pauh Kijang). *Significant differences in side penetration were found among the six species. The four under-utilized Malaysian hardwood species are amenable to the vacuum-pressure treatment with CCA preservative.*

INTRODUCTION

The Malaysian tropical rain forest is richly endowed with approximately 3,000 species of trees, of which 677 species of timber trees in 168 genera can attain a girth of 1.2 metre at breast height. Of these, 402 species are considered commercially important in the timber market. The remaining 275 species, distributed in 101 genera, are classified as under-utilized or lesser-known species and have been left unexploited

(Kochumen 1973). Studies in the natural forest of Sabah showed that the under-utilized species form about 16.8 per cent of the total timber volume (Udarbe 1974). In Sarawak, a similar situation prevails. Out of the 890 species of timber trees, 142 are classified as the under-utilized species (Anon 1983).

With the rapid development and economic growth of the country, the demand for durable timber has increased greatly. One of the possible ways to overcome the impending timber shortage is to promote greater utilization of the under-utilized species. The quality and serviceability of non-durable timber can be improved by means of chemical preservation. However, treatability studies of Malaysian under-utilized timber species are limited (Mohd. Dahlan 1983 Pers. comm.). Kempas (*Koompassia malaccensis*) which was once considered as a naturally non-durable species, is now an important commercial timber through chemical preservation. Its service life can be extended by six times its normal life span by preservative treatment (Stubbs 1967).

There is a need to optimize the utilization of these forest resources. The penetration study of four under-utilized species was conducted with the following objectives:

i. To evaluate the penetration of copper-chrome-arsenate within and between selected timber species.
ii. To determine the factors which influence the penetration of this preservative.

MATERIALS AND METHODS

Timber Species

Four under-utilized species namely Mempening (*Lithocarpus* spp.), Nyatoh Nangka Kuning (*Pouteria malaccensis*), Pauh Kijang (*Irvingia malayana*) and Petai (*Parkia speciosa*) and two commercially well-known species, namely Jelutong (*Dyera costulata* Hassk.) and Merbau (*Intsia palembanica* Miq.) were used in this study. These species were selected based on their potential as utility timber and their availability in volume from mixed-dipterocarp forest. Jelutong and Merbau were included as control.

Preparation of Specimens

The average diameter of the selected trees was about 45 cm. Good sound logs were selected and transported to the sawmill for conversion into scantling sizes of 3 m lengths. The scantlings were cut into 5 cm × 5 cm × 60 cm specimens. Twenty specimens were prepared from each species. These specimens were dried for one month in a dehumidified room at a temperature of 25°C and relative humidity of 50%. The moisture content and specific gravity of each species were determined in accordance with Malaysian Standard MS 3.38 (Anon 1976).

Anatomical Study

Anatomical properties (pore diameter, pore density and lumen percentage) of these species were examined from prepared slides using a light microscope. 30 cross-sectional fields were measured for each species at 40x magnification. The measurements were made and recorded automatically with an image analyser model Quantimet Q520+.

Chromated-Copper-Arsenate Preservatives (Celcure A)

CCA product, Celcure 'A' was used to treat the wood samples. The preservative solution was prepared at 3% concentration. The wood specimens were tied together and placed in a treatment vessel of 60 cm diameter and 3 m length. The specimens were then treated with Celcure 'A' solution using the full-cell treatment process in accordance with schedule 3 of the Malaysian Standard, MS 3.39 (Anon 1976).

Penetration Study

Two freshly-cut discs of 15 mm thickness were obtained from each specimen (*Fig. 1*). Chrome-

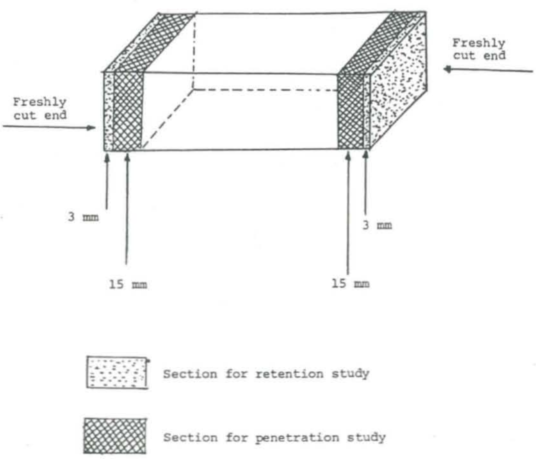

Fig 1: Cutting of specimen for penetration and retention studies.

Azurol-S solution was used to detect the presence of copper. The solution was sprayed evenly over the two freshly-cut treated wood surfaces. A deep-blue colour revealed the presence of copper. The depth of penetration was then measured with vernier calipers. The grading of side penetration was classified into six grades from no penetration (0) to complete penetration (5) (Koh 1979).

RESULTS AND DISCUSSION

Moisture Content and Density of the Treated Specimens

The final moisture content and the density of the six selected timber species are shown in Table 1. The moisture content ranged from 13.3 per cent for Nyatoh Nangka Kuning to 17.5 per cent for Jelutong. Results reveal that the density of the four under-utilized species varied. Pauh Kijang which is classified under the very heavy group, recorded the highest of 1201.6 kg/m^3 followed by Mempening (858.4 kg/m^3), Nyatoh Nangka Kuning (644.4 kg/m^3) and Petai (625.7 kg/m^3). The control samples, Jelutong had (457.2 kg/m^3) and Merbau 822 kg/m^3, are classified as light and heavy hardwood respectively. The moisture content level was well within the 25 per cent value as recommended for well seasoned timber for wood preservation treatment (Anon 1974, 1976).

TABLE 1
Average percentage of moisture content and densities of the six selected timber species

Species	Moisture content (%) Mean ± S.D	Density (kg/m^3) Mean ± S.D
Jelutong (*Dyera costulata*)	17.5 ± 0.3	457.2 ± 3.5
Petai (*Parkia speciosa*)	15.3 ± 0.2	625.7 ± 7.1
Nyatoh N.K. (*Pouteria malaccensis*)	13.3 ± 0.2	644.4 ± 7.1
Merbau (*Intsia palembanica*)	15.4 ± 0.3	822.0 ± 8.0
Mempening (*Lithocarpus* spp.)	17.2 ± 0.2	858.4 ± 9.2
Pauh Kijang (*Irvingia malayana*)	16.4 ± 0.2	1201.6 ± 8.9

S.D. : Standard deviation

TABLE 2
Average penetration rating for the six selected timber species

Species	Average penetration rating (mean ± S.D.)	Multiple comparisons by the Quade-test
Merbau (*Intsia palembanica*)	0	0 d*
Pauh Kijang (*Irvingia malayana*)	1.5 ± 0.14	1.5 c
Mempening (*Lithocarpus* spp.)	1.75 ± 0.14	1.75 c
Nyatoh Nangka Kuning (*Pouteria malaccensis*)	3.6 ± 0.13	3.6 b
Jelutong (*Dyera costulata*)	4.9 ± 0.07	4.9 a
Petai (*Parkia speciosa*)	5.0 ± 0	5.0 a

Grade: 0= No penetration 5= Full penetration
S.D:= Standard deviation
* Means with the same letter in this column are not significantly different at t = 0.05

Side Penetration

Table 2 shows the average visual ratings of the side penetration for the six selected timber species, pressure treated with CCA. The results indicate that the absorptive capabilities among these timber species varied. Among the four under- utilized species, Petai exhibited the deepest penetration (5), followed by Nyatoh Nangka Kuning (3.6), Mempening (1.75) and Pauh Kijang (1.5). By comparison, the side penetration for the controls, i.e. Jelutong and Merbau, were 4.9 and 0, respectively.

The rankings for the side penetration within and among the six selected timber species were tested using Kendall's coefficient of concordance (W-test) and were found to be unbiased. The differences in the side penetration of the CCA preservative among these species were examined using Quade's multiple comparison test.

The results show that there was no significant difference (P > 0.05) between the penetration rating for Petai (5) and Jelutong (4.9) and also between Mempening (1.75) and Pauh Kijang (1.5). The penetration of Merbau (0) and Nyatuh Nangka Kuning (3.6) were significantly different from the rest (Table 2).

Generally, sapwood can be treated more easily than heartwood (Anon, 1956; Jurazs and Wellwood 1965). In heartwood, extractives can infiltrate completely into the cell walls or they may occur as surface deposits or plugs in cell lumina. Their presence in wood affects the permeability and physical properties of wood (Hunt and Garratt 1967; Panshin and de Zeeuw 1980). This is probably one of the reasons which explains the untreatable nature of Merbau which contained yellowish deposits in the vessels of the seasoned specimen. A dark brown, sticky paste-like substance was observed on the specimens after the impregnation process. On the other hand, the higher absorptive capability of Jelutong, Mempening, Nyatoh Nangka Kuning, Pauh Kijang and Petai could probably be attributed to their low content of deposits or extraneous materials in the cell lumina (Wong 1976). The duration of treatment and intensity of pressure applied are among the factors which can influence the penetration and retention of preservatives (McLean 1960; Rak 1975). Lee and Ong (1972) observed that the penetration and salt retention of CCA preservatives in Meranti Tembaga (*Shorea leprosula* Miq.) could be increased by increasing the pressure and the period of impregnation.

The ability of a preservative to penetrate deeply into the structure of wood is important for satisfactory preservation (Rak 1975). For effective protection of wood against bio-degrading agents, the preservative must be evenly distributed in sufficient concentration throughout the vulnerable portions of wood. Preservative penetration could be more critical in the performance of treated wood than in preservative retention (Blew *et al.* 1970). Gersonde (1967) found that shallow penetration of preservative, though at high concentration levels of preservative in the outer zone, did not provide adequate protection to the treated wood. In other words, deep and uniform penetration of preservatives should be considered since achievement of minimum retention does not necessarily guarantee the effectiveness of any treated timber products against biodegradation (Hunt and Garratt 1967; Hickin 1972).

The results of penetration studies on these timber species indicate that some samples did not show any sign of being penetrated by CCA preservative, yet they possessed certain levels of net dry salt retention. This could be due to the salt deposited on the timber surface. Jalaluddin (1980) and Francis (1981) also observed similar results from their treatability studies on other Malaysian hardwoods.

Preservative penetration is influenced by various factors, particularly the anatomy of wood (Siau 1971; Nicholas 1973; Rak 1975; Yata *et al.* 1979, 1981, 1982). The longitudinal preservative flow path in hardwood species is mainly through the vessels. The lateral movements of preservatives to the adjacent element is through the small bordered or half-bordered pit pairs (Hunt and Garratt 1967; Nicholas 1973; Greaves 1974). The polar liquid was found to pass readily along the vessel in hardwoods (Anon 1964). The rate of movement is dependent on the liquid's polarity and temperature as well as the structure and density of the wood. This movement is of great practical importance in treating species of high density such as Mempening and Pauh Kijang.

Pore size (Siau 1971) and available flow passage of liquid (Panshin and de Zeeuw 1980) were reported to have a significant effect on the permeability of wood. The results show that Petai attained the deepest penetration followed by Jelutong, Nyatoh Nangka Kuning, Mempening, Pauh Kijang and Merbau, respectively. Such differences could be attributed to the variation in pore size, pore density and the percentage of lumen between the species concerned (Table 3). One should realise the complexity of the factors governing the penetration of the preservative into the wood. Deep penetration in Petai, Jelutong and Nyatoh Nangka Kuning may be due to a combination of factors involving pore diameter, pore density and higher lumen percentage. The number of pore per sq. mm of Petai and Nyatoh Nangka Kuning is about double that of Merbau and Mempening; and could have accounted for to the extent of the preservative penetration (Table 3). The relationship between percentage of lumen and degree of penetration is further illustrated in *Fig. 2.*

Kumar and Sharma (1982) reported that the penetration of preservatives is influenced by

TABLE 3
Average vessel (pore) diameter, pore density, lumen percentage and density of six Malaysian hardwood species

Species	Pore diam. (µm)	Pore/mm^2	Lumen percentage %	Density (kg/m^3)
Pauh Kijang	178.42	3.92	25.09	1201.60
Merbau	219.96	3.33	31.34	822.00
Mempening	206.59	3.00	41.61	858.40
Nyatoh N.K.	80.48	7.33	43.36	644.40
Petai	198.76	6.48	47.64	625.70
Jelutong	167.96	3.90	58.00	457.20

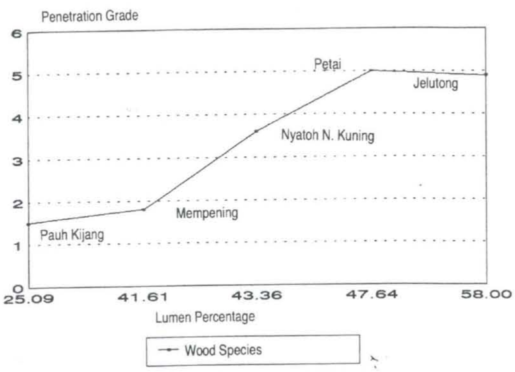

Fig. 2: Lumen percentage vs CCA penetration relationship of 5 Malaysian hardwood sepcies

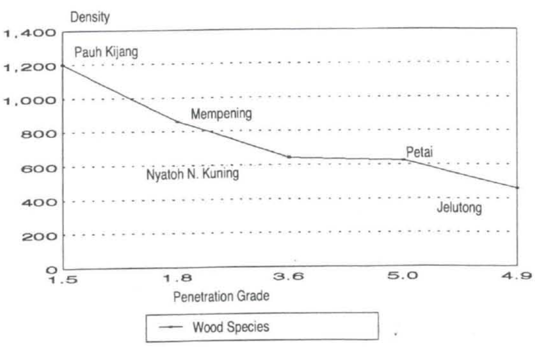

Fig. 3: Density vs CCA penetration relationship of 5 Malaysian hardwood species

the density of the wood. The relationship between the density and the penetration grades of these species is illustrated in *Fig. 3.* A lower specific gravity means less cell wall material and a correspondingly higher void volume; and a higher void volume corresponds to a higher amount of preservative that could be absorbed. Observations in this study reflect a general correlation between the density of wood and the penetrability of the solution. Species with a lower density such as Jelutong, Petai and Nyatoh Nangka Kuning exhibited good penetration, while those with a higher density, such as Mempening, Merbau and Pauh Kijang showed poor penetration. Similar observations were observed by Cheow (1978) and Koh (1979).

CONCLUSION

This study shows that Petai and Nyatoh Nangka Kuning exhibited better penetrability to CCA preservative than Mempening and Pauh Kijang. There is a general correlation between the density of the wood and the penetration of the solution, i.e. higher density species tend to absorb less preservative. To justify the durability and performance of these species, more extensive studies such as grave-yard tests should be carried out. The serviceability of timber can be improved through proper preservation techniques. Our study describes one such technique which could enhance wider utilization of the under-utilized species, particularly the light hardwoods, which could help overcome the impending shortage of durable timber in Malaysia by supplementing traditional resoures.

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