Asian Journal of Plant Sciences, 2015
ISSN 1682-3974
© 2015 Asian Network for Scientific Information

ansinet
Asian Network for Scientific Information

RESEARCH ARTICLE OPEN ACCESS

DOI: 10.3923/ajps.2015.

Wood Anatomical from Indonesian Genus *Cinnamomum* (Lauraceae) and their Identification Key

[1]Andianto, [2]Imam Wahyudi, [1]Totok Kartono Waluyo, [3]Rudi Dungani, [3]A. Hadiyane and [4]M. Fikri Hernandi
[1]Forestry Research and Development Agency (FORDA), Center for Forestry Engineering and Forest Product Research and Development, Bogor, 16610, Indonesia
[2]Deparment of Forest Product, Faculty of Forestry, Bogor Agricultural University, Kampus IPB Dramaga Bogor, Indonesia
[3]School of Life Sciences and Technology, Institute of Technology Bandung, Gedung Labtex XI, Jalan Ganesha No. 10 Bandung, 40132, West Java, Indonesia
[4]Department of Agricultural Technology, Samarinda Agricultural Polytechnic, Samarinda, East Kalimantan, Indonesia

ARTICLE INFO
Article History:
Received:
Accepted:

Corresponding Author:
Andianto,
Forestry Research and Development Agency (FORDA),
Center for Forestry Engineering and Forest Product Research and Development, Bogor, 16610, Indonesia

ABSTRACT
The purpose of this study was to identify the anatomical structure of four *Cinnamomum* species (Lauraceae) and as comparison using *Cryptocarya* species in same family. *Cinnamomum* is the potential medical plants species. Wood anatomical and their tentative identification key need to be done. Anatomical properties can be beneficial tool for developing the *Cinnamomum* species. Anatomical description was performed by microscopic evaluation. In this study, *Cinnamomum burmannii* Blume, *Cinnamomum xanthoneureum* Blume, *Cinnamomum zeylanicum* Blume, *Cinnamomum coriaceum* Camm and *Cryptocarya aromatica* Kosterms species were identified. The Standard of diagnostic and quantitative anatomy used the IAWA list of microscopic features for hardwood identification. The mostly diagnostic features of *Cinnamomum* species and family of Lauraceae founded are alternate intervessel pits, parenchyma vasicentric and oil cells present. Type of parenchyma and vessel-ray pitting can be used to determine among *Cinnamomum* species.

Key words: Wood anatomy, medical plants species, *Cinnamomum* sp., *Cryptocarya aromatica*

INTRODUCTION

Indonesia is endowed with about 30.000 various species and about 1000 of them can be used for medicinal purposes (Zuhud, 1991). According to Jafarsidik (1997), currently there have been known 87 medicinal plant species of forest trees. Among those species are *Cinnamomum* plants, whereby its bark portion has been used in food, medicinal and pharmacy industries. There are about 250 species of the genus *Cinnamomum* of the family Lauraceae in the world and they are spread out mostly in tropical and subtropical Asia (Ho and Hung, 2011). In the tropical Asia, *Cinnamomum* sp. consists of 54 species in which 12 of them are in Indonesia (Nurdjannah, 1992). These species grow extensively in Jambi province, Sumatra and Jawa Island (Hasanah *et al*., 2004). Early work in anatomical aspects of the family Lauraceae has been reported by Metcalfe and Chalk (1950), further the characteristics of *Cinnamomum* has been conducted by Lemmens *et al.* (1995).

Description of *Cinnamomum* wood anatomy has been described by the wood anatomists. However, such descriptions

are still not yet specific and moreover resulting from the observation on only a few species. Wood identification through the scrutiny on the wood anatomy as one of the basic wood properties can be beneficial tool for developing the *Cinnamomum* wood uses. This paper aims to identify the four *Cinnamomum* species and one *Cryptocarya* species. For this purpose, made their tentative identification key.

MATERIALS AND METHODS

Materials: Samples of the four *Cinnamomum* species and one *Cryptocarya* species selected were taken from trees felled down in several site in Indonesia (Table 1), where the *Cinnamomum* species dominant in their site (Fig. 1). The site and soil no analyses were done to determine site characteristics.

Restrictions in examinations: There were some restrictive factors in the study. One was the selection of the areas to measure anatomical characteristics of wood samples another restrictive factor was unknown tree age and growing conditions of the *Cinnamomum* species samples used in this study. Since, changes in wood structure depend on age, growing conditions and location height that the specimen is taken from the tree, even the same wood species can show more or less variations in anatomical properties, such as growth ring width, cell size and cell wall thickness (Bozkurt and Erdin, 2000).

Methods: Standard techniques applied to all samples for sectioning and maceration (Sass, 1989; Tesoro, 1989). The light weight samples were soaked in aquades one night and the medium weight samples were soaked one week in alcohol-glycerine solution. Anatomical descriptions and identifications of each sample were performed based on the microscopic studies of transverse (CS), radial (RS) and Tangential Sections (TS). For these purposes, approximately 10 by 20 mm blocks were cut from the samples. Well-preserved samples were cut to thin sections (about 15-25 μm) from the inner heartwood using a Reichert sliding microtome. However, heavily decomposed samples were not suitable for cutting with a microtome. Such samples were hand-cut with a razor blade. Quantitative features and qualitative anatomical properties of the samples were needed in wood identification and were observed under light microscope.

The samples were stained with safranine and then observed under the Light Microscope of Olympus BX51. Analysis FIVE software and a DP71 Digital Camera were used to take images, which were installed and adapted on the microscope. Quantitative and qualitative features of the wood samples were described according to the IAWA List of microscopic features for hardwood identification (Wheeler *et al*., 1989).

RESULTS AND DISCUSSION

The qualitative results of the four *Cinnamomum* and one *Cryptocarya* species and comparisons to literature are summarized below and the quantitative results are given in Table 2 and 3, respectively.

***Cinnamomum burmannii* Blume:** Growth rings boundaries distinct which marked by differences in wall thickness of

Table 1: Localities of *Cinnamomum* samples

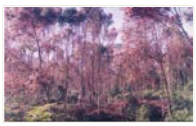
Species samples	Collected site	Condition of site
Cinnamomum burmannii blume	Solok (west sumatra)	
Cinnamomum xanthoneureum blume	Donggala (central sulawesi/celebes)	
Cinnamomum zeylanicum blume	Kerinci (jambi)	
Cinnamomum coriaceum camm	Maros (south sulawesi/celebes)	
Cryptocarya aromatica kosterms	Collection of the xylarium bogoriense 1915 bogor, indonesia	

Fig. 1: Map of geographical distribution of *Cinnamomum* cultivation, (1) Solok (West sumatra), (2) Kerinci (Jambi), (3) Banyumas (Central java), (4) Donggala (Central sulawesi/Celebes) and (5) Maros (South sulawesi/Celebes)

Table 2: Comparison of wood anatomical features among four *Cinnamomum* sp. and *Cryptocarya aromatic*

Anatomical characteristics	*Cinnamomum burmannii* blume	*Cinnamomum xanthoneureum* blume	*Cinnamomum zeylanicum* blume	*Cinnamomum coriaceum* camm	*Cryptocarya aromatic* kosterms
Growth ring boundaries	Distinct	Distinct	Distinct	Distinct	Indistinct
Vessels					
Solitery vessel (%)	83	83	94	6373	
Multiples vessel	2 (-3-4)	2 (-3-4)	2	2-3 (-4-6)	2 (-3)
Diameter (µm)	125±17	228±28	192±23	191±24	239±75
Frequency (mm^{-2})	16	8	18	10	6
Average length (µm)	531±99	623±114	498±65	530±94	486±138
Intervessel pit					
a Arrangement	Alternate	Alternate, pits polygonal	Alternate	Alternate	Alternate
b Diameter (µm)	11	13	15	14	13
Vessel-ray pitting	With much reduced borders to apparently simple: pits rounded or angular	With much reduced borders to apparently simple: pits horizontal to vertical	With much reduced borders to apparently simple: pits horizontal to vertical	With distinct borders, similar to intervessel pits in size and shape	With much reduced borders to apparently simple: pits horizontal to vertical
Parenchyma					
Paratracheal axial	Unilateral paratracheal, vasicentric	Unilateral paratracheal, vasicentric	Unilateral paratracheal,	Unilateral paratracheal	Vasicentric
Apotracheal axial	-	-	-	-	bands 3-4 cells wide
Strand length, cells	3-4	4-7	3-8	4-7	2-4
Rays					
Width, (seriate)	(1) -2	1-2	2-3	(1-2) -3-5	(2) -5
Average height (µm)	627	535	458	434	594
Max. height (µm)	996	973	728	902	966
Frequency per mm	25	9	18	19	8
Fibres					
Pit type	Simple to minutely bordered pits	Distinctly bordered pits	Distinctly bordered pits	Simple to minutely bordered pits	Distinctly bordered pits
Wall thickness (µm)	2.2	4.1	4	2.2	5
Diameter (µm)	28	37	25	34	28
Length (µm)	1455	1510	1427	1311	1 391

+ : Present, -: Absent, ( ): Occasionally

fibres. Diffuse-porous woods with frequency ranges 16 mm^{-2}, 83% solitary and in radial multiples 2 (-3-4), solitary vessels are round, average vessel length 322-764 µm, average tangential vessel diameter 93-62 µm, simple perforations. Intervessel pits alternate with average horizontal diameter intervessel pit size 11 µm, vessel-ray pits are usually with reduced borders to apparently simple and pits rounded or angular. Tyloses are present. Parenchyma types are unilateral paratracheal and vasicentric, axial parenchyma strand length 3-4 cells. Rays are heterocellular with (-1) 2 seriate, frequency 25 mm^{-1} and 627 µm in height, the composition of procumbent ray cells with 1 row upright and/or square

Table 3: Tentative identification key for *Cinnamomum* and *Cryptocarya* wood

Codes	Quantitative and qualitative features	Species
1	Intervessel pitting alternate, pits 11-14 µm in diameter (horizontal dimension), unilateral paratracheal to vasicentric parenchyma, fibers with bordered pits, oil cells associated with axial parenchyma and present among fibres	
2A	Unilateral paratracheal and/vasicentric parenchyma	3
2B	Unilateral paratracheal parenchyma	4
3A	Vessel-ray pits with much reduced borders to apparently simple: pits rounded or angular, 16 vessels frequency per mm^2	*Cinnamomum burmannii*
3B	Vessel-ray pits with much reduced borders to apparently simple: pits horizontal to vertical	5
4A	Vessels in radial multiples of 2, vessel-ray pits with much reduced borders to apparently simple: pits Horizontal to vertical, 18 vessels per mm^2	*Cinnamomum zeylanicum*
4B	Vessels in radial multiples of 2-3 (-4-6), vessel-ray with distinct borders, similar to intervessel pits in size and shape throughout the ray cell, frequency of vessel 10 per mm^2	*Cinnamomum coriaceum*
5A	Shape of alternate pits polygonal	*Cinnamomum xanthoneureum*
5B	Axial parenchyma vasicentric and bands 3-4 cells wide, vessels in radial multiples of 2 (-3) 6, 6 vessels per mm^2	*Cryptocarya aromatic*

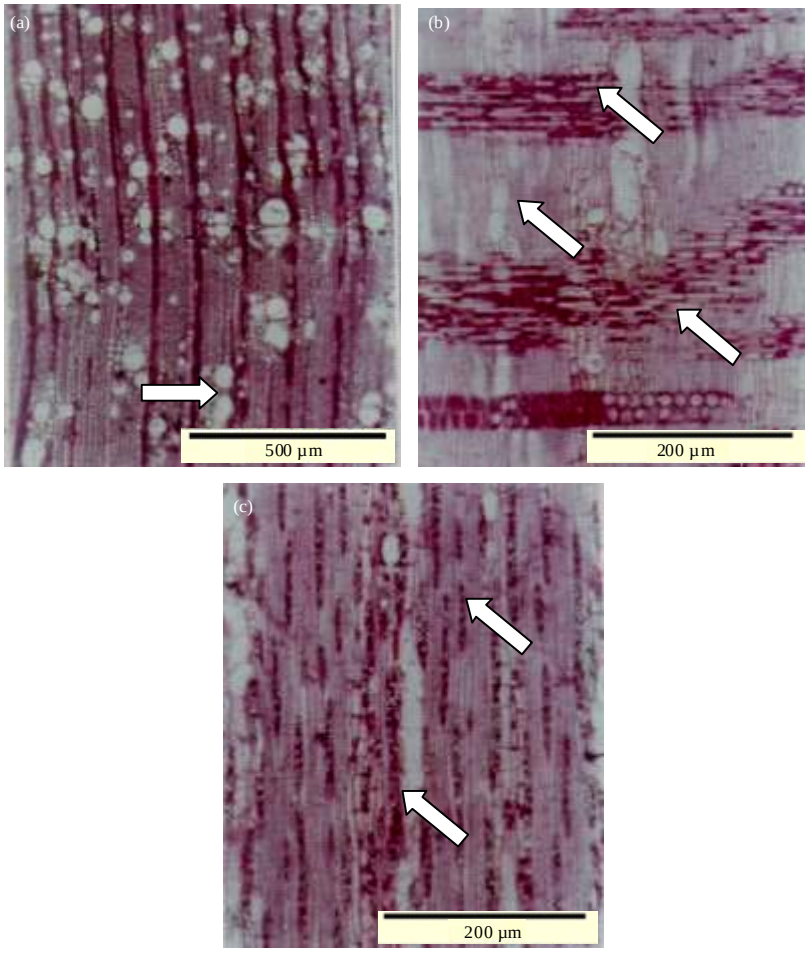


Fig. 2(a-c): (a) *Cinnamomum burmannii* blume samples obtained from the solok, West sumatera (40×magnification). Diffuse-porosity at transverse section, (b) Radial section of procumbent body ray cells (arrows showed one row of upright or square marginal cells and some rays with procumbent, square and upright cells mixed, oil cells associated with axial parenchyma) and (c) (-1) 2 seriate rays at tangential section

marginal cells, occasionally procumbent, square and upright cells mixed. The fibres are non-septate with simple to minutely bordered pits, average fibre length 1455 µm, average fibre tangential diameter 28 µm, average fibre wall thickness 2.2 µm. Oil cells associated with axial parenchyma and present among fibres (Fig. 2).

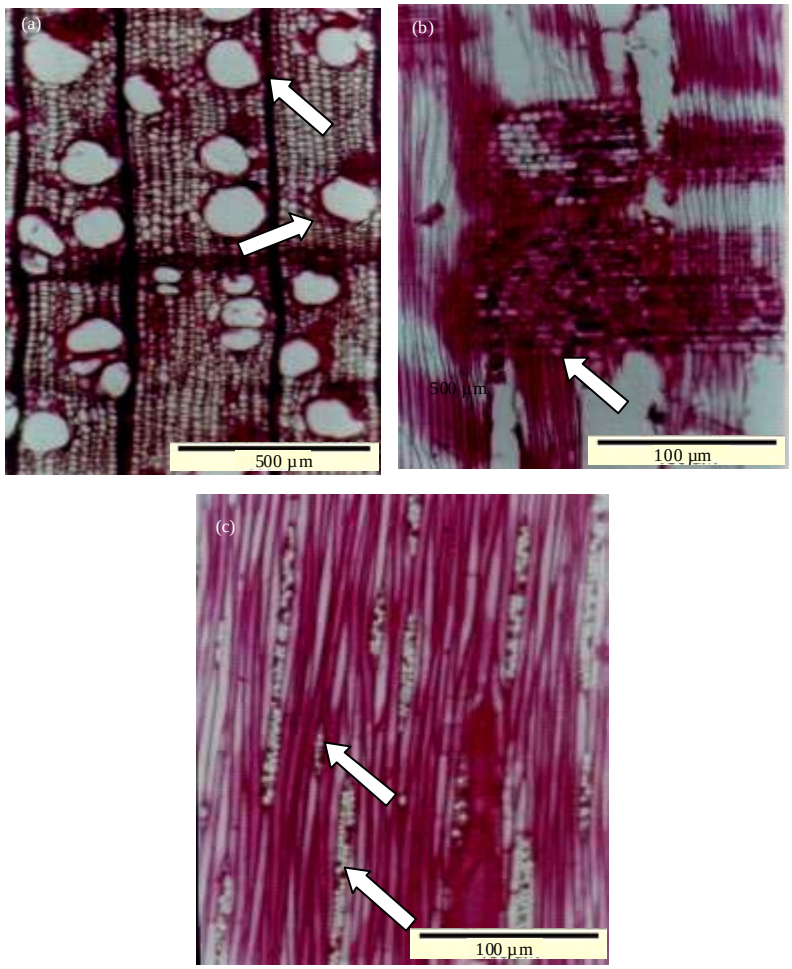


Fig. 3(a-c): *Cinnamomum xanthoneureum* Blume samples obtained from the Donggala, Central Sulawesi/Celebes (40×magnification), (a) Transverse section: Parenchyma unilateral paratracheal and vasicentric, (b) Radial section: Procumbent body ray cells with one row of upright or square marginal cells and (c) Tangential section: 1-2 seriate rays

***Cinnamomum xanthoneureum* Blume:** Growth rings boundaries distinct which marked by differences in wall thickness of fibres. Diffuse-porous woods with frequency ranges 8 mm^{-2}, 83% solitary and in radial multiples 2 (-3-4), solitary vessels are round, average vessel length 458-831 µm, average tangential vessel diameter 176-272 µm, simple perforations. Intervessel pits alternate and shape is polygonal with average horizontal diameter intervessel pit size 13 µm, vessel-ray pits are usually with reduced borders to apparently simple and pits horizontal or vertical. Tyloses are present. Parenchyma types are unilateral paratracheal and vasicentric, axial parenchyma strand length 4-7 cells. Rays is heterocellular with 1-2 seriate, frequency 9 mm^{-1} and 535 µm in height, the composition of procumbent ray cells with 1 row upright and/or square marginal cells. The fibres are non-septate with distinctly bordered pits, average fibre length 1510 µm, average fibre tangential diameter 37 µm, average fibre wall thickness 4,1 µm. Oil cells associated with axial parenchyma and present among fibres (Fig. 3).

***Cinnamomum zeylanicum* Blume:** Growth rings boundaries distinct which marked by differences in wall thickness of fibres. Diffuse-porous woods with frequency ranges 18 mm^{-2}, 94% solitary and in radial multiples 2, solitary vessels are round, average vessel length 389-572 µm, average tangential vessel diameter 153-229 µm, simple perforations. Intervessel pits alternate with average horizontal diameter intervessel pit size 15 µm, vessel-ray pits are usually with reduced borders to apparently simple and pits horizontal or vertical. Tyloses are present. Parenchyma type is unilateral paratracheal, axial parenchyma strand length 3-8 cells. Rays is heterocellular with 2-3 seriate, frequency 18 mm^{-1} and 458 µm in height, the composition of procumbent ray cells with 1 (-3) row upright and/or square marginal cells. The fibres are non-septate with distinctly bordered pits, average fibre length 1427 µm, average fibre tangential diameter 25 µm, average fibre wall thickness 4 µm. Oil cells associated with axial parenchyma (Fig. 4).

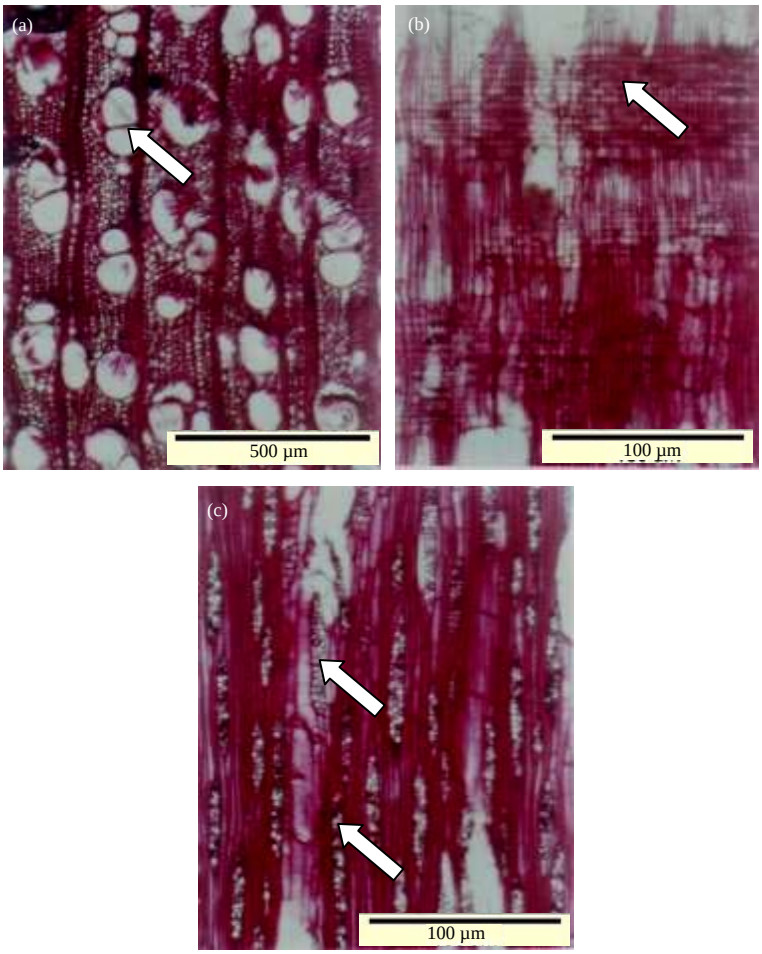


Fig. 4(a-c): *Cinnamomum zeylanicum* blume samples obtained from the kerinci, jambi (40×magnification), (a) Transverse section: Multiples vessel of 2, (b) Radial section: All ray cells upright and square and (c) Tangential section: 2-3 seriate rays

***Cinnamomum coriaceum* Camm:** Growth rings boundaries distinct which marked by differences in wall thickness of fibres. Diffuse-porous woods with frequency ranges 10 mm^{-2}, 63% solitary and in radial multiples 2-3 (-4-6) and occasionally in clusters, solitary vessels are round, average vessel length 391-675 µm, average tangential vessel diameter 151-247 µm, simple perforations. Intervessel pits alternate with average horizontal diameter intervessel pit size 14 µm, vessel-ray pits are usually with distinct borders; similar to intervessel pits in size and shape. Tyloses are present. Parenchyma type is unilateral paratracheal, axial parenchyma strand length 4-7 cells. Rays is heterocellular with (-1-2) -3-5 seriate, frequency 19 mm^{-1} and 434 µm in height, the composition of procumbent ray cells with 1-3 row upright and/or square marginal cells, all ray cells procumbent, occasionally procumbent, square and upright cells mixed. The fibres are non-septate with simple to minutely bordered pits, average fibre length 1311 µm, average fibre tangential diameter 34 µm, average fibre wall thickness 2 µm. Oil cells associated with axial parenchyma and present among fibres (Fig. 5).

***Cryptocarya aromatica* Kosterms:** Growth rings boundaries indistinct. Diffuse-porous woods with frequency ranges 6 mm^{-2}, 73% solitary and in radial multiples 2 (-3), solitary vessels are round, average vessel length 282-682 µm, average tangential vessel diameter 135-343 µm, simple perforations. Intervessel pits alternate with average horizontal diameter intervessel pit size 13 µm, vessel-ray pits are usually with reduced borders to apparently simple and pits horizontal or vertical. Tyloses are present. Parenchyma types are vasicentric and banded parenchyma 3-4 cells wide, axial parenchyma strand length 2-4 cells. Rays is heterocellular with (-1-2) -3-5 seriate, frequency 19 mm^{-1} and 434 µm in height, the composition of procumbent ray cells with 1-3 row upright and/or square marginal cells, all ray cells procumbent, occasionally procumbent, square and upright cells mixed. The fibres are non-septate with simple to minutely bordered pits, average fibre length 1311 µm, average fibre tangential diameter 34 µm, average fibre wall thickness 2 µm. Oil cells associated with axial parenchyma and present among fibres (Fig. 6).

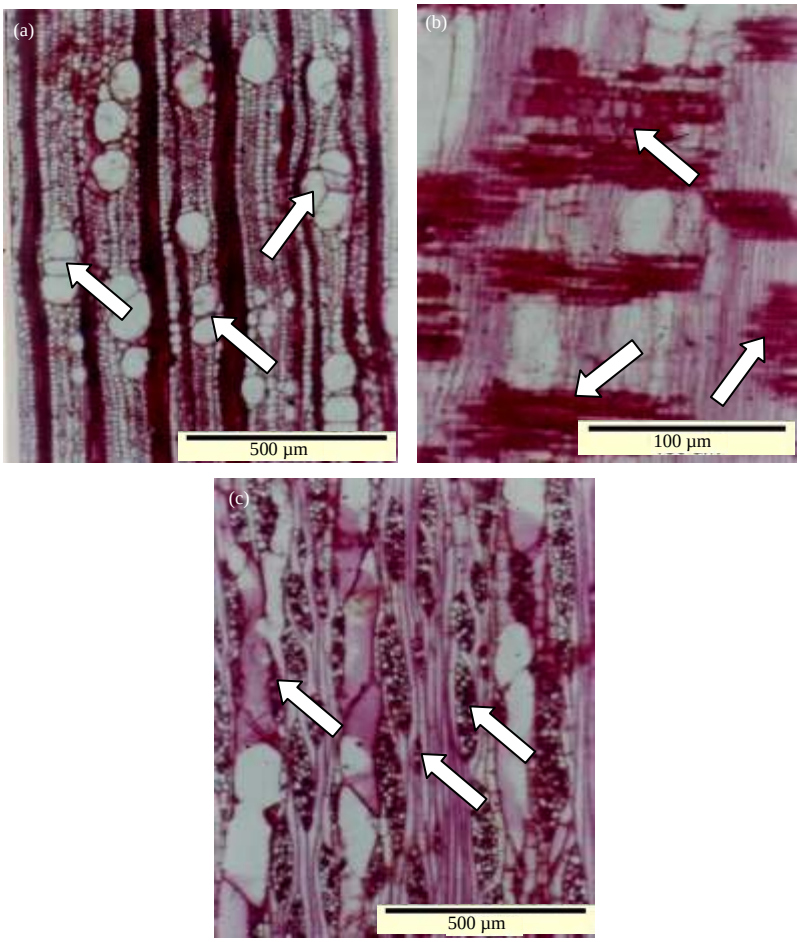


Fig. 5(a-c): *Cinnamomum coriaceum* camm samples obtained from the maros, south sulawesi/Celebes (40×magnification), (a) Transverse section: Multiples vessels of 2-3(-4-6) and clusters, oil cells present among the fibres, (b) Radial section: Body ray cells procumbent with 1-3 rows of upright and square marginal cells, all ray cells procumbent, some rays with procumbent, square and upright cells mixed and (c) Tangential section: (-1-2)-3-5 seriate rays and simple perforation plate

The species of *Cinnamomum* can be determined by wood anatomical structure. The following are commonly features founded in *Cinnamomum*: diffuse-porous wood, simple perforation plates, alternate intervessel pits, unilateral paratracheal and/vasicentric parenchyma, uniseriate and multiseriate rays, fibres with simple to minutely bordered pits and oil cells. Lemmens *et al.* (1995) have been described wood anatomy of *Cinnamomum* (species study: *C. porrectum*, *C. sintoc* and *C. verum*), which have simple perforation plates, alternate intervessel pits, tyloses present, scanty to many parenchyma, vasicentric to aliform and diffuse parenchyma (Lemmens *et al*., 1995). According to Metcalfe and Chalk (1950), wood of Lauraceae has simple perforation plates, alternate intervessel pits, scanty paratracheal to vasicentric and occasionally aliform, marginal bands parenchyma present in some genus and sometimes contains oil. Mandang and Pandit, (2004) have also been described *Alseodaphne foetida* K. and *Litsea odorifera* Val. (Lauraceae), both have intervessel pits alternate; polygonal, vasicentric parenchyma and contain oil. The mostly diagnostic features of *Cinnamomum* and family of Lauraceae that founded are alternate intervessel pits, parenchyma vasicentric and oil cells present. Type of parenchyma and vessel-ray pitting both are the main diagnostic features to differentiate among one *Cinnamomum* species with the others Mandang and Pandit (2004).

Table 2 and 3 listed the comparison of wood anatomical features and tentative identification key for *Cinnamomum* and *Cryptocarya* wood. This situation is well understood as the different of anatomical features of plant depend on the locality in which it is grown (Osorio *et al*., 2010). Table 2 show that the species with vasicentric parenchyma bands were founded in two different species; *C. burmannii* (species from Solok-West Sumatera) and *C. xanthoneureum* (species from Donggala-Central Sulawesi). Another species

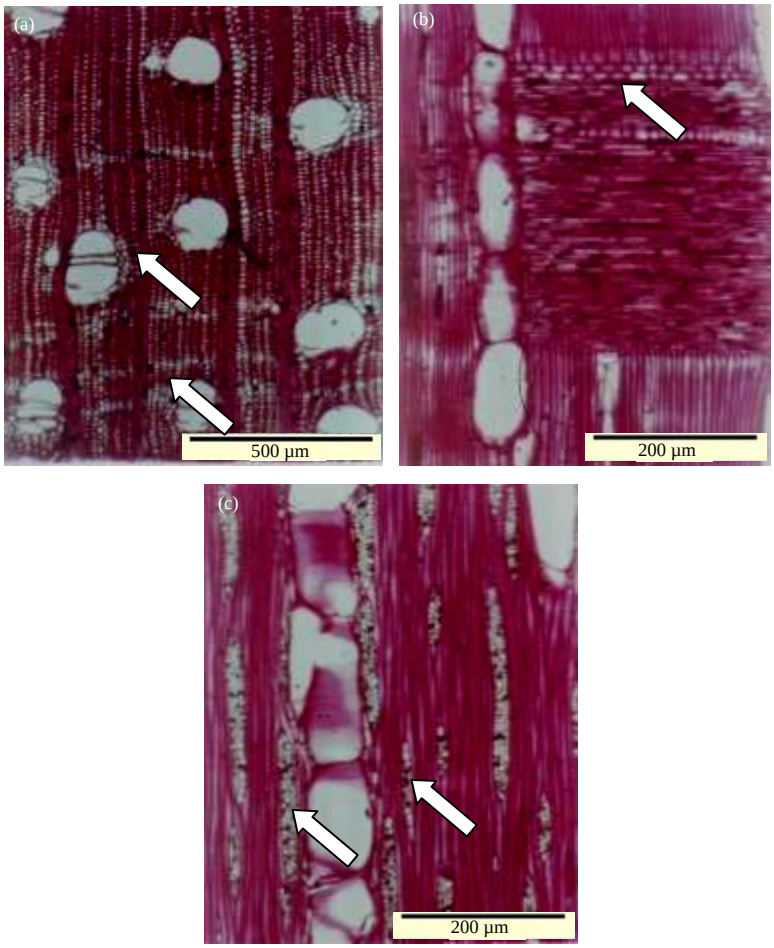


Fig. 6(a-c): *Cryptocarya aromatica* kosterms samples obtained from collection of the xylarium bogoriense 1915 bogor, Indonesia (40×magnification), (a) Transverse section: Axial parenchyma vasicentric and axial parenchyma bands 3-4 cells wide, (b) Radial section: Body ray cells procumbent with 3 rows of upright and square marginal cells and (c) Tangential section: (-2)-5 seriate rays

are characterized by the presence of unilateral paratracheal parenchyma. It will be evident from the foregoing, that wood anatomical characters within the Lauraceae can be used to identify (species of) genera.

Table 3 shows rays cell height and the relative distribution of rays can best judged on a tangential surface. On radial surfaces ray fleck may be distinctive. The presence of oil cells associated with axial parenchyma and present among fibres as well as the relative abundance of oil cell formation is usually a consistent feature of *Cinnamomum* pores.

CONCLUSION

Wood anatomical features of *Cinnamomum* and *Cryptocarya* are diffuse-porous wood, simple perforation plates, alternate intervessel pits, unilateral paratracheal and/vasicentric parenchyma, uniseriate and multiseriate rays, fibres with simple to minutely bordered pits and contain oil cells. Banded parenchyma 3-4 cells wide only found on *Cryptocarya*. Type of parenchyma and vessel-ray pitting both are the main diagnostic features to differentiate among one *Cinnamomum* species with the others.

ACKNOWLEDGMENTS

The authors wish to thank government of West Sumatera Province, Central Sulawesi, Jambi, South Sulawesi and Xylarium Bogoriense, which has provided the samples material for this study and this research was sponsored by Ministry of Forestry, Republic of Indonesia.

REFERENCES

Bozkurt, A.Y. and N. Erdin, 2000. Odun Anatomisi [Wood Anatomy]. Dilek Press, Istanbul.

Hasanah, M., Y. Nuryani, A. Djisbar, E. Mulyono, E. Wikardi and A. Asman, 2004. Indonesian Cassia (Indonesian Cinnamon). Medicinal and Aromatic Plants-Industrial Profiles. CRC Press, New York, Washington, DC..

Ho, K.Y and T.Y. Hung, 2011. Cladistic relationships within the genus *Cinnamomum* (Lauraceae) in Taiwan based on analysis of leaf morphology and inter-simple sequence repeat (ISSR) and internal transcribed spacer (ITS) molecular markers. Afr. J. Biotechnol., 10: 4802-4815.

Jafarsidik, Y., 1997. Potential of Medicinal traditional plant (trees). Proceedings of the International Conference on the use of Wood is Less known Species, September 10-11, 1997, Bogor, pp: 126-132.

Lemmens, R.H.M.J., I. Soerianegara and W.C. Wong, 1995. Plant resources of South-East Asia. Report No 5, Minor Commercial Timbers, Bogor, Indonesia, pp: 229-2241.

Mandang, Y.I. and I.K.N. Pandit, 2004. Manual of Identification Wood Species in Field. Prosea Indonesia, Yayasan Prosea, Bogor, Indonesia.

Metcalfe, C.R and L. Chalk, 1950. Anatomy of the Dicotyledons: Leaves, Stem and Wood in Relation to Taxonomy With notes on Economic uses. The Clarendon Press, Virginia.

Nurdjannah, N., 1992. Processing of the genus cinnamomum. Proceedings of the Conference on Research and Development of Biological Resources Center for Biology, April 4, 1992, Bogor, pp: 321-330.

Osorio, L., E. Trujillo, A.W. van Vuure, F. Lens, J. Ivens and I. Verpoest, 2010. The relationship between the bamboo fibre microstructure and mechanical properties. Proceedings of the 14th European Conference on Composite Materials, June 7-10, 2010, Budapest, Hungary, pp: 467-473.

Sass, J.E., 1989. Botanical Microtechnique. The IOWA State University Press, IOWA., USA..

Tesoro, F.O., 1989. Methodology for Proyect 8 on Corypha and livistona. FPRDI, College, Laguna, Philippines, pp: 198-203.

Wheeler, E.A., P. Baas and P.E. Gasson, 1989. IAWA list of microscopic features for hardwood identification. IAWA Bull., 10: 219-332.

Zuhud, E.A.M., 1991. Sustainable of medicinal plant from tropical forest Indonesia. Cooperation among Department of Forest Resources Conservation Faculty of Forestry, Bogor Agricultural University and Foundation of Development Sanctuary and Wildlife Indonesia, Bogor, pp: 37-42.