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**Government of the Union of Myanmar**  
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**Forest Research Institute**



**Utilization of Rubberwood**  
*(Hevea brasiliensis Muell. Arg.)*

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and  
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## ရာဘာသစ်၏ အသုံးချမှု

ဦးစိုးတင့်၊ B.Sc. (For.), M.Sc. (ANU) ၊ ဌာနမှူး  
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## စာတမ်းအကျဉ်းချုပ်

ရာဘာစိုက်ခင်းများမှ ရာဘာစေးအထွက်နည်းသည် ရာဘာပင်အိမ်များကို ခုတ်လှဲရာမှ ရရှိလာသည့် သစ်များကို ထင်းမှအပ၊ အခြားပိုမိုကောင်းမွန်သော အသုံးချမှုများကို ဖော်ထုတ်ရန် လိုအပ်လျှင်ရှိပါသည်။ ဤသို့ဖော်ထုတ်နိုင်ရန် ၎င်းသစ်၏ သစ်အင်္ဂါဗေဒ၊ သစ်အင်အား၊ ဓာတုဂုဏ်သတ္တိ၊ သစ်အခြောက်ခံခြင်း၊ ကြာရှည်ခံခြင်းနှင့် ကိုင်တွယ်မှု၊ လွယ်ကူခြင်းတို့ကို သိရှိရန်လိုအပ်ပါသည်။ ၎င်းအပြင် ရာဘာသစ်နှင့် ပြုလုပ်ထားသည့် ပရိဘောဂနှင့် အခြားပစ္စည်း အမျိုးမျိုးတို့ကို လက်တွေ့စမ်းသပ်သုံးစွဲရာမှ ရရှိလာမည့် တွေ့ရှိချက်များအပေါ်တွင်လည်း မူတည်လျှင်ရှိပါသည်။ ယခုစာတမ်းတွင် သစ်အင်္ဂါဗေဒ၊ သစ်အင်အား၊ သစ်အခြောက်ခံစမ်းသပ်ခြင်းများနှင့် ပရိဘောဂအပါအဝင် အခြားပစ္စည်းများကို ပြုလုပ်စမ်းသပ်ရာမှ တွေ့ရှိချက်များပေါ်တွင်မူတည်ပြီး ရာဘာသစ်၏ အသုံးချနိုင်မှု အလားအလာကို ပဏာမအနေဖြင့် တင်ပြထားပါသည်။ အခြားလိုအပ်မည့် စမ်းသပ်မှုများကိုလည်း ဆက်လက်ဆောင်ရွက် တင်ပြမည် ဖြစ်ပါသည်။

**Utilization of Rubberwood**  
**(*Hevea brasiliensis* Muell. Arg.)**

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**Abstract**

Older trees in rubber plantations which do not yield adequate latex have to be removed and new trees planted. The objective of this study was to determine better uses for these old trees than for firewood. To determine the potential of these trees the anatomical structure, the physical and mechanical properties, the drying characteristics, the preservative treatability, the working properties and the chemical properties need to be examined. In addition, the behavior of these timbers in actual service indoors must be tested. In this paper, the anatomical, physical, mechanical and drying properties of the wood are investigated together with the behavior of some products in use indoors. From the results obtained, some possible end uses of rubberwood are suggested as preliminary findings. Further research on this wood will be continued.

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## Introduction

The rubber tree is in fact a woody, medium size tree, planted mainly for its latex which commercially is known as rubber. In Burma, administration of rubber production and plantations is under the Agricultural Corporation. Some rubber plantations are owned by the State and some are in private ownership.

There are about 200,000 acres of rubber plantations in Burma. It is planned that 75,000 acres are to be replanted within the next 5 years. Some of these acres contain trees 60-70 years old. These old trees will be felled and replanted. The 75,000 acres will produce about 1,031,000 tons of logs, estimated on the basis of 70 trees per acre, each tree having a log 3'10" girth and 15' long, containing 13.75 cu.ft. of wood. If the planting programme is completed in 5 years, there will be 206,000 tons of logs available annually.

At present old rubber trees are used only for firewood because of high transportation costs. Most of the trees felled are left to rot at the site. The present investigation looks for the possibility of better utilizing this timber. Investigation into the anatomical, physical, mechanical and seasoning properties were made together with its suitability for some indoor uses. The paper is divided into four parts, Part (1) deals with the anatomical structure, Part (2) presents the physical and mechanical properties, Part (3) examines drying, and Part (4) looks at end-uses. Finally Part 5 discusses all the findings in these investigations.

## Literature Review

In Malaysia, after the age of about 25 years, when tapping for latex ceases to be economical, rubber trees are felled and replanted. At the age of 20-25 years, the tree attains an average diameter of 12 inches and a clear bole of 30' (High and Choh). In Burma, some trees 60 years old still exist which allows research on the production of latex at different ages, especially after 25 years.

In terms of working quality, rubberwood is easy to saw and can be machined to a fairly smooth surface but is liable to bowing, springing and end splitting. Internal stresses may be the reason for such defects and it is suggested that these defects may be reduced by the exclusion of pith. For such purpose the timber will have to be sawn around rather than sawn through and through. In such an operation; clogging of saw teeth by latex occurs, but one study (Seng and Ten) suggested that wetting the saw teeth with diesel fuel will reduce the clogging.

Rubberwood is very susceptible to sapstain mould growth and attack by insect (powder post). This deterioration is in fact one of the serious complaints against this timber and can happen even after preservative treatment. Freshly felled trees and cut timbers are liable to blue stain and it was suggested that trees felled should be left at the plantation site for not more than two days. (Griffin and Heimburger).

Some preventive measures indicated that they should be stored in log form in log ponds. Using bituminous-based mixture are said to be also efficient. Removing the end of the logs before sawing is also suggested. In the case of sawn timber, kiln drying soon after conversion and dipping in sodium pentachlorophenate are some of the means of preventing sap staining in both logs and lumber. The same researchers pointed out that, treatment against decay will be effective if pressure treatment using CCA with full cell vacuum pressure treatment to a retention of 16 kg/m<sup>3</sup> is carried out. Against insects, spraying the logs with 0.75 % a.i. lindane emulsion or dipping sawn timber in 1-2% by weight each of gamma (BHC 26 % wp) borax and sodium pentachlorophenate is suggested. (Hong *et.al*).

Malaysia, being a country with an large area of rubber plantation (over 656,000 acres), has developed the means to utilize rubber wood efficiently. It contributes up to 20% of the total log supply from the forests. According to their report this wood is found to be useful for the following:

1. Furniture making and mouldings (Treated)
2. Roof trusses, weather board, door and window frames (Treated)
3. Fuelwood and charcoal making
4. Chips for pulp
5. Panelling, parquet flooring, particle board, strip flooring (Treated)
6. Veneer and Plyboard
7. Handicraft (Treated), and
8. Boxes and crates (Treated)

## **Part I. Anatomical Properties of Rubberwood**

### **Microscopic characteristics**

**Tracheids and fibres:** Fibre tracheids and libriform fibres moderately thin to thick-walled; interfibre pits abundant and mostly confined to the radial walls; bordered pits slit-like with oblique orifice; length of each member from 425-2205  $\mu$ , mean length is 1746  $\mu$ .

**Vessel elements:** Number per sq. mm. ranges from 5-20, pore distribution solitary or in radial multiples or in clusters; diffuse porous; pores oval or elliptical in shape as seen in cross section, medium thin walled, tangential diameter ranges from 99.6-249  $\mu$ , tyloses present, perforation plates simple; with walls horizontal or nearly so; intervascular pitting alternate or scalariform, crowded, size of pits 6-10  $\mu$ , shape of pits vary from circular oval or pentagonal, length of vessel elements ranges from 298.5  $\mu$  - 879.8  $\mu$  and most frequently from 415.0-697.2  $\mu$ .; mean length is 599.9  $\mu$ . ; pits to vessels alternate or opposite in arrangement, crowded, bordered oval or angular; size of pots less than 7  $\mu$  ; pits to parenchyma opposite or alternate, oval or elongated in shape with 2.7  $\mu$  in size.

**Vascular rays:** Number per mm. ranges from 4-10, heterogeneous type I, 1-2 cells wide, mostly uniseriate, height of uniseriate rays ranges from 83-531.2  $\mu$  and most frequently from 249-448.2  $\mu$ , the height of biseriate rays ranges from 149.2-332  $\mu$  and most frequently from 232-256.6  $\mu$ , pits between ray cells and contiguous parenchyma cells few to many and are usually small in size.

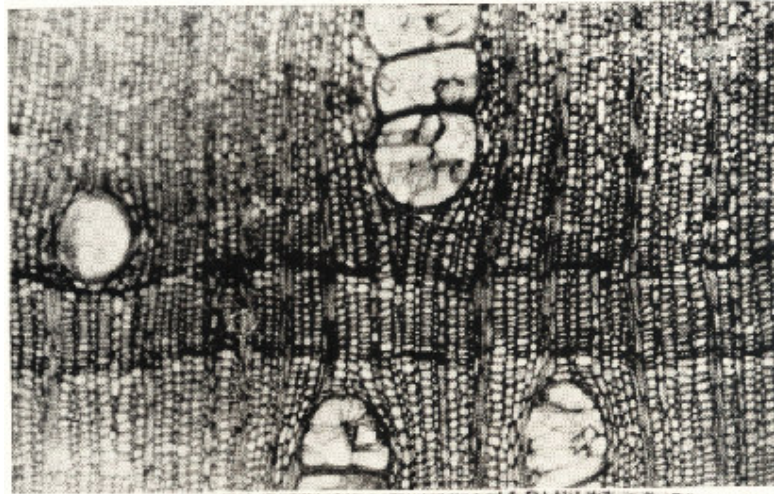
**Xylem parenchyma:** Abundant, paratracheal parenchyma vasicentric to aliform, some incompletely vasicentric, pitting between xylem parenchyma cells small in size and few in number. Microphotographs of rubberwood are shown in Plate 1.

**PLATE 1**

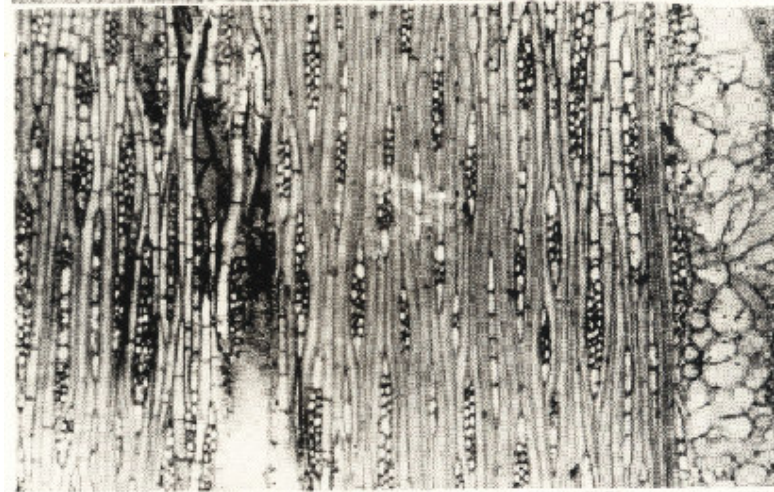
Rubberwood (x 83)

- A. Transverse section showing tyloses and diffuse and scattered parenchyma.
- B. Tangential longitudinal section view of multiseriate rays with uniseriate marginal upright cells.
- C. Radial Longitudinal section showing small pits of ray to vessels

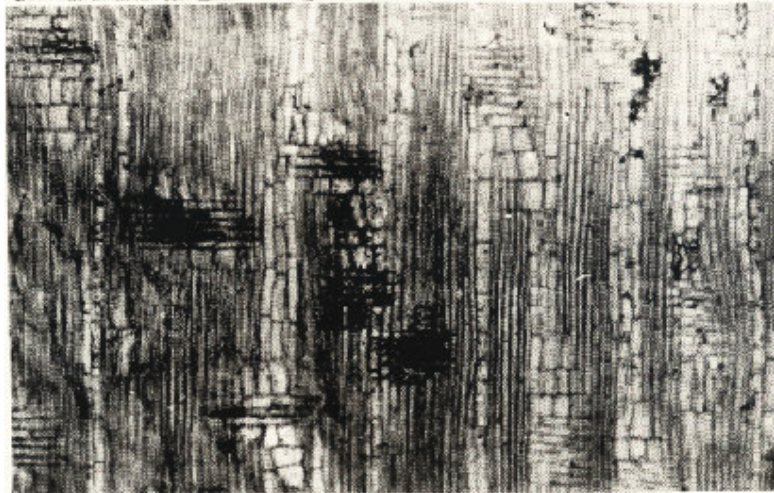
*Hevea brasiliensis* Muell. Arg. (Rubber)



A



B



C



## **Part II. Physical and Mechanical Properties of Rubberwood**

### **Objective**

The objective of this section was to explore the physical and mechanical properties of rubberwood for the potential end uses of it, especially as an structural timber. There has been no recorded research carried out for this aspect of rubberwood grown in Burma. The Rubberwood is light yellowish white when freshly cut and turning light brown or milky brown on exposure, occasionally tinged with pink. It has a wavy grain but sometimes straight grain. The texture is coarse and the sapwood and heartwood are not distinctly demarcated.

### **Materials and Methods**

The wood to be tested was supplied by the Agricultural Corporation. The 12 logs received were from 60-70 year old plantations in Kyaikhto Township. The dimensions of the logs were 10 feet long and of the following size classes;

- 3 logs - Girth Class 1' - (1' - 1'11")
- 3 logs - Girth Class 2' - (2' - 2'11")
- 3 logs - Girth Class 3' - (3' - 3'11")
- 3 logs - Girth Class 4' - (4' - 4'11")

The logs were said to be freshly felled. By the time they were received the log ends showed signs of insect attack. Five logs were converted immediately and samples prepared for physical and mechanical testing (3 in the 3' class and 2 in the 4' class). The logs were sawn to get matched specimens for testing green and dry as described in the American Society for Testing and Material Standard D 143 (A.S.T.M). Careful selection of wood samples to get clear and straight grain specimen were made after having confirmed their authenticity both anatomically and taxonomically.

### **Physical Properties Test Material**

Twelve samples of sizes 1" x 1" x 4" were selected at random for the determination of shrinkage. Eighteen specimens were taken for specific gravity determination, using water displacement method.

### **Mechanical Properties Test Material**

The dimensions of the specimens for various tests are given below. Cleavage and Impact bending tests could not be carried out as the appropriate instruments were not available in the Institute. The Avery Universal Testing Machine was used for the remaining of the tests.

### Dimensions of specimens for various tests

No.	Type of test	Size of specimens
1.	Static Bending	2" x 2" x 30"
2.	Compression parallel to grain	2" x 2" x 8"
3.	Hardness	2" x 2" x 6"
4.	Shear	2" x 2" x 2"

The properties computed from such tests are: -

#### 1. Static Bending :

- (a) Fibre Stress at Proportional Limit FS (at)PL.
- (b) Modulus of Rupture (MR)
- (c) Modulus of Elasticity (ME)
- (d) Work to Elastic Limit (Not stated)

#### 2. Compression parallel to grain

- (a) Fibre Stress at Proportional Limit FS (at)PL.
- (b) Maximum Stress
- (c) Modulus of Elasticity

#### 3. Hardness

- (a) Radial (Rad)
- (b) Tangential (Tan)
- (c) End (End)

#### 4. Shear Test

- (a) Radial (Rad)
- (b) Tangential (Tan)

The tests for green specimens were made soon after the timbers were received and those for the dry tests were air dried and later reconditioned to 12 % moisture content. The temperature of the testing room could not be maintained to a required stable condition, but tests were made lasting for short period as possible to prevent great variation in room temperature.

The moisture content of all specimens were determined by oven dry method. The preparation of the specimens and the methods of test followed the standards laid down.

## Results

### Physical Properties

Results of the physical properties such as density and shrinkage are given in Table 1. The physical properties of some of the Burmese species are also given for comparison with the rubberwood 1\*

### Mechanical Properties

The mechanical properties of the rubberwood tested are also given in Table 1. Only few essential properties are mentioned in the table. Tests on compression strength and toughness were not performed. The results stated are the mean values of the test data.

Table 2 presents an index of suitability of the species for different purposes, teak being taken as 100% standard for all aspects. This basis provides an easy comparison between rubberwood and other species.

**Table 1. Physical and Mechanical Properties of Rubberwood as compared to other species**

Species	Moisture Content	Density lb/c.ft	Shrinkage % (G-OD)			Static Bending Comp. II to grain			Shear Max psi	Hardness		
			Tan.	Rad.	Vol.	MR	ME103	Max str psi		Rad.	Tan.	End.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Rubber wood	Green	57.5	7.5	4.5		6490	1060	3180	1066	810	710	695
	AD 12%	38.5				7150	15400	6295	1896	1006	880	865
Teak	Green	55	3.3	2.1	6.8	11460	1640	5710	1035	960	960	860
	AD 12%	40				14465	1830	8350	1142	980	990	910
Kanyin	Green	68	8.9	4.2	15.0	11020	2020	5865	1057	1020	1010	1060
	AD 12%	49				15605	2240	7745	1252	1395	1285	1315
Leza	Green	64	6.4	4.2		11005	1695	5115	1312	985	990	1055
	AD 12%	42				13265	1940	7145	1320	1125	1076	1120

## Discussion

Rubberwood from the physical point of view is a medium light weight wood and in retention of shape is quite stable as can be seen in Table 2. Although it is inferior to Teak, Hnaw, Sagawa, Yemane and Nabe in stability, it is superior to Kanyin, Pynma, In, Binga, Taunghayet, Leza, Sit and Yinma. This indicates that rubberwood can be useful for making furniture where stability is a requisite property. Judging from the mechanical properties, it is not advisable to use it in heavy construction, but it will be suitable for light structural uses as walls, panels, partitions and light framing. Another use will be in making boxes and crates.

\* See appendix I for scientific names of tree species concerned.

Parquet flooring, mouldings, light building components and handicraft are some of the possibilities for the utilization of timber with such strength properties.

**Table 2. Relative Suitability of rubberwood and other Species as a percentage of Teak**

Sr. No.	Species	Weight	Strength as a beam	Stiffness as a beam	Suitability as a post	Rention of shape	Shear	Hardness
	Teak	100	100	100	100	100	100	100
1.	Rubberwood	96	64	69	57	72	112	68
2.	Kanyin	122	99	122	102	56	911	112
3.	Pyinkado	140	128	135	135	179	155	187
4.	Pyinma	95	73	78	76	67	100	110
5.	In	140	104	110	100	57	105	147
6.	Binga	102	90	83	92	69	111	107
7.	Hnaw	102	77	74	81	88	111	110
8.	Sagawa	75	62	72	69	88	83	68
9.	Taungthayet	102	73	100	80	74	108	77
10.	Yemane	75	60	68	61	85	80	65
11.	Leza	105	91	103	95	70	110	104
12.	Nabe	90	55	51	51	85	76	76
13.	Sit	95	85	80	85	75	130	105
14.	Yinma	95	75	80	70	75	120	110

### Part III. Drying Behaviour of Rubberwood

#### Objective

The principal objective of this study was to find the drying behavior of rubberwood, specifically:

1. To describe the principles and practices of lumber drying using solar energy.
2. To compare the drying rates and characteristics of rubberwood in solar drying and in air drying.

#### Literature Review

This review is divided into two sections. The first describes the drying studies of rubberwood and the second gives a brief background review of solar drying of lumber.

#### Drying Studies on Rubberwood

A study in Indonesia tested 1.5 inch-thick rubberwood in a greenhouse type solar kiln built at Bogor (6°45' S, 106°45' E). To get a comparison, the same species of the same thickness was also air-dried. It was concluded that solar drying was always faster than air-drying. Unfortunately, no other information is available on the performance. (Martawijay *et. al.*).

Air-drying and Kiln-drying of rubberwood were tested in Malaysia. It was reported the rubberwood could be air dried fairly rapidly compared to other species of similar density. It was noted that 25 mm (about 1 inch) and 50 mm (about 2 inches) thick boards were dried

to a final moisture content of 15 percent in 56 and 63-64 days, respectively. It took 25 mm-thick boards about 6 days and 50 mm boards about 10 days, to dry to a final moisture content of 10 percent. (Sen and Ten).

Lumber, from plantation rubberwood trees no longer efficient for latex production, was used for making low-cost furniture at Borwood Ltd., a furniture factory in Horana (6°58' N, 79°52' E ), Sri Lanka. A solar lumber dryer was built at the factory in February, 1981. Before installing this kiln, the factory had only air-drying sheds for drying rubberwood. Air-drying required 3 months to reach 15 percent moisture content. The solar kiln was operated continuously for 18 months and it was reported that 1 inch green rubberwood of 60 percent moisture content could be dried to 15 percent moisture content within two to three weeks. (Simpson and Tschernitz).

## **Review of Solar Lumber kilns**

Several studies of solar drying of lumber began at about the same time in the United States and in India (Johnson) (Rehaman and Chawla). There are now at least 250 solar lumber kilns throughout the world. Of these, about 40 are experimental kilns built at universities or government research laboratories, and the others are commercial kilns. Countries in which solar drying of lumber have been conducted in chronological order are, United States of America, India, Puerto Rico, Japan Taiwan, Uganda, Tanzania, Philippines, Ghana, Madagascar, Australia, Brazil, United Kingdom, Indonesia, Fiji, West Germany, Canada, Ivory Coast, South Africa, China, Sri Lanka, Pakistan, Bangladesh and Burma.

## **Materials and Methods**

### **Description of the Kiln**

The prototype external- collector solar lumber kiln used in this study is located at the Forest Research Institute, Yezin (19°47' N, 96°15' E). This is Burma's first solar lumber kiln. It was designed by J.L. Tschernitz and W.T.Simpson, of the U.S. Forest Products Laboratory, Madison, Wisconsin, and constructed by C.de Zeeuw<sup>1\*</sup> and U Soe Tint, of the Forest Research Institute, Yezin, in September, 1982. This kiln is of the same design and size as the Madison (Forest Products Laboratory) prototype except that the collector is 60 percent larger than that of the Madison Kiln. It is identical to a kiln which was built in Sri Lanka in February, 1981, by the same designers. It mainly consists of two parts, the solar collector and the drying chamber, as shown in Figure 1.

### **Solar Collector**

The collector is external to the drying chamber. It is 8 feet wide and 40 feet long. Air space between the cover and absorber is 6 inches for air movement.

A layer of granulated charcoal about ½ inch thick was used as a heat-absorbing surface and heat transfer medium. The collector cover material is a single layer of fiberglass-reinforced polyester 0.1cm thick.

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<sup>1\*</sup> C.de Zeeuw, Consultant in Wood Technology, Forest Research Institute, Yezin. Burma.

The path of air circulation between the collector and the dryer is indicated by arrows in Figure 1. Air is drawn from one side of the dryer, travels down the West Side of the collector, then across the end and down the East Side of the collector and back into the dryer. A blower a about ½ HP just inside the drying chamber induces air flow through the collector.

### **Drying Chamber**

The drying chamber is approximately 9 feet square by 10 feet high with a capacity of about 80 cubic feet (2.3 cubic meter) of 1-inch lumber. The walls are framed with 4 x 2- construction lumber, paneled inside with ½ inch exterior grade plywood, and outside with 1-inch Teak (*Tectona grandis*) lumber. The 4-inch space between inside and outside walls is insulated with 3-inch fiberglass insulation batt and 1 inch polystyrene sheet.

A polyethylene vapor barrier is placed behind the interior plywood sheet. The roof is similar except that the rafters are 7 inches wide instead of 4 inches. The rafter space is filled with loose fiberglass insulation, and roofing paper is used on the outside. The floor is 4 inches of gravel with a sheet of polyethylene placed below.

Two 2-speed overhead fans each of about ½ HP, are used to circulate the air through the lumber pile. An exhaust fan of about ⅓ HP, located at the bottom of the east wall, is used for venting.

A timer was set up to control the fans, blower and exhaust. Two humidistats, a thermostat and a differential temperature control were also set up in order to control each of these independently.

The humidistat switch RH 1 (F.1 in Fig 1) controlled the venting. It was used to establish the minimum relative humidity in the chamber which the exhaust fan would not operate.

A second humidistat switch RH 2 (F.2 in Fig 1) was also used to establish the maximum relative humidity above which the dryer would not operate, specially for long periods of low solar input and high humidities, i.e rainy periods.

The fan thermostat was used to establish a minimum temperature above which the fans would operate even after the timer was off, especially for the typical sunny days.

The differential temperature control was used in order to turn the blower on whenever the temperature in the collector was higher than that in the drying chamber.

Three counters monitored the running times for each of the blower, the exhaust fan and circulating fans.

### **Material**

Lumber used in this study was collected from 40 different trees from Mayangong rubber plantation at Kyaikhto. The age of the trees was about 70 years. The lumber was cut in the Forest Research Institute sawmill from 40 8½ - foot logs whose girths ranged from 2 ft – 11 inches to 4 ft-8 inches.

### **Experimental procedure**

Each board was marked according to the log number immediately after cutting. There were a total of 178 boards. The width of each board was measured, and ranged from 6.4 to 12.8 inches. The length and average thickness of the boards were 8 feet and 1.2 inches, respectively.

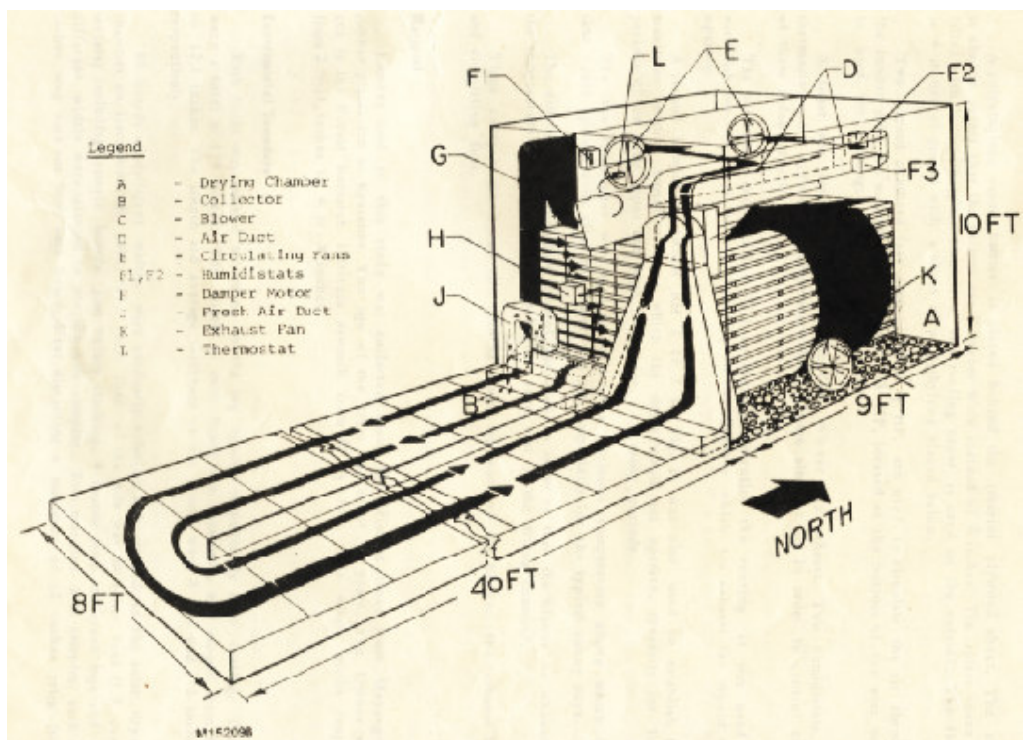


Figure1. External Collector Kiln, Yezin. (Courtesy USDA Forest Products Laboratory)

89 boards of different widths were randomly selected and stacked in the solar drying chamber on December 18, 1983. The total load of the pile was 60 cubic feet (1.7 cubic meters) including sample boards. Just before stacking, 4 boards from different logs and of different widths were selected to provide kiln samples. Two matched kiln samples, each 26 inches long were cut from each board, after discarding a minimum of 12 inches trim from both ends of the boards. Care was also taken to ensure that the sample boards contained a minimum amount of natural defects such as knots, bark and decay.

One-inch moisture content sections were cut from both ends of each sample board. Then each sample and each moisture content section was weighed. The sample boards were end coated with Thitsi oleo-resin and weighed again to estimate the weight of end-coating material. The moisture content sections were then oven-dried at 219° F (104°C) for 36 hours, and weighed again in order to calculate the average green moisture content, which was used in turn to estimate the oven-dried weight of each sample board. Before oven drying, the green volume of each moisture content section was also measured by water displacement in order to determine the average green specific gravity.

The width of the pile was 4 feet. There were 19 layers with teak stickers piled about 4 feet high. The stickers 0.75" x 1.5" x 4' were spaced 2 feet apart.

Sample boards were placed at 8 different positions, 4 on one side and 4 on the other side of the pile.

To record the relative humidities inside the chamber and of the ambient atmosphere, two hygrothermographs were placed one inside and the other outside the chamber.

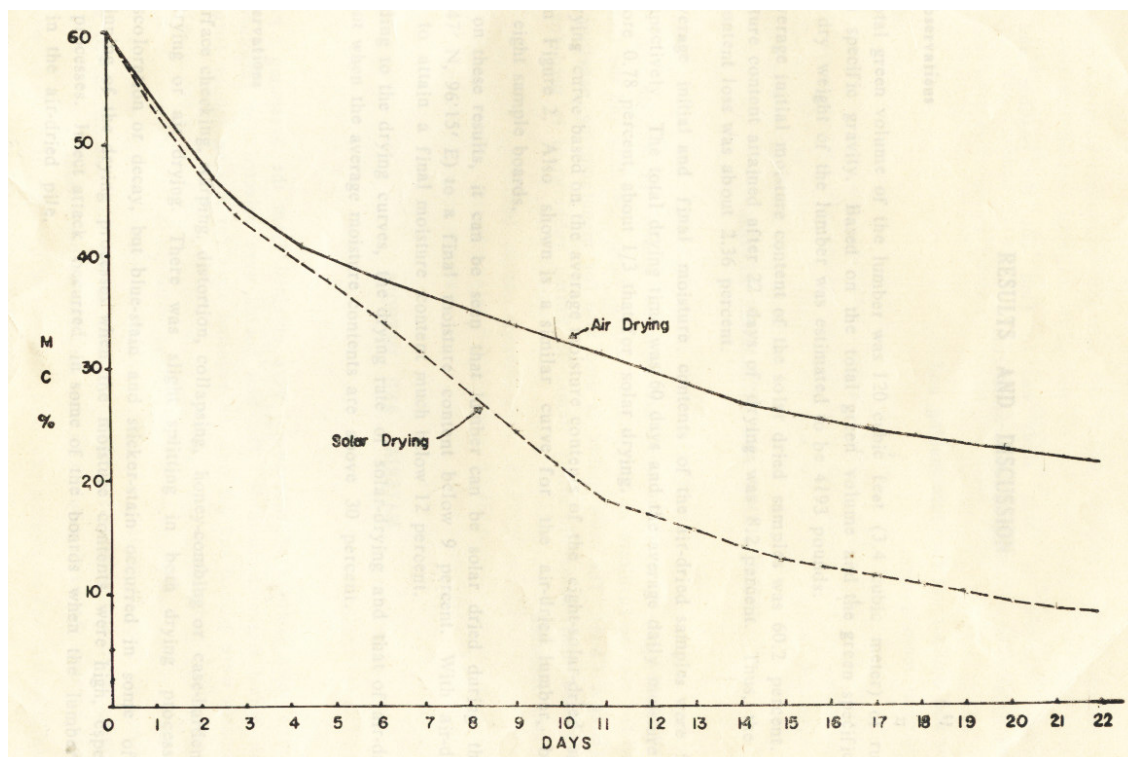


Figure 2 : Solar and Air-drying Curves of Rubberwood

To get a comparison with solar drying, the remaining 89 boards were stacked in the air-drying shed on December 19, 1983, for air-drying. The total load of the pile was also about 60 cubic feet (1.7 cubic meters). Following the same procedure as in the solar drying, 8 boards were also used as sample boards in the air-dried pile.

Solar drying was started on December 20, 1983. All sample boards were weighed every morning before 8 a.m. The moisture content of each sample board was calculated immediately after weighing.

The two humidistats in the drying chamber were re-set as necessary, according to the average moisture content of the sample boards.

The cover of the collector was cleaned every morning to remove the accumulated dust, and maintain the transmission efficiency of the cover.

The fans were run at high speed at the beginning of the test and it was changed to the low speed when the average moisture content of the samples decreased to 27.6 percent on day 8.

The first humidistat (RH1) and the second (RH2) were set initially at 70 and 100 percent humidity, respectively. They were reset to 50 and 90 percent on day 8 when the average moisture content of the samples was 27.4 percent.

They were again reset to 40 and 70 percent on day 14 when the average moisture content was 13.9 percent. Finally on day 16 they were reset up at 30 and 60 percent when the average moisture content of the samples was 12.2 percent.

The solar drying was terminated on January 12, 1984, after 22 days of drying. The pile was unstacked and each board was examined carefully to determine the drying defects such as, checks, warping, distortion, collapse, blue stain, sticker stain and discoloration.



Air-drying was started on December 20, 1983. All sample boards were weighed every morning before 8 a.m. and the moisture content determined.

## **Results and Discussion**

### **Drying Observations**

The total green volume of the lumber was 120 cubic feet (3.4 cubic meter) of rubberwood of 0.56 green specific gravity. Based on the total green volume and the green specific gravity, the total oven dry weight of the lumber was estimated to be 4193 pounds.

The average initial moisture content of the solar dried samples was 60.2 percent. The average final moisture content attained after 22 days of drying was 8.2 percent. Thus, the average daily moisture content loss was about 2.36 percent.

The average initial and final moisture contents of the air-dried samples were 58.1 and 11.2 percent respectively. The total drying time was 60 days and the average daily moisture content loss was therefore 0.78 percent, about  $\frac{1}{3}$  that for solar drying.

The drying curve based on the average moisture contents of the eight-solar dried sample boards is shown in Figure 2. Also shown is a similar curve for the air-dried lumber, based on the average of eight sample boards.

Based on these results, it can be seen that lumber can be solar dried during the winter in Yezin (19°47' N, 96°15'E) to a final moisture content below 9 percent. With air-drying, it was impossible to attain a final moisture content much below 12 percent.

According to the drying curves, the drying rate of solar-drying and that of air-drying are not too different when the average moisture contents are above 30 percent.

### **Defect Observations**

No surface checking, warping, distortion, collapsing, honey-combing or case-hardening occurred in solar drying or air-drying. There was slight splitting in both drying processes.

No discoloration or decay, but blue-stain and sticker-stain occurred in some of the boards, at the beginning of the drying processes when the moisture contents were high, especially in the air drying processes. Insect attack occurred in some of the boards when the lumber was dried, especially in the air-dried pile.

## **Part IV. End Uses of Rubberwood**

### **Objective**

The principal objective of this study was to find out the possible end uses of rubberwood, specifically the suitability of rubberwood for:

- (a) indoor and outdoor use furniture making, and
- (b) for charcoal manufacture

## **Introduction and Literature Review**

Several reports and articles on rubberwood are reported. Lumber from plantation rubberwood trees, was used for making furniture in Malaysia , Sri Lanka, Japan, Germany and the United States (Seng & Ten) (Hing & Choh). The sawn timber is used also for manufacturing panelling, parquet flooring, novelty and small household utility items. In Burma rubberwood is used for fuelwood with no other uses reported.

## **Materials and Methods**

Well- seasoned sawn timbers of rubberwood were obtained from the Seasoning & Preservation Section of the Forest Research Institute. The best boards were selected for furniture making. The selected boards were planed and cut into the required sizes for making indoor furniture such as armless chairs stools and shelves.

The remaining wood and parts of logs were collected at the mill site and moved to the kiln site for charcoal burning. An earth mould kiln was used for carbonization.

## **Results**

### **Furniture Making**

Rubberwood has good machining properties for boring, planing, turning, shaping and sanding. It laminates well with normal adhesives. It is easy to saw and causes no significant blunting of saw-teeth. It takes varnish and polish with no difficulty. The surfaces of the furniture are fairly smooth. The finished furniture is in use and remains under observation. The color is uniform. There were evidences of insect attacks on the dried wood.

### **Carbonization**

There were no technical problems during charcoal production. The rubberwood had a normal burning character. The smoke, issuing from the outlets had no unpleasant odor. The charcoal yield was 30% by weight. A sample was analysed at the Central Research Organization (CRO), Rangoon, with the following results;

#### **CRO Analysis No. 1330/12-130/84-85**

Moisture Content	6.57%
Ash Content	1.05%
Volatile Matter m.c%	9.21%
Fixed carbon content	83.17%
Calorific value B.T.U/kg. oven dry basis	12457,6

## **Discussions**

Rubberwood has good machinery properties, is relatively uniform in density and color, and could be used in making mass produced furniture. The wood stains rapidly (blue-stain fungus) and showed evidence of insect attack which would degrade quality. If used in construction or as core stock in block board which is covered, would be acceptable where such discoloration does not show.

Rubberwood charcoal produced in an earth kiln was acceptable for domestic use. The yield, while not premium, was still most acceptable.

## **Part V - Conclusion**

A supply of rubberwood will be available on a sustained basis as long as rubber production is continued in Burma. There is a relatively large supply of raw material available from trees no longer productive for latex. As plantations of 60-70 years old trees are replaced, and the period of tapping is reduced 25-30 years as recommended, the quality of the timber available for use should improve both in strength and in amount of defect.

Rubberwood possesses good timber quality, is easy to saw, plane, bore and turn and has adequate strength properties for many uses except heavy building work. Dimensional stability is fairly good and it seasons well. With proper seasoning, the stability can be improved to a certain extent.

Compared to some of the natural grown forest tree species of Burma, rubberwood is not as good as Kanyin, Pyinkado, In, Binga, Hnaw, Sagawa, Taungthayet, Sit and Yinma. On the other hand it is as good as or even better in strength than Pyinma, Yemane and Nabe.

Although this wood is suitable for many uses, there are some major drawbacks, the first problem is its relative susceptibility to insect and fungus attack. Prompt transporting, conversion, storage and preservative treatment can prevent such problems. Once a fungus has become established in rubberwood, preservative treatment does not stop to decay. The tendency to warp immediately after sawing and end splitting in drying are other problems which can be minimized by proper handling, manufacturing and drying.

Kiln drying is strongly recommended if rubberwood is to be used in furniture or other uses where dimensional stability is important. Lacking a conventional kiln, rubberwood can be dried to a final moisture content of 9 percent in about 22 days in a solar kiln during the winter in Yezin. Air drying rubberwood below 12 percent moisture content was not possible. The rates of drying above fiber saturation point for air drying and solar drying are very similar. Therefore, lumber can be air-dried down to the fiber saturation point (about 25-30 percent moisture content) and then solar dried to about 8 percent and thus save drying costs.

Uses of rubberwood in lumber form are best directed towards mass-production furniture items and light construction where moderately strong stable material of uniform texture density and color is needed.

Though currently used only for local firewood, rubberwood can be used to make very acceptable charcoal. The quality, while not of the highest grade, displayed heating values amply suited to domestic consumption. It may be that, as the price of charcoal increases in urban centers, the continuing supply of wood available from replacement of rubber plantations, may become attractive for more efficient charcoal production.

Thus, there is a need for additional research on this renewable resource to insure its greatest potential is achieved.

## Appendix I

### Botanical Names of Some Tree Species

<b>Burmese Name</b>	<b>Botanical Names</b>
Binga	<i>Mitragyna rotundifolia</i> O.Ktze
Hnaw	<i>Adina cordifolia</i> Hook. F.
In	<i>Dipterocarpus tuberculatus</i> Roxb.
Kanyin	<i>Dipterocarpus turbinata</i>
Leza	<i>Lagerstroemia tomentosa</i> Presl.
Nabe	<i>Lannea grandis</i> Engler.
Pyinma	<i>Lagerstroemia speciosa</i> Pers.
Pyinkado	<i>Xylia dolabriformis</i> Benth.
Sagawa	<i>Michelia champaca</i> L.
Sit	<i>Albizia procera</i> Benth.
Thitsi	<i>Melanorrhoe usitata</i> Wall.
Taungthayet	<i>Swintonia floribunda</i> Griff.
Yemane	<i>Gmelina arborea</i> Roxb.
Yinma	<i>Chukrasia tabularis</i> A. Juss.

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