ANATOMY AND MACERATION OF WOOD

5.1 Anatomy of wood:

The vascular system of the plant is composed of xylem, the principal water-conducting tissue, and phloem, the food conducting tissue. As components of the vascular system xylem and phloem are called vascular tissues. The term ‘xylem’ was coined by Nageli (1858) and is derived from Greek ‘xylos’ meaning wood (Esau, 1965).

Several anatomical features are species specific, therefore, these anatomical features having taxonomic values, which used for separating species, genera and even families.

The anatomy of the wood gives following criteria.

i) Transverse section: growth rings, porosity, axial parenchyma, vessel arrangement, vessel grouping, tracheids, tyloses.

ii) Tangential longitudinal section: rays, vessel elements, perforation plates, inter vessel pits, vestured pits, fibres, depositions.

iii) Radial longitudinal section: ray type, vessel-ray pitting, tyloses, deposition.

1. Terminalia bellirica (Gaertn.) Roxb.

Transverse section:

Growth ring boundaries distinct, wood diffuse porous, vessels radially arranged, vessels in radial multiple of 2 – 4 or more. Vessel elements 75.8 – 178.5 μm in diameter. Tracheids few vasicentric. Ground tissue fibres thin to thick walled, polygonal, rhomboidal. Axial parenchyma paratracheal, winged-aliform. Ray parenchyma exclusively uniseriate, in numerous, closely-spaced lines, cells radially elongate, rectangular or oblong elongate with deposition of starch and tannins.
Tangential Longitudinal Section:

Vessel elements 215.7 – 801.8 × 76.2 – 79.4 µm, end wall oblique, pits on lateral wall vestured alternate. Fibres thin very long. Rays uniseriate, squarish, rectangular, rhomboid, 2 – 52 cells in length, ca 99.1 – 645.2 µm in length, cells at the end tapering, rays deposited with starch grains and tannin.

Radial Longitudinal Section:

Rays heterogenous, cells squarish, procumbent and upright, deposited with starch grains, upright and square cells with deposition of prismatic crystals. Vessel-ray pits much reduced borders to apparently simple, pit outline rounded (Plate- 13).

2. **Terminalia bialata** (Roxb.) Steud.

Transverse section:

Growth ring boundaries distinct, wood diffuse porous, vessels in radial multiple of 2 – 3, impregnated with prismatic crystals. Vessel elements 72.2 – 133.3 µm in diameter. Tracheids few vasicentric. Ground tissue fibres thin to thick walled, polygonal, rhomboidal. Axial parenchyma predominantly paratracheal. Ray parenchyma exclusively uniseriate, numerous, closely-spaced lines, cells radially elongate, rectangular or oblong elongate with deposition of starch, tannins and prismatic crystals. Intercellular canals of traumatic origin present.

Tangential Longitudinal Section:

Vessel elements 76.5 – 115.1 × 199.8 – 587.5 µm, end wall oblique, pits on lateral wall vestured alternate. Fibres thin walled, very long. Rays uniseriate, squarish, rectangular, rhomboid, 2 – 41 cells in height, ca 71.7 – 1131.9 µm, cells at the end winged, ray deposited with starch grains and tannin.
Radial Longitudinal Section:
Rays heterogenus, cells squarish, procumbent and upright, deposited with starch grains, upright and square cells with deposition of prismatic crystals and few druces. Vessel-ray pits much reduced borders to apparently simple, pit outline rounded (Plate-14).

3. **Terminalia catappa** L.
Transverse section:
Growth ring boundaries indistinct, wood diffuse porous, vessels in radial multiple of 2 – 4. Vessel elements ca 65.2 – 168.8 µm in diameter. Tracheids few, vasicentric. Ground tissue fibres thin to thick walled, polygonal, rhomboidal. Axial parenchyma paratracheal, winged-aliform with deposition of druces. Ray parenchyma mostly uniseriate, rarely biseriate, cells radially elongate, rectangular or oblong elongate with deposition of starch.

Tangential Longitudinal Section:
Vessel elements 147.6 – 428.8 × 88.7 – 114.1 µm, end wall oblique, pits on lateral wall vestured alternate, perforation plates simple. Fibres thin, very long. Rays mostly uniseriate, rarely biseriate, squarish, rectangular, rhomboid, 2 – 30 cells in height, ca 60.7 – 750.9 µm in length, cells at the end tapering, ray deposited with starch grains and tannin. Axial parenchyma showed presence of druces.

Radial Longitudinal Section:
Rays heterogenus, cells squarish, procumbent and upright, deposited with starch grains and druces, upright. Vessel-ray pits much reduced borders to apparently simple, pit outline, rounded (Plate-15).
4. **Terminalia chebula** Retz.
Transverse section:

Growth ring boundaries indistinct, wood diffuse porous, vessels in radial multiple of 2 – 4 or more. Vessel elements 136.8 – 157.4 µm diameter. Tracheids few vasicentric. Ground tissue fibres very thick walled with small lumen, polygonal, rhomboidal. Axial parenchyma paratracheal, winged-aliform. Ray parenchyma mostly uniseriate, some biseriate, cells radially elongate, rectangular or oblong elongate with deposition of starch and tannin.

Tangential Longitudinal Section:

Vessel elements 171.1 – 493.9 × 46.9 – 121.4 µm, end wall oblique, pits on lateral wall vestured alternate, perforation plates simple. Fibres thick, very long. Rays mostly uniseriate, some bi-triseriate, squarish, rectangular, rhomboid, 2 – 28 cells in height, ca 97.6 – 1133.8 µm in length, cells at the end tapering, ray deposited with starch grains and tannin.

Radial Longitudinal Section:

Rays heterogenous, cells squarish, procumbent and upright, deposited with starch grains. Vessel-ray pits much reduced borders to apparently simple, pit outline rounded (Plate- 16).

5. **Terminalia citrina** Roxb. ex Flem.
Transverse section:

Growth ring boundaries indistinct, wood diffuse porous, vessels mostly single, rarely in radial multiple of 2 – 5. Vessel elements ca 69.1 – 147.7 µm in diameter. Tracheids few vasicentric. Ground tissue fibres thin to thick walled with, polygonal, rhomboidal. Axial parenchyma paratracheal, winged-aliform. Ray parenchyma mostly uniseriate, some biseriate, cells radially elongate, rectangular or oblong elongate with deposition of starch and tannin.
Tangential Longitudinal Section:

Vessel elements 128.1 – 485.7 × 85.5 – 136.4 µm, end wall oblique, pits on lateral wall vestured, alternate, perforation plates simple. Fibres thick, very long. Rays mostly uniseriate, rarely biseriate, squarish, rectangular, rhomboid, 2 – 25 cells in height, ca 58.2 – 609.2 µm in length, cells at the end tapering, ray deposited with starch grains and tannin.

Radial Longitudinal Section:

Rays heterogenous, cells squarish, procumbent and upright, deposited with starch grains and unknown content. Vessel-ray pits much reduced borders to apparently simple, pit outline rounded (Plate- 17).

6. **Terminalia cuneata** Roth.

Transverse section:

Growth ring boundaries distinct, wood diffuse porous, vessels radially arranged, vessels in radial multiple of 2 – 4. Vessel diameter 122.7 – 188.5 µm. Tracheids few vasicentric. Ground tissue fibres thin to thick walled, polygonal, rhomboidal. Axial parenchyma paratracheal, winged-aliform. Ray parenchyma strictly uniseriate, cells radially elongate, rectangular or oblong elongate with deposition of starch.

Tangential Longitudinal Section:

Vessel elements 194.3 – 426.1 × 40.0 – 190.6 µm, end wall oblique, pits on lateral wall vestured alternate. Fibres thin to thick, very long. Rays strictly uniseriate, squarish, rectangular, rhomboid, 2 – 23 cells in height, ca 47.1 – 658.8 µm in length, cells at the end tapering, ray deposited with starch grains.

Radial Longitudinal Section:
Rays heterogenus, cells squarish, procumbent and upright, deposited with starch grains. Vessel-ray pits with much reduced borders to apparently simple, pits vertical (Plate- 18).

7. **Terminalia elliptica** Willd.

Transverse section :

Growth ring boundries distinct, wood diffuse porous, vessels in radial multiple of 2 – 4. Vessel diameter 109.0 – 140.7 µm. Tracheids few vasicentric. Ground tissue fibres thick walled, lumen small, polygonal, rhomboidal. Axial parenchyma paratracheal, winged-aliform. Ray parenchyma mostly uniseriate, rarely biseriate, cells radially elongate, rectangular or oblong elongate with deposition of starch and tannin.

Tangential Longitudinal Section :

Vessel elements 194.3 – 426.1 × 40.0 – 190.6 µm, end wall oblique, pits on lateral wall vestured alternate. Fibres thin to thick walled, long. Rays mostly uniseriate, rarely biseriate, squarish, rectangular, rhomboid, 2 – 22 cells in height, ca 99 – 854.0 µm in length, cells at the end tapering, ray deposited with starch grains.

Radial Longitudinal Section :

Rays heterogenus, cells squarish, procumbent and upright, deposited with starch grains. Vessel-ray pits with much reduced borders to apparently simple, pit outline rounded (Plate- 19).

8. **Terminalia myriocarpa** Van Heurck & Mull.-Arg.

Transverse section :

Axial parenchyma paratracheal, winged-aliform. Ray parenchyma mostly uniseriate, rarely biseriate, cells radially elongate, rectangular or oblong elongate with deposition of starch and tannin.

Tangential Longitudinal Section:

Vessel elements 171.2 – 400.7 × 70.1 – 137.5 µm, end wall oblique, pits on lateral wall vestured, alternate. Tyloses very common in vessels. Fibres thin to thick, elongate. Rays mostly uniseriate, rare biseriate, squarish, rectangular, rhomboid, 3 – 45 cells in height, ca 87.9 – 1000.2 µm in length, cells at the end tapering, rays deposited with starch grains and prismatic crystals.

Radial Longitudinal Section:

Rays heterogenous, cells squarish, procumbent, deposited with starch grains, prismatic crystals. Tyloses very common in vessels. Vessel-ray pits with much reduced borders to apparently simple, pit outline rounded (Plate-20).

9. **Terminalia pallida** Brandis

Transverse section:

Growth ring boundaries indistinct, wood diffuse porous, vessels in radial multiple of 2 – 5. Vessel diameter 45.2 – 92.8 µm. Tracheids few vasicentric. Ground tissue fibres thin to thick walled, polygonal, rhomboidal. Axial parenchyma paratracheal, winged-aliform. Rays mostly uniseriate, some biseriate, cells radially elongate, rectangular or oblong elongate with deposition of starch.

Tangential Longitudinal Section:

Vessel elements 171.0 – 500.7 × 42.3 – 81.7 µm, end wall oblique, pits on lateral wall vestured alternate, perforation plate simple. Fibres thin to thick walled, long. Rays mostly uniseriate, rarely biseriate, squarish, rectangular,
rhomboid, 3 – 41 cells in height, ca 58.7 – 977.1 µm in length, cells at the end winged, ray deposited with starch grains, tannin and prismatic crystals.

Radial Longitudinal Section :

Rays heterogenous, cells squarish, procumbent and upright, deposited with starch grains, tannin and prismatic crystals. Vessel perforation plate simple. Vessel-ray pits with much reduced borders to apparently simple, pit outline rounded (Plate- 21).

10. Terminalia paniculata Roth.

Transverse section :

Growth ring boundaries indistinct, wood diffuse porous, vessels in radial multiple of 2 – 6. Vessel diameter 64.3 – 147.6 µm. Tracheids few vasicentric. Ground tissue fibres thin to thick walled, polygonal, rhomboidal. Axial parenchyma paratracheal, winged-aliform. Rays mostly uniseriate, rarely biseriate, cells radially elongate, rectangular or oblong elongate with deposition of starch.

Tangential Longitudinal Section :

Vessel elements 158.2 – 495.6 × 75.6 – 120.4 µm, end wall oblique, pits on lateral wall vestured alternate, perforation plate simple. Fibres thin to thick walled, very long. Rays mostly uniseriate, rarely biseriate, squarish, rectangular, rhomboid, 2 – 24 cells in height, ca 87.4 – 982.1 µm in length, cells at the end winged, rays deposited with starch grains, tannin and prismatic crystals.

Radial Longitudinal Section :

Rays heterogenous, cells squarish, procumbent and upright, deposited with starch grains, tannin and prismatic crystals. Vessel perforation plate simple. Vessel-ray pits with much reduced borders to apparently simple, pit outline rounded (Plate- 22).
11. **Terminalia procera** Roxb.

Transverse section:

Growth ring boundaries indistinct, wood diffuse porous, vessels in radial multiple of 2 – 5. Vessel diameter 37.3 – 84.3 µm. Tracheids few vasicentric. Ground tissue fibres thin to thick walled, polygonal, rhomboidal. Axial parenchyma paratracheal, winged-aliform. Rays uniseriate, cells radially elongate, rectangular or oblong elongate with deposition of starch and prismatic crystals.

Tangential Longitudinal Section:

Vessel elements 181.1 – 726.7 × 62.6 – 89.1 µm, end wall oblique, pits on lateral wall vestured alternate, perforation plate simple. Fibres thin to thick walled, very long. Rays mostly uniseriate, rarely biseriate, squarish, rectangular, rhomboid, 2 – 28 cells in length, ca 65.8 – 876.0 µm in length, cells at the end winged, rays deposited with starch grains, tannin and prismatic crystals.

Radial Longitudinal Section:

Rays heterogenous, cells squarish, procumbent and upright, deposited with starch grains and prismatic crystals. Vessel perforation plate simple. Vessel-ray pits with much reduced borders to apparently simple, pit outline rounded (Plate- 23).

12. **Terminalia travancorensis** Wight & Arn.

Transverse section:

Growth ring boundaries indistinct, wood diffuse porous, vessels in radial multiple of 2 – 4. Vessel diameter 42.1 – 132.8 µm. Tracheids few vasicentric. Ground tissue fibres thick walled, polygonal, rhomboidal. Axial parenchyma paratracheal, winged-aliform. Rays strictly uniseriate, cells radially elongate, rectangular or oblong elongate with deposition of starch and prismatic crystals.

Tangential Longitudinal Section:

Vessel elements 64.3 – 463.3 × 28.9 – 85.7 µm, end wall oblique, pits on lateral wall vestured alternate, perforation plate simple. Fibres thick, very
long. Rays strictly uniseriate, squarish, rectangular, rhomboid, 2 – 46 cells in height, ca 68.1 – 1116.9 µm in length, cells at the end winged, ray deposited with starch grains, tannin and prismatic crystals.

Radial Longitudinal Section :

Rays heterogenous, cells squarish, procumbent and upright, deposited with starch grains, tannin and prismatic crystals. Vessel-ray pits with much reduced borders to apparently simple, pit outline rounded (Plate- 24).
5.2 Maceration of wood:

1. **Terminalia bellirica** (Gaertn.) Roxb.

Parenchymatous cells are of two types:

i) Parenchyma with few pits: Cells rectangular, squarish or rhomboid, cells thick walled, cell wall continuous, pits few circular or oval, distributed along cell wall at one side average size 111.0 × 41.0 µm and range ca 50.0 – 120.0 × 30.0 – 50.0 µm.

ii) Parenchyma with many pits: Cells rectangular, squarish or rhomboid, pits alternate, with much reduced borders to apparently simple, pit outline rounded or oval, distributed throughout, cell wall interrupted, may be wavy average size 73.33 × 51.66 µm and range ca 50.0 – 90.0 × 50.0 – 60.0 µm.

Fibres simple, long, slender, tapering and sharply pointed, outline irregular, ca 1222.5 × 24.0 µm average and range ca 900.0 – 1615.0 × 20.0 – 30.0 µm.

Tracheids are of two types:

i) Long, slender, ends blunt, pits few- Many, elongate, in one-many rows, alternate, ca 583.0 × 30.0 µm average and range ca 370.0 – 840 × 20 – 40 µm.

ii) Few, short, elongate, rectangular with only one end tapering, pits few-many, elongate, in one-many rows, alternate, ca 271.7 × 26.5µm.

Vessel elements are of three types:

i) Vessel elements much broader, end walls horizontal with simple perforation, lateral walls with vestured, alternate pits, beak long and or short, may present on both ends, ca 235.3 × 128.7 µm.

ii) Vessel elements long, slender, beaked at both ends, beak very long or short, end walls oblique with simple perforation, lateral wall vestured pitted, pits alternate, circular or oval, ca 206.9 × 51.73 µm average and range ca 390.5 – 506.8 × 44.0 – 60.2 µm.

iii) Vessel elements long, slender, with or without beak, end wall shifted towards lateral side, pits circular or oval, ca 567.7 × 60.1µm average and range ca 500.8 – 739.8 × 43.6 – 100.7 µm (Plate- 13).
2. **Terminalia bialata** (Roxb.) Steud.

Parenchymatous cells are of two types:

i) Parenchyma without pits: Cells rectangular, squarish, rhomboid, cell wall thick, continuous size 60.28 × 29.08 µm and range ca 33.3 – 94.7 × 15.8 – 37.9 µm, pits absent.

ii) Parenchyma with few pits: Cells rectangular, squarish or rhomboid, cells thick walled, cell wall continuous, pits few, small, alternate, elongate, oval, distributed all over the cell, ca 128.87 × 26.32 µm average and range ca 81.9 – 215.6 × 16.2 – 32.7 µm.

iii) Parenchyma with many pits: Cells rectangular or squarish, rhomboid, very long, pits alternate, with much reduced borders to apparently simple, pit outline rounded or oval, distributed throughout, cell wall continuous, ca 62.6 × 24.01 µm average and range ca 33.3 – 92.7 × 12.7 – 32.1 µm.

Fibres simple, long, slender, tapering and sharply pointed, outline may be irregular, ca 825.6 × 315.0 µm average and range ca 849.9 – 1141.4 × 17.3 – 35.9 µm.

Tracheids shorter than fibres, slender, ends blunt or pointed, pits few, elongate, in one-many rows, alternate, ca 420.6 × 21.81 µm average and range ca 338.9 – 467.7 × 28.8 – 33.8 µm.

Vessel elements are of two types:

i) Vessel elements broader, end walls horizontal with simple perforation, lateral walls with vestured, alternate pits, beak short, may present on both the ends, ca 443.45 × 110.52 µm average and range ca 377.1 – 489.0 × 82.6 – 138.5 µm.

ii) Vessel elements long, slender, beaked at one or both ends, end walls oblique shifted to lateral side, perforation simple, lateral wall simple pitted, pits vestured, alternate, circular or oval, 472.33 × 41.73 µm average and range ca 374.6 – 656.8 × 26.3 – 73.6 µm (Plate- 14).
3) **Terminalia catappa** L.

Parenchymatous cells are of two types:

i) Parenchyma with few pits: Cells rectangular, squarish or rhomboid, trigonal, cells thick walled, cell wall interrupted, pits few circular or oval, distributed along cell wall, ca 54.25 × 25.5 µm average and range ca 30.0 – 85.0 × 12.5 – 30.0 µm.

ii) Parenchyma with many pits: Cells rectangular, squarish or rhomboid, pits alternate, with much reduced borders to apparently simple, pit outline rounded or oval, distributed throughout, cell wall continuous, wavy, ca 23.8 × 17.0 µm average and range ca 20.0 – 31.0 × 16.0 – 18.0 µm.

Fibres are of two types:

i) Fibres simple, slender, tapering and sharply pointed, outline entire, ca 680.0 × 19.5 µm average and range ca 490.0 – 550.0 × 10.0 – 25.0 µm.

ii) Fibres simple slender, tapering and sharply pointed, outline irregular ca 856.7 × 39.2 µm average and range ca 854.4 – 859.1 × 39.1 – 39.3 µm.

Tracheids shorter than fibres, rarely very short, slender, ends blunt or pointed, pits few, elongate, in one-many rows, alternate, ca 339.1 × 17.27 µm average and range ca 220.0 – 520.0 × 10.0 – 20.0 µm.

Vessel elements broader, end walls horizontal with simple perforation, lateral walls with vestured, alternate pits, beak short to long, may present on both the ends, ca 348.0 × 76.0 µm average size and range ca 220.0 – 420.0 × 40.0 – 100.0 µm (Plate- 15).

4) **Terminalia chebula** Retz.

Parenchymatous cells are of two types:

i) Parenchyma with few pits: Cells rectangular, squarish or rhomboid, trigonal, cells thick walled, cell wall interrupted, pits few circular or oval, distributed along cell wall, ca 47.67 × 27.67 µm average and range ca 42.1 – 77.6 × 20.8 – 39.8 µm.

ii) Parenchyma with many pits: Cells rectangular, squarish or rhomboid, pits alternate, with much reduced borders to apparently simple, pit outline
rounded or oval, distributed throughout, cell wall continuous, may wavy, average size ca 50.7 × 26.8 µm and range ca 35.1 – 82.1 × 17.4 – 34.1 µm.

Fibres are of two types:

i) Fibres simple, slender, tapering and sharply pointed, outline entire, average size ca 818.1 × 21.79 µm and range ca 702.6 – 968.9 × 17.1 – 32.6 µm.

ii) Fibres branched, slender, tapering and sharply pointed, outline irregular ca 687.2 × 24.0 µm.

Tracheids shorter than fibres, slender, ends blunt or pointed, pits few, elongate, in one-many rows, alternate, ca 356.4 × 20.9 µm average and range ca 276.4 – 492.8 × 16.8 – 23.8 µm.

Vessel elements are of two types:

i) Vessel elements broader, end walls horizontal with simple perforation, lateral walls with vestured, alternate pits, beak short, may present on both the ends, ca 333.1 × 50.3 µm average and range ca 245.7 – 365.8 × 29.4 – 71.0 µm.

ii) Vessel elements long, slender, beaked at one or both ends, end walls oblique shifted to lateral side, perforation simple, lateral wall with scalariform, alternate pits, average size ca 407.9 × 33.64 µm and range ca 345.6 – 712.6 × 21.4 – 45.2 µm (Plate- 16).

5) **Terminalia citrina** Roxb. ex Flem.

Parenchymatous cells are of two types:

i) Parenchyma with few pits: Cells rectangular, squarish or rhomboid, cells thick walled, cell wall interrupted, pits few, small, alternate, elongate, oval, distributed all over the cell, ca 61.36 ×37.95 µm average size and range ca 40.0 – 87.5 × 20 – 47.5 µm.

ii) Parenchyma with many pits: Cells rectangular, squarish or rhomboid, pits alternate, with much reduced borders to apparently simple, pit outline
rounded or oval, distributed throughout, cell wall continuous, ca $57.94 \times 30.0$ µm average size and range ca $47.5 - 87.5 \times 20.0 - 47.5$ µm.

Fibres are of three types:

i) Fibres simple, slender, tapering and sharply pointed, outline entire, ca $994.5 \times 27.1$ µm average and range ca $532.0 - 1254.0 \times 20.0 - 35.0$ µm.

ii) Pitted fibres slender, tapering and sharply pointed, outline entire, pits simple, elongate, alternate, may present in one-many rows, average size ca $952.88 \times 25.83$ µm and range ca $532.0 - 1824.0 \times 20.0 - 35.0$ µm.

iii) Fibres branched, slender, tapering, ca $860 \times 25.5$ µm.

Tracheids shorter than fibres, slender, ends blunt or pointed, pits few, elongate, in one-many rows, alternate, average size ca $344.0 - 32.0$ µm and range ca $250.0 - 470.0 \times 20.0 - 40.0$ µm.

Vessel elements are of two types:

i) Vessel elements broader, end walls horizontal with simple perforation, lateral walls with vestured, alternate pits, ca $330.9 \times 89.09$ µm average and range ca $140.0 - 490.0 \times 30.0 - 130.0$ µm.

ii) Vessel elements long, slender, beaked at one or both ends, end walls oblique shifted to lateral side, perforation simple, lateral wall simple pitted, pits vestured, alternate, circular or oval, ca $347.0 \times 80.0$ µm average and range ca $190.0 - 470.0 \times 40.0 - 120.0$ µm (Plate- 17).

6) **Terminalia cuneata** Roth.

Parenchymatous cells are of two types:

i) Parenchyma with few pits: Cells rectangular, squarish or rhomboid, cells thick walled, cell wall continuous, pits few circular or oval, distributed along cell wall at one side, with or without deposition of starch grains, ca $45.75 \times 27.75$ µm average and range ca $37.5 - 57.5 \times 22.5 - 35.0$ µm.

ii) Parenchyma with many pits: cells rectangular, squarish or rhomboid, pits alternate, with much reduced borders to apparently simple, pit outline rounded or oval, distributed throughout, cell wall interrupted, with or without
deposition of starch grains, ca 60.25 × 27.5 µm average and range ca 55.0 – 95.0 × 17.5 – 40.0 µm.

Fibres simple, long, slender, tapering and sharply pointed, with or without deposition of starch grains, ca 1027.9 × 21.5 µm average and range ca 950.0 – 1140 × 12.5 – 25.0 µm.

Tracheids shorter than fibres, slender, ends blunt or pointed, pits few, elongate, in one-many rows, alternate, ca 372.0 × 26.0 µm average and range ca 290.0 – 500.0 × 20.0 – 30.0 µm.

Vessel elements are of two types:

i) Vessel elements broader, end walls horizontal with simple perforation, lateral walls with vestured pits, pits alternate, beak short, may present on both the ends, ca 336.0 × 88.0 µm average and range ca 180.0 – 570.0 × 50.0 – 130.0 µm.

ii) Vessel elements long, slender, beaked at one or both ends, end walls oblique shifted to lateral side, perforation simple, lateral wall with vestured pits, alternate, circular or oval, ca 477.5 × 75.0 µm average and range ca 380.0 – 550.0 × 60.0 – 80.0 µm (Plate- 18).

7) Terminalia elliptica Willd.

Parenchyma are of three types:

i) Parenchyma with few pits: Cells rectangular or squarish, cells thick walled, cell wall interrupted, pits few circular or oval, distributed overall the cell, ca 97.3 × 28.27 µm average and range ca 62.7 – 147.1 × 15.0 – 466 µm.

ii) Parenchyma with many pits: cells rectangular, squarish or rhomboid, pits alternate, with much reduced borders to apparently simple, pit outline rounded or oval, distributed throughout, cell wall interrupted, ca 73.0 × 22.97 µm average and range ca 50.2 – 139.0 × 18.0 – 42.2 µm.

iii) Parenchyma with many pits: cells rectangular or squarish, pits alternate, with much reduced borders to apparently simple, pits vertical, distributed throughout, cell wall interrupted, with or without deposition of starch grains, ca 111.1 × 29.31 µm average and range ca 91.8 – 178.7 × 23.7 – 37.6 µm.
Fibres simple, long, slender, tapering and sharply pointed, with or without deposition of starch grains, ca $732.52 \times 17.6 \mu m$ average and range ca $515.6 - 994.7 \times 13.1 - 26.6 \mu m$.

Tracheids shorter than fibres, slender, ends blunt or pointed, pits few, elongate, in one-many rows, alternate, ca $417.14 \times 21.34 \mu m$ average and range ca $344.4 - 502.0 \times 16.9 - 30.2 \mu m$.

Vessel elements are of three types:

i) Vessel elements broader, end walls horizontal with simple perforation, lateral walls with vestured, alternate pits, beak short to long, may present on both the ends, ca $333.1 \times 95.65 \mu m$ average and range ca $109.8 - 472.6 \times 11.5 - 138.6 \mu m$.

ii) Vessel elements short to very long, slender, beaked at one or both ends or without beaks, end walls oblique or horizontal, perforation simple, lateral wall scalariform pitted, pits alternate, ca $333.1 \times 95.65 \mu m$ average and range ca $109.8 - 472.6 \times 11.5 - 138.6 \mu m$.

iii) Vessel elements very long, with spiral thickening, ca $335.13 \times 29.1 \mu m$ average and range ca $101.5 - 591.8 \times 17.5 - 45.4 \mu m$ (Plate- 19).

8) Terminalia myriocarpa Van Heurck & Mull.-Arg.

Parenchyma are of two types:

i) Parenchyma with few pits: Cells rectangular or squarish, cells thick walled, cell wall interrupted, pits few circular or oval, distributed overall the cell, average size ca $104.71 \times 26.2 \mu m$ and range ca $32.5 - 172.5 \times 20.3 - 41.6 \mu m$.

ii) Parenchyma with many pits: cells rectangular, squarish or rhomboid, pits alternate, with much reduced borders to apparently simple, pit outline rounded or oval, distributed throughout, cell wall interrupted, with or without deposition of starch grains, average size ca $71.2 \times 39.62 \mu m$ and range ca $53.0 - 95.1 \times 19.7 - 47.7 \mu m$. 

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Fibres are of four types:

i) Simple fibres, short to long, slender, tapering and sharply pointed, mean size ca 1152.9 × 27.54 µm and range ca 712.3 – 1550.0 × 21.8 – 30.9 µm.

ii) Septed fibres very long, tapering and sharply pointed, outline entire, mean size ca 1043.3 × 26.63 µm and range ca 835.8 – 1449.8 × 18.1 – 30.9 µm.

iii) Pitted fibres slender, tapering and sharply pointed, outline entire, pits simple, elongate, alternate, may present in one-more rows, ca 712.3 – 1550.0 × 21.8 – 30.9 µm, average and range ca 712.3 – 1550.0 × 21.8 – 30.9 µm.

iv) Crystalline fibre, very short and thick, bearing crystals, ca 372.0 × 26.0 µm average and range ca 290.0 – 500.0 × 20.0 – 30.0 µm.

Tracheids slender, ends blunt or pointed, pits many, elongate, in one-many rows, alternate, ca 511.73 × 36.33 µm average and range ca 286.9 – 653.3 × 28.7 – 45.2 µm.

Vessel elements are of two types:

i) Vessel elements broader, end walls horizontal with simple perforation, lateral walls with vestured, alternate pits, ca 228.2 × 191.48 µm average size and range ca 144.9 – 352.6 × 173.9 – 219.8 µm.

ii) Vessel elements long, slender, beaked at one or both ends, end walls oblique shifted to lateral side, perforation simple, lateral wall simple pitted, pits vestured, alternate, circular or oval, ca 334.2 × 135.6 µm average and range ca 240.6 – 441.5 × 91.5 – 202.2 µm (Plate- 20).

9) Terminalia pallida Brandis

Parenchyma are of two types:

i) Parenchyma with few pits: Cells rectangular or squarish, cells thick walled, cell wall interrupted, pits few circular or oval, distributed overall the cell, ca 74.34 × 26.49 µm average and range ca 26.7 – 163.6 × 19.9 – 34.4 µm.

ii) Parenchyma with many pits: cells rectangular, squarish or rhomboid, pits alternate, with much reduced borders to apparently simple, pit outline rounded or oval, distributed throughout, cell wall interrupted, with or without
deposition of starch grains, ca $60.02 \times 29.35$ $\mu$m average and range ca $43.4 - 111.9 \times 23.7 - 35.4$ $\mu$m. Both the cell types may contain tannin.

Fibres simple, short to long, slender, tapering and sharply pointed, ca $980.41 \times 21.1$ $\mu$m average and range ca $928.1 - 1308.5 \times 13.6 - 28.5$ $\mu$m.

Tracheids slender, thick, ends blunt or pointed, pits few, elongate, in one-many rows, alternate, ca $386.68 \times 26.12$ $\mu$m average and range ca $296.9 - 536.6 \times 17.5 - 34.6$ $\mu$m.

Vessel elements are of two types:

i) Vessel elements broader, end walls horizontal with simple perforation, lateral walls with vestured, alternate pits, beak short to long, may present on both the ends, ca $373.1 \times 105.96$ $\mu$m average and range ca $215.8 - 488.2 \times 72.8 - 139.1$ $\mu$m.

ii) Vessel elements short to very long, slender, beaked at one or both ends or without beaks, end walls oblique or horizontal, perforation simple, lateral wall scalariform pitted, pits alternate, ca $535.61 \times 47.43$ $\mu$m average and range ca $348.0 - 742.5 \times 35.5 - 64.0$ $\mu$m (Plate- 21).

10) **Terminalia paniculata** Roth.

Parenchymatous cells are of two types:

i) Parenchyma without pits: Cells rectangular, squarish, rhomboid, cell wall thick, continuous, ca $64.8 \times 31.3$ $\mu$m.

ii) Parenchyma with few pits: Cells rectangular, squarish or rhomboid, cells thick walled, cell wall interrupted, pits few, small, alternate, elongate, oval, distributed all over the cell, ca $78.45 \times 45.78$ $\mu$m average and range ca $50.7 - 104.8 \times 34.2 - 58.7$ $\mu$m.

iii) Parenchyma with many pits: Cells rectangular or squarish, rhomboid, very long, pits alternate, with much reduced borders to apparently simple, pit outline rounded or oval, distributed throughout, cell wall continuous, ca $88.44 \times 43.85$ $\mu$m average and range ca $61.9 - 127.5 \times 25.6 - 60.6$ $\mu$m.
Fibres are of two types:

i) Fibres simple, slender, tapering and sharply pointed, outline entire, ca $958.46 \times 21.03 \mu m$ average and range, ca $723.4 - 1107.3 \times 18.1 - 26.6 \mu m$.

ii) Fibres branched, slender, tapering and sharply pointed.

Tracheids shorter than fibres, slender, ends blunt or pointed, pits few, elongate, in one-many rows, alternate, ca $453.02 \times 24.32 \mu m$ average and range ca $297.3 - 655.1 \times 16.2 - 36.9 \mu m$.

Vessel elements are of two types:

i) Vessel elements broader, end walls oblique or horizontal with simple perforation, lateral walls with vestured, alternate pits, beak short to long, may present on both the ends, ca $476.96 \times 120.36 \mu m$ average and range ca $362.1 - 584.6 \times 87.6 - 153.2 \mu m$.

ii) Vessel elements short to very long, slender, beaked at one or both ends or without beaks, end walls oblique or horizontal, perforation simple, lateral wall scalariform pitted, pits alternate, ca $520.1 \times 66.09 \mu m$ average and range ca $362.7 - 642.0 \times 34.6 - 98.1 \mu m$ (Plate- 22).

11) Terminalia procera Roxb.

Parenchyma are of two types:

i) Parenchyma with few pits: Cells rectangular, squarish or rhomboid, cells thick walled, cell wall interrupted, pits few, small, alternate, elongate, oval, distributed all over the cell, ca $44.55 \times 22.25 \mu m$ average and range ca $28.1 - 64.8 \times 17.4 - 25.9 \mu m$.

ii) Parenchyma with many pits: Cells rectangular or squarish, rhomboid, may very long, pits alternate, with much reduced borders to apparently simple, pits vertical, distributed at one side, cell wall continuous, ca $48.55 \times 24.25 \mu m$ average and range ca $32.1 - 68.8 \times 19.4 - 27.9 \mu m$.

Fibres simple, slender, tapering and sharply pointed, outline entire, ca $978.01 \times 15.53 \mu m$ average and range ca $531.0 - 1206.1 \times 12.1 - 24.0 \mu m$. 

64
Some intermediate tracheids were found which are long, thick, ends tapering, with only one simple, perforation plate, pits few, alternate, ca $964.9 \times 39.9\ \mu m$.

Tracheids shorter than fibres, slender, ends blunt or pointed, pits few, elongate, in one-many rows, alternate, ca $538.19 \times 26.94\ \mu m$ average and range ca $473.0 - 629.9 \times 18.8 - 37.2\ \mu m$.

Vessel elements are of two types:

i) Vessel elements broader, end walls horizontal with simple perforation, lateral walls with vestured, alternate pits, ca $329.96 \times 90.53\ \mu m$ average and range ca $251.3 - 415.2 \times 33.7 - 115.3\ \mu m$.

ii) Vessel elements long, slender, beaked at one or both ends, end walls oblique shifted to lateral side, perforation simple, lateral wall simple pitted, pits vestured, alternate, circular or oval, ca $416.32 \times 80.57\ \mu m$ average and range ca $323.8 - 520.8 \times 42.3 - 108.6\ \mu m$ (Plate- 23).

12) **Terminalia travancorensis** Wight & Arn.

Parenchyma are of two types:

i) Parenchyma with few pits: Cells rectangular, squarish or rhomboid, cells thick walled, cell wall continuous, pits few, small, alternate, elongate, oval, distributed all over the cell, ca $105.58 \times 38.31\ \mu m$ and range ca $94.1 - 131.5 \times 8.9 - 26.3\ \mu m$.

ii) Parenchyma with many pits: Cells rectangular or squarish, rhomboid, may very long, pits alternate, with much reduced borders to apparently simple, pits circular to oval, distributed all over, cell wall interrupted, ca $57.84 \times 21.25\ \mu m$ in average and range ca $36.2 - 87.0 \times 11.8 - 35.4\ \mu m$.

Fibres are of two types:

i) Fibres simple, slender, long, tapering and sharply pointed, outline entire, ca $1051.9 \times 27.54\ \mu m$ and range ca $721.3 - 1225.0 \times 21.8 - 29.3\ \mu m$.

ii) Fibres pitted, slender, long, tapering and sharply pointed, outline entire, pits simple, elongate, alternate, may present in one-many rows, average size ca $958.88 \times 24.43\ \mu m$ and range ca $532.0 - 1812.2 \times 20.8 - 34.1\ \mu m$. 

65
Tracheids shorter than fibres, slender, ends blunt or pointed, pits few, elongate, in one-many rows, alternate, ca 453.02 × 24.32 µm average and range ca 287.3 – 665.1 × 15.2 – 35.9 µm.

Vessel elements are of two types:

i) Vessel elements broader, end walls oblique or horizontal with simple perforation, lateral walls with vestured, alternate pits, beak short to long, may present on both the ends, ca 422.4 × 125.6 µm average and range ca 286.2 – 572.6 × 91.5 – 202.2 µm.

ii) Vessel elements short to long, slender, beaked at one or both ends or without beaks, end walls oblique or horizontal, perforation simple, lateral wall scalariform pitted, pits alternate, ca 563.2 × 45.32 µm average and range ca 472.4 – 644.4 × 26.3 – 73.6 µm (Plate- 24).