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Development of Coconut Palm Wood Seasoning Schedules

Gayathri Mukundan, E. V. Anoop, Anish Mavila Chathoth, and Comath Shibu*

Kerala Agricultural University, Department of Forest Products & Utilization, College of Forestry, Thrissur, Kerala, India pin-680656

* Corresponding author. Email: cshibu999@gmail.com

Abstract

Coconut palm is a versatile palm in the tropical and subtropical regions. This study attempts to standardize moisture content-based kiln seasoning schedules for high-density and medium-density coconut palm wood and also understand the relationship between Pilodyn Penetration Depth (PPD) and basic density for three density classes (high, medium, and low). A quick drying test was conducted to study the degree and type of drying defects, namely surface cracking, end splitting, honeycombing, and deformation. Defects were graded according to the Terasawa (1965) scale. The baseline parameters, such as initial dry-bulb temperature, final dry-bulb temperature, and the wet-bulb depression for high and medium-density coconut palm wood, were chosen by considering the major seasoning defects. The samples were subjected to different seasoning schedule treatments in a convection kiln to determine the best treatment based on the grading of defects. The optimal kiln drying schedule for 25 mm thickness, high-density coconut palm wood was: initial dry-bulb temperature (DBT) 45°C (relative humidity 87%), wet-bulb depression (WBD) 2°C, and final dry-bulb temperature 80°C. For medium-density wood, the schedule was: initial DBT 50°C (relative humidity 88%), WBD 2°C, and final DBT 80°C. The ideal drying period was 11 days for high-density coconut palm wood and 12 days for medium-density coconut palm wood. The schedule developed has good potential for industrial application in seasoning coconut palm wood with reduced defects in coconut-growing regions of the world.

Key words: Coconut palm wood, seasoning schedule, kiln drying, Terasawa scale

Introduction

Asia-Pacific region has the lowest per capita forest cover (0.18 ha), which is just one-third of the world's per capita forest cover (0.64 ha) (FAO, 2019). Considering the growing population, per capita forest cover is declining in most countries, including India. According to ITTO (2010), East Asia (mainly China) and South Asia (mainly India) will rely heavily on imports, thereby creating intense pressure on forest-deficit countries. The global trade in tropical primary wood products is concentrated within the Asia-Pacific region. Tropical sawn-wood and veneer log exports from Asia-Pacific producers account for about three-quarters of global exports (ITTO, 2017). According to Pryor (2019), the US hardwood exports to India with sawn hardwood rose to 72%, and veneers increased by 4%. In 2019, China's hardwood log imports fell to 15% (15.31 million m3; 25% of the total national log imports) with a strong preference for teak (ITTO, 2020). Alternate sources of timber include legal sources from the northern and western hemispheres, predominantly of temperate species (teak etc.) and illegal sources (from tropical countries). The supply of plantation-grown species like Indian rubber wood (*Hevea brasiliensis*) is declining due to the steep and unstinted fall in the price of its latex. Apart from that, Acacias and Eucalypts are posing serious ecological and social concerns. These aspects imply an insufficient raw material base for the timber industry in the future. The prospects of proper utilization of lesser-known timber species gains importance in this context (Basri et al., 2009). Potentially valuable yet underutilized hardwood substitutes such as palm 'wood' from coconut palm stems provide a viable and durable industrial raw material.

India has a vast coastline of about 7,517 km, both on the Western and Eastern coasts combined, and the state of Kerala, which has the largest planted area alone, has a 580 km coastline where large numbers of tall senile palms are present. India stands third in terms of the total area of coconut palms (2.14 million hectares), which constitute roughly 20 per cent of the total planted area. However, a large number of these palms are old, senile, and diseased (CDB, 2016). The large number of old and senile palms in Kerala and the neighboring states of Tamil Nadu necessitates large-scale felling of such tall palms and replanting with high-yielding varieties. This will increase the supply of raw materials, which are equally durable as conventional species for construction and furniture industries, albeit at a lower price.

Proper utilization of any particular wood species must be based on basic and processing properties. Drying properties are the most important processing properties (Effah, 2014). An appropriate seasoning process will be the main key to efficient utilization to ensure good quality for wood products (Hoadley, 2000). For most timber products, pre-seasoning is essential. It reduces not only the presence of water in the wood but also reduces the danger of movement of water once timber is in use. The art of successful seasoning lies mainly in maintaining a balance between the evaporation of water from the surface of the timber and the movement of water from the interior of the wood to the surface (Desch and Dinwoodie, 1981).

Coconut palm wood has an initial moisture content ranging from 60% in high-density wood (above 600 kg/m³) to as high as 230% in low-density wood (below 400 kg/m³) (Killmann, 1983). Much emphasis is placed on producing seasoned timber as quickly and economically as possible within the quality limits of specified standards. This study analyzed the green moisture content, basic density, shrinkage, and drying tests to determine drying rates and associated defects of coconut palm wood. This study aims to develop a kiln seasoning schedule for coconut palm wood based on a quick drying method for high-density and medium-density (basic density 400-600 kg/m³) coconut palm wood utilization. Low-density wood was excluded from the seasoning schedule development as it is unsuitable for making load-bearing structures.

Materials and Methods

The study was conducted in the Forest Products and Utilization laboratory, College of Forestry, KAU, Vellanikkara. Physical properties (moisture content, basic density, and shrinkage) and drying behavior of coconut palm wood were investigated through standard procedures.

Conversion of samples

Mature West Coast Tall (WCT) coconut palm trees (*Cocos nucifera*) exceeding 40 years of age and 11 m in height were selected for sample collection. The trees were collected from Thrissur district, Kerala, India (10.5276° N, 76.2144° E). Samples were then prepared according to the prescribed dimensions outlined in Indian Standard IS: 1708 (1986). For moisture content and basic density analysis, samples with dimensions of 20 mm × 20 mm × 25 mm were prepared following IS: 1708 (1986) specifications. Volumetric shrinkage analysis employed samples measuring 20 mm × 20 mm × 60 mm, as per the same standard. Samples of size 20 mm × 100 mm × 200 mm (thickness, width and length) were used for the quick drying test to understand the drying behavior.

Physical properties

1. Basic density

Thirty samples of size 20 mm × 20 mm × 25 mm were oven-dried at 103 ± 2°C to constant weight, and their oven-dried weight was calculated using a precision electronic balance (Shimadzu AUY 220). Basic density was calculated using the formula.

$$\text{Basic Density} = \frac{\text{Oven Dry Weight}}{\text{Green Volume}}$$

1.1. Indirect estimation of Basic density

Pilodyn Penetration Depth (PPD) in mm was estimated using a Non-Destructive Tool (NDT) Pilodyn 6 J (Fujiteck) for 30 samples from each of the three density classes (inner core, semi-dermal and outer dermal wood) and regression analysis was carried out to understand the relationship between PPD and basic density of coconut Palm wood. The indirect estimation can also provide a rapid estimate of wood density for grading once seasoning schedules are developed.

2. Moisture content

Ten samples of each high, medium and low-density wood type (with dimensions of 20 mm × 20 mm × 25 mm) were used to determine their moisture content. The initial weight (Wi) of each sample was measured using an electronic balance (Shimadzu AUY 220) with a precision of 0.001 g. The samples were then oven-dried at 103 ± 2°C until a constant weight (Wod) was achieved. Moisture content (MC) on a dry basis was subsequently calculated using the following formula:

$$\text{Moisture Content} = \left[\frac{(W_i - W_{od})}{W_{od}}\right] \times 100$$

Where Wi is the initial weight of the specimen (in g), and Wod is the oven-dry weight of the same specimen.

3. Volumetric shrinkage

Ten samples of each type (high, medium, and low-density wood) with dimensions of 20 mm × 20 mm × 60 mm were used to determine the volumetric shrinkage. The test followed the procedure prescribed in Indian Standard IS 1708 (part 3) 1986. One-way analysis of variance (ANOVA) was used to determine the average volumetric shrinkage differences across the density classes. The volumetric shrinkage was calculated by using the following formula:

$$\text{Volumetric shrinkage} = \left[\frac{(V_i - V_{od})}{V_{od}}\right] \times 100$$

Where Vi is the initial volume of the specimen in green condition (in cc), Vod is the oven-dry volume of the same specimen.

Quick drying test

Ten samples of size 20 mm × 100 mm × 200 mm for both high and medium-density wood were placed edgewise in an oven at 103°C ± 2°C until constant weight was obtained. Each specimen was taken from the oven every hour for the first 8 h for weight measurement and to evaluate initial drying defects (end and surface checking). The same procedure was repeated at 24th and 30th h on the second day and 48th h (third day) to determine the weight and defects. The measurements and observations were repeated until the samples achieved constant weight. The drying defects of the samples were compared with the criteria set by Terazawa (1965). The specimens were given scores based on the classification of drying defects. Subsequently, control parameters such as the initial dry-bulb temperature, initial wet-bulb depression (difference between dry-bulb temperature and wet-bulb temperature) and final dry-bulb temperature were determined.

Table 1. Classification of defects based on Terazawa (1965) and modified by Jankowsky (1992) and method for Classification of degree of deformation on the section

	Checks		Deformation
Level of defects	**End checks (mm)**	**Surface check (mm)**	**A-B (mm)**
1.	No checks	No checks	0 - 0.3
2.	Small checks L < 10, W< 0.8	Small checks L<50, W<0.5	0.3 - 0.5
3.	Small checks L >10, W< 0.8	Small to medium checks L < 100, W > 5, W < 1, W > 1	0.5 - 0.8
4.	Medium check L >10, W< 0.8	Small to medium checks L < 100, W > 5, W < 1, W > 1	0.5 - 0.8
5.	Medium to large checks L > 10, W > 0.8, W < 1.5	Large Checks L > 150, W > 1.5	1.2 - 1.8
6.	Large checks L > 10, W< 1.5	Large Checks L > 150, W > 1.5	1.8 - 2.5
7.	Large checks L > 10, W< 1.5	Large Checks L > 150, W > 1.5	2.5 - 3.5
8.	Large checks L > 10, W< 1.5	Large Checks L > 150, W > 1.5	Over 3.5

L= Check length, W = Check width, mm=Millimeter

1. Evaluation of drying defects

A scale of 1 to 8 was used to evaluate initial checks and deformation (Table 1), while a scale of 1 to 6 was used to evaluate honeycombing (Table 2). The condition of maximum checks was compared to the checking criteria established by Terazawa (1965), and the samples were subsequently given a corresponding score based on the classification. In saccordance with the methodology established by Terazawa (1965) and subsequently employed by Brandão & Jankowsky (1992), Basri et al. (2005), Tan et al. (2010), Ofori & Brentuo (2010), Effah (2014), and Kumar et al. (2018), each wood piece was assigned a defect score based on the severity and prevalence of defects.

Table 2. Classification of degree of honeycomb (Internal checks)

Class	1 (mm)	2 (mm)	3 (mm)
Degree of internal check	No check	Wide or Narrow checks	2-3 wide checks; 4-5 narrow check; 1 wide and 3 narrows

Class	4 (mm)	5 (mm)	6 (mm)
Degree of internal check	4-5 wide; 9 narrow; 1 wide and 4-6 narrow	6-8 wide; 15 narrow; 4 wide and 6-8 narrow	15-17 wide or continuous checks

2. Evaluation of initial check

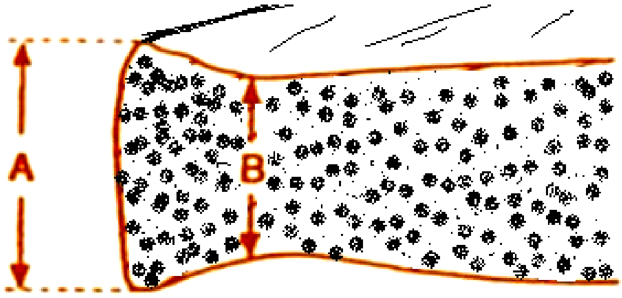
The weight and drying defects of each test sample were measured at one-hour intervals for an initial period of 8 h of drying in order to evaluate defects that evolved during the early stages of drying. The same procedure was repeated after the 24th, 30th and 48th hs of drying to determine the weight and defects. The measurements and observations were repeated until the samples achieved constant weight. Finally, the degree of initial checks was assessed on the basis of Terazawa (1965) criteria modified by Brandão & Jankowsky (1992).

3. Evaluation of honeycombs

Once the test samples attained constant weight, the samples were cross-cut in the middle part to measure the degree of honeycombing. The size and number of honeycombs on the newly exposed surfaces were recorded based on the classification of the degree of honeycombing (Table 2). Honeycombing is a specific type of cracking or splitting that occurs during the drying process of wood. Internal pressures cause an array of radial and circular cracks to form within the inner parts of the wood, resulting in a honeycomb pattern texture.

4. Evaluation of deformation

The thickness at points A and B at the four edges of the two halves (newly exposed surface) were measured using a digital calliper, and the differences between the thickest (A) and the thinnest (B) sizes for each of the four positions were then determined (Figure 1). Mean values of the four differences, the thickest and thinnest (A-B) for the edge of each sample were assessed and classified as a cross-sectional deformation based on the prescribed classification (Table 1).



A: The portion thickest at the edge
B: The portion thinnest 1-2 cm apart from the edge

Figure 1. Method for evaluating deformation on the section

5. Determination of initial temperature, wet-bulb depression and final dry-bulb temperature

After the determination of sample scores for various defects (defects degrees), the respective drying parameters, such as initial dry-bulb temperature, initial wet-bulb depression and final dry-bulb temperature, were chosen from the predetermined chart (Table 3) prescribed for the level of checks, deformation, and honeycombing.

Selection of schedules for moisture content, dry-bulb temperatures and wet-bulb depression

Due to the lack of accepted schedules exclusively for coconut palm wood, appropriate schedules for moisture content, dry-bulb temperatures and wet-bulb depression were chosen by considering high-density coconut palm wood under the hardwood category and medium-density coconut palm wood under the category of softwood, respectively. Based on the parameters such as initial and final dry-bulb temperature, initial wet-bulb depression and initial moisture content, the corresponding schedules were selected from the Table prescribed by F.P.L. in Madison U.S.A (Simpson, 1991).

1. Determination of Relative Humidity (RH) and Equilibrium Moisture Content (EMC)

The relative humidity and equilibrium moisture content corresponding to dry-bulb and wet-bulb temperatures were estimated using a Psychrometric Chart (Simpson, 1991).

Table 3. Classification of Initial DBT, Initial WBD Final DBT based on level of checks, deformation, and honeycombing

Variety of defecet	Drying condition	Defect degrees			
		1	2	3	4
I. Surface check	Initial DBT °C	70	65	60	55
	Initial WBD	6.5	5.5	4.3	3.6
	Final DBT °C	95	90	85	80
II. Deformation	Initial DBT °C	70	66	58	54
	Initial WBD	6.5	6	4.7	4
	Final DBT °C	95	88	83	80
III. Honeycomb	Initial DBT °C	70	55	50	49
	Initial WBD	6.5	4.5	3.8	3.3
	Final DBT °C	95	83	77	73

Drying schedule test

The kiln treatment was designed after quick drying tests. The highest score was selected from each type of drying defect (surface cracking, end splitting, honeycombing and deformation), and the treatment schedules were developed for each highest score based on the Terazawa (1965) method. The developed treatment schedules were imposed in a convection kiln to determine the best schedule suited for high-density and medium-density coconut palm wood. A total of forty samples were used for each treatment.

Results and Discussion

The study investigated the physical properties of coconut palm wood in order to standardize moisture content-based kiln seasoning schedule for high-density and medium-density coconut palm wood under the prevailing local climatic conditions (Average daily high temperature of 32°C and relative humidity of 60-67 %).

Physical properties of coconut palm wood

1. Basic density and Pilodyn Pin Penetration Depth (PPD)

Basic density values ranged from 214.83 kg/m³ to 977.19 kg/m³ for the coconut palm wood samples. The pilodyn penetration depth was recorded as 0 to 11 mm for high-density coconut palm wood, 12 to 35 mm for medium-density, and 38 to 42 mm for low-density coconut palm wood. Regression analysis by considering density as the dependent variable and PPD as the independent variable showed a linear relationship (Figure 2). With a significant R^2 value of 0.94, the analysis revealed a strong linear relationship between density and pilodyn penetration depth (PPD). This suggests that PPD can be a reliable predictor of density in coconut palm wood within the tested range. The specific equation for this relationship is as follows:

$$Y = -0.02 (X) + 1.08$$

An inverse relationship is observed between pilodyn penetration depth (independent variable) and density (dependent variable). This variation from the core of the trunk to the dermal area can be attributed to several factors: (1) the number of vascular bundles (VBs) in the trunk, (2) the dimensions of the cell walls of vascular bundles, and (3) the cell wall thickness of the parenchyma, which acts as the ground tissue of timber. These factors contribute to the findings of Fathi & Frühwald (2014) that the density of palm wood increases from the inner core wood to the outer dermal wood, unlike other timber species. The density variation certainly affects coconut palm wood's strength and drying properties.

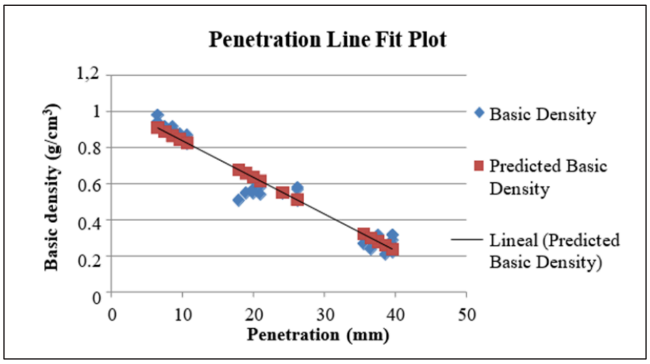


Figure 2. Relation between basic density (g/cm+) and penetration depth (mm) coconut palm wood

2. Moisture content

Moisture content in the wood is one of the key factors in the utilization of coconut palm wood. The higher moisture content in coconut palm wood makes it more susceptible to mold and fungi. This is mainly attributed to the non-homogenous nature of palm wood, as stated by Killmann (1983). The moisture content of freshly cut coconut palm wood samples showed significant variation between different density classes. The mean moisture content for high-density coconut palm wood was 52.67 %, while a higher value of 103.96 % was observed for medium-density coconut palm wood. The moisture content profile showed a similar trend as that of dicotyledon wood in green conditions, in which the percentage moisture content values decreased drastically with increased wood density. This may be due to the higher number of parenchymatous cells in medium-density wood and the higher number of fibrous bundle caps in high-density coconut palm wood. The study of Bakar et al. (2013) also goes in tune with the present findings.

3. Volumetric shrinkage

Results on volumetric shrinkage of high, medium, and low-density coconut palm wood are presented in Table 4. Volumetric shrinkage ranged from 7.68% to 12.86% for high-density coconut palm wood, with a mean of 9.90%. For medium-density coconut palm wood, the volumetric shrinkage ranged from 9.03% to 13.74%, with a mean of 11.01%. The range of volumetric shrinkage for low-density coconut palm wood was 9.14% to 20.27%, with a mean of 12.03%. Interestingly, despite variations in density, no significant differences were observed in volumetric shrinkage across the wood classes. This may be attributed to the higher proportion of soft tissues within the lower-density samples. Richolson & Swarup (2007) reported similar shrinkage values for varying density classes of coconut palm wood.

Table 4. Mean physical properties of coconut palm wood of different density classes

Density classes	Moisture content (%)	Volumetric shrinkage (%)
High-density	52,67 ± 1,3[a]	9,90 ± 0,53
Medium-density	103,95 ± 0,83[b]	11,01 ± 0,49
Low-density	186,54 ±1,2[c]	12,03 ± 1,04
P Value	<0,001**	0,140[ns]

** significant at 1per cent level and 'ns' indicate non-significant

Susceptibility to drying defects

The results obtained from the quick drying test are shown in Table 5. It includes the types of defects observed, the maximum score obtained for each defect, and drying parameters (Initial DBT, Initial WBD, and Final DBT) for high-density and medium-density coconut palm wood. Among the defects, surface cracking and end splitting were found to be more severe in both high- and medium-density wood samples during the initial stages of the test. However, these defects became less noticeable in the final drying stages (Plate 1).

Kiln seasoning schedules were chosen based on the severity of the observed defects. Four unique schedules (KSH1, KSH2, KSH3, and KSH4) were selected for high-density wood, while three schedules (KSM1, KSM2, and KSM3) were chosen for medium-density wood. Since the score obtained for initial surface checks (Surface cracking and end splitting) of the medium-density samples were the same, it was considered a single treatment.

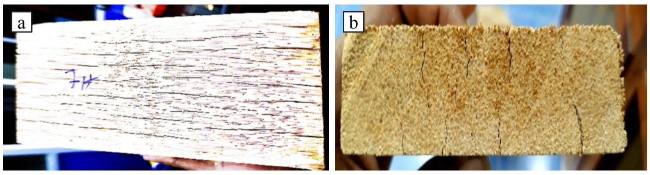


Plate 1. (a) Surface checks (b) End checks at the initial stages of quick drying test

Table 5. Drying schedule treatments used in the convection kiln to determine the best drying schedule for high and medium-density coconut palm wood

Kiln seasoning schedule treatment	Defect Observed	Max. score obtai-ned	Initial DBT (°C)	Initial WBD (°C)	Final DBT (°C)
c	Surface cracking	8	45	1,8	79
KSH2	End splitting	7	47	2,0	80
KSH3	Honey-combing	3	50	3,8	77
KSH4	Defor-mation	4	54	4,0	80
KSM1	Surface cracking, End splitting	7	47	2	80
KSM2	Honey-combing	3	50	3,8	77
KSM3	Defor-mation	5	50	0,6	77

KSH denotes- Kiln Seasoning schedule for High-density coconut palm Wood

KSM denotes- Kiln Seasoning schedule for Medium-density coconut palm Wood

The highest degree of surface cracking observed in high-density wood was 8, while medium-density wood reached a maximum score of 7. The increased severity of defects in coconut palm wood is attributed to variations in moisture content and anatomical orientation of tissues. The quick drying defects distinctly displayed the higher susceptibility of high-density coconut palm wood to defects compared to medium-density wood. This could be explained by the rigid tissue composition in high-density wood, which restricts free moisture diffusion during the drying process.

Plate 2. 25 mm thick coconut palm planks stacked in the convection Kiln

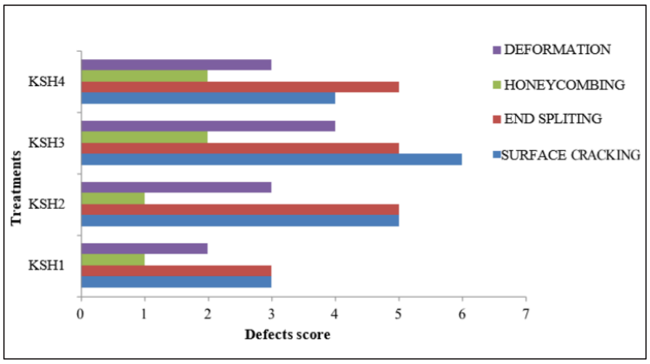


Figure 3. The treatment wise defects scores obtained for high-density coconut palm wood

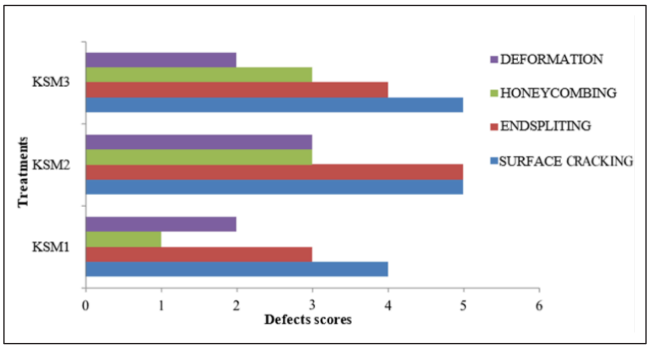


Figure 4. The treatment wise defects scores obtained for medium-density coconut palmwood

Testing of drying schedule

Treatment schedules were applied to 25 mm thick planks of coconut palm wood after stacking them in a drying chamber (Plate 2). The Terazawa (1965) scale was used to evaluate and select the most effective drying schedule. Figures 3 and 4 illustrate the results of seasoning schedule treatments for high-density and medium-density coconut palm wood, respectively. These figures depict the degrees of defects observed in the wood when subjected to various drying schedules in a convection kiln. For high-density wood, treatment KSH1 resulted in the least cracking, splitting, honeycombing, and deformation compared to the other schedules. Similarly, KSM1 proved to be the most effective treatment for medium-density wood due to minimal defects.

Table 6. Kiln drying schedule for high-density coconut palm wood

Moisture content (%)	DBT (°C)	WBT (°C)	WBD (°C)	RH (%)	EMC (%)
60-40	45	43	2	87	18
40-35	45	42	3	84	16
35-30	45	40	5	82	15
30-25	50	42	8	64	10
25-20	55	37	18	38	6
20-15	60	30	30	38	6
15-10	80	50	30	26	3

EMC = Equilibrium moisture content

Table 7. Kiln drying schedule for medium-density coconut palm wood

Moisture content (%)	DBT (°C)	WBT (°C)	WBD (°C)	RH (%)	EMC (%)
110-70	50	48	2	88	18
70-60	50	47	3	85	16
60-50	50	45	5	74	13
50-40	50	42	8	62	10
40-35	50	39	11	49	8
35-30	50	36	14	40	7
30-25	55	38	17	35	6
25-20	60	38	22	25	4
20-15	65	43	22	24	4
15-10	80	50	30	24	3

Kiln drying schedule

Kiln drying schedules were developed based on the initial moisture content of the wood. The average initial moisture content was 53% for high-density and 104% for medium-density coconut palm wood. In order to obtain satisfactory drying, less severe schedules were chosen, particularly for high-density wood, which is

Figure 5. Relation between moisture content and drying rate of high-density coconut palm wood

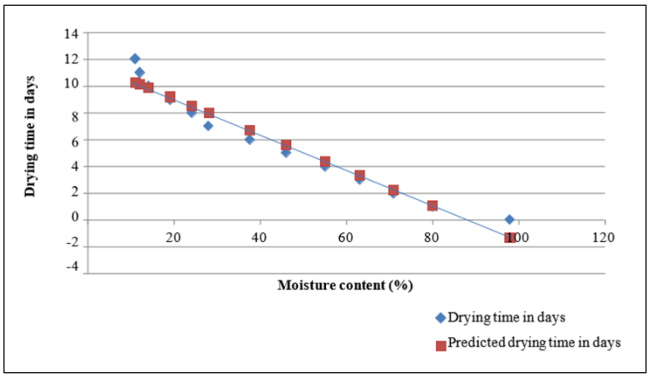
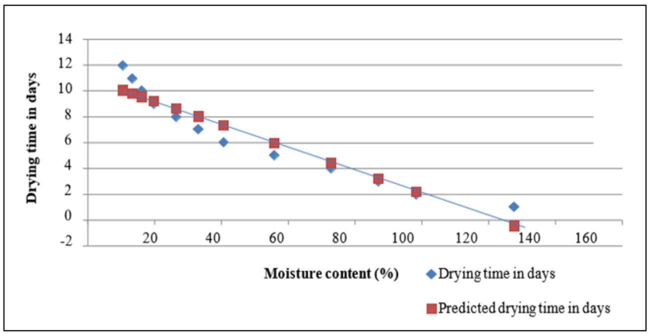


Figure 6. Relation between moisture content and drying time of medium-density coconut palm wood



more susceptible to defects during drying. The most recommended kiln drying schedule for 25 mm thickness high-density coconut palm wood was the schedule with initial DBT of 45°C (Relative humidity 87%), WBD of 2°C and final dry-bulb temperature of 80°C. Whereas, for medium-density coconut palm wood, with its lower susceptibility to defects observed in quick drying tests, a slightly more aggressive schedule (initial DBT 50°C) was found to be most effective. This difference can be attributed to the gradual moisture diffusion capacity of the medium-density wood during the drying process. Nine stages for high-density wood and 12 stages for medium-density wood are required. The detailed drying schedules for high and medium-density coconut palm wood are presented in Tables 6 and 7, respectively.

Kiln drying time

The period required for attaining equilibrium moisture content (EMC: 10 – 15 %) for each density class was also evaluated using 25 mm thick plank samples. The high-density coconut palm wood took 11 days to reach EMC, whereas medium-density wood took 12 days of kiln treatment to attain the prescribed equilibrium moisture content. The relation between moisture content and drying time of both high and medium-density coconut palm wood was plotted in Figures 5 and 6. The regression equation for high-density coconut palm wood is Y = (-0,1335 × X) + 11.737. The R^2 for high-density coconut palm wood is 0.95. the regression equation for medium-density coconut palm wood is Y = (– 0,08503 × X) + 11.0064. The R^2 is 0.91 for medium-density coconut palm wood, where Y is the kiln drying time in days and X is h moisture content in percentage. The drying time plotted against the moisture content percentage for high- and medium-density coconut palm wood showed linear relationships.

Conclusion

Proper seasoning is a pre-requisite for producing quality wood products. The requirement of a scientifically proven drying schedule for lesser-known and underutilized timbers like coconut palm wood becomes important in the current context of raw material shortage for the timber industry. This study aimed to standardize moisture content-based kiln seasoning schedules for high-density and medium-density coconut palm wood. Kiln drying schedules were developed based on a quick drying test commonly used for hardwoods and softwoods. The baseline parameters, such as initial dry-bulb temperature, final dry-bulb temperature and the wet-bulb depression for high-density and medium-density coconut palm wood, were experimentally chosen by considering the major seasoning defects. Among the major seasoning defects, the most severe seasoning defect observed was surface checking. The schedules that could deliver dried timber with the least defects were evaluated based on the subsequent tests. The most recommended kiln drying schedule for 25 mm thickness high-density coconut palm wood was the schedule with initial DBT of 45°C (Relative humidity 87 %), WBD of 2°C and final dry-bulb temperature of 80°C, while, for medium-density wood, initial DBT 50°C (Relative humidity 88 %), WBD 2°C and final dry-bulb temperature 80°C.

These schedules can also find utility in the pursuit of further optimizing coconut palm wood planks of different sizes through the application of trial-and-error methods. Adapting the procedure outlined in this study also facilitates the development of drying schedules for coconut palm wood, characterized by different dimensions. The schedules developed have good potential in industrial applications for mass production of dimensionally stable dried coconut palm wood lumber.

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