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Comparative Study of Morphology and Anatomical Structure of 5 LKS (Lesser Known Species) of Myanmar

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မြန်မာ့လူသုံးနည်းသစ်မာ (၅)မျိုး၏ ပြင်ပရုပ်သွင်နှင့် သစ်အင်္ဂါရုပ်များကိုလေ့လာခြင်း

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ဦးသိန်းကြွယ်၊ M.Sc. (Ygn.) M.S (SUNY, CESF)
ဒုတိယညွှန်ကြားရေးမှူး၊ သစ်တောသုတေသနဌာန၊ရေဆင်း

စာတမ်းအကျဉ်းချုပ်

ပဲခူးမြို့နယ်၊ ပျဉ်းမနားမြို့နယ်၊ ပုသိမ်ကြီးမြို့ယ်တို့မှ မြန်မာ့လူသုံးနည်းသစ်မာ (၅) မျိုးကို လေ့လာ၍ ၄င်းတို့၏ပြင်ပရုပ်သွင်၊ သစ်အင်္ဂါရုပ်များကို နှိုင်းယှဉ်ဆွေးနွေး တင်ပြထားပါသည်။ ၄င်းတို့၏ သစ်သား၏ သိပ်သည်းဆ၊ ကျုံ့ခြင်းတို့ကိုလည်း ဖော်ပြထားပါသည်။ ၄င်းသစ်မာမျိုးစိတ် (၅) မျိုးမှာ အောက်ပါအတိုင်း ဖြစ်ပါသည်။

၁။ *Berrya ammonilla* Roxb. (ဖက်ဝန်း)
၂။ *Pterospermum semisagittatum* Buch-Hum. (နဂျယ်)
၃။ *Melanorrhoea usitata* Wall. (သစ်စေး)
၄။ *Terminalia chebula* Retz (ဖန်းခါး)
၅။ *Diospyros burmanica* Kurz (တယ်)

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Abstract

Comparative Morphological and Anatomical Study of 5 LKS of Myanmar from Bago, Pyinmana and Patheingyi townships has been made. Specific gravity and shrinkage properties of the timber are studied and described. The species investigated are as follows.

1. *Berrya ammonilla* Roxb. (Petwun)
2. *Pterospermum semisagittatum* Buch-Hum. (Nagye)
3. *Melanorrhoea usitata* Wall. (Thitsi)
4. *Terminalia chebula* Retz (Panga)
5. *Diospyros burmanica* Kurz (Te)

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1. Introduction

In Myanmar, there exists about a thousand and five hundred tree species of which forty to fifty are in use commercially throughout the country. The remaining species are still unused or little used. The commercially important timber species become scarce due to the development of wood-based industries and increases of domestic and international timber trade. Thus officials in the forestry section become to consider that commercially important timbers should be substituted by other appropriate woody species or by some lesser known species the so called secondary species.

Resources of the preferred commercial wood species are dwindling and greater efforts are needed to introduce lesser-known wood species and to intensify their regeneration. The reasons for wood species to be lesser-known may be manifold and it is needed to support research and data collection activities aimed at clarifying the use potential of lesser-known species as a basic requirement for the promotion of individual or groups of wood species and their products.

As long term supply is not assured, lesser used species are not introduced to the market at all. However some of them possessed equal properties or even superior to known commercial species. Apart from that the wood of lesser used species could be promoted by developing management, proper drying and preservative treatment.

In the improved utilization of lesser used species, many researchers investigated on strength, physical and mechanical properties belonging to its structure and durability. Some workers also studied on their properties and utilization according to their species gravity (green). According to their specific gravity (green), the timber species are grouped as heavy hardwoods, medium or moderately heavy hardwoods and light woods. Woods with green specific gravity of 0.36 or less are considered to be light; 0.36 to 0.50, moderately light to moderately heavy; above 0.50, heavy.

Thus the present research aims to clarify the potential uses of secondary woods, to get better knowledge of wood properties, and to know commercial importance of some lesser-known species.

In Myanmar, nine commercially less acceptable heavywood species were studied in respect with their morphology, wood anatomy and uses (Kyu Kyu Thin, 1996) other than the specie described in this research.

In the present study, the habit, distribution, morphological and taxonomic characteristics, flowering and fruiting periods, macro-and microscopic characteristics and physical properties of the wood have been described.

Five commercially less acceptable species studied in the present research are as follow:-

1. *Berrya ammonilla* Roxb. (Petwun)
2. *Pterospermum semisagittatum* Buch-Hum. (Nagye)
3. *Melanorrhoea usitata* Wall. (Thitsi)
4. *Terminalia chebula* Retz (Panga)
5. *Diospyros burmanica* Kurz (Te)

2 Literature Review

In the forests of Myanmar, there were most abundant tree species called lesser known species (LKS) or commercially less acceptable species and commercially important timber species. There was a vast resource of LKS which account for 75-80 % of the total growing stock. Moreover, the dry deciduous forest of Myanmar comprised mostly these lesser known species.

In the classification of Lawrence (1951) Benson (1967), Rendle (1967) and Heywood (1978), *Berrya ammonilla* and *Pterospermum semisagittatum* belonged to the family Tiliaceae and Streculiaceae respectively of the order Malvales. These two families had been placed under the order Tiliales by Hutchinson (1964).

According to Lawrence (1951), Hutchinson (1964), Benson (1967), Rendle (1967) and Heywood (1978) *Melanorrhoea usitata* belonged to the family Anacardiaceae of the order Sapindales.

According to Hutshinson (1964), Rendle (1967) and Heywood (1978), *Terminalia chebula* was placed in the family Combretaceae under the order Myrtales.

Diospyros burmanica belonged to the family Ebenaceae of the order Ebenales by the classification of Hutchinson (1964), Rendle(1967)and Heywood (1978).

1. *Berrya ammonilla* Roxb.

Gamble (1922) stated that it was found in the forests of the dry country of Sri Lanka, the Shan Hills, the drier upper mixed and hill Eng forests of Pyinmana, Ruby mines, Mattaban, Pegu Yoma and Coco Island.

Morphological characteristics of *B.ammonilla* were described by Kurz (1877), Hooker (1885), Brandis (1906) Troup (1921), Bor (1953), Hutchinson (1964) and Backer (1968).

General characteristics and properties of the wood were mentioned by Gamble (1922), Pearson and Brown and Dastur (1964), the wood of *B.ammonilla* was dark red in colour, very hard, strong and tough; it was well known for its durability and resistant to wear and tear both on the ground and in contact with water. Pearson & Brown (1932) also mentioned that the sapwood was brownish - white; heartwood dark red to brown, with darker lines.

Microscopic characteristics of vessels, rays fibres and parachyma in the wood of *B.ammonilla* were revealed by Gamble (1922), Pearson & Brown (1932) and Metcalfe & Chalk (1950). Vessels were small to medium-sized, occluded with tyloses, lighter than background and appearing punctate to the naked eye. Parenchyma were paratracheal - zonate and metatracheal. Fibres were libriform with very thick walls and narrow lumina (Pearson & Brown, 1932).

2. *Pterospermum semisagittatum* Buch-Ham.

As stated by Hooker (1885) and Gamble (1922), this species was frequent in mixed and dry forests all over Myanmar from Sittagoung and Inwa down to Tenasserim.

Morphological studies of *Pterospermum semisagittatum* were described by Hooker (1885), Brandis (1906), Gamble (1922) and Soe Myint Aye(1994). According to them, it was a moderate -sized tree with an irregular-shaped, fluted stem.

The description on the general characteristics of the wood of *P. semisagittatum* had been made by Gamble (1922), Pearson & Brown (1932) and Metcalfe & Chalk (1950). They described that the wood was reddish-grey in colour, moderately hard, but with numerous pores and a few broader medullary rays. Kurz (1877) stated that the wood was heavy, brown and close- grained.

Microscopic features on the vessels, rays, fibres and parenchyma of the wood of *P. semisagittatum* were revealed by Metcalfe & Chalk (1950).

3. Melanorrhoea usitata Wall.

Kurz (1877), Brandis (1906) and Gamble (1922) stated that this species was distributed in upper and lower Myanmar, chiefly in Eng forests. Rodger (1936) also described that it was common in drier plains and lower hill forests of Myanmar up to 3500 ft on laterite and sandy soils.

Investigations on morphological characteristics of *Melanorrhoea usitata* were mentioned by Hooker (1885), Kurz (1877) and Brandis (1906).

General characteristics of the wood of this species were revealed by Gamble (1922), Pearson & Brown (1932) and Metcalfe & Chalks (1950). They described that the wood was dark red, very hard, striated with yellowish-red turnning much darker with age. But Kurz (1877) stated that the wood was reddish-brown in colour, close-and fine-grained. Rodger (1936) and Anonymous (1990) also revealed that this timber was difficult to season and it was very durable.

Gamble (1922), Pearson & Brown (1932) and Metcalfe & Chalk (1950) mentioned its microscopic features in detail on vessels, rays, fibres and parenchyma.

Pearson & Brown (1932) stated that the wood was moderately heavy, straight and somewhat uneven- grained and coarse- textured.

4. *Terminalia chebula* Retz.

According to Troup (1921) and Gamble (1922), *Terminalia chebula* was distributed throughout the greater parts of India and Myanmar in mixed deciduous forests.

In Myanmar it occurred in deciduous forests both of the upper and the lower mixed types among with teak, *T. tomentosa, Dipterocarpus tuberculatus.*

Pearson & Brown (1932) described that this species was found in Myanmar, locally in Tenasserim but more common further north in lower Myanmar.

Thein Kywe & Kyaw Soe (1983) also stated that *Terminalia chebula* was commonly found growing in the deciduous and dry forests throughout Myanmar.

Morphological descriptions of *T. chebula* were made by Kurz (1877), Brandis (1906), Bor (1953), Dastur (1964), Thein Kywe & Kyaw Soe (1983), Maung Thynn (1983), Khin Mar Than (1994) and Tun Yin (1995).

General characteristics of the wood *T. chebula* had been described by Gamble (1922), Pearson & Brown (1932), Metcalfe & Chalk (1950) and Thein Kywe & Kyaw Soe (1983). According to them, the wood was very hard, brownish- grey with a greenish or yellowish tinge and with an irregular small dark purple heartwood. Kurz (1877) also stated that its

sapwood was greyish streaked and heart wood was hard yellowish or dark brown to blackish in colour.

Microscopic characteristics of the wood on vessels, parenchyma, fibres and rays of *T. chebula* were made by Gamble (1922), Pearson & Brown (1932), Metcalfe & Chalk (1950) and Thein Kywe & Kyaw Soe (1983).

According to them, the vessels were very small to medium- sized and parenchyma were paratracheal and paratracheal zonate. Pearson & Brown (1932) stated that the fibres were libirform, angled or rounded in transverse sections and more or less aligned in radial rows. They also stated that the rays were extremely fine, uni-or biseriate and heterogeneous.

5. *Diospyros burmanica* Kurz

Kurz (1877), Brandis (1906), Gamble (1922) and Pearson & Brown (1932) had stated that this species was commonly distributed in the dry and open forests, especially in the Eng forest of Prome and Ava; less frequent in all over Pegu and Martaban.

Davis (1960) also described that Diospyros (Te) scrub forests were edaphic scrub forests on red and ferruginous sandy soils. They were most prevalent mainly to areas in the northern part and north of the central dry zone where rainfall was about 50 inches a year.

Morphological identification of *Diospyros burmanica* was revealed by Kurz (1877), Hooker (1885), Brandis (1906), Bor (1953), Khin Khin (1991) and Tun Yin (1995).

The investigations on general characteristics of the wood of *Diospyros burmanica* were revealed by Pearson & Brown (1932) and Rodger (1936). The wood was light red to purplish or blackish-grey in colour and brownish black or black heartwood was narrow and irregular (Pearson & Brown 1932).

Pearson & Brown (1932) and Metcalfe & Chalk (1950) had described in detail on the microscopic characteristics of the wood of *D. burmanica*. According to them, the vessels were small to very small; the rays were very fine, uniseriate to biseriate, heterogeneous and reddish - brown gummy deposits present in them. Pearson & Brown (1932) stated that the parenchyma were paratracheal and metatracheal with reddish brown gummy infiltration. The fibres were libriform and very fine.

3. Materials and Methods

The plants described in this research were taken from Pyinmana and Patheingyi townships in Mandalay and Bago Divisions. The species and parts of the plants concerned were collected at the flowering and fruiting periods.

To investigate the morphological characteristics, the vegetative and reproductive parts were pressed and dried as well as preserved in FAA (formalin-acetic acid-alcohol solution). For the classification and morphological identification, all the fresh and preserved specimens of each species were utilized.

To study the anatomical characteristics of the woods of each plant, a portions of stem with intact bark measuring 20 cm x 15 cm x 2.5 cm was cut. The wood samples of all species are comprised with bark, sapwood and a portion of heartwood.

For the microscopic studies of the wood specimens, Jeffery's method (1917) was used.

For anatomical observation, specimens with heartwood were selected and cut into small cubes of 1 cm x 1 cm x 2 cm. Transverse, tangential and radial sections were made by using sliding microtome.

To study individual elements, wood specimens were macerated with a mixture of equal volumes of 30% hydrogen-peroxide and glacial acetic acid by Franklin's method (1946).

Terminology of microscopic description was used according to Chattaway (1932) and Wheeler, Baas and Gassom (1989).

Photomicrographs were also made by use of Olympus Universal Research microscope Vanox model AHB-2-HL.

General characteristics of wood, especially colour, weight, texture, grain direction and porosity of each species were macroscopically studied with 20 cm x 15 cm x 2.5 cm block of wood samples.

For evaluating the Physical properties, six samples each measuring 2.5 cm x 2.5 cm x 10 cm were taken from each block. Green specific gravity and oven-dry specific gravity were calculated by using water displacement method. Radial and tangential shrinkage (Green to oven-dry) were also worked out at the same time.

4. Observations

1. Morphology

All species studied in this research are deciduous trees. *Terminalia chebula* is medium-sized to large tree and *Diospyros burmanica* is small to medium-sized tree whereas the remaining 3 species are large trees.

The leaves of all species studied in this research are simple and alternate except in those of *Terminalia chebula* in which they are sub- opposite. With exception of *Berrya ammonilla* and *Pterospermum semisagittatum,* the remaining species are exstipulate..

Various types of leaf shape, leaf base and leaf tip are observed in the species studied as shown in table 1.

The petioles in all species are terete except in those of *Melanorrhoea usitata* and *Diospyros burmanica,* of which are slightly flattened, and slightly winged and canaliculate above.

The inflorescences are terminal and axillary many-flowered panicles in *Berrya ammonilla* and *Melanorrhoea usitata,* terminal and axillary paniculate spikes in *Terminalia chebula,* terminal or axillary cymes in *Pterospermum semisagittatum* and *Diospyros burmanica.*

The flowers of all species are bisexual except in *Diospyros burmanica.* The flowers are unisexual in *D. burmanica.* The flowers of *Terminalia chebula* are epigynous whereas those of the rests are hypogynous. All sepcies studied have regular and pedicellate flowers except in the case of *T. chebula* in which the flowers are sessile.

The calyces of all species studied are gamosepalous and the corollas are polypetalous except in those of *Diospyros burmanica* in which they are gamopetalous. The corollas of

Berrya ammonilla and *Melanorrhoea usitata* are persistent. Corollas are modified into wings in the fruit of *M. usitata.*

The hairy characters of the calyx and corolla of the species studied are shown in table 2.

Stamens are numerous in *Berrya ammonilla* and *Melanorrhoea usitata* in which they are free and borne on a very short androgynophore in the former and triseriate in the latter. Stamens are biseriate in *Terminalia chebula, Pterospermum semisagittatum* and in the male flowers of *Diospyros burmanica.* However, bisexual flowers of *D.burmanica* consist of only 8 sterile stamens. In *Pterospermum semisagittatum,* the outer 15 stamens are fertile and in 5 groups, 3 in each group and the inner 5 being staminodes.

The stamens are dorsifixed in *Berrya ammonilla* and *Melanorrhoea usitata,*versatile in *Terminalia chebula,* and basifixed in *Pterospermum semisagittatum* and *Diospyros burmanica.*

In this study, the gynoecia of *Melanorrhoea usitata* and *Terminalia chebula* are monocarpellary. The gynoecium is found to be tricarpellary in *Berrya ammonilla,* pentacarpellary in *Pterospermum semisagittatum* and tetracarpellary in *Diospyros burmanica* respectively. The ovaries found in all species are syncarpous.

The ovaries of the species studied are superior in position except in those of *Terminalia chebula* which are inferior. The shape and hairy characters of ovary and placentation of ovules are shown in table 3.

The styles of all species studied are terminal except in *Melanorrhoea usitata* in which the style is sublateral. Stigamas are simple in *Melanorrhoea usitata* and *Terminalia chebula*, five- furrowed and seemingly ellipsoidal in *Pterospermum semisagittatum,* trilobed in *Berrya ammonilla* and tetralobed in *Diospyros burmanica.*

The type, shape, colour and hairy characters of the fruits are shown in table 4. The fruits of *Melanorrhoea usitata, Terminalia chebula* and *Diospyros burmanica* are indehiscent and those of *Berrya ammonilla* and *Pterospermum semisagittatum* are dehiscent.

Seeds are ovoid in *Berrya ammonilla,* ovoid and winged in *Pterospermum semisagittatum,* sub-globose in *Melanorrhoea usitata., ellipsoidal in terminalia chebula* and oblongoid in *Diospyros burmanica*

Table 1. Types of leaf shape, leaf base and leaf tip of the five species studied.

No.	Species	Leaf shape	Leaf base	Leaf tip
1.	*Berrya ammonilla*	orbicular	Cordate	acute
2.	*Pterospermum semisagittatum*	lanceolate to oblong lanceolate	oblique sagtittate on one side	acuminate
3.	*Melanorrhoea usitata*	oblong or obovate-cuneate	cuneate or attenuate	acute or obtuse
4.	*Terminalia chebula*	ovate or elliptic	acute to obtuse	acute to acuminate
5.	*Diospyros burmanica*	elliptic to oblong-elliptic	Acute	acute to acuminate

Table 2. Hairy characters of the calyx and corolla of the five species studied.

No.	Species	Calyx	Corolla
1.	*Berrya ammonilla*	densely pubescent without glabrous within	glabrous on both sides
2.	*Pterospermum semisagittatum*	velvetly within brown stellate without	glabrous on semisagittatum glabrous within brown stellate without
3.	*Melanorrhoea usitata*	pubescent on both sides	pubescent on both sides
4.	*Terminalia chebula*	woolly within puberulous without	-
5.	*Diospyros burmanica*	shinning brown tomentose without, tomentose within	shinning tomentose without glabrous within

Table 3. The shape and hairy characters of the ovary and placentation of the ovules of the five species studied.

No.	Species	Shape	Hairy character	Placentation of ovules
1.	*Berrya ammonilla*	ovoid or globose	Villous	Axile
2.	*Pterospermum semisagittatum*	oblogoid	densely stellate tomentose	Axile
3.	*Melanorrhoea usitata*	ovoid or globose with stalk	Glabrous	pendulous
4.	*Terminalia chebula*	ovoid	Glabrous	pendulous
5.	*Diospyros burmanica*	ovoid	shinning tomentose	axile pendulous

Table 4. Type,shape,colour and hairy characters of the fruits of the five species studied.

No.	Species	Type	Shape	Colour	Hairy character
1.	*Berrya ammonilla*	loculicidal caspsule with 6-8 wings	ovoid	light brown when dry	pubescent
2.	*Pterospermum semisagittatum*	loculicidal caspsule	obovoid	Brown	densely rustystellate tomentose glaborus
3.	*Melanorrhoea usitata*	drupe with accrescent petals and stalk	globose with accrescent petals	light red when fresh, light brown when dry	glabborus
4.	*Terminalia chebula*	drupe with 5 angles when dry	ellipsoidal or ovoid	greenish yellow	glabrous
5.	*Diospyros burmanica*	berry	globose	dark green when young, orange- yellow at maturity	shinning tomentose when young, glabrous at maturity

2. Anatomy

Key to the species

1. Number of pore per sq. mm. more than 20; rays heterocellular; crystals absent in axial parenchyma……..2

1. Number of pore per sq. mm. less than 20; rays heterocellular to homocellular; crystals absent or present in axial parenchyma …….3

   2. Pores very small to medium-sized; maximum length of vessel elements more than 500µm; rays uniseriate to biseriate, mostly uniseriate; tile cells absent and crystals present in ray cells; texture very fine …….. *Diospyros burmanica.*

   2. Pores moderately small to medium -sized; maximum length of vessel elements less than 500 µm ; rays uniseriate to pentaseriate; mostly uniseriate and biseriate; tile cells present and crystals absent in ray cells; texture fine…….. *Pterospermum semisagittatum.*

3. Rays exclusively uniseriate; crystals present in ray cells; maximum solitary pore percentage more than 80%; tyloses absent; pits vestured; …… *Terminalia chebula*

3. Rays uniseriate to multiseriate; crystals absent in ray cells; maximum solitary pore percentage less than 80%; tyloses present; pits simple ……4.

   4. Maximum tangential diameter of pore more than 210 µm; rays homocellular; silica present; crystals absent in axial parenchyma; straight- grained …… *Melannorrhoea usitata.*

   4. Maximum tangential diameter of pore less than 210 µm; rays heterocellular; silica absent; crystals present in axial parenchyma; twisted grained …… *Berrya ammonilla.*

1. *Berrya ammonilla* Roxb.

General Characteristics and Properties of the Wood

Sapwood brownish -grey, heartwood not distinct; odour and taste not distinct; heavy (Specific gravity (Green) 0.51); hard, fine -textured; twisted- grained; diffuse-porous; growth ring distinct.

Microscopic Characteristics

Vessel elements: Diffuse - porous; moderately small to medium - sized, mean tangential diameter 118 µm (range 51-195 µm); number per sq. mm few to moderately numerous (range 3-17); average solitary pores 38% (range 12.5-75); pores solitary or as radial pore multiples of 2-6 or sometimes pore clusters; circular or oval in cross section; thin-walled; tyloses present, gum deposits present; perforation plate simple, end walls of elements oblique or transverse, truncate; intervascular pitting alternate, crowded, circular or oval; chamber with mean tangential diameter 3 µm (range 2.5 -5.0 µm); vessel elements moderately short to medium - sized, mean length 394 um (range 308-492 µm).

Fibres : Libriform, moderately short to moderately long, mean length 1207 µm (range 851-1661 µm); F/V ratio 3.1 (range 2.0-4.6,) mean tangential diameter 26 µm (range 13-30); non-septate, thin-walled, 2.5 -5.0 µm thick, interfibre pit minute, simple, slit-like.

Rays : Heterocellular, uniseriate to tetraseriate, mostly uniseriate and biseriate, 11-23 per mm tangentially, very numerous; uniseriate rays extremely fine to moderately fine, mean width 16µm (range 10-31 µm), mean height 466µm (range 82-780 µm), 3-22 cells high; multiseriate rays extremely fine to medium-sized, mean width 27 µm (range 10-62 µm), mean height 513µm (range 308-1025µm), 8-36 cells high; ray vessel pitting alternate,oval or circular in shape, 2.5-5.0 µm in diameter, gum deposits present in procumbent cells; tile cells presents.

Axil parenchyma : Abundant, paratracheal scanty; apotracheal diffuse, diffuse in aggregate; gum deposits and crystals presents.

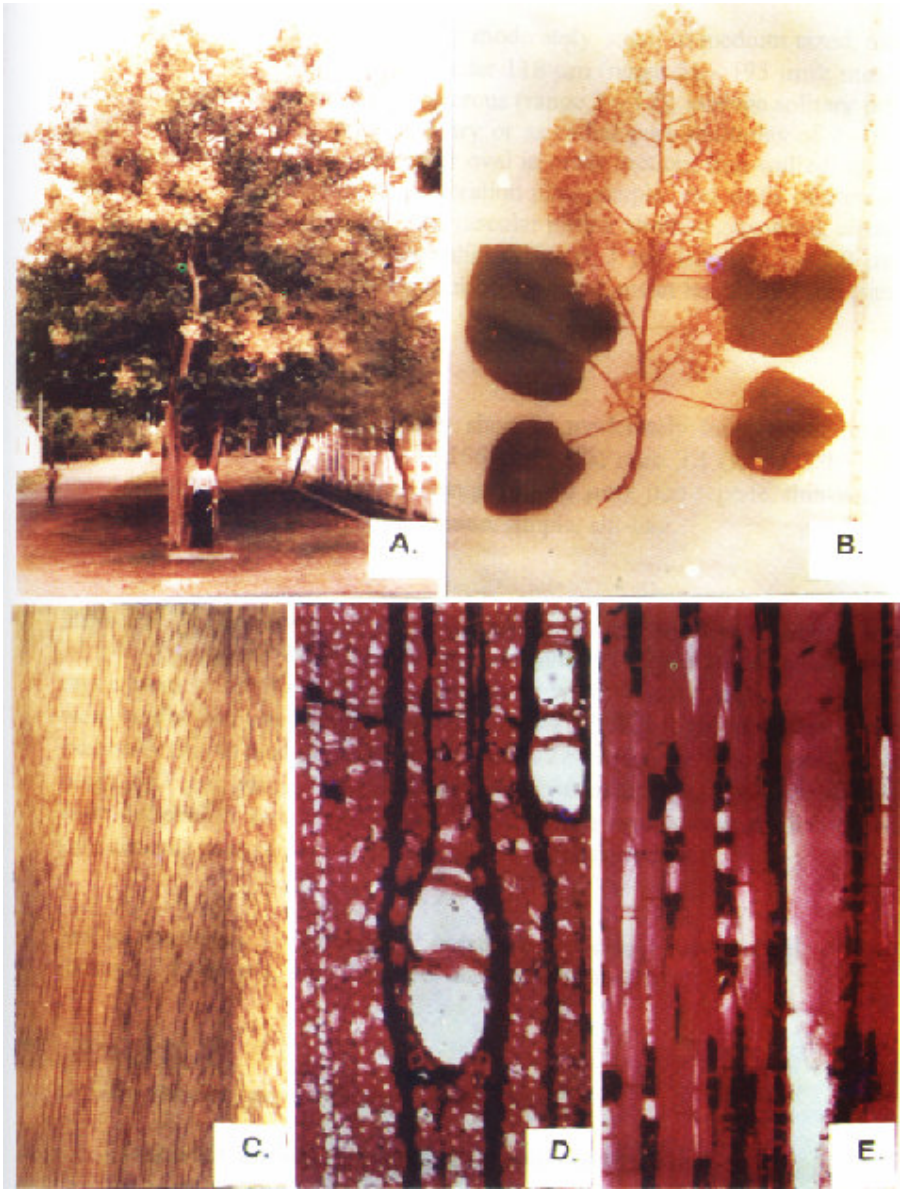


Plate 1. *Berrya ammonilla* Roxb

A. A plant in nature habit.
B. A flowering branchlet.
C. Portion of a wood in natural colour as seen.
D. Transverse section of wood (X. 115)
E. Tangential longitudinal section of wood (X.115)

2. *Pterospermum semisagittatum* Buch-Ham.

General Characteristics and Properties of the Wood.

Sapwood light brown, heartwood reddish-grey; odour and taste not distinct; heavy (specific)gravity (Green)0.78) ; hard, fine-textured; straight - grained; diffuse -porous; growth ring distinct.

Microscopic Characteristics

Vessel elements: Diffuse - porous; pores moderately small to medium-sized, mean tangential diameter 106 μm (range 62-146 μm); number per sq. mm moderately few to numerous (range 7-24); average solitary pores 40% (range 9-90); pores solitary or as radial pore multiples of 2-9 or sometimes pore clusters; circular or oval in cross section; thin-walled; tyloses absent, rarely reddish-brown gum deposits present; perforation plate simple, end -walls of elements oblique or transverse, truncate; intervascular pitting alternate, crowded, circular or oval; chambers with mean tangential diameter 3 μm (range 2.5 -5.0 μm); vessel elements moderately short to medium-sized, mean length 383 μm (range 277-461 μm).

Fibres : Libriform, moderately short to moderately long, mean length 1214 μm (range 841-1743 μm);F/V ratio 3.2 (range 2.1-4.7, μm), mean tangential diameter 19 μm (range 10-28 μm); non-septate, thick-walled, 2.5 -8.0 μm thick, interfibre pit minute, simple, slit-like.

Rays : Heterocellular, uniseriate to pentaseriate, mostly uniseriate and biseriate, 9-17μm tangentially, very numerous; uniseriate rays extremely fine to very fine, mean width 14μm (range 10-21 μm), mean height 281μm (range 113-410 μm), 5-23 cells high; multiseriate rays very fine to medium-sized, mean width 35 μm (range 21-62 μm), mean height 523μm (range 236-1497 μm), 8-40 cells high; ray vessel pitting alternate, oval or circular in shape, 2.5-5.0 μm in diameter, gum deposits present in procumbent cells; tile cells presents.

Axil parenchyma : Abundant, paratracheal scanty; apotracheal diffuse, diffuse in aggregate; reddish-brown gum deposits present.

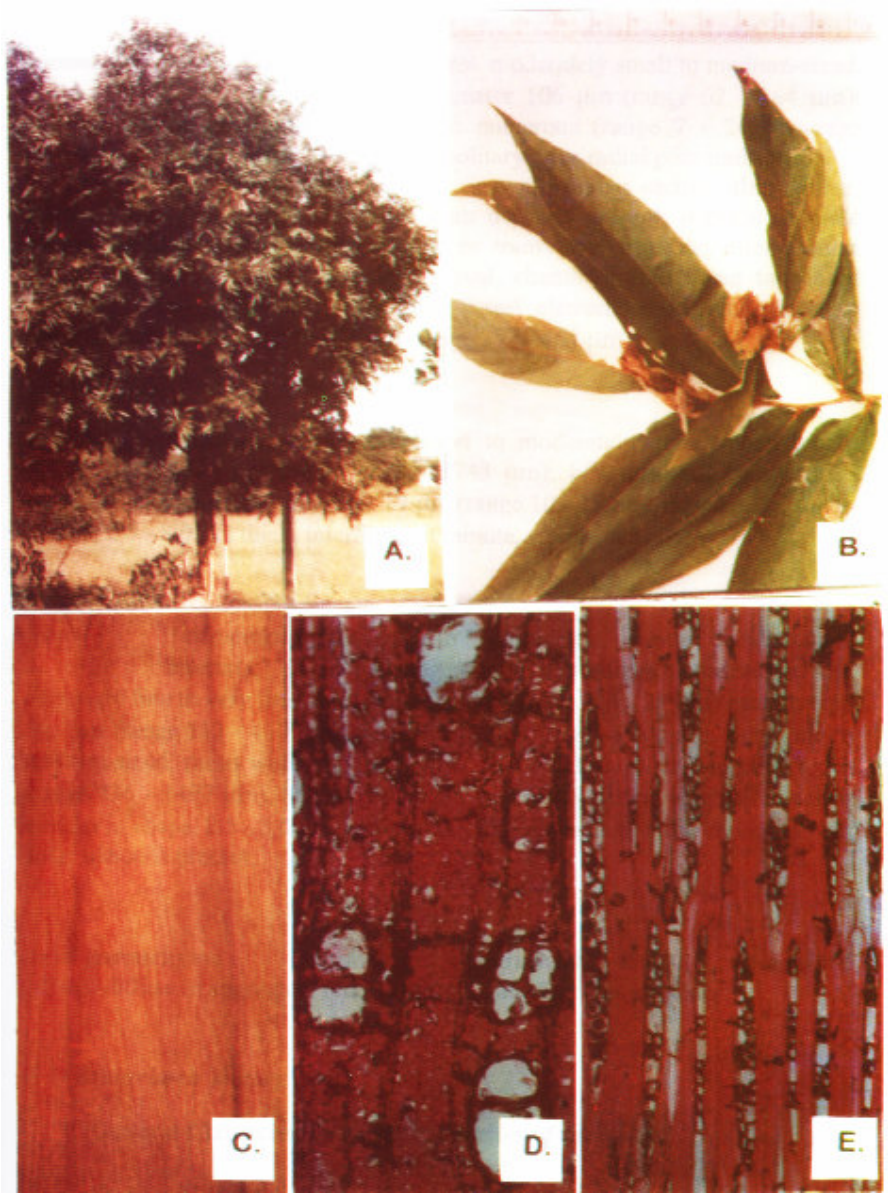


Plate 2. *Pterospermum semisagittatum* Buch. Ham.

A. A plant in natural habit
B. A flowering branchlet.
C. Portion of a wood in natural colour as seen.
D. Transverse section of wood (X.115).
E. Tangential longitudinal section of wood (X.115)

3. *Melanorrhoea usitata* Wall.

General Characteristics and Properties of the Wood.

Sapwood brownish-yellow to golden yellow, heart-wood reddish-brown to dark red; odour and taste not distinct; heavy (specific gravity (Green) 0.73); hard; medium - textured; straight-grained; diffuse-porous wood; growth ring distinct.

Microscopic Characteristics

Vessel elements: Diffuse- porous; moderately small to moderately large; mean tangential diameter 160 μm (range 72-246 μm); number per sp. mm few to moderately numerous (range 3-13); average solitary pore 49% (range 25-75); pores solitary or as radial pore multiples of 2-10 or pore clusters; circular or oval in cross section; thin-walled; tyloses abundant, dark-red gum deposits present; perforation plate simple, end walls of elements oblique or transverse, truncate; intervascular pitting alternate, crowded, oval or rounded or angular, chamber, with mean diameter 7μm (range 5 -10 μm); vessel elements moderately short to medium-size, mean length 513 μm (range 308-687 μm).

Fibres : Libriform, moderately short to medium-sized, mean length 1011 μm (range 820-1271 μm); F/V ratio 2.1 (range 1.2-3.3),mean tangential diameter 17 μm (range 10-25 μm); non-septate, thin to thick- walled, 2.5-8.0 μm thick, interfibre pits minute, simple, slit-like, gum deposites present.

Rays : Homocellular, uniseriate to tetraseriate, mostly uniseriate, 12-17 per mm tangentially, very numerous; uniseriate rays extremely fine to moderately fine, mean width 21 μm (range 10-31μm), mean height 316μm (range 72-492μm), 2-20 cells high; multiseriate rays moderately fine to medium-sized, mean width 50 μm (range 31-72 μm), mean height 373 μm (range 236-533 μm), 8-19cells high; ray vessel pitting alternate, oval or circular in shape, 5-8 μm in diameter, gum deposits present; occasionally gum canals in multiseriate rays; silica bodies present; tile cells absent.

Axil parenchyma : Abundant, paratracheal scanty; banded, connecting vessel pores forming 2-13 seriate bands, apotracheal diffuse in aggregate; gum deposits in some parenchyma.

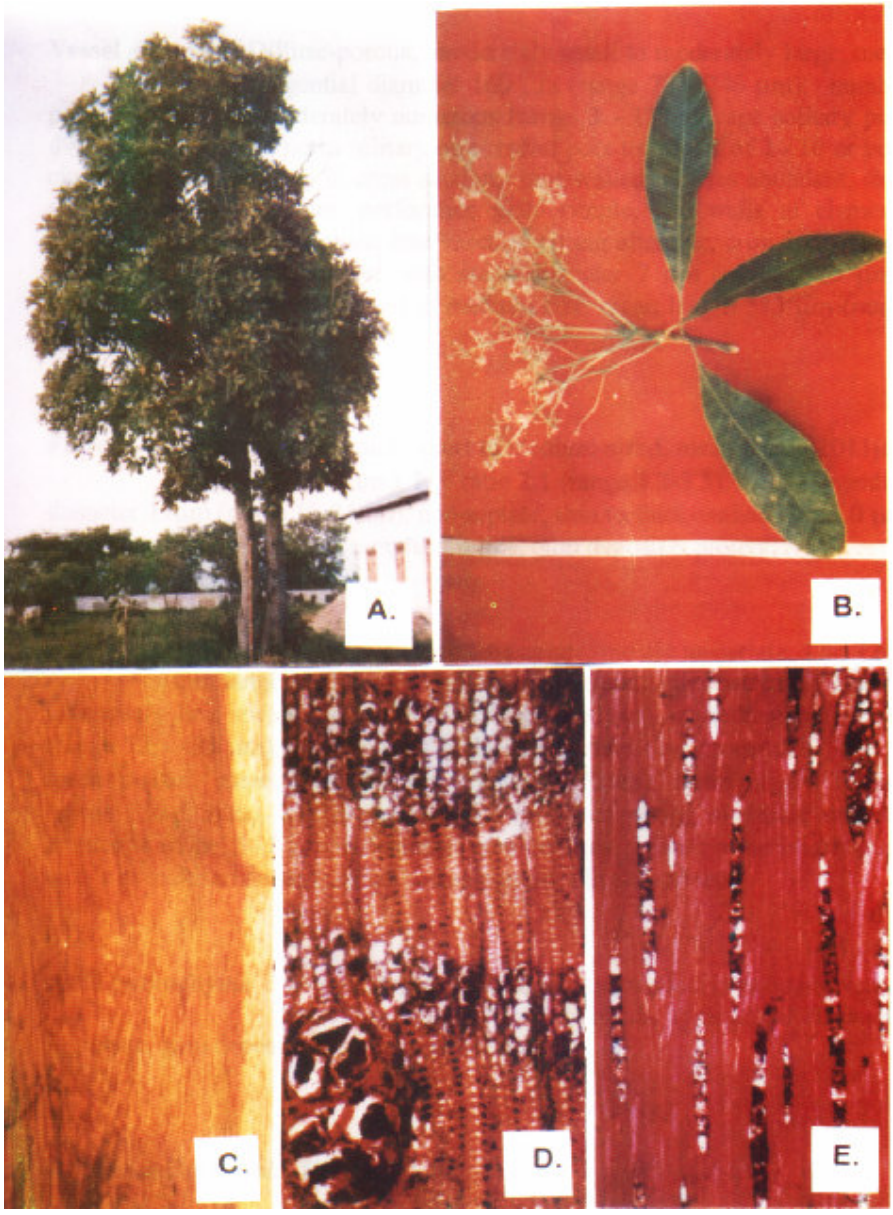


Plate3. *Melanorrhoea usitata* Wall.

A. A plant in natural habit
B. A flowering branchlet.
C. Portion of a wood in natural colour as seen.
D. Transverse section of wood (X.115).
E. Tangential longitudinal section of wood (X.115)

4. *Terminalia chebula* Retz.

General Characteristics and Properties of the Wood.

Sapwood yellowish - brown, heartwood dark yellowish- brown; odour and taste not distinct; heavy (specific gravity (Green) 0.76); hard; very fine-textured; twisted - grained; diffuse-porous wood; growth ring fairly distinct.

Microscopic Characteristics

Vessel elements: Diffuse- porous, pores very small to medium - sized, mean tangential diameter 86 µm (range 41-133 µm); number per sq. mm moderately few to moderately numerous (range 9-16); average solitary pores 87% (range 70-100); pores solitary or as radial pore multiples of 2-8 or occasionally pore clusters; circular or oval in cross section; thin-walled; tyloses absent sometimes pale red gum deposits present; perforation plate simple, end walls of elements oblique to transverse, truncate or tailed one end or both ends; intervascular pitting alternate, crowded, circular or oval, vestured, chambers with mean diameter 4µm (range 2.5 -8.0 µm), vessel elements moderately short to medium-sized, mean length 511 µm (range 328-728 µm).

Fibres : Libriform, medium-sized to very long, mean length 1692 µm (range 1076-2511 µm); F/V ratio 3.5 (range 2.2-7.3); mean tangential diameter 16 µm (range 10-25 µm); non-septate; thick to very thick-walled, 2.5-10µm thick, interfibre pit minute, slit-like, crystal absent.

Rays : Homocellular; mostly uniseriate, very occasionally biseriate in part, 8-17 per mm tangentially, numerous to very numerous; uniseriate rays extremely fine to very fine, mean width 14 µm (range 10-21µm), mean height 352µm (range 96-666µm), 2-19 cells high; rays vessel pitting alternate to opposite, oval or circular in shape, vestured 2.5-5.0 µm in diameter; elongated crystals present, gum deposits present; tile cells absent.

Axil parenchyma : Abundant, paratracheal scanty; unilateral, aliform and aliform confluent connecting 2-5 vessel pores; apotracheal diffuse and diffuse in aggregate, elongated crystals frequently in axial parenchyma, pale reddish-brown gum deposits present.

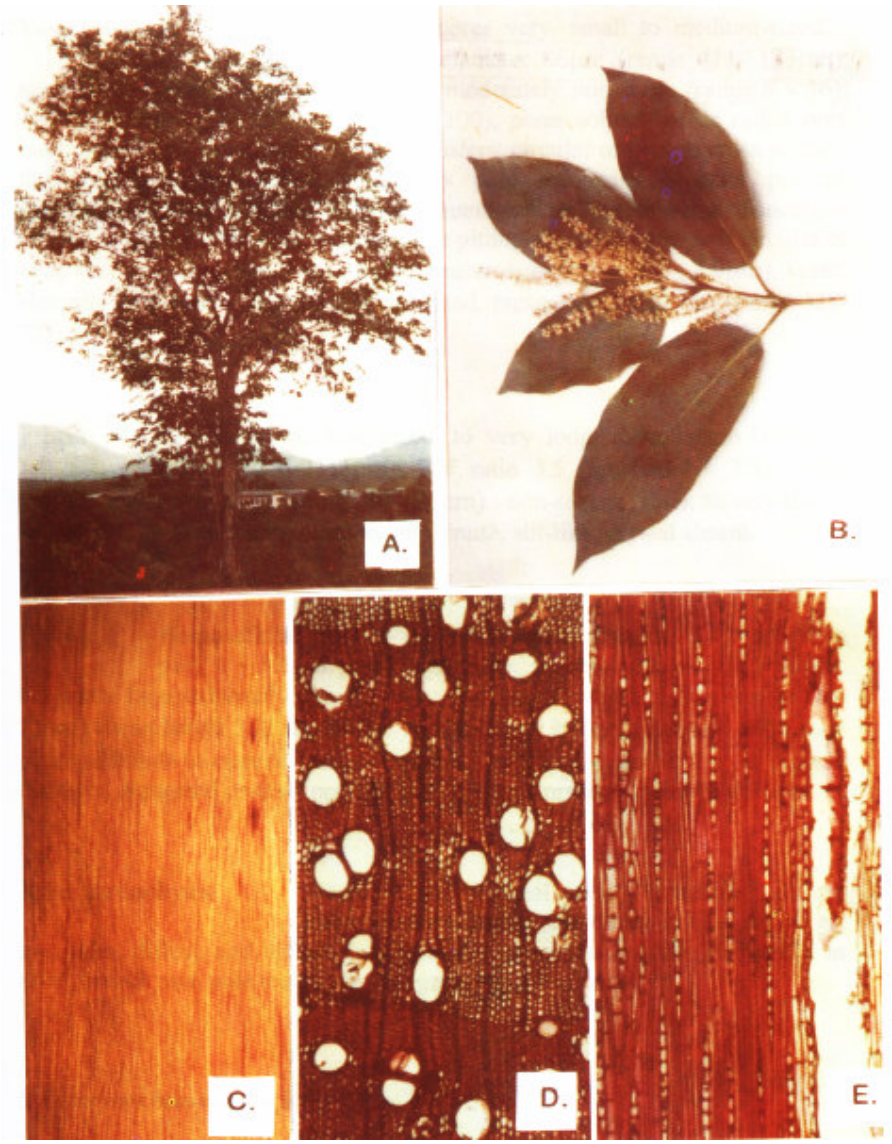


Plate 4. ***Terminalia chebula*** **Retz.**.

A. A plant in natural habit
B. A flowering branchlet.
C. Portion of a wood in natural colour as seen.
D. Transverse section of wood (X.115).
E. Tangential longitudinal section of wood (X.115)

5. *Diospyros burmanica* Kurz.

General Characteristics and Properties of the Wood.

Sapwood pinkish- brown, heartwood not distinct; odour and taste not distinct; heavy (specific gravity (Green) 0.65); very fine-textured; straight -grained; diffuse-porous; growth ring distinct.

Microscopic Characteristics

Vessel elements: Diffuse- porous, pores very small to medium - sized, mean tangential diameter 99 µm (range 31-154 µm); number per sq. mm. moderately numerous to numerous (range 12-35); average solitary pores 34% (range 9-80); pores solitary or as radial pore multiples of 2-8 sometimes pores clusters; circular or oval in cross section; thin-walled; tyloses absent; perforation plate simple, end walls of elements oblique or transverse, truncate or tailed at one end or both ends; intervascular pitting alternate, crowded, circular or oval; chamber with mean tangential diameter 3µm (range 2.5 -5.0 µm); vessel elements moderately short to medium-sized, mean length 430 µm (range 336-564 µm).

Fibres : Libriform, very short to medium-sized, mean length 1020 µm (range 697-1353 µm); F/V ratio 2.4 (range 1.5-3.4); mean tangential diameter 15 µm (range 8-20 µm); non-septate; thick- walled, 2.5 -8.0 µm thick, interfibre pit minute, simple, slit-like.

Rays : Heterocellular; uniseriate to biseriate, mostly uniseriate 13-20 per mm tangentially, very numerous; uniseriate rays extremely fine to moderately fine, mean width 25 µm (range 10-41µm), mean height 365µm (range 82-933µm), 2-28 cells high: biseriate rays moderately fine to medium - sized, mean width 36 µm (range 20-51µm), mean height 402µm (range 174-964µm) 5-23 cells high rays vessel pitting alternate, oval or circular in shape, 2.5-5.0 µm in diameter; gum deposits and crystals present; tile cells absent.

Axil parenchyma : Abundant, paratracheal scanty; apotracheal diffuse, diffuse in aggregate; gum deposits in some axial parenchyma.

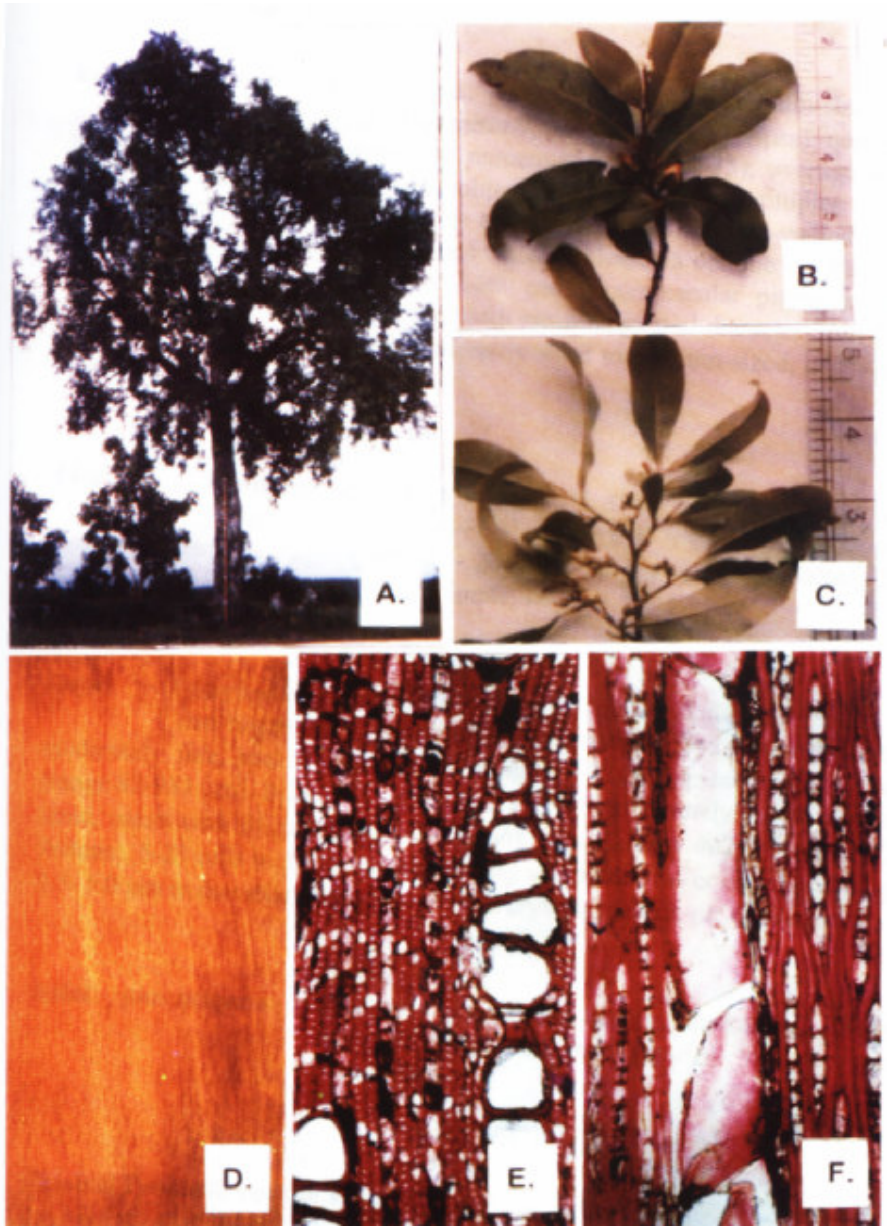


Plate 5. ***Diospyros burmanica*** **Kurz.**

A. A plant in natural habit
B. A flowering branchlet of bisexual plant.
C. A flowering branchlet of male plant.
D. Portion of a wood in natural colour as seen.
E. Transverse section of wood (X.115).
F. Tangential longitudinal section of wood (X.115)

Physical Properties of the Wood Studied

In this work, some physical properties such as specific gravity (green and oven-dry), radial shrinkage and tangential shrinkage (green to oven-dry) and stability of the five commercially less acceptable species are tested and compared with those of Kyun are given in Table 5.

According to these results obtained from five species, *Melanorrhoea usitata* has a minimum value of shrinkage in both radial and tangential from green to oven-dry, whereas *Terminalia chebula* shows the maximum radial shrinkage from green to oven-dry and *Diospyros burmanica* shows the maximum tangential shrinkage from green to oven-dry.

But, *Pterospermum semisagittatum* and *Berrya ammonilla* are found to be the most stable species whereas *Diospyros burmanica* is the least stable one among them as shown in Diagram. 1.

6. Discussion

1. Morphology

In this work, the leaves of *Berrya ammonilla* are orbicular with 5-7 palmately basal nerves and cordate base which are in agreement with Hooker (1885) and Brandis (1906). But Kurz (1877) stated that the leaves were broadly cordate-rotundate with 7-9 palmately basal nerves. Moreover Backer (1968) also described that the leaves were ovate-oval-oblong with deeply cordate base.

The stipules of the leaves are ensiform which agree to Hooker (1885), but Brandis (1906) stated that they were linear-setaceous.

The flowers are white and numerous on the terminal and axillary panicles which agree to Hooker (1885), Brandis (1906), Ridley (1923), Dastur (1964) and Backer (1968).

The calyx is campanulate, cleft into 2-3 lobes, persistent and densely pubescent which agree to Kurz (1877). But Ridley (1923) stated that it was tomentose.

The style is filiform and glabrous which agrees to Kurz (1877). But Backer (1968) stated that it was filiform and slightly papillose at the base.

The leaves of *Pterospermum semisagittatum* are lanceolate to oblong lanceolate with 6-8 pairs of lateral veins which agree to Kurz (1877), Hooker (1885), Soe Myint Aye (1994) and Tun Yin (1995).

The inflorescences are terminal to axillary 1- to 3-flowered cymes which are in agreement with Kurzz (1877), Hooker (1885), Soe Myint Aye (1994) and tun Yin (1995).

The bracts and bracteoles are deciduous, but Tun Yin (1995) stated that those were caduous.

The sepals are linear oblaneolate and yeloowish-green which agree to Kurz (1877), Hooker (1885) and Soe Myint Aye (1994).

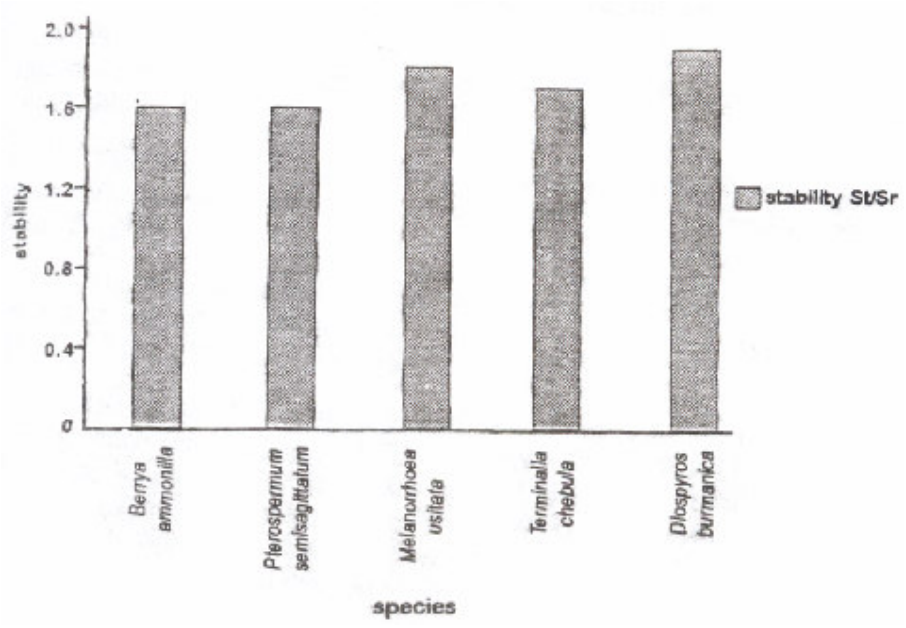
The petals are oblique-obovate cuneate, glabrous within and brown stellate without which agree to Hooker (1885), Brandis (1906) and Tun Yin (1995). However Soe Myint Aye (1994) stated that those were oblique- oblanceolate.

Table 5. Comparison of some Physical properties of tested species and *Tectona grandis*

Species	Specific gravity (green)	Specific gravity (Oven-dry)	Radial Shrinkage (Sr) Green to oven-dry (%)	Tangential Shinkage (St) Green to oven-dry (%)	Stability St/Sr
Berrya ammonilla	0.51	0.56	3.8	6.1	1.6
Pterospermum semisagittatum	0.78	0.74	4.5	7.2	1.6
Melanorrhoea usitata	0.73	0.97	2.7	4.8	1.8
Terminalia chebula	0.76	0.89	5.8	9.9	1.7
Diospyros burmanica	0.65	0.78	5.3	10.1	1.9
*Tectona grandis**	0.58*	-	2.3*	4.2*	1.6*

* The result obtained from Win Kyi (1) (1993)

Diagram 1. Comparison of stability of five commercially less acceptable species



The fruits are loculicidal capsules, obovoid, woody, many- seeded and densely rusty-tomentose which agree to Hooker (1885) and Soe Myint Aye (1994). But Kurz (1877) and Tun Yin (1995) stated that those were ovate-oblong and 5-celled.

In this study, the leaves of M*elanorrhoea usitata* are oblong to obovate-cuneate which are in agreement with Kurz (1877), Hooker (1885), Brandis (1906) and Tun Yin (1995). Moreover the leaf has 26-30 pairs of lateral nerves which agrees to Hooker (1885). But Tun Yin (1995) stated that the leaf had 20-30 pairs of nerves.

The penduncle is terete, tomentose and pale green in colour which agree to Kurz (1877), Hooker (1885), Brandis (1906) and Tun Yin (1995).

The calyx is pubescent in both sides, calyptriform, pale green in colour to beaked which is in agreement with Kurz (1877), Hooker (1885) and Tun Yin (1995).

The petals are linear-oblong, coriaceous, pubescent on both sides, accrescent and persistent which agree to Hooker (1885), Brandis (1906) and Tun Yin (1995).

The fruits are drupes with accrescent petals, globose, glabrous, light red in colour and light brown when dry which are in agreement with Kurz (1877), Hooker (1885),Brandis (1906) and Tun Yin (1995).

The leaves of *Terminalia chebula* are sub-opposite and pubescent when young which agree to Kurz (1877), Hooker (1885), Brandis (1906) and Thein Kywe & Kyaw Soe (1983). But Dastur (1964) stated that the leaves were distinct and opposite. Khin Mar Than (1994) also stated that those were alternate or opposite. However Tun Yin (1995) stated that the leaves were alternate or opposite and decussate.

The inflorescences are terminal and axillary paniculate spikes as described by Brandis (1906), Dastur (1964), Thein Kywe & Kyaw Soe (1983), Khin Mar Than (1994) and Tun Yin (1995).

The bract is lanceolate, yellowish green. longer than the floral bud, pubscent in both sides and deciduous which agrees to Kurz (1877) and Hooker (1885). Brandis (1906) also stated that the flower was subtended by a subulate downy bractlet.

The calyx is woolly within and puberulous without which agrees to Hooker (1885) and Brandis (1906). Moreover Kurz (1877) described that it was villous inside. But Khin Mar Than (1994) stated that the calyx was pubescent within and glabrous without.

The stamens are 10, free biseriate and episepalous which are in agreement with Thein Kywe & Kyaw Soe (1983), Khin Mar Than (1994) and Tun Yin (1995).

The fruits are drupes, 5- angled when dry and ellipsoidal or obovoid from a cuneate base which agree to Hooker (1885), Brandis (1906) , Bor (1953), Dastur (1964), Thein Kywe & Kyaw Soe (1983) Khin Mar Than (1994) and Tun Yin (1995). However Kurz (1877) stated that those were oval in shape.

The leaves of *Diospyros burmanica* are elliptic to oblong-elliptic in this work which are in agreement with Kurz (1877), Hooker (1885), Brandis (1906), Khin Khin (1991) and Tun Yin (1995).

The male flowers are found to be 2- to 5- flowered (mostly-3) cymes which agree to Tun Yin (1995). But Hooker (1885) and Khin Khin (1991) stated that those were 3 to 8-flowered cymes. The bisexual flowers of which all of the stamens are sterile are solitary and axillary which agree with the female flowers described by Kurz (1877), Hooker (1885) and Tun Yin (1995). The calyx of bisexual flower described in this study is 4- to 5 lobed. But Kurz (1877) stated that it was 5- lobed, rarely 4- to 6- lobed. It had been stated that 4- to 6-lobed by Brandis (1906) and as 5- lobed by Tun Yin (1995).

2. Anatomy

All the general characteristics such as the colour, grain and texture of the species are different from each other. The relative differences in the characteristics of the five commercially less acceptable species are described in the table 6.

In this work, the sapwood of *Berrya ammonilla* is brownish-grey in colour. But as stated by Pearson & Brown (1932), it was brownish-white. The sapwood of *Pterospermum semisagittatum* is light brown which agree to Kurz (1877). But Gamble (1922) and Rodger (1936) stated that the wood was reddish-grey in colour and moderately hard. The sapwood of *Melanorrhoea usitata* is brownish-yellow in colour. But Pearson & Brown (1932) stated that it was pinkish-white and narrow.

The sapwood of *Terminalia chebula* is yellowish-brown in colour. However Gamble (1922), Pearson & Brown (1932) and Thein Kywe & Kyaw Soe (1983) stated that it was light greenish, yellowish or brownish-grey.

The sapwood of *Diospyros burmanica* is seen to be pinkish-brown in this study. But Pearson & Brown (1932) stated that it was light red turning purplish or blackish grey with age. Moreover, Bor (1953) described that it was white which turned black or dark brown within a few moments after cutting.

Table 6. Comparison of Macroscopic characteristics of wood

Species observed	Colour	Odour and taste	Specific gravity (green)	Grain	Texture
Berrya ammonilla	brownish grey	not distinct	Heavy	twisted grained	fine-textured
Pterospermum semisagittatum	light brown to reddish grey	not distinct	Heavy	straight grained	fine-textured
Melanorrhoea usitata	brownish yellow to dark reddish brown	not distinct	Heavy	straight grained	medium - textured
Terminalia chebula	yellowish brown to dark yellowish brown	not distinct	Heavy	twisted grained	very fine - textured
Diospyros burmanica	pinkish brown	not distinct	Heavy	straight grained	very fine - textured

The heartwood of *Berrya ammonilla* is not distinct. But as stated by Gamble (1922), Pearson & Brown (1932), Rodger (1936) and Dastur (1964), it was dark red to brown in colour. In *Pterospermum semisagittatum,* the heartwood is found to be reddish -grey in colour which agrees to Gamble (1922).

The heartwood of *Melanorrhoea usitata* is dark reddish-brown in colour which is in agreement with Gamble (1922), Pearson & Brown (1932) and Rodger (1936). The heartwood of *Terminalia chebula* is seen to be dark yellowish-brown in colour. However, as stated by Gamble (1922), Pearson & Brown (1932), Dastur (1964) and Thein Kywe & Kyaw Soe (1983), the heartwood was dark purple in colour, small and irregular.

The heartwood of *Diospyros burmanica* is not distinct. However Pearson & Brown (1932) stated that it was brownish-black or black, narrow and irregular. Gamble (1922) stated that the wood was reddish with a small black central heartwood. Rendle (1938) described that the heartwood of various species of *Diospyros* is ebony, and Rodger (1936) also described that the wood was reddish-grey with irregular, but ebony-like heartwood.

In this study, the woods of these five commercially less acceptable species are straight or twisted grained in which *Pterospermum semisagittatum, Melanorrhoea usitata,* and *Diospyros burmanica* are straight -grained; *Berrya ammonilla* and *Terminalia chebula* are twisted-grained.

In *Berrya amonilla ,* the wood is twisted -grained. But Gamble (1922) described that it was close-grained. As stated by Pearson & Brown (1932), it was even and somewhat interlocked-grained.

In *Pterospermum semisagittatum,* the wood is straight-grained which agrees to Gamble (1922). However Kurz (1877) stated that it was close grained.
The wood of *Melanorrhoea usitata* is straight -grained in this study and however Pearson & Brown (1932) stated as straight and somewhat uneven - grained. The wood of *Terminalia chebula* is twisted-grained which is in accordance with Pearson & Brown (1932) and Thein Kywe & Kyaw Soe (1983). But Gamble (1922) stated that it was close-grained. The wood of *Diospyros burmanica* is straight -grained as given by Pearson & Brown (1932).

In this study, the wood of *Berrya ammonilla* is fine -texture and Pearson & Brown (1932) also stated that it was fine-textured. The wood of *Pterospermum semisagittatum* is also fine-textured as described by Gamble (1922).

The wood of *Melanorrhoea usitata* medium - textured, but Pearson & Brown (1932) stated that it was coarse-texture. The wood of *Terminalia chebula* is very fine-textured which agrees to Gamble (1922), Pearson & Brown (1932) and Thein Kywe & Kyaw Soe (1983).

In this study, the wood of *Diospyros burmanica* is very fine-textured as given by Pearson & Brown (1932).

The anatomical characteristics of the woods studied in this work are in accordance with the description of the species given in the literature. These anatomical characteristics observed in all five species are shown in the table 7. All species show distinct growth rings.

The woods of all the species studied are diffuse-porous.
The vessel pores found in the wood of *Berrya ammonilla* are moderately small to medium-sized as stated by Pearson & Brown (1932) and Metcalfe & Chalk (1950). The vessel pores of *Pterospermum semisagittatum* are moderately small to medium -sized as stated Metcalf & Chalk (1950).

The vessel pores in the wood of *Melanorrhoea usitata* are moderately small to moderately large which agree to Metcalfe & Chalk (1950). But Pearson & Brown (1932) stated that those were very large to medium sized. The pores of the wood of *Terminalia chebula* are very small to medium sized as given by Pearson & Brown (1932) and Metcalfe & Chalk (1950).

The vessel pores of *Diospyros burmanica* are very small to medium-sized as described by Gamble (1922) and Metcalfe & Chalk (1950). However, Pearson & Brown (1932) described that those were very small to extremely small.

The maximum mean tangential diameter of the pores is observed in *Melanorrhoea usitata* and minimum in *Terminalia chebula* as shown in Diagram 2.
In this study, the vessel elements in the woods of most species studied are moderately short to medium-sized.

Average length of the vessel elements of these five species are shown in the diagram 3, in which the range of their mean length is not wide significantly. The maximum mean length of vessels is observed in *Melanorrhoea usitata* and minimum in *Pterospermum semisagittatum.*

The vessel elements of all the five species are thin-walled. Perforation plates are simple and end walls of elements are oblique to transverse in all species. Intervascular pits are seen to be oval or circular or angular in shape in most species. Vestured pittings are observed in *Terminalia chebula*.

The number of pores per square millimeter is varies among the species and their frequency and range are also mentioned in the Diagram 4.

In this study, all species possess solitary or multiple pores or cluster of pores. Solitary pore percentage is calculated in Dragram 5. The maximum means solitary pore is observed in *Terminalia chebula* and minimum in *Diospyros burmanica.*

Table 7. Quantitative characteristics of microscopic wood structure

Mean value Species observed	Pore frequency (per sq.mm)	Vessel diameter (µm)	Vessel length (µm)	Fibre diameter (µm)	Fibre length (µm)	Fibre thickness (µm)	Uniseriate ray height (cells)	Uniseriate ray height (µm)	Uniseriate ray width (µm)	Ray frequency (per mm)	Multiseriate ray height (cells)	Multiseriate ray height (µm)	Multiseriate ray width (µm)
Berrya ammonilla	10	118	394	26	1207	3.1	11	466	16	16	16	513	27
Pterospermum semisagittatum	15	106	383	19	1214	5.3	10	281	14	16	21	523	35
Merlanorrhoea usitata	6	160	513	17	1011	4.0	9	316	21	14	12	373	50
Terminalia chebula	12	86	511	16	1692	5.7	10	352	14	13	-	-	-
Diospyros burmanica.	25	99	430	15	1020	4.7	12	365	24	16	11	402	36

Diagram 2. Comparison of vessel pore diameters among the five commercially less acceptable species

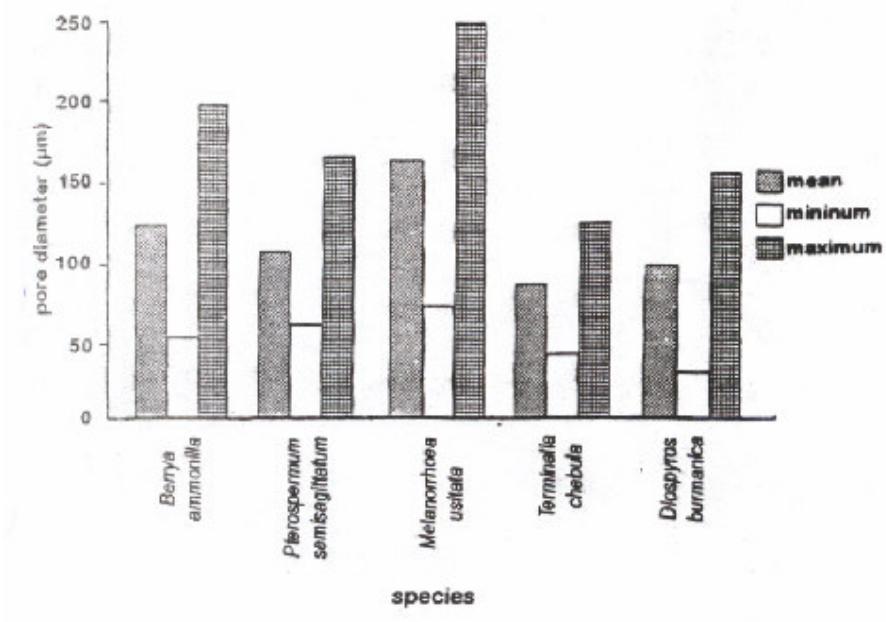


Diagram 3. Comparison of vessel length among the five commercially less acceptable species

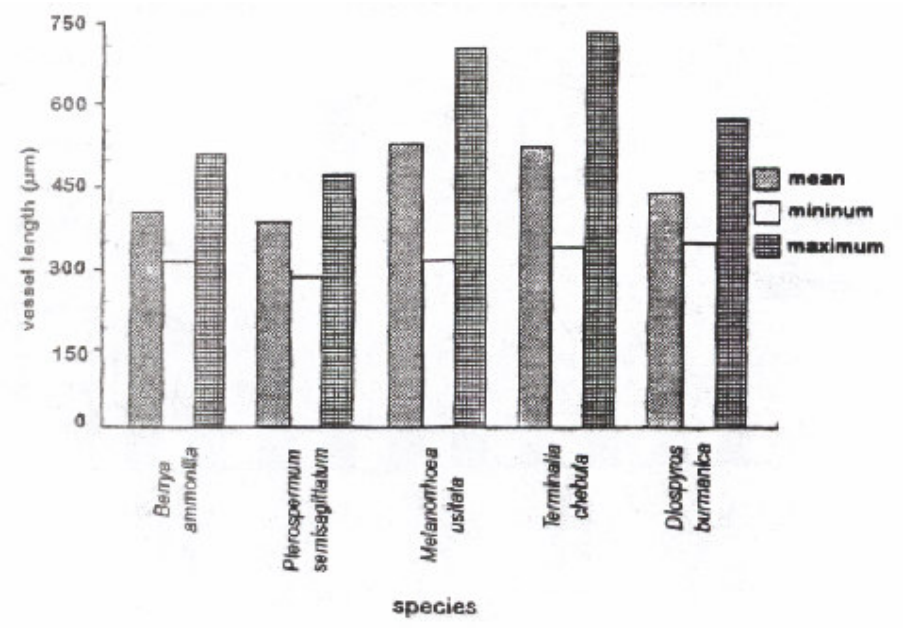


Diagram 4. Comparison of pore per square millimeter among the five commercially less acceptable species

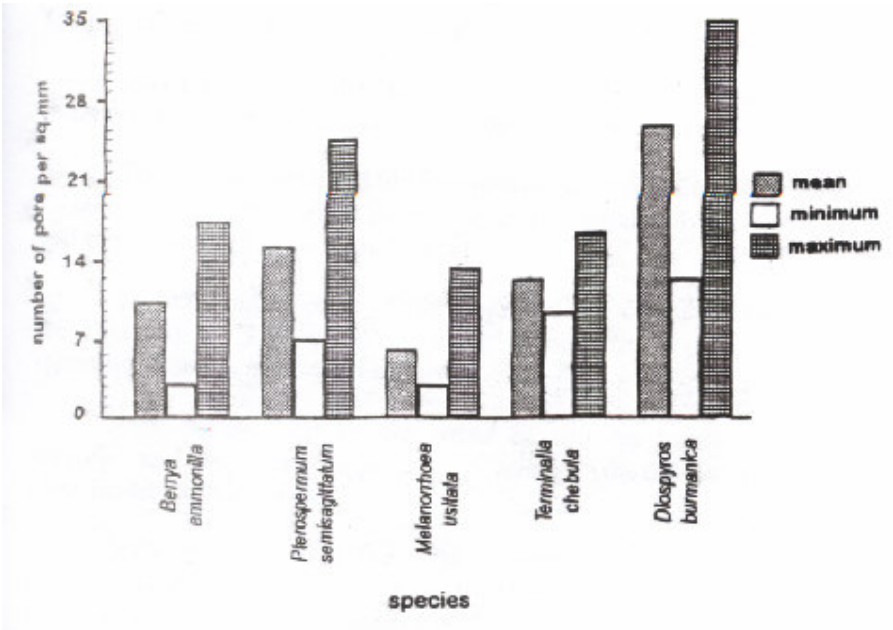
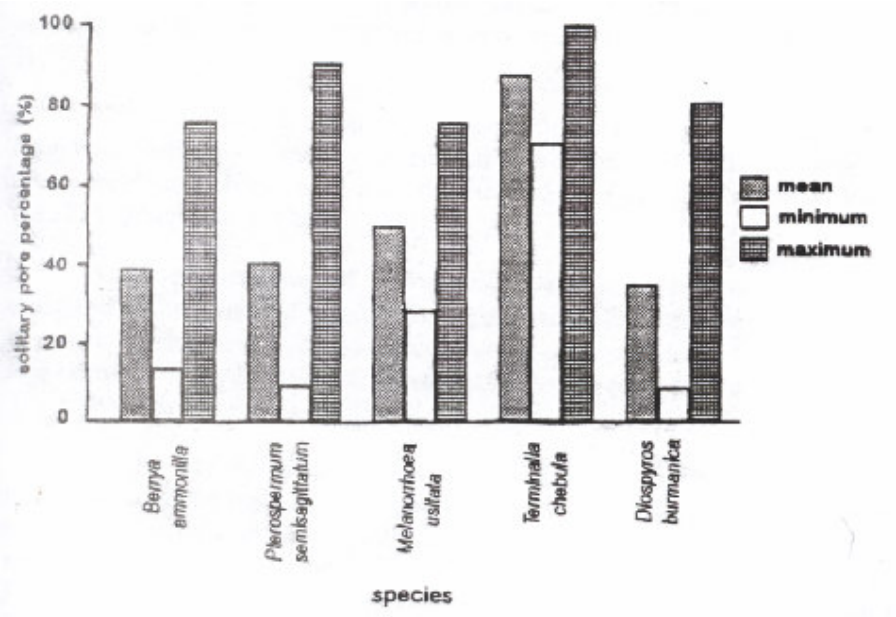


Diagram 5. Comparison of solitary pore percentage (%) among the five commercially less acceptable species



The fibres of the woods of all five species are libriform. The fibres in the wood of *Berrya ammonilla* are moderately short to moderately long, and those of *Pterospermum semisagittatum* are also moderately short to moderately long. The fibres of *Melanorrhoea usitata* are moderately short to medium-sized. The fibres of *Terminalia chebula* are medium-sized to very long and those of *Diospryos burmanica* are very short to medium-sized.

Maximum mean fibre length is examined in *Terminalia chebula* and minimum in *Melanorrhoea usitata* as mentioned in Diagram 6.

The fibre diameters of the five species are not widely varied as shown in Diagram 7. The maximum mean diameter is observed in *Berrya ammonilla* and minimum in *Diospyros burmanica.*

The ratio of the length of fibre and vessel is calculated and mentioned in the Diagram 8. The maximum mean is found in *Terminalia chebula* and minimum mean in *Melanorrhoea usitata.*

Axial parenchyma in the wood as seen in transverse sections are variable and they are regarded as reliable diagnostic features in the identification of the species.

In *Berrya ammonilla,* the axial parenchyma are scanty paratracheal and diffuse and diffuse in aggregate apotracheal with gum deposits and crystals which agree to Pearson & Brown (1932), Metcalfe Chalk (1950) and Kirbs (1959).

Axial parenchyma of *Pterospermum semisagittatum* and *Diospyros burmanica* are abundant, scanty paratracheal and apotracheal diffuse, diffuse in aggregate as described by Pearson & Brown (1932) and Metcalfe & Chalk (1950).

The axial parenchyma of *Melanorrhoea usitata* are found to be abundant, scanty and banded paratracheal and diffuse and diffuse in aggregate apotracheal parenchyma with gum deposits which agree to Pearson & Brown (1932) and Metcalfe & Chalk (1950).

Axial parenchyma of *Terminalia chebula* are abundant, scanty and unilateral aliform confluent paratracheal and diffuse and diffuse in aggregate apotracheal with elongated crystals and gum deposits which are as had been stated by Pearson & Brown (1932) and Metcalfe & Chalk (1950) and Thein Kywe & Kyaw Soe (1983).

The rays of the woods of all five species vary from low to high and uniseriate to multiseriate from species to species. The minimum mean number of rays per millimeter tangentially are observed in *Terminalia chebula* and maximum in *Berrya ammonilla* and *Pterospermum semisagittatum* and *Diospyros burmanica.* Variations observed in these five species are shown in Diagram 9.

The rays of these species are homocellular and heterocellular in which *Melanorrhoea usitata* and *Terminalia chebula* are homocellular and others are heterocellular.

The rays of most of these species are uniseriate to pentaseriate and those of *Terminalia chebula* and *Diospyros burmanica.* are uniseriate and biseriate, but mostly uniseriate.

The mean height of uniseriate rays is maximum in *Berrya ammonilla* and minimum in *Pterospermum semisagittatum* . The variation of width of uniseriate ray is narrow. The mean width of uniseriste rays is maximum in *Diospyros burmanica* and minimum in *Pterospermum semisagittatum* and *Terminalia chebula.*

The mean height of multiseriate rays of *Pterospermum semisagittatum* is maximum and that of *Melanorrhoea usitata* is minimum. Maximum mean width of multiseriate rays is found in *Melanorrhoea usitata* and minimum in *Berrya ammonilla.*

Ray vessel pittings of all species studied are alternate and oval or circular in shape. Vestured pittings in the rays are found in *Terminalia chebula.*

Gum deposits in the ray cells are found in all species. In some multiseriate rays of *Melanorrhoea usitata*, the gum canals are observed and silica bodies are also found in the rays which agree to Pearson & Brown (1932) and Metcalfe & Chalk (1950). Crystals are present in the rays of *Terminalia chebula* and *Diospyros burmanica.* which are in agreement with Pearson & Brown (1932) and Metcalfe & Chalk (1950).

Diagram 6. Comparison fibre length among the five commercially less acceptable species

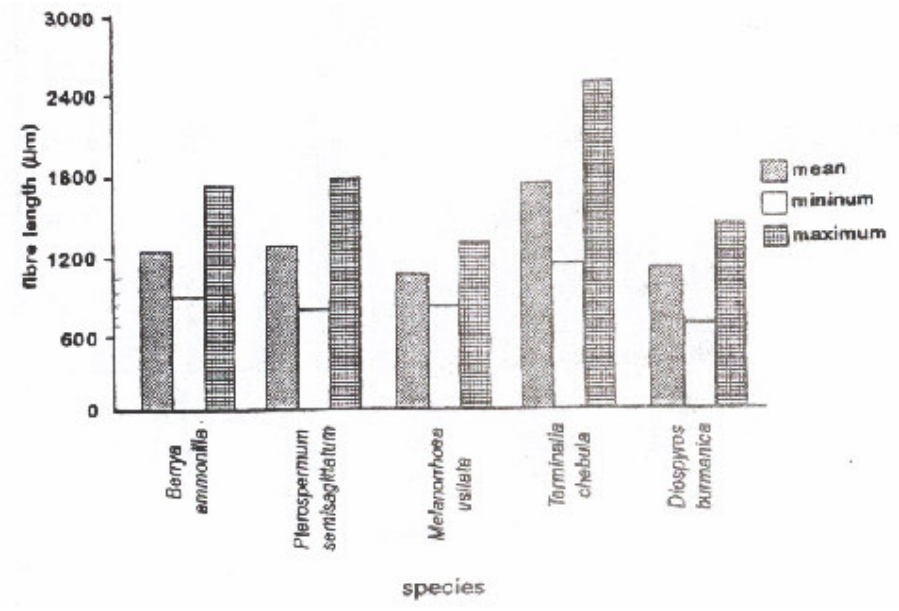


Diagram 7. Comparison of fibre diameter among the five commercially less acceptable species

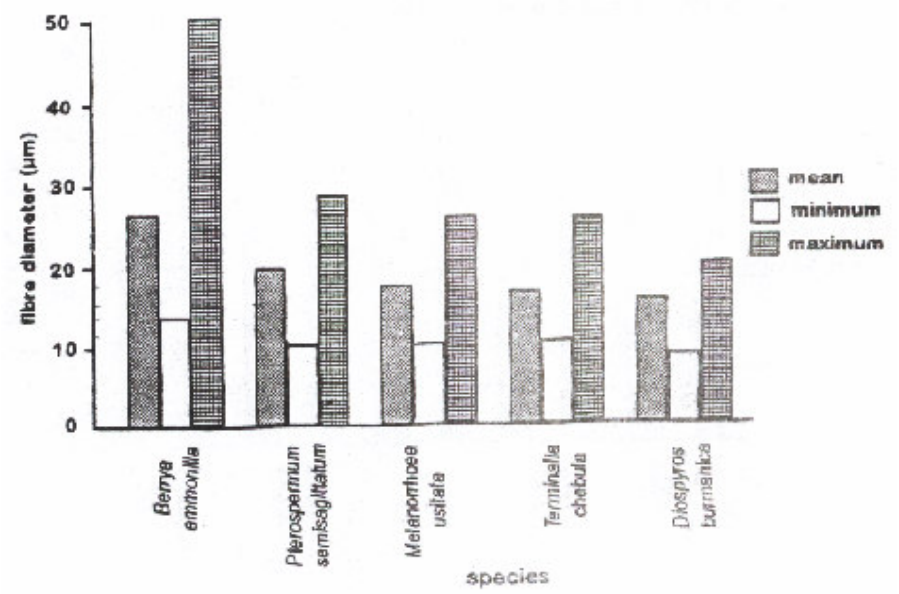


Diagram 8. Expression of fibre length and vessel length ratio among the five commercially less acceptable species

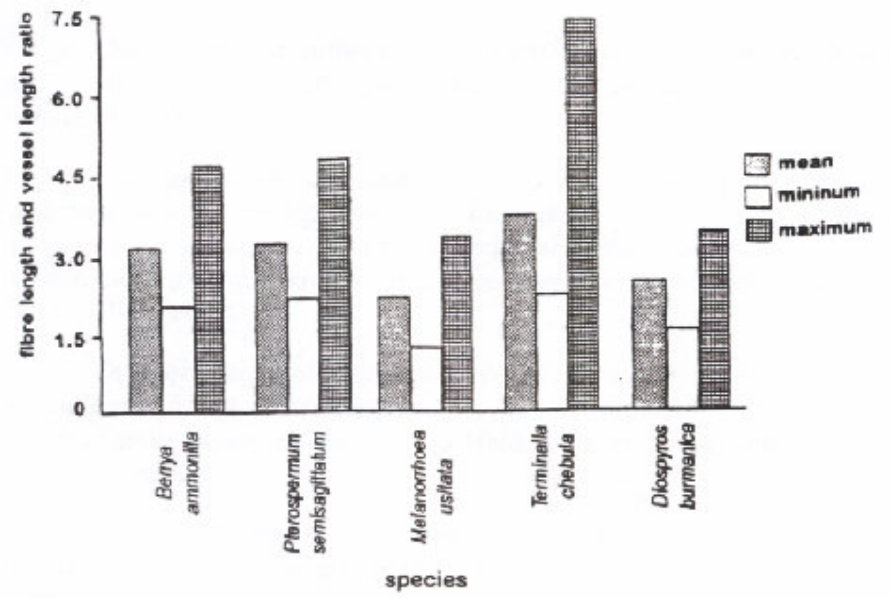
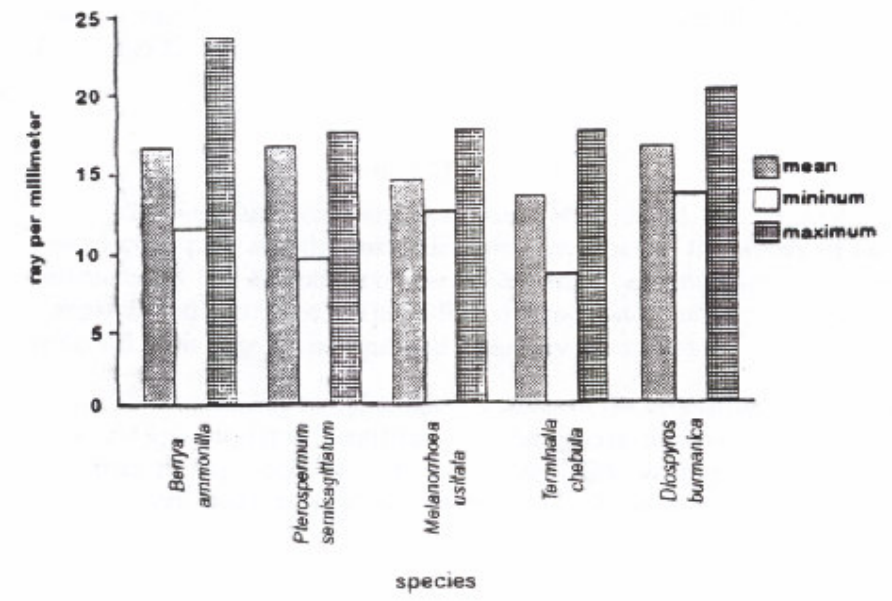


Diagram 9. Comparison of ray number per millimeter for five commercially less acceptable species



6. Conclusion

The morphological characteristics of both of the vegetative and reproductive parts and the anatomical characteristics of the woods of the five commercially less acceptable timber species have been investigated, described, compared and discussed. These five commercially less timber species are collected from Bago, and Pyinmana, and Patheingyi townships.

The outstanding morphological features of the vegetative and floral parts are found to be useful in identification of the species. From this study, physical properties of the wood of each species are also described. Therefore this research work would be supported in the application of these commercially less acceptable species.

In this study, the number of vessel pores per unit area, variation in the tangential diameter of vessel pores, the presence or absence of tyloses and gum deposits, the types of fibres and rays, parenchma patterns and solitary pore percentage are described and discussed which are diagnostic features of the wood to distinguish these timber species.

Thus, the present research clarify the potential uses of these secondary woods or lesser-known timber species to get better knowledge of wood properties of commercial importance.

Moreover, the commercial interest of the wood of lesser-known species could be promoted by developing management, proper drying and preservative treatment to replace the commercial species.

Meanwhile, the results and observations of this study may share the knowledge in the application and study on the commercially less acceptable species of Myanmar forests.

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