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PROPERTIES OF VENEER AND MOULDED CHAIR FROM SESENDUK (*ENDOSPERMUM DIADENUM*)

[1]Yanti AK, [1]Siti Zaliha A, [1]Khairul M, [2]Izran K, [1]Mohd Jamil AW & [1]Tuan Anis Nadia TMS
[1]Forest Research Institute Malaysia (FRIM), 52019 Kepong, Selangor, Malaysia
[2]Johor Biotechnology and Biodiversity Corporation (J-Biotech), Bio-XCell Malaysia, No. 2, Jalan Bioteknologi 1, Kawasan Perindustrian SiLC, 79200 Iskandar Puteri, Johor

INTRODUCTION

Being one of the most popular raw materials for furniture industry in Malaysia, the continuous demand for rubberwood has led to shortage of supply and escalating market price. Timber of *Endospermun diadenum* (or locally known as sesenduk) is a potential alternative to rubberwood. Sesenduk is a fast-growing plantation species with a comparable mechanical and physical properties, and the colour of the wood is bright yellow when fresh and darkening to light brown on exposure (Khairul et al. 2010). Sesenduk is also suitable for particleboard, veneer and plywood. In manufacturing engineered woods such as plywood made of lignocellulosic material, study on the recovery rate is very important. It refers to the ratio of veneer volume to log volume which is affected by log diameter (Kewilaa 2007). Veneer recovery is defined as the volume of veneer produced from a given volume of log or block which is affected by several factors such as log diameter, wood species, age, wood quality and specific gravity (Sastrodiharjo 1977, Kamil 1970). Veneer recovery can help manufacturers to optimize their processing system in order to achieve the targeted veneer production volume. Usually, the veneer recovery increases in line with the increase of log diameter (Fonseca 2006). Thus, the objectives of this research were to determine the veneer recovery rate and the surface quality properties of the sesenduk veneers. Using the hot press technology, furniture prototypes of curve-shaped design were produced from the sesenduk veneer. Surface roughness and surface checking tests were carried out to evaluate the surface quality. In the local industry, furniture productions of the curved forms are very limited due to technology restriction and material suitability. The results of this study provide the technical knowledge for the fabrication of curve-shaped furniture product from sesenduk timber.

MATERIALS AND METHODS

Sample trees of sesenduk were collected from Kepong Botanical Garden in Forest Research Institute Malaysia (FRIM). Sesenduk trees of 10 years old with 20–30 cm diameter were chosen for a peeling study. The trees were marked as tree No.1 and No. 2. Each tree was divided into several billets of 1.5 m (5 feet) long and labelled in alphabetical order (A, B, C, D & E) from basal to top section as shown in Figure 1.

Before peeling, all billets were manually debarked to avoid any damage on the peeler knife. Initial and round up diameters for both ends were recorded. The first stage of the peeling process was conducted using a peeler with chuck and the remaining billets were transferred to a spindleless peeler for improved recovery (Figure 2). The total length of veneers produced were marked and measured for a recovery analysis. Veneers with length less than 10 cm were considered as waste. The spur trim and core diameter were also recorded. For recovery study, all data were collected according to ITTO Testing Method (Tan et al. 2010).

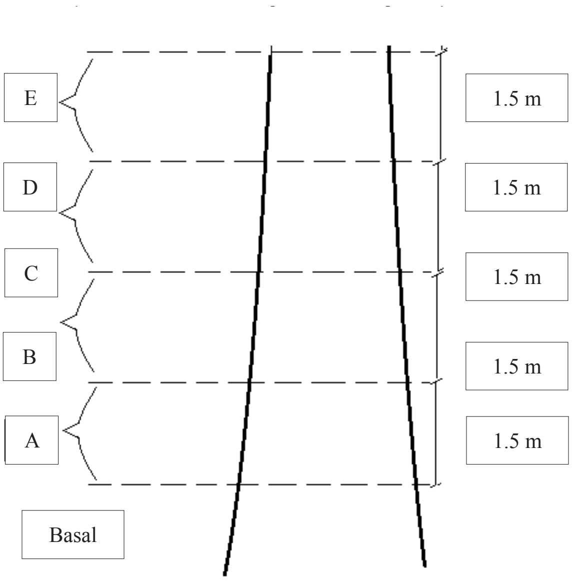

Figure 1 Tree divided into billets of 1.5m length

The total volume of veneer (V_v) , in m^3,was computed using the formula:

$$V_v = t \times w \times \Sigma L_v \times 10^{-6}$$

Where t = mean veneer thickness (cm)
w = width of veneer sheets (cm) (parallel to the grain)
L_v = length of veneer (cm) (perpendicular to the grain)

The round-up billet volume, in m^3, was computed by using the formula:

$$V_r = \pi \times L_b \times (D^2/4) \times 10^{-6}$$

Where L_b = Length of billet (cm)
D = Diameter of round-up billet (cm)

Figure 2 Peeling process

Veneer with defects such as dead knot, loose knot, borer track or rotten were not considered in the recovery rate calculation. Sesenduk veneers produced with 1.2 ± 0.2 mm thickness were dried to 8–10% MC using the roller conveyor dryer. Tests for surface roughness and surface check were conducted at the Timber Research & Technical Training Centre (TRTTC), Kuching, Sarawak.

Selected dried veneers were chosen for producing the moulded chair prototype. The veneers were arranged in perpendicular arrangement of 11 layers (plywood type) (Figure 3). Urea formaldehyde (UF) resin was used as adhesive and applied onto the veneers using a glue spreader. UF resin was selected due to its suitability for interior products. The bonded veneers were placed onto a metal mould before being hot-pressed at 110 ºC with a pressure of 6.89 MPa (1000psi) for 10 minutes (Figure 3). Later, the curved product was put on a cold mould for conditioning purpose for about one hour. To obtain the required shape and type, the curved product was cut, trimmed and edged using a copy shaper and a CNC machine. Sealer and lacquer were applied for finishing before the curved product was assembled onto metal legs. The final moulded chair was then tested according to BS EN 12520:2010 standard for performance.

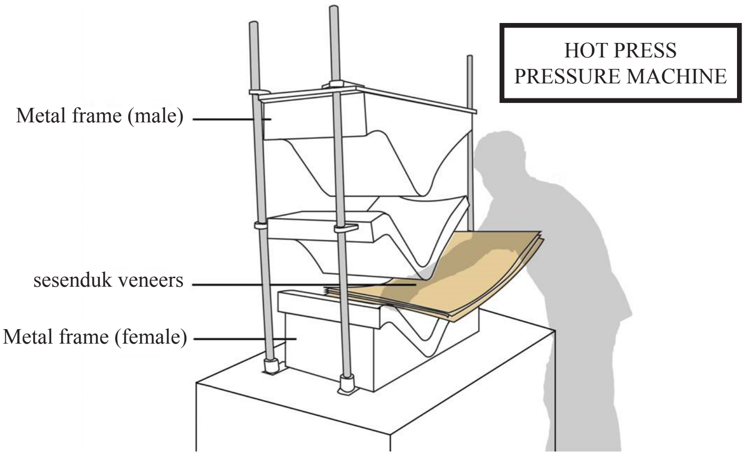

Figure 3 Hot press process

RESULTS AND DISCUSSION

Veneer recovery

Table 1 shows the percentage of veneer recovery for nine logs. Billet 1-E was rejected because it was not straight and would cause difficulty for veneering.

Billets 1-A, 1-B, 1-C and 1-D showed the average recovery rates of 56%, 43%, 19% and 29% respectively. While billet 2-A, 2-B, 2-C, 2-D and 2-E showed average recovery rates of 56%, 45%, 23%, 59% and 57% respectively. The recovery rate from billet C (which was the middle part of the tree) showed the lowest percentage. The factors that caused the lower yield were cracks and end splits of the logs during the peeling process.

From Table 1, billets 2-A, 2-D and 2-E showed the highest recovery of 59% and 57% respectively. This was due to a low waste loss despite having comparatively smaller initial diameter and small round up diameter.

Table 1 Mean recovery percentage

Sample No	Diameter (cm)	Diameter round-up (cm)	Veneer produced (cm)	Recovery rate (%)
1-A	26.25	19.42	2171.00	56.00
1-B	21.86	16.23	1177.00	43.90
1-C	20.75	18.14	470.00	19.00
1-D	17.00	16.55	444.00	29.96
2-A	22.40	14.96	1665.00	59.00
2-B	20.63	16.87	1094.00	45.86
2-C	20.13	15.76	524.00	23.07
2-D	19.00	15.60	1214.00	59.00
2-E	18.25	13.62	600.00	57.00
Mean	20.70 (2.7)	16.35 (1.7)	1039.89 (598.09)	43.64 (15.91)

Note : Values in parentheses are Standard Deviations (SD)

Surface roughness

Sesenduk is categorised as a low density timber (385–655 kg/m^3) and this low density had contributed to the roughness of the veneer surface. Table 2 exhibits the surface roughness values for sesenduk veneers from two sample trees. The mean surface roughness was 139.38 µm. Surface roughness is important because it will influence the veneer quality. Decrease of surface roughness can improve glue wettability and increase interfacial bonding between veneers to produce engineered woods, which have good bonding strength (Tiryaki et al. 2014). However, surface that is too smooth can cause the bonding strength of the engineered woods to decrease rapidly (Aydin 2004).

Table 2 Surface roughness value for sesenduk veneer

Tree	Ra (µm)	Rmax (µm)	Rz (µm)
1	14.88	145.51	106.14
2	13.5	133.25	90.75
Mean	14.19	139.38	98.45

Where: Ra= surface roughness (arithmetic average)
Rmax= maximum surface roughness
Rz= surface roughness depth

Test for surface checking

Surface checking is one of the machining defects which will decrease the veneer quality during product manufacturing. The number and depth of surface checking were identified on the sesenduk veneers through this test by using a surface checking device. Table 3 shows that the mean depth of checking in sesenduk veneers was approximately 0.67 mm.

Table 3 Results for surface checking

Tree	No of checks	Depth of checks (mm)
1	11	0.65
2	13	0.69
Mean	12	0.67

PERFORMANCE TEST ON CHAIR MADE FROM SESENDUK VENEERS

The performance tests for moulded chair (Figure 4) made from sesenduk veneer were conducted at the Furniture Testing Laboratory (FTL), Forest Research Institute Malaysia (FRIM). Only one prototype chair was tested for all parameters.

Figure 4 Moulded chair made from sesenduk veneer

Table 5 Performance test of the prototype chair made of sesenduk

No.	Test BS EN 12520 : 2010	Test parameters	Result
1	Forward overbalancing	Seat Load : 600 N Horizontal Force : 20 N	Pass
2	Sideway overbalancing all seating without arms	Seat Load : 600 N Horizontal Force : 20 N	Pass
3	Rearward overbalancing all seating with back	Seat Load : 600 N Back Force : 155 N	Pass
4	Seat & back static load test	Seat Force : 1300 N, 10 times Back force : 450 N, 10 times	Pass
5	Seat front edge static load test	Force : 1300 N, 10 times	Pass
6	Seat & back fatigue	Seat Force : 1000 N, cycle : 25000 Seat Force : 300 N, cycle : 25000	Pass
7	Seat front edge fatigue	Force : 800 N, cycle : 20000	Pass
8	Leg forward static load test	Force : 400 N, Seat load : 1000 N, 10 times	Pass
9	Leg sideway static load test	Force : 300 N, Seat load : 1000 N, 10 times	Pass
10	Seat impact	Drop height : 180mm, 10 times	Pass
11	Backward fall test	Number of impacts : 5 times, Force : 10 N	Pass

The test results in Table 5 showed that the sesenduk chair had fulfilled the standard requirement according to the BS EN 12520:2010 requirements. The European standard imposes the minimum requirements for the safety, strength and durability for all type of seating for adult, which the chair made from sesenduk has surpassed them all. These results could be used as a selling point for this chair.

CONCLUSION

The study showed that the sesenduk veneers has favourable physical and mechanical properties appropriate for moulded chair making. The prototype chair made from moulded sesenduk veneer has passed all the requirements for furniture performance which entails to the stability, strength, fatigue, impact and safety criteria. The results demonstrated that sesenduk veneer has the commercial viability to be used in the wood-based industry. With better promotional activities, veneers from sesenduk can provide as an alternative raw material such that the dependence on rubberwood in the furniture industry is reduced.

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This paper reports on the recovery rate, surface quality and the fabrication of a moulded chair prototype from sesenduk (*Endospermum diadenum*) veneer. Surface roughness, surface check and contact angle tests were carried out to determine the veneer properties. Sample trees were obtained from the campus of Forest Research Institute Malaysia (FRIM). Processed logs were peeled using a double chuck rotary peeler for round-up until core section and subsequently transferred to a spindleless peeler for an improved recovery. The average recovery rate for sesenduk veneer was 43.64% in dried condition. Surface roughness (Rz) value was 98.45 μm while the number and surface depth checking were 12 times of occurences and at mean depth of 0.67 mm respectively. A moulded chair from sesenduk veneer was fabricated by using a hot press machine. Strength, durability and safety requirement for domestic seating were tested at the Furniture Testing Laboratory (FTL) FRIM. All tests according to BS EN 12520:2010 were favourable. The overall findings showed that the veneers from sesenduk can be formed into curve-shaped products and suitable to be used in veneer-based industries, especially for furniture making.

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