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A Review of Botanical Characteristics, Chemical Composition, Pharmacological Activity and Use of *Scorodocarpus borneensis*

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Abstract: *Scorodocarpus borneensis*, an indigenous tree from Kalimantan, was used traditionally. This forest plant is from the genus Olacaceae with a unique characteristic of their bark that smells like onions. The scientific information about the potential activity of this plant was very limited. In this study, the chemical compounds and potential activities of *S. borneensis* were reviewed in this article. The information was collected from several databases, such as Google Scholar, PubMed, Science Direct, DOAJ, and Elsevier. Chemical compounds of *S. borneensis* were dominated by the volatile compound. That species has several activities, such as antioxidant, antibacterial

Keywords: *Scorodocarpus borneensis*; chemical content; bioactivities

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1. Introduction

Scorodocarpus borneensis is one of the species from the Oleaceae family. Some people call it Kulim or garlic tree because it has a strong smell of garlic. *S. borneensis* grows in the tropical rainforest area, and the distribution is found at Kalimantan and Sumatra islands [1, 2]. A villager widely utilizes Kulim in forest areas in East Kalimantan as spices and traditional medicine [3]. In this time, the study of biochemistry compounds was tried extensively for an alternative to provided health problems.

The information about this endemic species from East Kalimantan is still limited. The aim of this review is to provide up-to-date information about the potential use of forest plant extracts *Scorodocarpus borneensis* as medicine.

2. Materials and Methods

This review was collected from a journal database with specific keywords to cite. Google Scholar, Science Direct, PubMed, DOAJ, Scopus, and Elsevier was a database that we used. The keywords for this review are Kulim, *Scorodocarpus borneensis*, phytochemical, compound, bioactivity, and pharmacological activity. The range of source articles was from 2010 to 2021, with some important additional information before 2010 was also collected. The local information about this subject was also considered to be added in this review.

3. Results and Discussion

3.1. Plant characterization.

Kulim tree (*Scorodocarpus borneensis*) is a kind of woody tree, the only member of the *Scorodocarpus* genus, Olacaceae tribe. It is also known as the garlic tree or the forest onion due to its strong onion or garlic-like odor that is emitted by its leaves and stem. The plant is a large tree, 10-40 m high, the trunk diameter can reach 20-80 cm. Parts of the tree give off an onion-like odor, especially after it rains or is injured. The leaves are single, arranged in a spiral, flat-edged, without a supporting leaf. The blades are generally oblong, 7-15 cm long, tapering to a pointed tip 1-2 cm long, at the base rounded like a wedge, glossy green on top and pale on the underside with 4-5 pairs of secondary veins; Petiole 1-1.5 cm long, bulging on the distal side. The inflorescence is in the form of short bunches in the axils of the leaves, with short reddish to gray hair; bunch shaft 2 cm long; Flowers attached alone or in clusters of 2-3 buds, stems 1.5-2 mm. Small petals form a bowl with wavy or scalloped edges; corolla oval and narrow, 8-10 mm long, curved back outwards, yellowish, pink, or creamy white; yellow stamens, 3-4 mm. The stone fruit is green, almost round or slightly pear-like, 4-5 cm long, glabrous, with faint vertical lines like ribs, thin flesh, one seed [4]

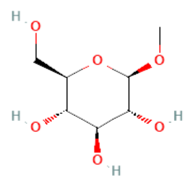
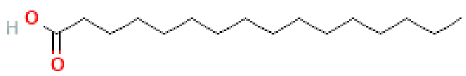
3.2. Traditional use of Kulim.

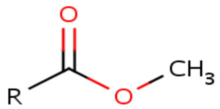
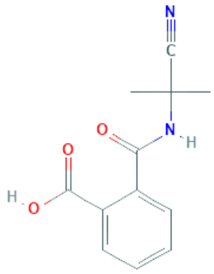
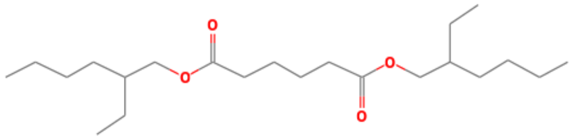
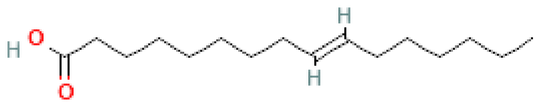
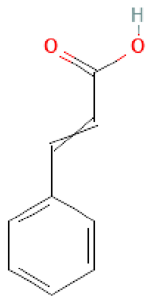
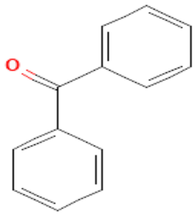
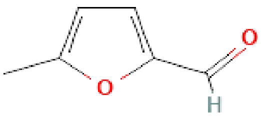
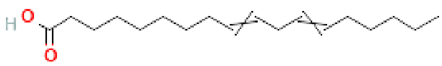
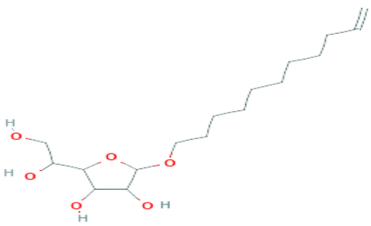
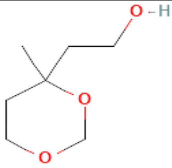
Scorodocarpus borneensis traditionally used by forest villagers as spices and medicinal plants [5–7].

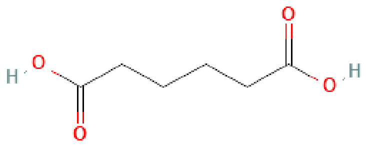
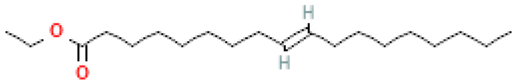
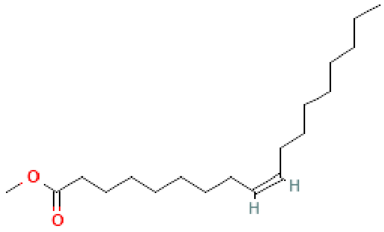
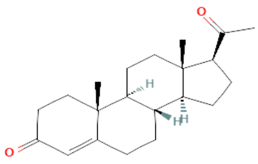
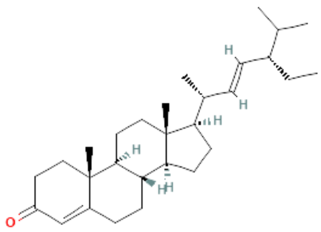
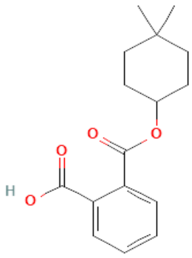
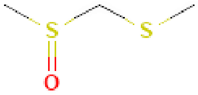
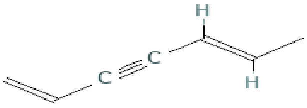
3.3. Chemical constituent of Kulim.

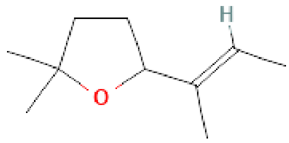
Kulim (*Scorodocarpus borneensis*) contains several secondary metabolites used for medicinal purposes. Multiple studies had determined the active compound from leaves, stem bark, and fruit of the Kulim tree. Due to its strong garlic-like odor, the Kulim tree contains a sulfur compound, especially from the leaves, important for its antimicrobial activity [8, 9]. Various alkaloids are also found, for instance, three tryptamine type alkaloids, scorodocarpine A, scorodocarpine B, and scorodocarpine C, and a sesquiterpene, scodopin, that isolated from the leaves [10]. Fourteen compounds have been elucidated from ethyl acetate extract of the stem bark as well as six compounds from the essential oil of the Kulim tree [10, 11]. Moreover, phenolic compounds, flavonoid, tannin are present in leaves, stem bark, and fruits and are associated with their antioxidant properties. The summary of phytochemical contents of the Kulim tree is provided in Table 1.

Table 1. The chemical compound of *Scorodocarpus boorneensis*

Part	Source	Compound name	Chemical structure	References
Stem bark	Ethyl acetate extract	beta-methyl glucoside		[12]
		hexadecanoic		

Part	Source	Compound name	Chemical structure	References
Stem bark	Ethyl acetate extract	methyl ester		[12]
		benzene dicarboxylic acid		
		bis(2-ethyl(hexyl) ester		
		9-hexadecenoic acid		
		3-phenyl-2 propanoic acid		
		benzophenone		
		5-oxymethyl furfurol		
		9,12-octadecadienoic acid		
		beta-D-mannofuranoside		
		methyl-m- dioxane		

Part	Source	Compound name	Chemical structure	References
Stem bark	Ethyl acetate extract	hexanedioic acid		[12]
Stem bark	n-hexane	9- octadecenoic acid (ethyl oleate)		[12]
		methyl 9 octadecenate (methyl oleate)		
		octadecanoic acid		
		progesterone		
		stigmasta-4 ,22-dien-3-one		
		1.2 benzene dicarboxylic acid		
Leaves	volatile oil	methyl (methylsulfinyl)methyl sulfide		[8]
		2,4,6-trithiaheptane		
		1,5-heptadien-3-yne		
		trisulfide, dimethyl		

Part	Source	Compound name	Chemical structure	References
Leaves	volatile oil	furan, tetrahydro-2,2-dimethyl-5-(1-methyl-1- propenyl)		[8]
		methane, (methylsulfinyl) (methylthio)		

3.4. Bioactivities of Kulim from Indonesia.

3.4.1. Antimicrobial activity.

One of the widest bioactivity studies on the Kulim tree (*Scorodocarpus borneensis* Becc.) is its antimicrobial activity. Almost all Kulim tree parts have been extracted, isolated, and evaluated their activity against various microbial organisms. The methanolic extract of Kulim tree leaves exhibits strong inhibition towards gram-positive bacteria, *Staphylocossus aureus*; gram-negative bacteria, *Salmonella thypii*; as well as unicellular fungi, *Candida albicans* [13]. The active compounds that are responsible for antimicrobial activity are sulfur-containing compounds, namely bis (methylthiomethyl) disulfide ($CH_3SCH_2SSCH_2SCH_3$) and methyl thiomethyl (methylsulphonyl) methyldisulphide that is found in the seed and fruit of this plant [9]. Another part of the Kulim tree that has been shown to have antimicrobial activity is the stem bark. Ethyl acetate extract of stem barks exhibits good inhibition against *S. aureus* and *E.coli*. Fourteen compounds have been identified from the ethyl acetate extract of Kulim tree stem bark, but it needs further studies to determine which compound has the most antimicrobial activity [10].

Table 2. Antimicrobial activity of *Scorodocarpus boorneensis.*

Part of plants	Origin	Extract	Compound	Inhibition	References
Leaves	Sanggau District, West Kalimantan Province	methanol	phenol	50% w/v (286.40 ± 19 mm)	[13]
	Botanical Garden of Mulawarman University, East Kalimantan Province	essential oil	trisulfide, dimethyl, methyl (methylsulfinyl) methyl sulfide, 2,4,6-trithiaheptane-2,2-dioxide, and methane, (methylsulfinyl) (methylthio)	*S. Typhii* (15,3±1,41 mm); *C. Albicans* (52,7±0,49 mm)	[11]
				S. aureus (52,89±0,51 mm); *C. albicans* (52,67±0,47 mm); *S. mutans* (53,67±0,94 mm); *S. sobrinus* (51,57±0,94 mm).	[14]
Bark	Botanical Garden of Mulawarman University, East Kalimantan Province	ethyl acetate	alkaloid, phenol, triterpenoid	*S.aureus* (6,687 mm±0,800 mm); *E.coli* (7,500 mm±0,735 mm)	[10]
Fruits	Sabah, Malaysia	ethanol	bis(methylthiomethyl) disulfide	12.5-25 mcg/ml	[9]

Moreover, six compounds have been elucidated in the essential oil extracted from Kulim tree leaves and display good inhibition against *C. albicans*, *S. aureus*, *S. mutans*, and *S. sobrinus* [11, 14]. The antimicrobial activity of the Kulim tree is summarized in Table 2.

3.4.2. Antioxidant activity.

Antioxidants are compounds that can prevent or inhibit the oxidation process caused by free radicals so as to minimize damage to the body. Antioxidants play an important role in food, which is used to maintain product quality, prevent physical damage, as well as prevent the growth of destructive microbes in food. Multiple reports have shown that the Kulim tree has antioxidant properties. The typical antioxidant activity evaluation is a radical scavenging assay using DPPH (*2,2-diphenyl-1-picrylhydrazyl*). The antioxidant activity of the Kulim tree is mostly attributed to its phenolic compounds that are found in almost all parts of the plants. Various extracts of leaves, stem bark, and fruits of the Kulim tree have phenolic compounds and showed antioxidant activity [15]. The phytochemical study and antioxidant activity of the Kulim tree are summarized in Table 3.

Table 3. Antioxidant activity of *Scorodocarpus borneensis.*

Part of plants	Extract	Compound	Inhibition (IC_{50})	References
Leaves	methanol	phenolic	36,88 ppm	[13]
	n-hexane	alkaloid, flavonoid, tannin, steroid, carbohydrate		[16]
	etyhl acetate	alkaloid, flavonoid, steroid, carbohydrate		
	methanol	alkaloid, flavonoid, tannin, saponin, tannin, steroid, carbohydrate		
Bark	methanol	phenolic	52,45ppm	[15]
	n-hexane	phenolic, tannin	613,15ppm	
	etyhl acetate	alkaloid, phenolic, flavonoid, tannin	57,88ppm	
	ethanol	alkaloid, phenolic, flavonoid, tannin	569,59ppm	
	methanol	alkaloid, phenolic, flavonoid, tannin	821,34ppm	
	methanol 70%	alkaloid, phenolic, flavonoid, tannin	1288,19ppm	
	n-butanol		58,3566ppm	
	etyhl acetate	flavonoid, triterpenoid, essential oil	51,52ppm	[17]
Fruits	n-hexane		49,31ppm	[18]
	methanol	phenolic	86,20ppm	[13]
	methanol	phenolic	14,54ppm	[19]

3.4.3. Anticancer activity.

Cancer is a condition in which cells in the tissue grow abnormally out of control and rapidly. Anticancer compounds are compounds that have the ability to inhibit or interfere with the growth of malignant tumor cells [20, 21]. In vitro cytotoxic studies of the Kulim tree have been reported against leukemia cell lines. Scorodocarpine B and dehydroxyscorodocarpin B that are isolated from the fruit have been shown to exhibit anticancer activity against lymphoid leukemia cell line L1210 with a strong IC_{50} value. The cytotoxic activity is also shown by the active compound from Kulim tree seed, namely bis-(methylthiomethyl)-disulfide, against CEM-SS leukemia cell line KU812F chronic myelogenous leukemia cell lines. In addition, the ethyl acetate extract of *S. borneensis* isolation compound (Cadalene-β-carboxylic acid) displays a cytotoxic effect when is tested on brine shrimp lethality test (BSLT) [22]. Together, the Kulim tree has potential as an anticancer, although further study is needed to be established in order to investigate this effect.

3.5. Potential bioactivities of the chemical compounds in Kulim.

Some of the compounds that have been found in *Scorodocarpus borneensis* are fatty acids and sulfate groups. These compounds were also found in other plants. The updated research about these compounds with their several activities is shown in Table 4.

Table 4. Potential bioactivities of the chemical compound in *Scorodocarpus borneensis*.

Compound Found in Kulim	Category	Potential Finding	References
hexadecanoic, methyl ester	saturated fatty acid ester	The synergistic effect of *Carica papaya* seed fraction rich on hexadecanoic acid, methyl ester,11-octadecenoic acid, methyl ester, N, N-dimethyl-, n-hexadecanoic acid, and oleic acid has anti-diabetic activity with strong antioxidant properties.	[23]
		Fatty acid content from ethyl acetate extract of *Piliostigma reticulatum* had antibacterial activity	[24]
		Hexadecenoic acid methyl ester from clove alcoholic fraction have an antimicrobial effect against clinical pathogenic bacteria	[25]
		The fatty acid compound from *Premna paucinervis* (C.B. Clarke) gamble (Lamiaceae) stems bark have antibacterial activity.	[26]
		The major compound from the hexane fraction of *Leonotis nepetifolia* leaves have antiinflammatory activity	[27]
9,12-octadecadienoic acid	monounsaturated fatty acid ester	The compound from Aspergillus spp. have potential as pathogen fungi inhibition against *Macrophomina phaseolina*	[28]
		9,12-octadecadienoic acid (Z,Z)-, compound from *Andrographis paniculata* have antiparasitic potency with higher binding affinity and inhibitory potential than the standard drugs for *S. mansoni*, *P. falciparum*, and *T. brucei* using SwissDock and Ligplot (in silico)	[29]
		Tapinanthus bangwensis and *Moringa oleifera* contain 9,12-Octadecadienoic acid, methyl ester as fatty acid with the potential to improve our health.	[30]
		The lipids extracted from roots of *Orchis chusua* D. Don contained fatty acids and have good activity on antimicrobial and antioxidant.	[31]
dimethyl trisulfide (DMTS)	a volatile sulfur compound	Intramuscular treatment with 10% DMTS in mice and rat models with acute CN toxicity improves survival and clinical recovery.	[32]
		DMTS have potential activity for complementary treatment of neuropathic pain	[33]
benzophenone	benzophenones	This compound has antitumor activity against hepatocarcinoma SMMC-7721 cells	[34]
		UV light significantly decreased the LC50 values (increased toxicity) of benzophenone and oxybenzone in the zebrafish embryo.	[35]
stigmasta-4 ,22-dien-3-one	stigmastanes and derivatives	Constituent on *Helicteres guazumifolia* Kunth (Malvaceae) leaves	[36]
		The roots of *Lindera glauca* Blume contain stigmasta-4,22-dien-3-one and have Anti-proliferative and Apoptotic Activity by enhanced Caspase-3 in Human HCT116 Colorectal Cancer Cells	[37]
1.2 benzenedicarboxylic acid	dibutyl phthalate	One of the bioactive compounds of methanolic extract of brown algae *Sargassum tenerrimum* and has antibacterial activity	[38]
		Vinca major var. *variegata* was contained 1.2 benzenedicarboxylic acid and antibacterial activity	[39]
1,5-heptadien-3-yne	heptane	The presence of this compound also contributed to the antioxidant activity of *Moringa oleifera* pods	[40]
2,4,6-trithiaheptane	heptane	Chemical content from Allium spp. has bioactivities	[41]
methyl (methylsulfinyl) methyl sulfide	a volatile sulfur compound	Essential oil from *Gallesia integrifolia* have anti insecticide activity	[42]
		Chemical content from hydromethanol extract of *A. hooshidaryae* was showed good activity in antioxidant, antibacterial, and anti cytotoxic (MOLT-4 and MCF-7)	[43]

3.6. Other pharmacological and non-pharmacological use.

Another pharmacological effect of the Kulim tree that has been reported was anti-blood aggregation. Sulfuric compounds from the Kulim tree also exhibit an anti aggregating effect of rabbit blood through inhibiting arachidonic acid metabolism and inhibiting the platelet aggregation. As non-pharmacological usage, according to the sensory acceptance parameter, the addition of the Kulim bark results in an increase in aroma acceptance but decreased color acceptance compared to non-aromatic cooking palm oil. Thus, the bark of the Kulim tree is a potential ingredient for making aromatic oil [44]. Another finding in *S. borneensis* was shown in Table 5.

Table 5. Other pharmacological and non-pharmacological effects of *Scorodocarpus borneensis*.

Finding	Discussion	References
The potential for Kulim trees with diameter > 20 cm is 367,287 m^3 while those with diameter > 50 cm are 186,344 m^3. The use of Kulim wood for the shipping industry and frames in the Kampae Regency reaches 23,366 m^3. Thus, it is estimated that trees with a diameter of > 50cm will only last for 8 years. Scarcity is caused by human factors (exploitation), physiological factors, forest conversion, and pests.	The results of the vegetation analysis in the Gelawan forest group measurement path showed an abnormality in the Kulim population; this was due to the number of trees that were more than the regeneration. This shows that the plant stand structure is leading to extinction. Based on the data on the number of trees per hectare per diameter class, the potential of Kayi Kulim is estimated at 367,287 m^3. Kulim trees that can be cut have a diameter of 50cm. Based on the local governor's decree, the number of Kulim trees that can be cut is 186,344 m^3 or 40,510 stems.	[6]
It contains dihydroxy scrodocarpin B, scrorodocarpin B, scrodocarpin X, cadalene-carboxylic acid, and stigmasterol.	The extraction process was carried out by maceration in 95% ethanol (7x), then partitioned with n-hexane and ethyl acetate as solvents. Determination of the chemical structure was carried out into two types, namely n-hexane extract compounds (dehydroxy scorodocarpin B and scorodocarpin B) and ethyl acetate extract compounds (scorodocarpin X, cadalene-carboxylic acid, and stigmasterol). The process of determining the chemical structure is carried out by interpreting the UV spectrum data.	[18]
Kulim plants in the arboretum of PT. Arara Abadi, Riau, Sumatra is easily accessible and safe from disturbance, has a number of old trees that can produce quality seeds, has seedlings and shoots in forest soil, and is free of pests.		[45]
Kulim has a habitat on sandy loam soil, yellowish-brown in color, average water content 5.88 with a pH of 5.4 (acidic). Kulim is found in groups in one forest area with an average flat topography. Based on altitude, the Kulim in the Rumbio customary prohibition forest is at an altitude of 93 masl ± 103 masl. An average temperature of 25, 71 °C and average humidity of 71, 46 %.	The location of the Kulim research was carried out in the Rumbio Prohibition Forest, Kampar Regency, Riau. The distribution of Kulim in the structure of the Kulim stand was unstable because only the seedling level was found, while at the sapling level, two stems and no poles were found in the research plot. 5 individuals were found in the Rumbio customary prohibition forest from five lanes. Kulim regeneration at the seedling level was found in 58 individuals, and regeneration at the sapling level was 2 individuals. The farthest distance of the saplings from the mother tree is 1015 cm, and the closest is 57 cm. The thickness of the litter was carried out at seven points, and obtained on the thick litter at the sixth point with a thickness of 45 cm.	[46]

4. Conclusions

Scorodocarpus borneensis have potential chemical compounds with several pharmacological activities, such as antioxidant, anticancer, antifungal, antimicrobial, and insecticide activity. The volatile compound or essential oil with sulfuric component was a dominant compound that affected the smell of plants. It has prospective bioactivities for drug development.

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Conflicts of Interest

The authors declare no conflict of interest

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