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Review Article

A PHYTOCHEMICAL, ETHNOMEDICINAL AND PHARMACOLOGICAL REVIEW OF GENUS DIPTEROCARPUS

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ABSTRACT

Dipterocarpus are the third largest and most diverse genus among Dipterocarpaceae. They are well-known for timber, but less acknowledged for its medicinal importance. Phytochemically genus Dipterocarpus has reported to contain resin, coumarin and dammar. The Resveratrol class of compounds is one of the major chemical constituent in this genus. Generally, the bark of Dipterocarpus is presumed to be the most active. Dipterocarpus species showed Anti-AIDS, cytotoxic, anti-inflammatory, anti-bacterial, anti-fungal and anti-oxidant activities. Therapeutically important species in this genus are *Dipterocarpus obtusifolius Teijsm ex Miq* because it may have cured against AIDS. We document number of species in this genus, their synonyms, distribution around the World, traditional names, ethnomedicinal uses, isolated compounds, chemical structure, chemical nature of isolated compounds, pharmacological reports and explain the relationship between isolated compounds from this genus and their therapeutic use.

Keywords: Dipterocarpus, Cytotoxicity, Anticancer, Anti-AIDS, Resveratrol.

INTRODUCTION

Natural products, including plants, animal and microorganism have been the basis of treatment of human diseases. Indigenous people derived therapeutic materials from thousands of plants. The World Health Organization (WHO) estimates that up to 80 percent of people still rely mainly on traditional remedies such as herbs for their medicines [1]. We observed that several Dipterocarpus species in the last half of the twentieth century have become renowned for timber, which is the most important economic product from dipterocarp but it results in the loss of our Natural flora. We still have not explored non-timber forest product that has much impact on an economy of the rural people and forest dwellers of Malaysia. Dipterocarpus has been traditionally a source of dammar, resin, nuts and camphor. Several phytochemical, ethnopharmacological and chemotaxonomy literatures are available for the species present in genus, but it is not documented yet that is beneficial for the future researchers.

These reviews will cover all literature data on the phytochemical ethnobotanical and pharmacological activities. Table 1 gives you a brief overview of Genus Dipterocarpus.

Botany

Dipterocarpus commonly known as "keruing" reported at least a genus of 75 species and is the third largest, after Shorea (150) and Hopea (100) from 16 genera in the plant family Dipterocarpaceae [2]. It exists in the tropical forest of dense evergreen or mixed dense forests. Dipterocarpus alatus is commonly found in Thailand, Cambodia, Laos, Vietnam, Philippines [3]. Dipterocarpus baudii occur in Cambodia; Indonesia (Sumatera); Malaysia; Myanmar; Thailand; Vietnam [4].

Dipterocarpus chartaceous which is also known as Dipterocarpus skinneri exsist in Peninsular Malaysia, Thailand [5]. Dipterocarpus dryobalanops is one of famous species in genus Dipterocarpus and found in Indonesia (Sumatera); Malaysia (Peninsular Malaysia, Sabah, Sarawak) [6]. Dipterocarpus globosus is native to Brunei Darussalam; Indonesia (Kalimantan); Malaysia (Sarawak) [7, 8]. Dipterocarpus gracilis is indigenous to Bangladesh; India (Andaman Is., Arunachal Pradesh, Assam, Tripura); Indonesia (Jawa, Kalimantan, Sumatera); Malaysia (Peninsular Malaysia); Myanmar; Philippines; Thailand [9, 10].

Dipterocarpus retusus is another major species in this genus which occur in China (Yunnan); India (Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland, Tripura, West Bengal); Indonesia (Jawa, Lesser Sunda Is., Sumatera); Malaysia (Peninsular Malaysia); Myanmar; Thailand; Vietnam [11, 12]. List of Species with distribution of plant and their synonyms are mentioned in table 2.

Ethnomedicinal uses of dipterocarpus

Although Dipterocarpus is renowned for timber purposes, but it has some medicinal use. Bark of Dipterocarpus alatus is used to treat Rheumatism, diseases of the liver, and to stimulate appetite in cattle. It has some common names in different languages such as Gurjun(Eng.); keruing, kruen (Fr.); gurjin (Ind.); mai yang (Laos); yang-na (Thai.); dau nooc (Viet.); yang, keruing (trade names) [13, 14]. Bark of Dipterocarpus dryobalanops commonly known as Borneo Camphor, Camphor Tree, Malay Camphor, or Sumatran Camphor is used in medicine in preparation of tooth paste, powder, diaphoretic and antiseptic, hysteria, dysmenorrhea [15-18]. Dispterocarpus co-status is used in the treatment of ulcer Its traditional names as follows chhë tiël niëng, chhë tiël bangkuëy, niëng daèng krâhâm (Cambodia,Thailand,Vietnam) [19, 20]. Dipterocarpus gracilis which is known as keriung-kesat in Malay is It is used as antiseptic for gonorrhoea and urinary disease [20, 21]. Dipterocarpus Indicus, Dipterocarpus turbinatus along with Dipterocarpus alatus is used for rheumatism. Some plants are traditionally phytotoxic such as Dipterocarpus turbinatus. Dipterocarpus turbinatus is also used to treat Gonorrhoea, gleets, ulcer, ringworm and skin diseases [22-26]. Dipterocarpus tuberculatus is traditionally used to treat various inflammatory symptoms. We found a common observation that most use part of the plant is bark. All the species with their common names, part use and their traditional use are mentioned in table 3.

Chemical compounds isolated from genus dipterocarpus

Most of the chemical constituents isolated from genus Dipterocarpus is from the bark of the plant. It is an important source of resins such as oleoresin, Dammars and camphor. The chemical nature of these constituents is sesquiterpenes, triterpenes (Resveratrol trimers, tetramer oligomer) and coumarin derivatives.

Chemical constituents isolated from Dipterocarpus baudii consist of Caryophyllene (1), humulene (2), caryophyllene oxide, humulene epoxide-II (3) clovane-diol (4), humulene epoxide-III (5), caryophyllenol-I (6), caryophyllenol-II (7). *Dipterocarpus confertus* possess β-sitosterol (8), betulinic acid (9), cinnamic acid (10),α-viniferin (11), betulinat acid, 5-hydroxy-2-Methoxy benzoate (12).

Table 1: Brief overview of genus Dipterocarpus

Order	Species	Order	Species	Order	Species
A	*Dipterocarpus affinis*	D	*Dipterocarpus dyeri*	*H*	*Dipterocarpus hasseltii*
	Dipterocarpus alatus		*Dipterocarpus dryobalanops*		*Dipterocarpus helicopteryx*
	Dipterocarpus angulatus				*Dipterocarpus hirtus*
	Dipterocarpus applanatus				
	Dipterocarpus apterus				
B	*Dipterocarpus balsamiferus*	E	*Dipterocarpus elongatus*	*I*	*Dipterocarpus indicus*
	Dipterocarpus basilanicus		*Dipterocarpus eurhynchus*		*Dipterocarpus insignis*
	Dipterocarpus baudii		*Dipterocarpus eurynchioides*		*Dipterocarpus insularis*
	Dipterocarpus blancoi		*Dipterocarpus exilis*		*Dipterocarpus intricatus*
	Dipterocarpus borneensis				
	Dipterocarpus bourdillonii				
C	*Dipterocarpus caudatus*	F	*Dipterocarpus fusiformis*	*J*	*Dipterocarpus jourdainii*
	Dipterocarpus camphorus	G	*Dipterocarpus geniculatus*	*K*	*Dipterocarpus kerrii*
	Dipterocarpus camellatus		*Dipterocarpus gibbosus*		*Dipterocarpus kunstleri*
	Dipterocarpus cancanus		*Dipterocarpus glabrigemmatus*		*Dipterocarpus kutaianus*
	Dipterocarpus chartaceus		*Dipterocarpus glandulosus*	*L*	*Dipterocarpus lamellatus*
	Dipterocarpus cinereus		*Dipterocarpus globosus*		*Dipterocarpus lasiopodus*
	Dipterocarpus concavus		*Dipterocarpus gracilis*		*Dipterocarpus littoralis*
	Dipterocarpus condorensis		*Dipterocarpus grandiflorus*		*Dipterocarpus lowii*
	Dipterocarpus confertus				
	Dipterocarpus conformis				
	Dipterocarpus cordatus				
	Dipterocarpus coriaceus				
	Dipterocarpus cornutus				
	Dipterocarpus costulatus				
	Dipterocarpus cuspidatus				

Order	Species	Order	Species
M	*Dipterocarpus malaanonan*	R	*Dipterocarpus retusus*
	Dipterocarpus macrorrhinus		*Dipterocarpus rigidus*
	Dipterocarpus megacarpus		*Dipterocarpus rotundifolius*
	Dipterocarpus microcarpus		
	Dipterocarpus mundus		
N	*Dipterocarpus nobilis*	S	*Dipterocarpus sarawakensis*
	Dipterocarpus nudus		*Dipterocarpus scaber*
			Dipterocarpus semivestitus
			Dipterocarpus sublamellatus
O	*Dipterocarpus oblongifolius*	T	*Dipterocarpus teres*
	Dipterocarpus oblongus		*Dipterocarpus thorelii*
	Dipterocarpus obtusifolius		*Dipterocarpus thurifer*
	Dipterocarpus ochraceus		
	Dipterocarpus orbicularis		
P	*Dipterocarpus pachyphyllus*	V	Dipterocarpus verrucosus
	Dipterocarpus palembanicus	W	Dipterocarpus warburgii
	Dipterocarpus palosapis	Z	*Dipterocarpus zeylanicus*
	Dipterocarpus parviflorus		
	Dipterocarpus penangianus		
	Dipterocarpus pentagonus		
	Dipterocarpus perakensis		
	Dipterocarpus plagatus		
	Dipterocarpus polyspermus		
	Dipterocarpus prismaticus		
	Dipterocarpus pseudofagineus		

Table 2: Dipterocarpus Species, synonyms and distribution around the World

Species	Synonyms	Distribution	Reference
Dipterocarpus alatus	*Dipterocarpus philippinensis* *Dipterocarpus gonopterus* *Dipterocarpus incanus* *Dipterocarpus lemeslei* *Dipterocarpus unesbi*	It is a tropical forest tree, of dense evergreen or mixed dense forests, common in Thailand, Cambodia, Laos and Vietnam. This species have also been found in the Philippines	[3]
Dipterocarpus baudii	*Dipterocarpus duperreana* *Dipterocarpus scortechinii*	Cambodia; Indonesia (Sumatera); Malaysia; Myanmar; Thailand; Viet Nam	[4]
Dipterocarpus chartaceus	*Dipterocarpus skinneri*	Malaysia (Peninsular Malaysia); Thailand	[5]
Dipterocarpus dryobalanops	*Dipterocarpus teres* *Dryobalanops camphora* *Dryobalanops junghuhnii*	Indonesia (Sumatera); Malaysia (Peninsular Malaysia, Sabah, Sarawak)	[6, 56]

	Dryobalanops sumatrensis *Dryobalanops vriesii* *Pterigium teres* *Shorea camphorifera* *Dryobalanops aromatic*		
Dipterocarpus globosus	*Dipterocarpus beccarii* *Dipterocarpus beccarianus*	Brunei Darussalam; Indonesia (Kalimantan); Malaysia (Sarawak)	[7, 8]
Dipterocarpus gracilis	*Dipterocarpus andamanicus* *Dipterocarpus angustialatus* *Dipterocarpus bancanus* *Dipterocarpus fulvus* *Dipterocarpus hispidus* *Dipterocarpus pilosus* *Dipterocarpus schmidtii* *Dipterocarpus marginatus* *Dipterocarpus schmidtii* *Dipterocarpus skinneri* *Dipterocarpus turbinatus var. andamanicus King* *Dipterocarpus van-der-hoevenii* *Dipterocarpus velutinus* *Dipterocarpus vernicifluus*	Bangladesh; India (Andaman Is., Arunachal Pradesh, Assam, Tripura); Indonesia (Jawa, Kalimantan, Sumatera); Malaysia (Peninsular Malaysia); Myanmar; Philippines; Thailand	[9, 10]
Dipterocarpus retusus	*Dipterocarpus austroyunnanicus* *Dipterocarpus luchunensis* *Dipterocarpus macrocarpus* *Dipterocarpus mannii* *Dipterocarpus occidentoyunnanensis* *Dipterocarpus pubescens* *Dipterocarpus spanoghei* *Dipterocarpus tonkinensis* *Dipterocarpus trinervis*	China (Yunnan); India (Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland, Tripura, West Bengal); Indonesia (Jawa, Lesser Sunda Is., Sumatera); Malaysia (Peninsular Malaysia); Myanmar; Thailand; Viet Nam	[11, 12]
Dipterocarpus acutangulus	*Dipterocarpus helicopteryx Slooten* *Dipterocarpus tawaensis Slooten*	Malaysia: Sarawak, Borneo, Elphinstone Province, British North Borneo	[54, 55]
Dipterocarpus gibbosus	*Dipterocarpus humeratus* *Dipterocarpus ursinus*	-----	[57]
Dipterocarpus glandulosus	*Dipterocarpus scabridus*	Sri Lanka	[58, 59]
Dipterocarpus grandiflorus	*Dipterocarpus griffithii* *Dipterocarpus motleyanus* *Dipterocarpus pterygocalyx* *Mocanera grandiflora*	India (Andaman Is.); Indonesia (Sumatera); Malaysia (Peninsular Malaysia, Sabah); Myanmar; Philippines; Singapore; Thailand; Viet Nam	[60]
Dipterocarpus hasseltii	*Dipterocarpus balsamiferus* *Dipterocarpus lampongus* *Dipterocarpus pentagonus* *Dipterocarpus quinquegonus* *Dipterocarpus subalpinus* *Dipterocarpus tampurau*	Indonesia (Bali, Jawa, Kalimantan, Sumatera); Malaysia (Peninsular Malaysia, Sabah); Philippines; Thailand; Viet Nam	[61, 62]
Dipterocarpus insularis	*Dipterocarpus angustifolius* *Dipterocarpus artocarpifolius* *Dipterocarpus costatus* *Dipterocarpus parvifolius*	Bangladesh; Cambodia; India (Andaman Is.); Lao People's Democratic Republic; Malaysia (Peninsular Malaysia); Myanmar; Thailand; Viet Nam	[63]
Dipterocarpus jourdainii	*Dipterocarpus laevis* *Dipterocarpus turbinatus C. F. Gaertn*	Bangladesh; Cambodia; India (Andaman Is., Arunachal Pradesh, Assam, Manipur, Meghalaya, Tripura); Lao People's Democratic Republic; Myanmar; Thailand; Viet Nam	[64]
Dipterocarpus oblongifolius	*Dipterocarpus pulcherrimus* *Dipterocarpus stenopterus*	Malaysia; Thailand	[65, 66]
Dipterocarpus obtusifolius	*Dipterocarpus obtusifolius Teijsm. ex Miq. subspecies cuspidatus C. E. C. Fisch.* *Dipterocarpus obtusifolius Teijsm. ex Miq. subspecies glabricalyx Smitinand* *Dipterocarpus obtusifolius Teijsm. ex Miq. subspecies subnudus Ryan & Kerr* *Dipterocarpus obtusifolius Teijsm. ex Miq. subspecies vestitus (Wall. ex Dyer) Smitinand* *Dipterocarpus punctulatus Pierre* *Dipterocarpus vestitus Wall. ex Dyer*	Brunei Darussalam; Cambodia; Lao People's Democratic Republic; Malaysia; Myanmar; Thailand; Viet Nam	[67]
Dipterocarpus tuberculatus	*Dipterocarpus cordatus* *Dipterocarpus grandifolius*	Cambodia; India; Lao People's Democratic Republic; Myanmar; Thailand; Viet Nam	[68]

Dipterocarpus dryobalanops is the most important species containing Bergenin (13), malaysianol A (14), laevifonol (15), ampelopsin E (16), α-viniferin (11), ε-viniferin(17), diptoindonesin A (18), diptoindonesin B (19), vaticanol B (20) vaticanol C (21), flexuasol A (22), Oleanolic acid acetate (23), Hedragonic acid (24), dryobalanonoloic acid (25), dryobalanolide (26), Dryobalanone (27),

dammarenediol-II (28), Erythrodiol (29), dipterocarpol (30), ocotillol-II. *Dipterocarpus elongates* comprise of Laevifonol (15), α-viniferin (11), vatikanol A (31), bergenin (13), dan 4'-O-metilgalokatecin (32). Dipterocarpus grandiflorus include Grandiphenols A (33), B, C (34) and D (35).

Dipterocarpus hasseltii encompass Diptoindonesin E, ε-viniferin (17), laevifonol (15), α-viniferin (11), vaticanol B (20), hopeaphenol (36), coumarin (37), scopoletin

Dipterocarpus pilosus as *Dipterocarpus dryobalanops* is another important species that possess Caryophyllene (1), humulene (2), caryophyllene oxide, humulene epoxide-II (3) clovane-diol (4), humulene epoxide-III (5), caryophyllenol-I (6), caryophyllenol-II (7), Dipterocarpol (30), dammara-20,24-dien-3-one, dammara-24-ene-3,20-diol, ocotillone-II, ocotillol-II hollongdione, dipterocarpolic acid, asiatic acid (40), 2α-hydroxyursolic acid (44) All the chemical constituents and their chemical nature present in the genus is enlist in table 4 and 5.

Table 3: Dipterocarpus species with their common names, part use and their traditional uses

Species	Common names	Part use	Traditional uses	Reference
Dipterocarpus alatus	Gurjun(Eng.); keruing, kruen (Fr.); gurjin (Ind.); mai yang(Laos); yang-na (Thai.); dau nooc (Viet.); yang, keruing (trade names).	Bark	Used in Rheumatism, diseases of the liver, and to stimulate appetite in cattle	[3, 13]
Dipterocarpus dryobalanops	Borneo Camphor, Camphor Tree, Malay Camphor, or Sumatran Camphor	Bark	It is used in medicine in preparation of tooth pase, powder, diaphoretic and antiseptic, hysteria, dysmenorrhoea	[15, 16, 17, 18]
Dispterocarpus costatus	Chhë tiël niëng, chhë tiël bangkuëy, niëng daèng krâhâm (Cambodia,Thailand, Vietnam)	Bark	It is used in the treatment of ulcer	[19, 20]
Dipterocarpus gracilis	keriung-kesat (Malay)	-	It is used as antiseptic for gonorrhoea and urinary disease	[20, 21]
Dipterocarpus Indicus	Arayangili, Vavangu, Kakka, Vella-ayani, Karanjili, Kalpayin (Malayalam)	-	It exists in west coast, tropical and evergreen forest India used as an application of rheumatism	[20, 69]
Dipterocarpus turbinatus	Chhë tië: l dâ: ng(Cambodia,Thi, Veitnam; gurjan (India), gurjun, gurgina; Chinese jie bu luo xiang Garjan (Bangali)	Leave and stem	Gonorrhoea, gleets, rheumatism,ulcer, ringworm and skin diseases. Ethnomedicinally toxic plant	[22, 23, 24, 25, 26, 70, 71]
Dipterocarpus tuberculatus	Gurjun tree (Eng)	-	Traditionally used to treat various inflammatory symptoms	[72, 73]

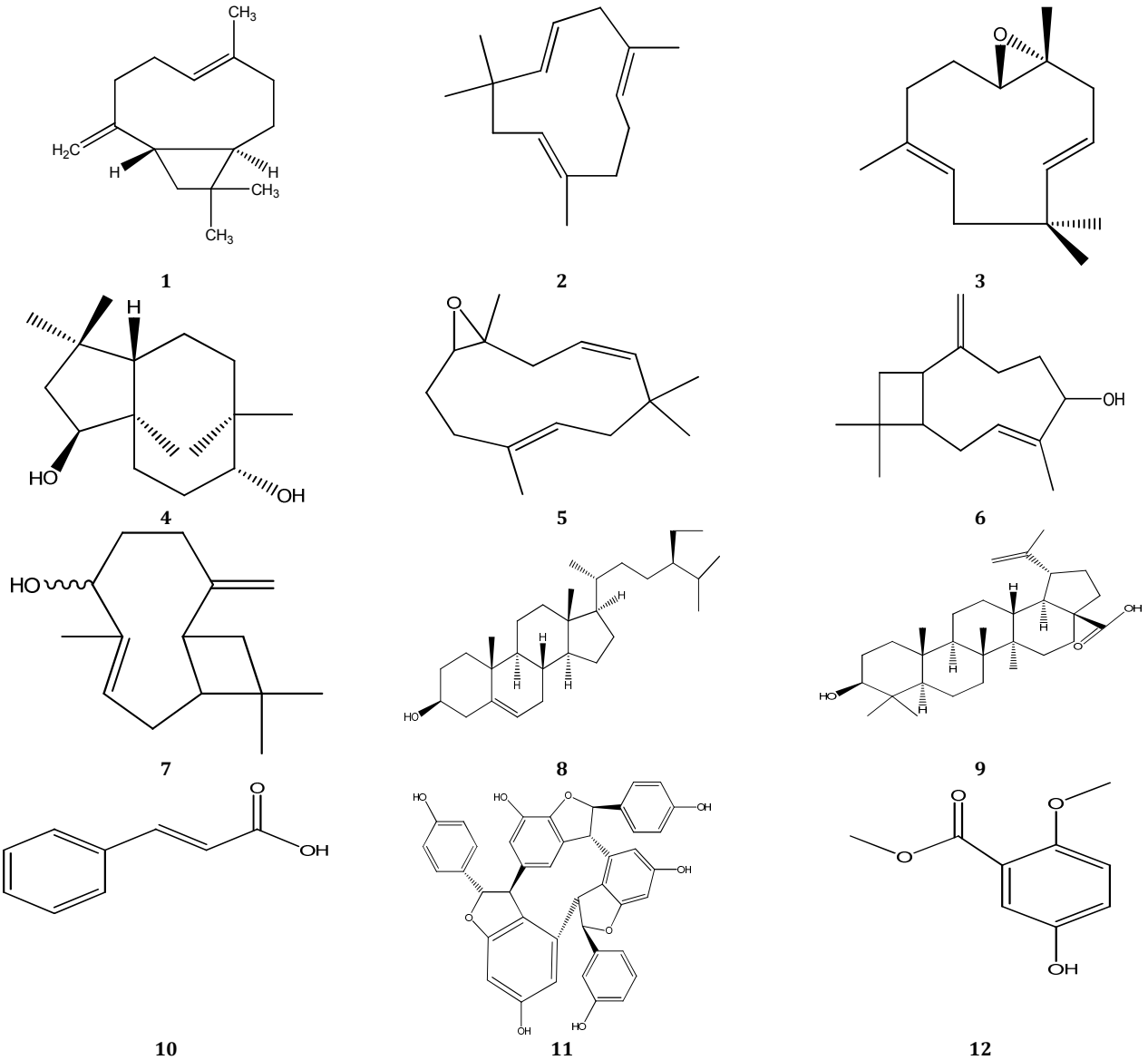
Table 4: List of Chemical constituents in genus Dipterocarpus

Species	Part Use	Chemical constituents	Reference
Dipterocarpus alatus	Bark	Oleoresin	[27]
Dipterocarpus confertus	Stem Bark	β-sitosterol (8), betulinic acid (9), cinnamic acid (10),α-viniferin (11), betulinat acid, 5-hydroxy-2-Methoxy benzoate (12)	[28, 29]
Dipterocarpus dryobalanops	Stem Bark	Bergenin (13), malaysianol A (14), laevifonol (15), ampelopsin E (16), α-viniferin (11), ε-viniferin(17), diptoindonesin A (18), diptoindonesin B(19), vaticanol B (20) vaticanol C (21), flexuasol A (22), Oleanolic acid acetate (23), Hedragonic acid (24), dryobalanonoloic acid (25), dryobalanolide (26), Dryobalanone (27), dammarenediol-II (28), Erythrodiol (29), dipterocarpol (30), ocotillol-II	[1, 13] [30] [31] [32] [95]
Dipterocarpus elongatus	-	Laevifonol (15), α-viniferin (11), vatikanol A (31), bergenin (13), dan 4'-O-metilgalokatecin (32)	[33]
Dipterocarpus grandiflorus	-	Grandiphenols A (33), B, C (34) and D (35)	[34, 35]
Dipterocarpus zeylanicus	-	2α,3β,23α-trihydroxyurs-12-en-28-oic and 2α,3β-dihydroxyurs-12-en-28-oic acids	[34]
Dipterocarpus hasseltii	Tree Bark	Diptoindonesin E, ε-viniferin (17), laevifonol (15), α-viniferin (11), vaticanol B (20), hopeaphenol (36), coumarin (37), scopoletin (38).	[36]
Dipterocarpus verrocosus		α-Viniferin (11)	[37]
Dipterocarpus tuberculatus	*Stem Bark*	Phenolic acid derivatives, β-sitosterol (8), bergenin (13)	[38]
Dipterocarpus hispidus	*Bark Timber*	Betulinic acid (9), dipterocarpol (30), dammarenediol, ocotillone (39) Dipterocarpol (30) asiatic acid (40)	[39, 20]
Dipterocarpus turbinatus	-	Borneol (41)	[40]
Dipterocarpus kerrii	-	α-gurjunene (42), gamma-gurjunene (43), gamma-gurjunenol	[41, 42]
Dipterocarpus retusus	*Tree Bark*	ε-viniferin (17), α-viniferin (11), vaticanol A (31), scopoletin (38), bergenin (13)	[43]
Dipterocarpus pilosus	*Bark*	Caryophyllene (1), humulene (2), caryophyllene oxide, humulene epoxide-II (3) clovane-diol (4), humulene epoxide-III (5), caryophyllenol-I (6), caryophyllenol-II (7), Dipterocarpol (30), dammara-20,24-dien-3-one, dammara-24-ene-3,20-diol, ocotillone-II, ocotillol-II hollongdione, dipterocarpolic acid, asiatic acid (40), 2α-hydroxyursolic acid (44)	[44, 45]
Dipterocarpus	*Stem*	3-oxo-20-hydroxy-30α-methyl,17(29)α-epoxy-28-norlupane, 3-oxo-20-hydroxy-30β-methyl-17(29)α-	[46]

obtusifolius		epoxy-28-norlupane, 3,20-dioxo-28,29-norlupan-17α-ol, 27-demethyl-20(S)-dammar-23-ene-20-ol-3,25-dione, and 3-epi-cecropic acid.	
Dipterocarpus verrucosus	Stem Bark	Laevifonol (15), α-viniferin (11), vaticanol B (20)	[53, 54]

Table 5: List of Chemical nature of Compounds isolated in genus Dipterocarpus

Chemical Nature	Compounds present
Sesquiterpenes	Caryophyllene (1), humulene (2), caryophyllene oxide, humulene epoxide-II (3) clovane-diol (4), humulene epoxide-III (5), caryophyllenol-I (6), caryophyllenol-II (7),α-gurjunene, gamma-gurjunene, gamma-gurjunenol
Triterpene	Betulinic acid (9), Oleanolic acid acetate (23), Hedragonic acid (24), Oleanolic acid acetate (23), Hedragonic acid (24), dryobalanonoloic acid (25), dryobalanolide (26), Dryobalanone (27), dammarenediol-II (28), Erythrodiol (29), dipterocarpol (30), ocotillol-II, Asiatic acid (40), 2α-hydroxyursolic acid (44).
Oligostilbenoid	Laevifonol (15), ampelopsin E (16), α-viniferin (11), diptoindonesin A (18), ε-viniferin (17), α-viniferin (11), vaticanol A
Coumarin compounds	Scopoletin (38), bergenin (13)
Resveratrol Compounds	Bergenin (13), malaysianol A (14), laevifonol (15), ampelopsin E (16), α-viniferin (11), ε-viniferin(17), diptoindonesin A (18), diptoindonesin B(19), vaticanol B (20) vaticanol C (21), flexuasol A (22), (−)-hopeaphenol, grandiphenols A, B, C and D, ampelopsin E(16), diptoindonesin A, bergenin
Phytosterol	β-sitosterol (8)

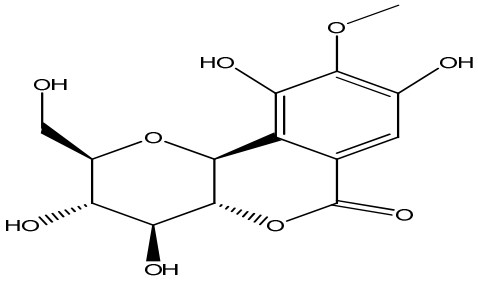


1 **2** **3**

4 **5** **6**

7 **8** **9**

10 **11** **12**



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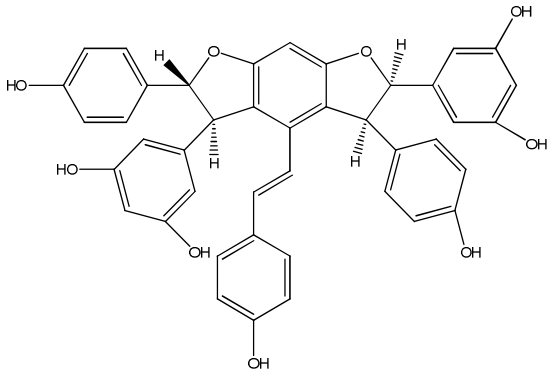

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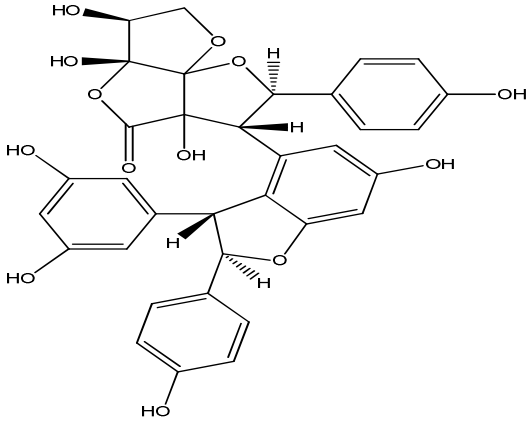

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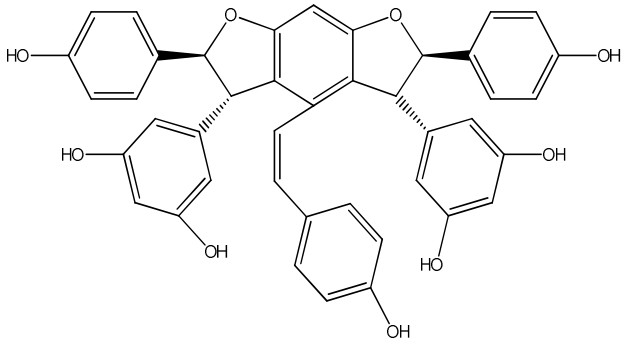

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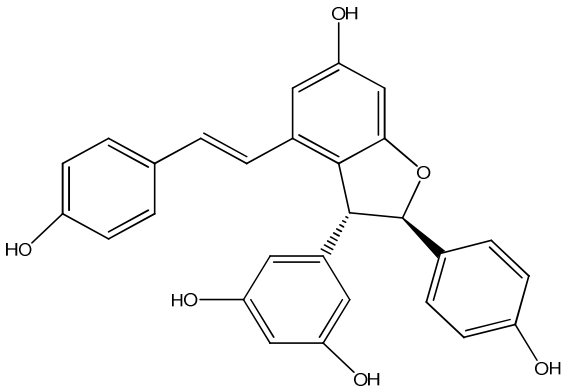

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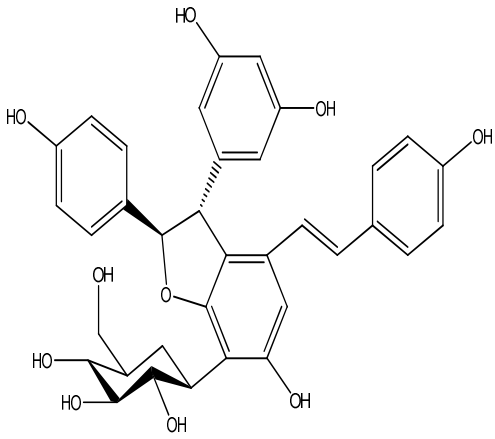

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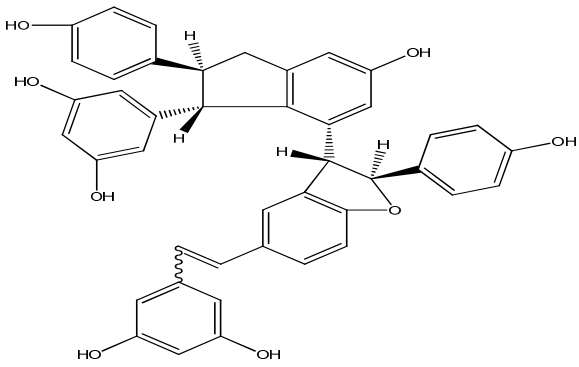

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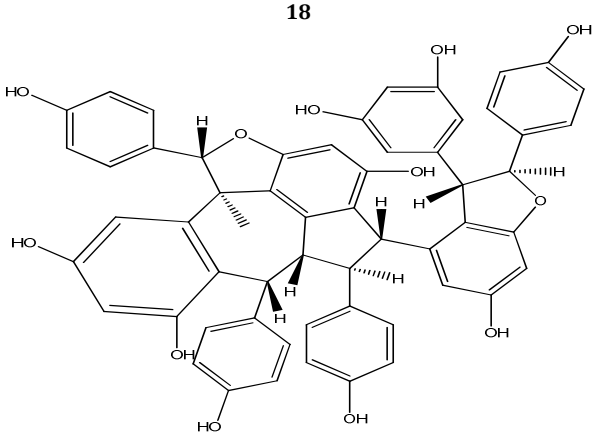

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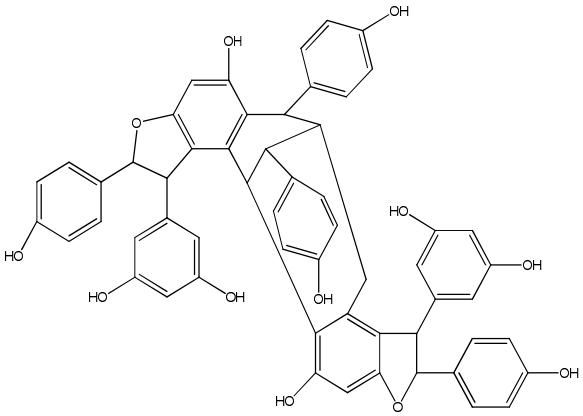

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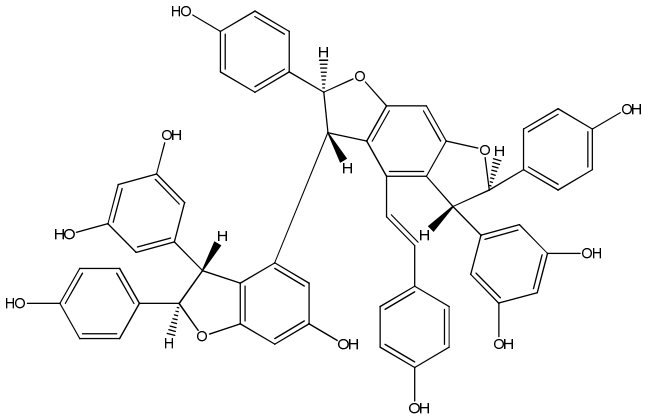

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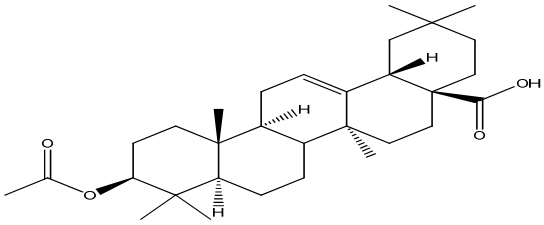

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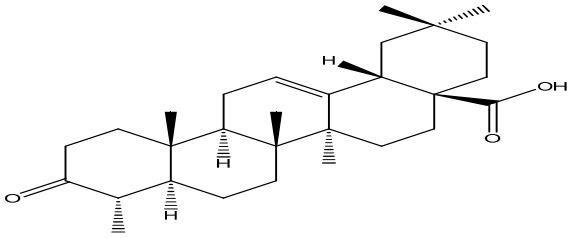

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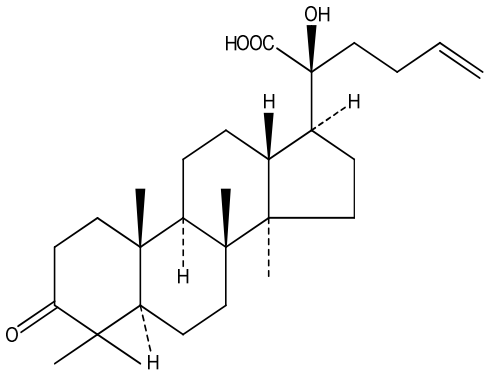

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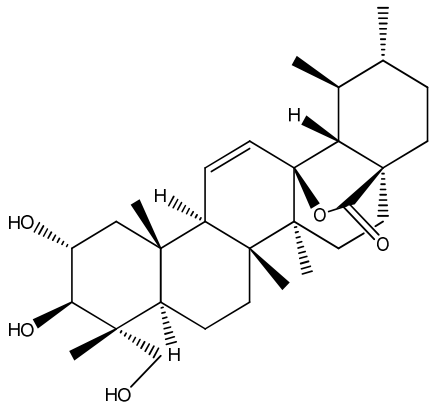

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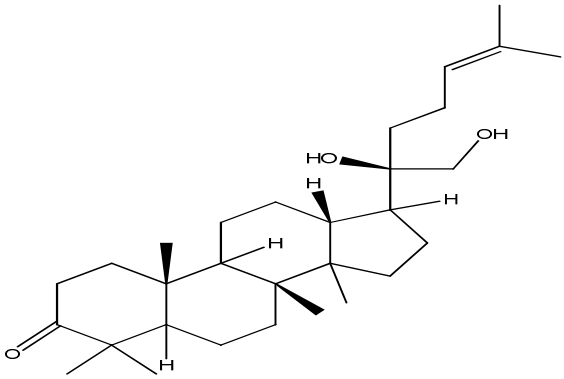

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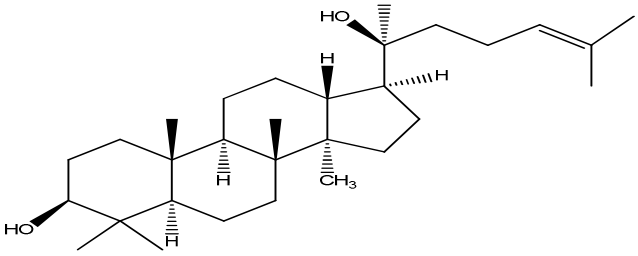

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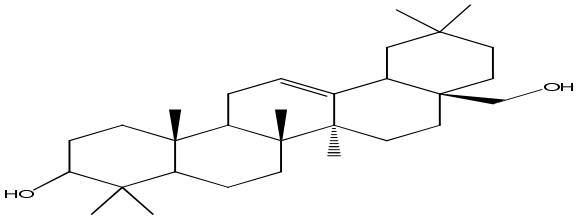

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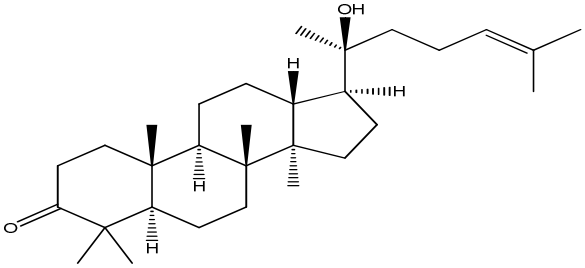

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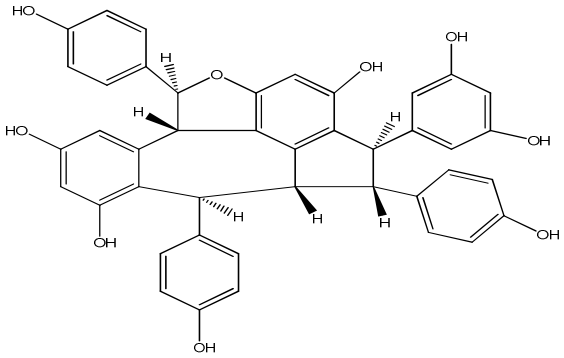

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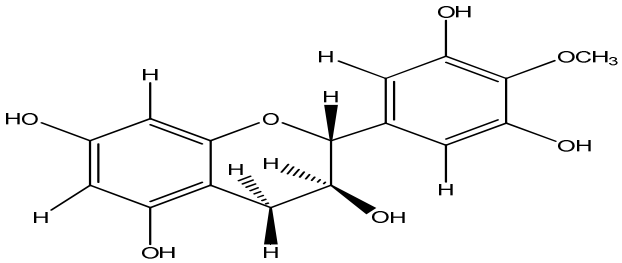

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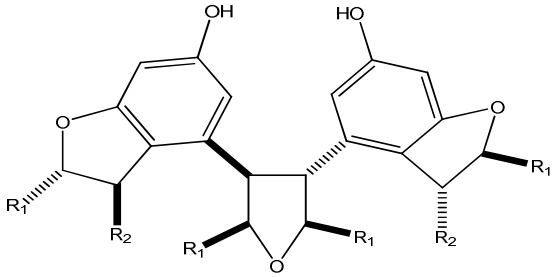

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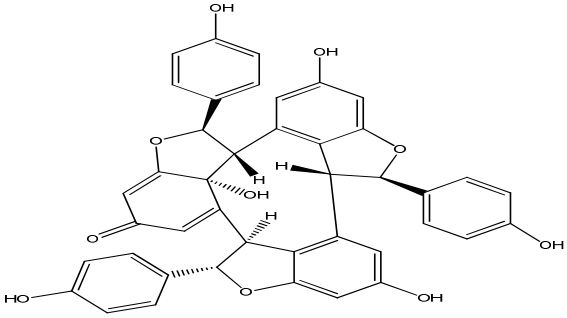

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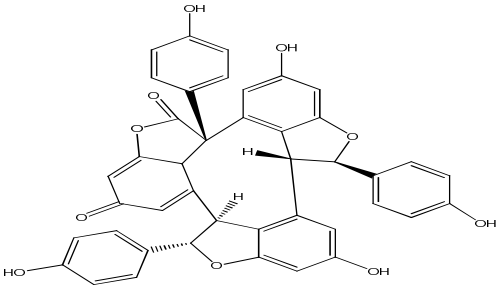

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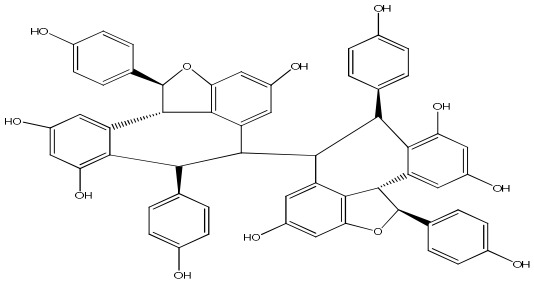

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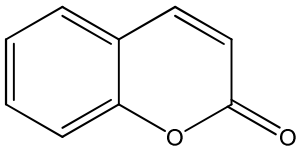

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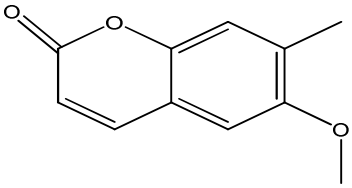

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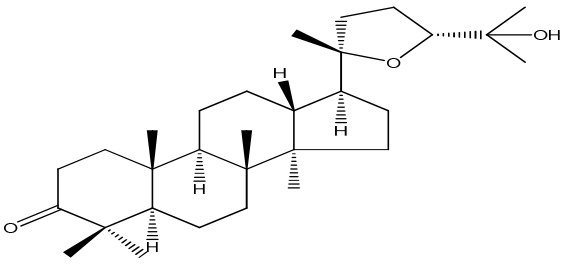

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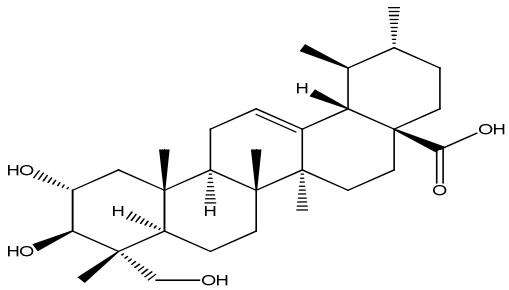

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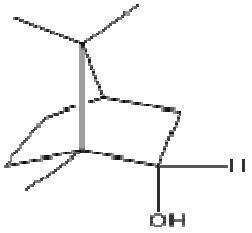

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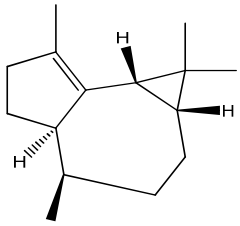

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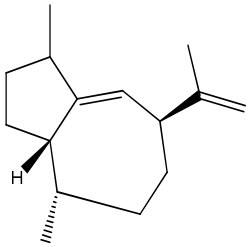

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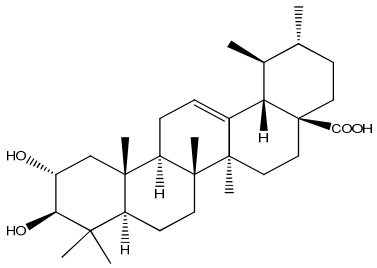

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Fig. **1: List of Chemical constituents isolated from genus Dipterocarpus**

Pharmacological activities

Most of the species in this genus are cytotoxic in nature but some are anti-inflammatory, Anti-fungal, anti-bacterial, anti-oxidant and even Anti-Aids. The most important species in this genus are *Dipterocarpus obtusifolius Teijsm ex Miq* because scientists report that it may have cured against AIDS. A composition comprising *Melastoma villosum Lodd., Dipterocarpus obtusifolius Teijsm ex Miq., Lyophyllum aggregatum, Dictyophora indusiata*, pu-erh tea, mentha and stevia, in a dry weight ratio of 2-5: 2-5: 1-4: 1-4: 1-4: 0.5-2: 0.5-2, respectively is the constituents used in the formulation. The inventive anti-AIDS agent was provided for 24 AIDS cases to be taken twice a day, said agent having been extracted in hot water of 90-100° C for 40 minutes. Periodical blood drawings were carried out during the intake period to measure the concentration level of HIV antigen RNA. *Dipterocarpus turbinatus, Dipterocarpus hasseltii, Dipterocarpus retusus, Dipterocarpus obtusifolius and Dipterocarpus converts* are cytotoxic and may have used against cancer cell. Detail enlists in table 6.

Table 6: List of Pharmacological activities reported

Species	Pharmacological properties	Application	Activity	Part used	Reference
Dipterocarpus tuberculatus	Anti-Inflammatory	In-vitro and In-Vitro	Ethanol extract strongly suppresses in vitro macrophage-mediated inflammatory responses and in-vivo acute gastritis	Bark	[31]
Dipterocarpus verrucosus	Antibacterial and antioxidant	In-Vitro	The result indicated that α-viniferin, resveratrol trimer from *Dipterocarpus verrucosus* gave moderate activity towards antibacterial and antioxidant values.	Bark	[37]
Dipterocarpus confertus	Cytotoxicity	Murin Cell P388 leukemia	Isolated compound of *Dipterocarpus confertus* (sinamat and acid betulinat) showed very active with IC50 each the size of 2.25 and 5.1 pg / mL.	Stem Bark	[42]
Dipterocarpus retusus	Cytotoxic activity	Murine leukaemia P-388 cells	ε-Viniferin, α-viniferin and vaticanol A showed cytotoxic activity against murine leukaemia P-388 cells with their IC50 values were 7,8; 17,5 and 27,0 µg/ml, respectively.	Bark	[43]
Dipterocarpus obtusifolius	Cytotoxic	Human cancer cell lines	It were found to be cytotoxic against human cancer cell lines.	Stems	[46]
Dipterocarpus verrucosus	Biological Activities	In-Vitro	Biological activities of the compounds were evaluated against six strains of bacteria; Pseudomonas aeruginosa, Klebsiella pneunomonia, Salmonella paratyphi, Bacillus subtilis, Stapylococcus aureus and E. coli by disc diffusion method while antioxidant were evaluated by DPPH, TPC, FTC and TBA. The DPPH radical scavenger test showed that tetramer gave a better result (36.6%) as compared to the dimmer and trimmer. TPC evaluations showed that the tetramer and dimer contain the same amount of phenolics which is 616.15mg/g of GAEs while trimer displayed lower amount of 340mg/g of GAEs. FTC and TBA methode revealed that the trimer showed better inhibition among the others with the value of 77.77 and 86.47% each. Antibacterial activity, trimer resveratrol with concentration of 50mg/ml showed to be the most active with inhibition toward Stapylococcus aureus (8.8 mm), Pseudomonas aeruginosa (8.5 mm) and E. coli (17 mm).	Stem bark	[47, 48, 49, 50, 51, 52]
Dipterocarpus kerrii	Anti-fungal	In-vitro	Fungicidal	Tree Resin	[72]
Dipterocarpus turbinatus	Cytotoxic Activity	Human Breast cancer cell line (MDA-MB-231)	It has shown activity against Human Breast cancer cell line (MDA-MB-231)	Bark and leave	[74]
Dipterocarpus hasseltii	Cytotoxic Activity	Murine leukemia P-388 cells.	A Chemical constituent hopeaphenol shows strongly inhibited murine leukemia P-388 cells.	Bark	[75]
Dipterocarpus obtusifolius Teijsm ex Miq	Anti-AIDS	Clinical trial for measuring the anti-AIDS effect	A composition comprising *Melastoma villosum Lodd., Dipterocarpus obtusifolius Teijsm ex Miq., Lyophyllum aggregatum, Dictyophora indusiata*, pu-erh tea, mentha and stevia, in a dry weight ratio of 2-5: 2-5: 1-4: 1-4: 1-4: 0.5-2: 0.5-2, respectively. The inventive anti-AIDS agent was provided for 24 AIDS cases to be taken twice a day, said agent having been extracted in hot water of 90-100° C for 40 minutes. Periodical blood drawings were carried out during the intake period to measure the concentration level of HIV antigen RNA	Fruit	[76]

Table 7: List of chemical constituents with Pharmacological properties

Chemical Constituents	Pharmacological properties	Reference
Betulinic acid	Antiretroviral, antimalarial, anti-inflammatory, Anticancer agent	[77]
beta-caryophyllene	Beta-caryophyllene was shown to be a selective agonist of cannabinoid receptor type-2 (CB2) and to exert significant cannabimimetic antiinflammatory effects in mice.	[78]
humulene	Anti-inflammatory effects in mammals. It produces similar effects to dexamethasone, and was found to decrease the edema formation caused by histamine injections. Humulene produced inhibitory effects on tumor necrosis factor-α (TNFα) and interleukin-1 β (IL1B) generation in carrageenan-injected rats.	[79, 80]
β-Caryophyllenol	β-Caryophyllenol has showed Inhibitory Effect of on Airway Inflammation and Elimination of Asthmatic Models in Guinea Pigs	[81]
α-viniferin	It has been shown to inhibit acetylcholinesterase	[82]
Bergenin	It shows a potent immunomodulatory effect	[83]
laevifonol	Anti-oxidant, Cytotoxic and Anti-bacterial actvity	[84]
ampelopsin	The compound is credited with hepatoprotective effects observed in rodents	[85]
ε-Viniferin	It shows a human cytochrome P450 enzymes inhition activity	[86]
Oleanolic acid acetate	Hepatoprotective, and exhibits antitumor and antiviral properties	[87]
dammarenediol-II	Antiviral activity against Herpes simplex virus types I and II in Vitro	[88]
Erythrodiol	Antiproliferative and apoptotic activity in HT-29 human adenocarcinoma cells	[89]
Coumarin	Reported coumarin activity includes anti-HIV, anti-tumor, anti-hypertension, anti-arrhythmia, anti-inflammatory, anti-osteoporosis, antiseptic, and analgesic. It is also used in the treatment of asthmaand lymphedema	[90, 91, 92, 93]
Scopoletin	Use of scopoletin to inhibit the production of inflammatory cytokines through inhibition of the IκB/NF-κB signal cascade in the human mast cell line HMC-1	[94]

CONCLUSION AND DISCUSSION

Dipterocarpus belong to southeast Asia mainly Malaysia, Indonesia, Thialand, Philippines. Although it is well-known for timber purposes, but it has some medicinal importance. It comprises resins, dammar and camphor. In the past Dipterocarpus was the main source of camphor, but now there are many alternative sources such as *Cinnamomum camphora* and pinene. Dipterocarpus consist of important chemical constituents such as Resveratrol, which appeared to prevent the development of mammary tumors in animal models; however, it had no effect on the growth of existing tumors. It slowed the growth of neuroblastomas [94]. Coumarin also comprise pharmacological activity such as anti-HIV, anti-tumor, anti-hypertension, anti-arrhythmia, anti-inflammatory, anti-osteoporosis, antiseptic, and analgesic. It is also used in the treatment of asthma and lymphedema[86, 87, 88, 89]. A clinical trial has shown that Dipterocarpus obtusifolius possess Anti-HIV property which can further be evaluated in isolation of novel compound. As most of the species in this genus are cytotoxic in nature so we can isolate new drugs against different types of cancer. For example Isolated compounds from the Bark of Dipterocarpus retusus (ε-Viniferin, α-viniferin and vaticanol) showed cytotoxic activity against murine leukaemia P-388 cells [41]. Similarly isolated compounds of Dipterocarpus confertus (sinamat and acid betulinat) showed cytotoxicity from the stem bark [42]. All documented data from the genus Dipterocarpus conclude that there are 75 species in this genus and we haven't explored the flora yet. With increased deforestation, we are losing Dipterocarps as it is a major source of timber in South east Asia. Most of the species are in critical danger of extinction.

We can isolate novel compounds against anticancer, Anti-Aids, Anti-inflammatory from remaining species and existing species. This will lead to develop large series of structural analogs of an initial lead compound and tested as part of a structure-activity relationship study. It will preserve for the future generation.

CONFLICT OF INTERESTS

None

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