UNIVERSITI PUTRA MALAYSIA

JUVENILITY IN RUBBERWOOD (HEVEA BRASILIENSIS) AND ITS RELATION WITH THE PHYSICAL AND MECHANICAL PROPERTIES

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JUVENILITY IN RUBBERWOOD (*HEVEA BRASILIENSIS*) AND ITS RELATION WITH THE PHYSICAL AND MECHANICAL PROPERTIES

By

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Thesis Submitted in Fulfilment of the
Requirements for the Degree of Master of Science
in the Faculty of Forestry
Universiti Putra Malaysia

March 1998

ACKNOWLEDGEMENTS

First and foremost, I would like to express my utmost gratitute to Allah the Al-Mighty for His blessing in allowing this thesis to be completed on time.

Special thanks and recognition are given to the committee chairman, Associate Prof. Dr. Mohd. Hamami Sahri for his guidance, suggestions and constructive criticisms throughout the preparation of this project. I am thankful for the guidance of my other committee members, namely Associate Prof. Mohd. Zin Jusoh and Dr. Zaidon Ashaari for their help and commitments during the preparation of this research. Sincere thanks to my former supervisor Dr. Mohamed Zakaria Hussin who is the first person to encourage me to pursue my study for the Master of Science. Sincere appreciation to the Dean of Faculty of Forestry for permission to use the facilities at the faculty. Special thanks to Dr. Faizah Abood Haris for editing the thesis.

Special thanks are also due to the Senior Research Officer of Golden Hope Plantations Bhd, Dr. Mohd. Noor Abdul Ghani for supplying the research materials, research grants and great contribution towards successful completion of this project. Many thanks are also due to his assistant Mr. Shahrom Jantan for the full cooperation given during preparation of rubberwood samples.

Sincere thanks to field assistants Mr. Razak and Mr. Rahmat for their contribution in preparation of the samples. Also, thanks to Mr. Omar Mohamad, Mr. Saad, Mr. Harmaen, Mr. Hasidin and Mr. Abd. Jalal Aman for their full cooperation in the laboratory works.

A very special note of gratitude for my beloved wife, Norafiza Ab. Rahman and my daughter, Fatin Faranisha for their encouragement, support and great contribution towards making this endeavour successful.

Special thanks to my beloved mother Jah bt. Tahir for her constant encouragement and support. Thanks are also due to my father in-law, Ab. Rahman Hj. Omar and mother in-law, Meriam bt. Mohamed and family members Norizan, Arshad, Aminuddin, Nurul Nisa, Noramalina and Nur Amira Syafiqah for their inspiration and encouragement.

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LIST OF ABBREVIATIONS

BS	British Standard
LSD	least significant difference
MC	moisture content
MDF	medium density fibreboard
MTIB	Malaysian Timber Industry Board
MOE	modulus of elasticity
MOR	modulus of rupture
MSR	machine-stress rating
OD	oven-dry
OSB	oriented strand board
PB	Prang Besar
RH	relative humidity
RRIM	Rubber Research Institute of Malaysia
SAS	statistical analysis system
SG	specific gravity

Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

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March 1998

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Knowledge on anatomical, physical and mechanical properties of wood is necessary in assessing the potential utilisation of wood. The main objectives of this study are to determine the cellular composition and anatomical variations of juvenile rubberwood (*Hevea brasiliensis*) and their extent in the selected clones and age groups. Another objective is to determine the structure of juvenile wood in relation to physical and mechanical properties. Three different clones, PB 359, PB 366 and RRIM 600 from two age groups, namely 10 and 22 years old were selected from Golden Hope Plantation Bhd. Three trees were felled for each clone and age group. Each tree was divided into three portions along the height namely, stump (S_1), trunk

(S_3) and branch (S_5). Outer and inner samples along the radial position were chosen for comparative studies on the anatomical, physical and mechanical properties. All samples for each test were prepared in accordance with the British Standard (BS 373: 1957) specifications.

Juvenile wood from the 10-year old, *Hevea* trees of the clone PB 359 exhibited the highest values for fibre length (1152.16μm) and initial moisture content (60.36%). Clone PB 366 showed the highest values in fibre proportion (53.83%), MOR (112.49N/mm^2), MOE (9149.90N/mm^2), and compression parallel to grain (50.64N/mm^2) whereas RRIM 600 possessed the highest value in fibre diameter (25.27μm), lumen diameter (12.28μm), shear parallel to grain (17.87N/mm^2), tangential shrinkage (2.13%) and radial shrinkage (0.99%).

For mature wood of 22-year old, clone PB 359 showed the highest values in fibre length (1248.69μm), initial moisture content (65.96%), radial (0.69%) and longitudinal shrinkage (0.34%). Clone PB 366 possessed the highest value in fibre proportion (47.32%) and MOR (137.60N/mm^2), whereas clone RRIM 600 showed the highest value in fibre diameter (24.61μm), specific gravity (0.61g/cm^3), tangential shrinkage (1.49%), MOE (10422.48N/mm^2), compression parallel to grain (64.05N/mm^2) and shear parallel to grain (20.57N/mm^2).

All clones from the 22-year old age groups showed higher values for the fibre length, proportion of rays, moisture content, specific gravity, MOR, MOE, compression and shear parallel to grain when compared to similar clones from the 10-year old age group. For both age groups, the values for fibre length, fibre diameter, lumen diameter, cell wall thickness, vessel diameter, proportion of rays, specific gravity, MOR, MOE, compression and shear parallel to grain at the trunk (S_3) section were higher compared to the stump (S_1) and branch (S_5) sections.

The mechanical strength of the wood was found to be affected by fibre length, fibre diameter, cell wall thickness, proportion of fibres and specific gravity. Based on mechanical strength, 10-year old juvenile rubberwood is suitable for the manufacturing of pulp and paper, solid wood products and medium-density fibreboard. Clone PB 366 is suitable for sawn timber due to the superior mechanical strength. Clone PB 359 can be processed to pulp and paper due to its lower lignin content and higher alpha-cellulose and hemicellulose contents. Branch wood (S_5) possess similar anatomical, physical and mechanical properties to the trunk (S_3), and is also considered suitable for industrial utilisation. The stump (S_1), however possess lower mechanical strength properties and is not recommended for industrial utilisation.

Abstrak tesis ini dikemukakan kepada Senat Universiti Putra Malaysia untuk memenuhi keperluan ijazah Master Sains.

**KAYU GETAH MUDA (*HEVEA BRASILIENSIS*)
DAN PERKAITAN DENGAN CIRI-CIRI
FIZIKAL DAN MEKANIKAL**

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Pengetahuan tentang sifat-sifat anatomi, fizikal dan mekanikal kayu adalah penting bagi menentukan ciri-ciri istimewa serta kegunaan kayu itu sendiri. Tujuan utama kajian ini ialah untuk mengkaji komposisi tisu dan anatomi kayu getah muda (*Hevea brasiliensis*) serta kehadiran dalam pelbagai jenis klon dan umur yang dipilih. Ia juga bertujuan untuk mengetahui struktur kayu muda serta perkaitannya dengan sifat-sifat fizikal dan mekanikal kayu. Tiga klon yang berbeza iaitu PB 359, PB 366 dan RRIM 600 daripada dua kumpulan umur iaitu 10 dan 22 tahun telah dipilih dan diperoleh daripada Golden Hope Plantation Bhd. Tiga batang pokok dipilih daripada

setiap klon dan umur yang sama yang terdiri daripada tiga bahagian ketinggian iaitu tunggul (S_1), batang (S_3) dan dahan (S_5). Manakala bahagian luar dan dalam kayu pula dipilih sebagai ujikaji perbandingan secara jejari untuk sifat-sifat anatomi, fizikal dan mekanikal kayu. Semua sampel untuk setiap ujikaji yang disediakan adalah mengikut spesifikasi British Standard (BS 373 : 1957).

Bagi kayu muda yang berumur 10 tahun, klon PB 359 mempunyai nilai tertinggi bagi panjang gentian (1152.16μm) dan kandungan lembapan (60.36%). Klon PB 366 menunjukkan nilai yang tertinggi untuk nisbah gentian (53.83%), MOR (112.49N/mm^2), MOE (9149.90N/mm^2) dan mampatan selari ira (50.46N/mm^2) manakala klon RRIM 600 pula menunjukkan nilai yang tinggi untuk diameter gentian (25.27μm), diameter lumen (12.28μm), ricihan selari dengan ira (17.87N/mm^2), pengecutan arah tangen (2.13%) dan jejari (0.99%).

Bagi kayu matang yang berumur 22 tahun pula, klon PB 359 menunjukkan nilai yang tertinggi bagi panjang gentian (1248.69μm), kandungan lembapan (65.96%), pengecutan arah jejari (0.69%) dan memanjang (0.34%). Klon PB 366 mempunyai nilai yang tertinggi untuk nisbah gentian (47.32%) dan MOR (137.60N/mm^2) manakala klon RRIM 600 pula menunjukkan nilai yang tertinggi untuk garis pusat gentian (24.61μm), graviti spesifik (0.61g/cm^3), pengecutan arah tangen (1.49%), MOE (10422.48N/mm^2), mampatan selari ira (64.05N/mm^2) dan ricihan selari ira (20.57N/mm^2).

Semua klon yang berumur 22 tahun menunjukkan nilai yang lebih tinggi bagi panjang gentian, nisbah ira, kandungan lembapan, graviti spesifik, MOR, MOE, mampatan selari ira dan ricihan yang selari ira jika dibandingkan dengan klon yang sama dari kumpulan umur 10 tahun. Bagi kedua-dua kumpulan umur, nilai pada bahagian batang (S_3) bagi panjang gentian, garis pusat gentian, garis pusat lumen, ketebalan dinding gentian, garis pusat vessel, nisbah ira, graviti spesifik, MOR, MOE, mampatan selari ira dan ricihan selari ira adalah tinggi jika dibandingkan dengan tunggul (S_1) dan dahan (S_5).

Kajian menunjukkan bahawa kekuatan mekanikal kayu adalah dipengaruhi oleh panjang gentian, garis pusat gentian, ketebalan dinding sel, nisbah gentian dan graviti spesifik. Berdasarkan kepada kekuatan mekanikal, kayu getah muda yang berumur 10 tahun sesuai digunakan dalam pembuatan pulpa dan kertas, proses kayu pejal dan kayu gentian ketumpatan sederhana. Klon PB 366 sesuai digunakan untuk pembuatan kayu gergaji disebabkan oleh kekuatan mekanikal kayu tersebut. Klon PB 359 sesuai diproses untuk pembuatan pulpa dan kertas disebabkan kandungan lignin yang rendah serta kandungan alfa-selulosa dan hemiselulosa yang tinggi. Kayu dahan (S_5) masih boleh digunakan untuk tujuan industri di mana ciri-ciri anatomi, fizikal dan mekanikal hampir sama dengan batang (S_3) tetapi bagaimanapun tunggul (S_1) tidak sesuai digunakan untuk tujuan industri sebab kekuatan mekanikal adalah rendah.

CHAPTER I

INTRODUCTION

There is still a lack of information on the properties of juvenile wood and its utilisation for industrial purposes such as for manufacturing of pulp and paper, furniture and wood composite boards in Malaysia.

However, some related studies have been conducted overseas. These include studies on juvenile wood in the manufacture of veneers from Douglas-fir (Kellogg and Kennedy, 1985), pulp and paper making (Jackson and Megraw, 1986), and the production of wood composite boards from Douglas-fir (Lehnman and Geimer,1974).

Generally, juvenile wood is known to be of lower quality than mature wood with respect to its low tensile strength, shorter fibre lengths and greater longitudinal shrinkage. Strength reduction and greater longitudinal shrinkage is due to greater average fibril angles in the cell wall (S_2 layer). The specific gravity of juvenile wood is either higher or lower depending on the species, but is usually lower due to the formation of fewer latewood cells and thinner cell wall layer. The chemical contents particularly lignin and hemicellulose are higher, thus resulting in a greater tendency of having spiral grains (Briggs and Smith, 1985).

In structural lumber, juvenile wood possesses lower strength values and tends to produce greater warpage as well as surface and cross checks. The strength values are usually around 15%-30% below normal although a reduction of 50% has been reported (Briggs and Smith, 1985). In veneer production, juvenile wood has a tendency to split and cause lathe checks which are rougher and deeper (Kelloggs and Kennedy, 1985). In the production of pulp and paper (Megraw, 1985) reported that the juvenile wood of Douglas-fir was of a lower density, possessed a higher lignin content and produced less pulp. Megraw (1985) also noted that the pulping condition needed to be less severe due to the fragile cell wall as the shorter fibre lengths and greater fibril angle lowered its tear strength. Lehnman and Geimer (1974) reported a particleboard produced from Douglas-fir tops and branches including bark, possess lower strength and substantially poorer dimensional stability properties

Several studies have been conducted on the juvenile wood from different clones of rubberwood, such as studies on the proportion of tension wood (Vijendra Rao et al., 1983). Vijendra Rao et al. (1983) noted that the proportion of tension wood in rubberwood from India varied for different samples taken from different heights of the same tree and also between different trees. The proportion of tension wood ranged from 15% to 65%. Ani and Lim (1992) studied the percentage of tension wood in two clones of rubberwood (PB 260 and RRIM 600) of different ages. They found that RRIM 600 possessed a lower percentage of tension wood (30%) than PB 260 (40%).

For PB 260, the percentage of tension wood increased with height, whereas for RRIM 600, the percentage of tension wood decreased (Table 1).

Table 1

Percentage of tension wood in rubberwood at various ages and tree heights.

Age (year)	Clone PB 260				RRIM 600			
	B	M	T	Mean	B	M	T	Mear
3	35	40	57	44	-	-	-	-
8	27	29	37	30	42	33	25	33
14	49	36	52	45	-	-	-	-
24	-	-	-	-	39	29	25	30

Note : B = Bottom M = Middle T = Top

Source : Ani Sulaiman and Lim (1992)

Due to the factors described, juvenile wood which is also called 'weak wood' possesses great problems in wood processing. Many setbacks have been faced by researchers when utilising juvenile wood for trusses, laminated beams and finger-jointed lumber. Similar problems are also faced by manufacturers of various panel products such as plywood, conventional particleboards, oriented strand board (OSB), medium density fibre board (MDF), weather boards and hard boards (Rice, 1973). It is therefore essential to determine the properties of juvenile wood from various clones and age groups of rubberwood. The selected clones are 10 and 20-year old of PB 359, PB 366 and RRIM 600. The main objectives of this study are to assess strength of juvenile rubberwood as well as to determine the structure of juvenile rubberwood and its relation to physical and mechanical properties.

Justification

Rubberwood is a versatile timber and is an important source of raw material for the production of many types of wood products (Lew, 1992; Chew, 1993). Recently, rubberwood emerged as the most popular wood used in the manufacture of furniture such as dining sets, occasional furniture, living room furniture, cabinets and even outdoor garden sets (Hong and Sim, 1985). The rubberwood supply from replanting schemes is decreasing from year to year. The availability of rubberwood in Peninsular Malaysia in 1992 was about 9,360,698 m^3 and decreased to about 8,909,272 m^3 in 1994 (Anon, 1995). The tendency of using younger wood and timber of smaller diameter is becoming more common. The trend may become a normal practice as the supply of this timber becomes more scarce.

The utilisation of juvenile rubberwood for industrial purposes needs to be given nore attention. Emphasis must be given on short rotation rubberwood especially for ubberwood plantations of less than 15 years. This is because young rubberwood tends o pose various problems in most manufacturing processes due to the greater ccurrence of spiral grain, the lower strength, lower density, shorter fibre length and also greater longitudinal shrinkage. This study is thus important in assessing the suitability of juvenile rubberwood for utilisation in the manufacturing process as compared to mature rubberwood. Indirectly, it will provide additional preliminary information for the local and foreign manufacturers. The proper understanding and documentation of the properties and processing variability of juvenile rubberwoood from various age groups will definitely help towards the production high quality products as the matured rubberwood.

Objectives

The two main objectives of this study are as follows :

1. To determine the extent of juvenility in rubberwood in 10 and 22-year old trees from three different clones.
2. To investigate the anatomical structure of juvenile rubberwood and their relation with the physical and mechanical properties.

CHAPTER II

LITERATURE REVIEW

Background of Rubberwood in Peninsular Malaysia

Peninsular Malaysia represents one of the world's largest producers of rubber. There is about 1.82 million hectares of *Hevea brasiliensis* plantations (Anon, 1992). Of the 1.82 million hectares found in Peninsular Malaysia, about 1.18 million hectares were reported to be small holdings. In 1990, about 0.94 million hectares of small holdings were managed by Rubber Industry Small Holders Development Authority (RISDA) and about 0.24 million hectares were individually owned by small holders. There were about 1,332 estate owners in Peninsular Malaysia (Ismariah and Norini, 1994).

The rubber trees generally reach their prime latex production in 25 years, after which they are no longer economical to produce latex, but their wood can be utilised for economic purposes (Anon, 1986). Within 25 years, rubber trees normally have clear boles of 3 to 10 m height depending on the clone. The diameter at breast height of rubber tree may reach 50 cm. Generally clone trees are shorter and smaller than trees raised from seeds (Hong and Lim, 1985).