CHEMICAL CONSTITUENTS WITH ALPHA-GLUCOSIDASE INHIBITORY ACTIVITY FROM *DENDROBIUM BRAIANENSE* AND *DENDROBIUM KENTROPHYLLUM*

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องค์ประกอบทางเคมีที่มีฤทธิ์ยับยั้งเอนไซม์แอลฟา-กลูโคซิเดสของเอื้องคำป๊อกลาวและเอื้องก้างปลาใหญ่

น.ส.ไมอา อินเดรีย เพอร์มาทาซารี

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Thesis Title	CHEMICAL CONSTITUENTS WITH ALPHA-GLUCOSIDASE INHIBITORY ACTIVITY FROM *DENDROBIUM BRAIANENSE* AND *DENDROBIUM KENTROPHYLLUM*
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Field of Study	Pharmaceutical Sciences and Technology
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ไมอา อินเดรีย เพอร์มาทาซารี : องค์ประกอบทางเคมีที่มีฤทธิ์ยับยั้งเอนไซม์แอลฟา-กลูโคซิเดสของเอื้องคำป๊อกลาวและเอื้องก้างปลาใหญ่. (CHEMICAL CONSTITUENTS WITH ALPHA-GLUCOSIDASE INHIBITORY ACTIVITY FROM *DENDROBIUM BRAIANENSE* AND *DENDROBIUM KENTROPHYLLUM*) อ.ที่ปรึกษาหลัก : รศ.บุญชู ศรีตุลารักษ์, อ.ที่ปรึกษาร่วม : ศ.กิตติศักดิ์ ลิขิตวิทยาวุฒิ

การศึกษาองค์ประกอบทางเคมีจากส่วนทั้งต้นของเอื้องคำป๊อกลาวสามารถแยกสกัดสารกลุ่มไบเบนซิลจำนวน 3 ชนิด ได้แก่ chrysotoxin moscatilin และ gigantol จากส่วนทั้งต้นของเอื้องก้างปลาใหญ่พบสารกลุ่มฟลาโวนอยด์จำนวน 3 ชนิด ได้แก่ quercetin kaempferol และ rutin การศึกษาโครงสร้างของสารที่แยกได้อาศัยการวิเคราะห์คุณสมบัติทางสเปกโทรสโกปีร่วมกับการเปรียบเทียบกับข้อมูลที่มีรายงานมาก่อน เมื่อนำสารทั้งหมดที่แยกได้มาทดสอบฤทธิ์ยับยั้งเอนไซม์แอลฟา-กลูโคซิเดสพบสารที่มีฤทธิ์แรงได้แก่ gigantol quercetin และ kaempferol เมื่อเปรียบเทียบกับ acarbose ที่เป็นสารควบคุมผลบวก ส่วนสาร chrysotoxin moscatilin และ rutin พบว่าไม่มีฤทธิ์ยับยั้งเอนไซม์

สาขาวิชา เภสัชศาสตร์และเทคโนโลยี ลายมือชื่อนิสิต .....
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To investigate the phytochemicals of the entire plants of *Dendrobium braianense* brought about in the isolation of three bibenzyls, which included chrysotoxin, moscatilin and gigantol. From the whole plant of *D. kentrophyllum* three flavonoids, namely, quercetin, kaempferol and rutin were isolated, the structures of which were decided by means of analysis of spectroscopic data to compare the values already reported. They were assessed for their alpha-glucosidase inhibitory activity. Gigantol, quercetin and kaempferolwere found to exhibit strong alpha-glucosidase inhibitory activity when compared with the positive control acarbose, while chrysotoxin, moscatilin and rutin were devoid of activity.

Field of Study:	Pharmaceutical Sciences and Technology	Student's Signature .....
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ABBREVIATIONS AND SYMBOLS

Acetone-d_6	=	Deuterated acetone
APCI-MS	=	Atmospheric Pressure Chemical Ionization Mass Spectrometry
br s	=	Broad singlet (for NMR spectra)
°C	=	Degree celsius
CC	=	Column chromatography
$CDCl_3$	=	Deuterated chloroform
CH_2Cl_2	=	Dichloromethane
cm	=	Centimeter
^{13}C-NMR	=	Carbon-13 Nuclear Magnetic Resonance
1-D NMR	=	One-dimensional Nuclear Magnetic Resonance
2-D NMR	=	Two-dimensional Nuclear Magnetic Resonance
d	=	Doublet (for NMR spectra)
dd	=	Doublet of doublets (for NMR spectra)
δ	=	Chemical shift
DMSO-d_6	=	Deuterated dimethylsulfoxide
EtOAc	=	Ethyl acetate
FCC	=	Flash Column Chromatography
g	=	Gram
Gal	=	Galactose
GF	=	Gel Filtration
Glc	=	Glucose
HMBC	=	^{1}H-detected Heteronuclear Multiple Bond Correlation
HR-ESI-MS	=	High Resolution Electrospray Ionization Mass Spectrometry

^{1}H-NMR	=	Proton Nuclear Magnetic Resonance
HSQC	=	^{1}H-detected Heteronuclear Single Quantum Coherence
Hz	=	Hertz
IC_{50}	=	Concentration exhibiting 50% inhibition
IR	=	Infrared
J	=	Coupling constant
Kg	=	Kilogram
L	=	Liter
$[M+H]^+$	=	Protonated molecular ion
$[M+Na]^+$	=	Sodium-adduct molecular ion
m	=	Multiplet (for NMR spectra)
MeOH	=	Methanol
mg	=	Milligram
µg	=	Microgram
min	=	Minute
ml	=	Milliliter
µl	=	Microliter
µM	=	Micromolar
mm	=	Millimeter
mM	=	Millimolar
MS	=	Mass spectrum
MW	=	Molecular weight
m/z	=	Mass to charge ratio
NA	=	Not applicable
nm	=	Nanometer
nM	=	Nanomolar
NMR	=	Nuclear Magnetic Resonance

NOESY	=	Nuclear Overhauser Effect Spectroscopy
OEt	=	Ethoxy group
OMe	=	Methoxy group
Rha	=	Rhamnose
s	=	Singlet (for NMR spectra)
t	=	Triplet (for NMR spectra)
TLC	=	Thin Layer Chromatography
UV-VIS	=	Ultraviolet and Visible spectrophotometry
VLC	=	Vacuum Liquid Column Chromatography
Xyl	=	Xylose

CHAPTER I

INTRODUCTION

Diabetes mellitus (DM) is characterized by high blood sugar and metabolic disorders of fat, carbohydrates as well as protein due to absolute or relative insulin deficiency. This disease has several symptoms including increased appetite, thirst, and frequency of urination (Fatimah, 2015). There are several complications of DM such as retinopathy, neuropathy, cardiovascular disease, stroke, and chronic kidney disease (Ahamad *et al*., 2011).

Diabetes Mellitus type 2 (DM II) stems from insulin resistance or abnormal insulin secretion. Pancreatic beta cells still produce insulin, therefore DM II is regarded as non-insulin-dependent diabetes mellitus (NIDDM) (Fatimah, 2015). DM II is more common in adulthood and elderly people. The exact causes of DM are unknown, but they are related to lifestyle factors and genetics such as obesity, lack of physical activity, poor diet, and stress (Patel *et al*., 2012).

Normal insulin has the work as the main regulator of fat, carbohydrate, and protein metabolism. First, it inhibits lipolysis of fat in adipose tissue which inhibits the release of fatty acid release in adipose tissue. Second, prevent gluconeogenesis in the liver which reducing the liver's glucose output. Third, it makes the glucose transporter type 4 (GLUT-4) transport the glucose into the muscle cells, which makes skeletal muscle increase the glucose uptake (Sears & Perry, 2015).

Hyperglycemia and more circulating fatty acids in DM II result from many factors, for instance, adipokines as well as inflammation of the diabetes genes. These factors affect how insulin is secreted in the pancreas and works. The reduced insulin secretion reduces the insulin signal in the target tissue. Insulin resistance has impacts on the action of insulin in every major target tissue, causing hyperglycemia and an

increase in circulating fatty acids. Insulin secretion and resistance were affected by the increase of glucose and fatty acids levels in the blood (Stumvoll *et al*., 2005).

There are several ways to treat and prevent diabetes and its secondary complications. One of these is herbal medicine. There are different mechanisms of action for different antidiabetic drugs in the treatment of high glucose levels. The initial increase in insulin secretion from sulphonylureas and meglitinides. Decreased gastrointestinal glucose absorption (GIT) is a mechanism of α-glucosidase inhibitors (AGIs) and dipeptide peptidase-4 inhibitors. Reduction in glucagon secretion from amylin analog α-glucosidase inhibitors and dipeptide peptidase-4 inhibitors (Choudhury *et al*., 2018).

Dendrobium plants have been reported to produce various classes of secondary metabolites, like phenanthrenes, bibenzyls, alkaloids, fluorenones as well as flavonoids, in which several compounds were found to possess antitumor, anti-inflammatory, antimutagenic, and α-glucosidase inhibitory activities (Na Ranong*., et. al*., 2019).

Dendrobium braianense Gagnep. (เอื้องคำป๊อกลาว), is distributed in South-Central China, Laos, Thailand, and Vietnam (Plants of the world online, 2017). The leaves of *D. braianense* gagnep have medium-sized, warm to cool growing epiphyte with pseudobulbous, slightly clavate stems carrying variably deciduous leaves that blooms in the winter and spring. The structural compound of the *D. braianense* gagnep flower has 1.6 inches or 4 cm (The Plant List, 2018).

Figure 1. *Dendrobium braianense*

Dendrobium kentrophyllum Hook. f. (เอื้องก้างปลาใหญ่) stem is 10-30 cm long, erect or ascending; leaves, narrow, slightly curved outwards. Its flower has pale greenish-yellow or whitish-yellow petals. It flowering in October – November. Distribution in India, Borneo, Laos, Malaysia, Sumatra, and Thailand (Khuraijam & Roy, 2016).

Figure 2. *Dendrobium kentrophyllum*

Prior to this report, there were no records on phytochemical constituents of *Dendrobium braianense* and *D. kentrophyllum*. Both plant crude extracts were

prepared through maceration of the dried powdered whole plants and methanol (MeOH). After being evaluated with α-glucosidase inhibitory activity, MeOH extracts of both plants at concentration of 100 μg/mL showed inhibition around 65% for *D. braianense* and around 80% for *D. kentrophyllum.* Isolation continues with liquid-liquid extraction of MeOH extracts with ethyl acetate (EtOAc), butanol (BuOH) and water (H_2O) to give EtOAc, BuOH and water extracts respectively. Both EtOAc and BuOH extracts then were tested with α-glucosidase inhibitory activity assay. The result showed that only EtOAc extracts of both plants have strong inhibitory effect with inhibition above 80% at the concentration of 100 μg/mL for *D. braianense* and more than 90% for *D. kentrophyllum*. Therefore the EtOAc extracts from *D. braianense* and *D. kentrophyllum* were selected for further chemical investigation. Regarding the biological activity of *D. braianense* and *D. kentrophyllum*, so far, there have been no previous reports.

The information of phytochemical constituents from *Dendrobium braianense* and *Dendrobium kentrophyllum* and their α-glucosidase inhibitory effect should be useful for the development of new anti-diabetic drugs from natural sources. To achieve this purpose, the objectives of this project are:

1. To isolate and purify the chemical constituents from *Dendrobium braianense* and *D. kentrophyllum* and analyze the chemical structure of each compound.
2. To investigate α-glucosidase inhibitory activity of isolated compounds.

CHAPTER II

LITERATURE REVIEW

1. Chemical constituents of *Dendrobium* species

Like other plants, orchids produce many phytochemicals. Chemical properties and biological activity have been studied in several of them. Dendrobine was the first alkaloid isolated from the orchid *Dendrobium nobile* and has been used in the Chinese traditional medicine "Shi-Hu" (Hossain, 2011). In Orchidaceae, *Dendrobium* is a large genus. In Chinese traditional medicine, dried *Dendrobium* spp. stems have been used to treat stomach, diabetes, kidney, and lung diseases (Xu *et al*., 2017). In Thailand, some of these orchids are also used in traditional medicine (Chuakul, 2002). According to reports, several types of secondary metabolites are already isolated from *Dendrobium* spp. such as, bibenzyls, phenanthrenes, alkaloids, and flavonoids which have certain biological activities (Wang *et al*., 2009).

Shi-Hu is deemed to be an important herb for replenishing yin (coldness, moistness, and so on) and is widely used in Chinese medicine. They are considered effective in some diseases or syndromes related to the deficiency of yin in the kidney, lung, and stomach—like thirst, fever, red tongue, faucitis, atrophic gastritis as well as diabetes (Bulpitt *et al*., 2007).

There is some traditional belief that suggests the use of several orchids in treating diabetes. Some of these orchids have also been validated by several scholars throughout the world experimentally, while some are still under study. The examples of the orchids that have a pathological condition to treat diabetes are whole *Dendrobium aphyllum* plants (Roxb.), infusion of leaves from *Dendrobium auranticum*, leaves from *Dendrobium candidum* wall ex Lindl., whole plants of

Dendrobium chrysotoxum, and whole plants of *Dendrobium officinale* kimura et migo (Mukherjee & Jagtap, 2020).

Table 1 and Figure 3 show compounds belonging to stilbenoids which can be divided into stilbenes, bibenzyls, bisbibenzyls, and phenanthrenes derivatives. The main structural skeleton of this group composes of 2 aromatic rings linked by an ethylene bridge. Stilbenoids are constructed from *trans*-cinnamic acid and three malonyl-CoA units. In phenylpropanoid biosynthesis, L-phenylalanine is deaminated by phenylalanine ammonia-lyase (PAL) to give *trans*-cinnamic which is then hydroxylated by cinnamate-4-hydroxylase (C4H) to yield 4-coumaric acid. This compound is then activated by 4-coumaroyl CoA ligase (4CL) to form 4-coumaroyl CoA. Subsequently, three acetate extender units from malonyl-CoA are added to 4-coumaroyl CoA by stilbene synthase (STS) to make tetraketide intermediate which consequently folds and cyclizes to shape as a chalcone or a stilbene structure (Tsopmo *et al*., 2013).

Bibenzyl is a type of active compound abundant in *Dendrobium* (Gong *et al*., 2013). The Bibenzyls constitute small-molecular compounds of natural origin and are widely source. In previous studies, the bibenzyls were shown to have good anti-tumor, anti-diabetes and its complications, and neuroprotective effects. One of their primary sources is the *Dendrobium* genus. Currently, 89 bibenzyl derivatives, for example, moscatilin (**1**), gigantol (**2**), and chrysotoxine (**3**), have been found in 46 species of *Dendrobium*. Moscatilin (**1**) has anti-tumor, neuroprotection as well as improvement of retinal vascular diseases. Gigantol (**2**) has anti-tumor, anti-diabetes as well as its complications, antioxidant, anti-inflammatory, antibacterial, antiviral, and antimalarial effects. Chrysotoxine (**3**) exhibited anti-lung cancer activity (He *et al*., 2020).

Flavonoids, one of the largest groups of low molecular weight secondary metabolites presenting common benzo-γ- pyrone structure, are naturally occurring

phenolic compounds. Due to the presence of aromatic hydroxyl groups, flavonoids have strong antioxidant properties. Many of the biological actions of flavonoids have been attributed to their powerful antioxidant properties. Since the beginning of the 1980s, the beneficial effects of flavonoids have been studied in DM. Flavonoids with antioxidant and free radical scavengering properties, in particular, prevent autopoly (ADP-ribosyl)-ation of poly synthetase polymerase and by stabilizing Reg gene transcriptional complex, result in the regeneration of β-cells and protect pancreatic islets. Recently, many biologically active flavonoids for treating DM and its complications have been found (Kumar, S., & Pandey, A. K., 2013).

Alkaloids is a very diverse group of compounds related only to the occurrence of a nitrogen atom in a heterocyclic ring. Plants are estimated to produce almost 12,000 different alkaloids, organized into groups based on their carbon skeletal structures (Ziegler, J., & Facchini, P. J., 2008).

Table 1. Stilbenoids from the genus *Dendrobium*

Stilbenoids	Plant	Plant part	Reference
Aloifol I [**1**]	*D. longicornu*	Stem	(Hu *et al.*, 2008a)
	D. williamsonii	Whole plant	(Yang *et al.*, 2018)
	D. infundibulum	Whole plant	(Na Ranong *et al.*, 2019)
Amoenylin [**2**]	*D. amoenum*	Whole plant	(Majumder *et al.*, 1999)
	D. williamsonii	Whole plant	(Yang *et al.*, 2018)
Batatasin [**3**]	*D. longicornu*	Stem	(Hu *et al.*, 2008a)
	D. plicatile	Stem	(Yamaki & Honda, 1996)
Batatasin III [**4**]	*D. aphyllum*	Whole plant	(Chen *et al.*, 2008a)
		Stem	(Yang *et al.*, 2015)
	D. cariniferum	Stem	(Chen *et al.*, 2008b)
	D. rotundatum	Whole plant	(Majumder & Pal, 1992)
	D. chrysotoxum	Whole plant	(Y. P. Li *et al.*, 2009)
	D. draconis	Stem	(Sritularak, Anuwat*, et al.*, 2011)
	D. formosum	Whole plant	(Inthongkaew *et al.*, 2017)
	D. gratiosissimum	Stem	(C. F. Zhang *et al.*, 2008)
	D. loddigesii	Stem	(Ito *et al.*, 2010)
	D. loddigesii	Stem	(Ma *et al.*, 2019)
	D. venustum	Whole plant	(Sukphan *et al.*, 2014)
	D. scabrilingue	Whole plant	(Sarakulwattana *et al.*, 2018)
	D. infundibulum	Whole plant	(Na Ranong *et al.*, 2019)
Brittonin A [**5**]	*D. secundum*	Stem	(Sritularak, Duangrak*, et al.*, 2011)
Chrysotobibenzyl [**6**]	*D. aurantiacum* var. *denneanum*	Stem	(L. Yang, Wang*, et al.*, 2006)
	D. capillipes	Stem	(Phechrmeekha *et al.*, 2012)
	D. chrysanthum	Stem	(L. Yang, Qin*, et al.*, 2006)
	D. venustum	Whole plant	(Sukphan *et al.*, 2014)

Stilbenoids	Plant	Plant part	Reference
	D. scabrilingue	Whole plant	(Sarakulwattana *et al.*, 2018)
	D. infundibulum	Whole plant	(Na Ranong *et al.*, 2019)
Chrysotoxine [**7**]	*D. aurantiacum* var. *denneanum*	Stem	(L. Yang, Wang, *et al.*, 2006)
	D. chrysanthum	Stem	(L. Yang, Qin, *et al.*, 2006)
Crepidatin [**8**]	*D. aurantiacum* var. *denneanum*	Whole plant	(Liu *et al.*, 2009)
	D. chrysanthum	Stem	(L. Yang, Qin, *et al.*, 2006)
	D. crepidatum	Whole plant	(Majumder & Chatterjee, 1989)
	D. loddigesii	Stem	(R. J. Ma *et al.*, 2019)
Cumulatin [**9**]	*D. cumulatum*	Whole plant	(Majumder & Pal, 1993)
4,5-dihydroxy-3,3'-dimethoxybibenzyl [**10**]	*D. nobile*	Stem	(H. Wang *et al.*, 1985; Ye & Zhao, 2002)
3,3′-Dihydroxy-4,5-dimethoxybibenzyl [**11**]	*D. williamsonii*	Whole plant	(Rungwichaniwat *et al*., 2014)
	D. infundibulum	Whole plant	(Na Ranong *et al*., 2019)
3,4′-Dihydroxy-5-methoxybibenzyl [**12**]	*D. amoenum*	Whole plant	(Majumder *et al*., 1999)
3,4′-Dihydroxy-5,5′-dimethoxydihydrostilbene [**13**]	*D. nobile*	Stem	(Hwang *et al*., 2010)
4,5-Dihydroxy-3,3′-dimethoxybibenzyl [**14**]	*D. nobile*	Stem	(Ye & Zhao, 2002)
Erianin [**15**]	*D. chrysotoxum*	Stem	(Hu *et al*., 2012)
Gigantol [**16**]	*D. aphyllum*	Whole plant	(Y. Chen *et al*., 2008)
	D. aphyllum	Stem	(D. Yang *et al*., 2015)
	D. aurantiacum var. *denneanum*	Whole plant	(Liu *et al*., 2009)
	D. brymerianum	Whole plant	(Klongkumnuankarn *et al*., 2015)

Stilbenoids	Plant	Plant part	Reference
	D. densiflorum	Stem	(C. Fan *et al*., 2001)
	D. devonianum	Whole plant	(Sun *et al*., 2014)
	D. draconis	Stem	(Sritularak, Anuwat, *et al*., 2011)
	D. formosum	Whole plant	(Inthongkaew *et al*., 2017)
	D. gratiosissimum	Stem	(C. F. Zhang *et al*., 2008)
	D. loddigesii	Whole plant	(Ito *et al*., 2010)
	D. longicornu	Stem	(Hu *et al*., 2008a)
	D. nobile	Stem	(X. Zhang, J. K. Xu, *et al*., 2007)
	D. officinale	Stem	(G. Y. Zhao *et al*., 2018)
	D. polyanthum	Stem	(Hu *et al*., 2009)
	D. trigonopus	Stem	(Hu *et al*., 2008b)
	D. venustum	Whole plant	(Sukphan *et al*., 2014)
	D. scabrilingue	Whole plant	(Sarakulwattana *et al*., 2018)
	D. loddigesii	Stem	(Ma *et al*., 2019)
	D. palpebrae	Whole plant	(Kyokong *et al*., 2019)
4-Hydroxy-3,5,3′-trimethoxybibenzyl **[17]**	D. nobile	Stem	(Ye & Zhao, 2002)
5-Hydroxy-3,4,3′,4′,5′-pentamethoxybibenzyl [**18**]	*D. secundum*	Stem	(Phechrmeekha *et al*., 2012)
Isoamoenylin [**19**]	*D. amoenum*	Whole plant	(Majumder *et al*., 1999)
Moniliformine [**20**]	*D. williamsonii*	Whole plant	(Yang *et al*., 2018)
Moscatilin [**21**]	*D. amoenum*	Whole plant	(Majumder *et al*., 1999)
3,3′,4-Trihydroxybibenzyl **[22]**	*D. longicornu*	Stem	(Hu *et al*., 2008a)
3,3′,5-Trihydroxy bibenzyl **[23]**	*D. cariniferum*	Whole plant	(Liu *et al*., 2009a)
	D. loddigesii	Stem	(Ma *et al*., 2019b)
3,5,4′-Trihydroxy bibenzyl **[24]**	*D. gratiosissimum*	Stem	(Zhang *et al*., 2008a)

Stilbenoids	Plant	Plant part	Reference
4,5,4′-Trihydroxy-3,3′-dimethoxybibenzyl [**25**]	*D. secundum*	Stem	(Sritularak, Duangrak and Likhitwitayawuid, 2011)
	D. ellipsophyllum	Whole plant	(Tanagornmeatar *et al*., 2014)
	D. parishii	Whole plant	(Kongkatitham *et al*., 2018)
	D. loddigesii	Stem	(Ma *et al*., 2019b)
	D. palpebrae	Whole plant	(Kyokong *et al*., 2019)
Tristin [**26**]	*D. aphyllum*	Stem	(Yang *et al*., 2015)
	D. chrysotoxum	Stem	(Hu *et al*., 2012)
	D. densiflorum	Stem	(Fan *et al*., 2001)
	D. gratiosissimum	Stem	(Zhang *et al*., 2008a)
	D. longicornu	Stem	(Hu *et al*., 2008a)
	D. officinale	Stem	(Zhao *et al*., 2018)
	D. trigonopus	Stem	(Hu *et al*., 2008b)
	D. loddigesii	Stem	(Ma *et al*., 2019b)
Dendromoniliside E [27]	*D. moniliforme*	Stem	(Zhao *et al*., 2003)
5,4′-Dihydroxy-3,4,3′-trimethoxybibenzyl [28]	*D. infundibulum*	Whole plant	(Na Ranong *et al*., 2019)
4,3′,4′-trihydroxy-3,5-dimethoxybibenzyl [**29**]	*D. parishii*	Whole plant	(Kongkatitham *et al*., 2018)
Dendrophenol [**30**]	*D. candidum*	S t e m	(Li *et al*., 2008)
3,4-Dihydroxy-5,4′-dimethoxybibenzyl [**31**]	*D. palpebrae*	Whole plant	(Kyokong *et al*., 2019)
	D. infundibulum	Whole plant	(Na Ranong *et al*., 2019)
	D. signatum	Whole plant	(Mittraphab *et al*., 2016)
	D. tortile	Whole plant	(Limpanit *et al*., 2016)
4,4′-Dihydroxy-3,5-dimethoxybibenzyl [**32**]	*D. candidum*	Stem	(Y. Li *et al*., 2008)
	D. ellipsophyllum	Whole plant	(Tanagornmeatar *et al*., 2014)
	D. williamsonii	Whole plant	(M. Yang *et al*., 2018)
Loddigesiinol C [**33**]	*D. loddigesii*	Whole plant	(Ito *et al*., 2010)
3-*O*-Methylgigantol [**34**]	*D. candidum*	Stem	(Y. Li *et al*., 2008)
	D. nobile	Stem	(Hwang *et al*., 2010)
	D. plicatile	Stem	(Yamaki & Honda, 1996)

Stilbenoids	Plant	Plant part	Reference
Dendrocandin A [35]	*D. candidum*	Stem	(Y. Li *et al*., 2008)
Dendrocandin B [36]	*D. candidum*	Stem	(Y. Li *et al*., 2008)
	D. signatum	Whole plant	(Mittraphab *et al*., 2016)
Dendrocandin C [37]	*D. candidum*	Stem	(Y. Li *et al*., 2009a)
Dendrocandin D [38]	*D. candidum*	Stem	(Y. Li *et al*., 2009a)
Dendrocandin E [39]	*D. candidum*	Stem	(Y. Li *et al*., 2009a)
	D. parishii	Whole plant	(Kongkatitham *et al*., 2018)
Dendrocandin F [40]	*D. candidum*	Stem	(Yan Li *et al*., 2009b)
Dendrocandin G [41]	*D. candidum*	Stem	(Yan Li *et al*., 2009b)
Dendrocandin H [42]	*D. candidum*	Stem	(Yan Li *et al*., 2009b)
Dendrosinen A [43]	*D. sinense*	Whole plant	(X. J. Chen *et al*., 2014)
Dendrosinen B [44]	*D. sinense*	Whole plant	(X.-J. Chen *et al*., 2014)
	D. infundibulum	Whole plant	(Na Ranong *et al*., 2019)
Dendrosinen C [45]	*D. sinense*	Whole plant	(Chen *et al*., 2014)
Dendroscabrol B [46]	*D. scabrilingue*	Whole plant	(Sarakulwattana *et al*., 2018)
Dendrosinen D [47]	*D. sinense*	Whole plant	(X. J. Chen *et al*., 2014)
Dendrocandin I [**48**]	*D. candidum*	Stem	(Y. Li *et al*., 2008)
	D. signatum	Whole plant	(Mittraphab *et al*., 2016)
Densiflorol A [**49**]	*D. densiflorum*	Stem	(C. Fan *et al*., 2001)
	D. loddigesii	Stem	(R. J. Ma *et al*., 2019)
Longicornuol A [**50**]	*D. longicornu*	Stem	(Hu *et al*., 2008a)
Trigonopol A [**51**]	*D. trigonopus*	Stem	(Hu *et al*., 2008b)
Trigonopol B [**52**]	*D. chrysotoxum*	Stem	(Hu *et al*., 2012)
	D. trigonopus	Stem	(Hu *et al*., 2008b)
	D. aphyllum	Stem	(D. Yang *et al*., 2015)
Crepidatuol A [**53**]	*D. crepidatum*	Stem	(C. B. Li *et al*., 2013)
Crepidatuol B [**54**]	*D. crepidatum*	Stem	(C. B. Li *et al*., 2013)
Loddigesiinol D [**55**]	*D. loddigesii*	Whole plant	(Ito *et al*., 2010)
Dencryol A [**56**]	*D. crystallinum*	Stem	(L. Wang *et al*., 2009)
Dencryol B [**57**]	*D. crystallinum*	Stem	(L. Wang *et al*., 2009)
Dengraol A [**58**]	*D. gratiosissimum*	Stem	(C. F. Zhang *et al*., 2008)
Dengraol B [**59**]	*D. gratiosissimum*	Stem	(C. F. Zhang *et al*., 2008)

Stilbenoids	Plant	Plant part	Reference
4-[2-(3-Hydroxyphenol)-1-methoxyethyl]-2,6-dimethoxyphenol [**60**]	*D. longicornu*	Stem	(Hu *et al*., 2008a)
Nobilin A [**61**]	*D. nobile*	Stem	(X. Zhang *et al*., 2006)
Nobilin B [**62**]	*D. nobile*	Stem	(X. Zhang *et al*., 2006)
Nobilin C [**63**]	*D. nobile*	Stem	(X. Zhang *et al*., 2006)
Nobilin D [**64**]	*D. nobile*	Stem	(X. Zhang, J. K. Xu, *et al*., 2007)
Nobilin E [**65**]	*D. nobile*	Stem	(X. Zhang, J. K. Xu, *et al*., 2007)
Dendrofalconerol A [**66**]	*D. falconeri*	Stem	(Sritularak & Likhitwitayawuid, 2009)
	D. signatum	Whole plant	(Mittraphab *et al*., 2016)
	D. tortile	Whole plant	(Limpanit *et al*., 2016)
Dendrofalconerol B [**67**]	*D. falconeri*	Stem	(Sritularak & Likhitwitayawuid, 2009)
Dendrosignatol [**68**]	*D. signatum*	Whole plant	(Mittraphab *et al*., 2016)
2,2′-Dihydroxy-3,3′,4,4′,7,7-hexamethoxy-9,9′,10,10′-tetrahydro-1,1′-biphenanthrene [**69**]	*D. nobile*	Stem	(H. K. Yang *et al*., 2007)
2,2′-Dimethoxy-4,4′,7,7′-tetrahydroxy-9,9′,10,10′-tetrahydro-1,1′-biphenanthrene [**70**]	*D. plicatile*	Stem	(Yamaki & Honda, 1996)
Flavanthrin [**71**]	*D. aphyllum*	Whole plant	(Y. Chen *et al*., 2008)
Phoyunnanin C [**72**]	*D. venustum*	Whole plant	(Sukphan *et al*., 2014)
Phoyunnanin E [**73**]	*D. venustum*	Whole plant	(Sukphan *et al*., 2014)
Amoenumin [**74**]	*D. amoenum*	Whole plant	(Veerraju *et al*., 1989)
Crystalltone [**75**]	*D. crystallinum*	Stem	(L. Wang *et al*., 2009)
Dendropalpebrone [**76**]	*D. palpebrae*	Whole plant	(Kyokong *et al*., 2019)
Chrysotoxol A [**77**]	*D. chrysotoxum*	Stem	(Hu *et al*., 2012)
Chrysotoxol B [**78**]	*D. chrysotoxum*	Stem	(Hu *et al*., 2012)

Stilbenoids	Plant	Plant part	Reference
Confusarin [**79**]	*D. chryseum*	Stem	(Ma *et al*., 1998)
	D. chrysotoxum	Stem	(Hu *et al*., 2012)
	D. formosum	Whole plant	(Inthongkaew *et al*., 2017)
	D. nobile	Stem	(X. Zhang, J. K. Xu, *et al*., 2008)
	D. officinale	Stem	(G. Y. Zhao *et al*., 2018)
2,6-Dihydroxy-1,5,7-trimethoxyphenanthrene [**80**]	*D. densiflorum*	Stem	(C. Fan *et al*., 2001)
Dendrochrysanene [**81**]	*D. chrysanthum*	Stem	(L. Yang, Qin, *et al*., 2006)
Bulbophyllanthrin [**82**]	*D. nobile*	Stem	(H. K. Yang *et al*., 2007)
5-Hydroxy-2,4-dimethoxyphenanthrene [**83**]	*D. loddigesii*	Whole plant	(Ito *et al*., 2010)
3-Hydroxy-2,4,7-trimethoxyphenanthrene [**84**]	*D. nobile*	Stem	(H. K. Yang *et al*., 2007)
Cypripedin [**85**]	*D. densiflorum*	Stem	(C. Fan *et al*., 2001)
Densiflorol B [**86**]	*D. densiflorum*	Stem	(C. Fan *et al*., 2001)
	D. venustum	Whole plant	(Sukphan *et al*., 2014)
Denbinobin [**87**]	*D. moniliforme*	Stem	(Lin *et al*., 2001)
	D. nobile	Stem	(H. K. Yang *et al*., 2007)
Fimbriatone [**88**]	*D. nobile*	Stem	(X. Zhang, J. K. Xu, *et al*., 2008)
	D. pulchellum	Stem	(Chanvorachote *et al*., 2013)
Dendroscabrol A [8**9**]	*D. scabrilingue*	Whole plant	(Sarakulwattana *et al*., 2018)
Loddigesiinol B [**90**]	*D. loddigesii*	Whole plant	(Ito *et al*., 2010)
Dendronone [**91**]	*D. cariniferum*	Whole plant	(Y. Chen *et al*., 2008)
	D. longicornu	Stem	(Hu *et al*., 2008a)
Ephemeranthoquinone [**92**]	*D. plicatile*	Stem	(Yamaki & Honda, 1996)

Stilbenoids	Plant	Plant part	Reference
5-Methoxy-7-hydroxy-9,10-dihydro-1,4-phenanthrenequinone [**93**]	*D. draconis*	Stem	(Sritularak, Anuwat, *et al*., 2011)
	D. formosum	Whole plant	(Inthongkaew *et al*., 2017)
Moniliformin [**94**]	*D. moniliforme*	Stem	(Lin *et al*., 2001)
Moscatin [**95**]	*D. aphyllum*	Whole plant	(Y. Chen *et al*., 2008)
	D. chrysanthum	Stem	(L. Yang, Qin, *et al*., 2006)
	D. chrysotoxum	Whole plant	(Y. P. Li *et al*., 2009)
	D. densiflorum	Stem	(C. Fan *et al*., 2001)
	D. polyanthum	Stem	(Hu *et al*., 2009)
	D. rotundatum	Whole plant	(Majumder & Pal, 1992)
Coelonin [**96**]	*D. nobile*	Stem	(Hwang *et al*., 2010)
	D. aphyllum	Whole plant	(Y. Chen *et al*., 2008)
	D. formosum	Whole plant	(Inthongkaew *et al*., 2017)
	D. nobile	Stem	(H. K. Yang *et al*., 2007)
	D. scabrilingue	Whole plant	(Sarakulwattana *et al*., 2018)
9,10-Dihydromoscatin [**97**]	*D. polyanthum*	Stem	(Hu *et al*., 2009)
9,10-Dihydrophenanthrene-2,4,7-triol [**98**]	*D. polyanthum*	Stem	(Hu *et al*., 2009)
4,5-Dihydroxy-2,3-dimethoxy-9,10-dihydrophenanthrene [**99**]	*D. ellipsophyllum*	Whole plant	(Tanagornmeatar *et al*., 2014)
	D. sinense	Whole plant	(Chen *et al*., 2014)
4,5-Dihydroxy-2,6-dimethoxy-9,10-dihydrophenanthrene [**100**]	*D. chrysotoxum*	Stem	(Hu *et al*., 2012)
	D. devonianum	Stem	(Wu *et al*., 2019)
4,5-Dihydroxy-3,7-dimethoxy-9,10-dihydrophenanthrene [**101**]	*D. nobile*	Stem	(Ye & Zhao, 2002)

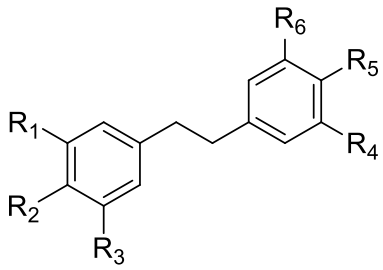
Stilbenoids	Plant	Plant part	Reference
4,5-Dihydroxy-2-methoxy-9,10-dihydrophenanthrene [**102**]	*D. nobile*	Stem	(H. K. Yang *et al*., 2007)
	D. devonianum	Stem	(Wu *et al*., 2019)
Lusianthridin [**103**]	*D. brymerianum*	Whole plant	(Klongkumnuankarn *et al*., 2015)
	D. nobile	Stem	(Hwang *et al*., 2010; H. K. Yang *et al*., 2007)
	D. formosum	Whole plant	(Inthongkaew *et al*., 2017)
	D. plicatile	Stem	(Yamaki & Honda, 1996)
	D. venustum	Whole plant	(Sukphan *et al*., 2014)
	D. scabrilingue	Whole plant	(Sarakulwattana *et al*., 2018)
	D. palpebrae	Whole plant	(Kyokong *et al*., 2019)
2,7-Dihydroxy-3,4,6-trimethoxy-9,10-dihydrophenanthrene [**104**]	*D. rotundatum*	Whole plant	(Majumder & Pal, 1992)
2,8-Dihydroxy-3,4,7-trimethoxy-9,10-dihydrophenanthrene [**105**]	*D. nobile*	Stem	(H. K. Yang *et al*., 2007)
4,7-Dihydroxy-2,3,6-trimethoxy-9,10-dihydrophenanthrene [**106**]	*D. sinense*	Whole plant	(X. J. Chen *et al*., 2013)
Ephemeranthol A [**107**]	*D. nobile*	Stem	(Hwang *et al*., 2010; H. K. Yang *et al*., 2007)
	D. officinale	Stem	(G. Y. Zhao *et al*., 2018)
	D. infundibulum	Whole plant	(Na Ranong *et al*., 2019)
Ephemeranthol C [**108**]	*D. nobile*	Stem	(Hwang *et al*., 2010)
Erianthridin [**109**]	*D. formosum*	Whole plant	(Inthongkaew *et al*., 2017)
	D. nobile	Stem	(Hwang *et al*., 2010; H. K. Yang *et al*., 2007)

Stilbenoids	Plant	Plant part	Reference
	D. plicatile	Stem	(Yamaki & Honda, 1996)
Flavanthridin [**110**]	*D. nobile*	Stem	(Hwang *et al*., 2010)
Hircinol [**111**]	*D. nobile*	Stem	(Hwang *et al*., 2010)
	D. aphyllum	Stem	(D. Yang *et al*., 2015)
	D. draconis	Stem	(Sritularak, Anuwat, *et al*., 2011)
	D. formosum	Whole plant	(Inthongkaew *et al*., 2017)
3-Hydroxy-2,4,7-trimethoxy-9,10-dihydrophenanthrene [**112**]	*D. nobile*	Stem	(H. K. Yang *et al*., 2007)
7-hydroxy-2,3,4-trimethoxy-9,10-dihydrophenanthrene [**113**]	*D. hainanense*	Aerial part	(Y. Y. Zhang *et al*., 2019)
Dendroinfundin A [**114**]	*D. infundibulum*	Whole plant	(Na Ranong *et al*., 2019)
Dendroinfundin B [**115**]	*D. infundibulum*	Whole plant	(Na Ranong *et al*., 2019)
3,4-Dimethoxy-1-(methoxymethyl)-9,10-dihydrophenanthrene-2,7-diol [**116**]	*D. hainanense*	Aerial part	(Y. Y. Zhang *et al*., 2019)
2-Hydroxy-4,7-dimethoxy-9,10-dihydrophenanthrene [**117**]	*D. nobile*	Stem	(H. K. Yang *et al*., 2007)
7-Methoxy-9,10-dihydrophenanthrene-2,4,5-triol [**118**]	*D. draconis*	Stem	(Sritularak, Anuwat, *et al*., 2011)
2,5,7-Trihydroxy-4-methoxy-9,10-dihydrophenanthrene [**119**]	*D. formosum*	Whole plant	(Inthongkaew *et al*., 2017)
Plicatol C [**120**]	*D. plicatile*	Stem	(Honda & Yamaki, 2000)

Stilbenoids	Plant	Plant part	Reference
Rotundatin [**121**]	*D. rotundatum*	Whole plant	(Majumder & Pal, 1992)
2,5-Dihydroxy-3,4 dimethoxyphenanthrene [**122**]	*D. nobile*	Stem	(H. K. Yang *et al*., 2007)
2,5-Dihydroxy-4,9-dimethoxyphenanthrene [**123**]	*D. nobile*	Stem	(X. Zhang, J. K. Xu, *et al*., 2008)
	D. palpebrae	Whole plant	(Kyokong *et al*., 2019)
2,8-Dihydroxy-3,4,7-trimethoxyphenanthrene [**124**]	*D. nobile*	Stem	(H. K. Yang *et al*., 2007)
Epheranthol B [**125**]	*D. chrysotoxum*	Stem	(Hu *et al*., 2012)
Fimbriol B [**126**]	*D. nobile*	Stem	(H. K. Yang *et al*., 2007);
Flavanthrinin [**127**]	*D. brymerianum*	Whole plant	(Klongkumnuankarn *et al*., 2015)
	D. nobile	Stem	(X. Zhang, J. K. Xu, *et al*., 2008)
	D. venustum	Whole plant	(Sukphan *et al*., 2014)
	D. parishii	Whole plant	(Kongkatitham *et al*., 2018a)
Loddigesiinol A [**128**]	*D. loddigesii*	Whole plant	(Ito *et al*., 2010)
Nudol [**129**]	*D. formosum*	Whole plant	(Inthongkaew *et al*., 2017)
	D. nobile	Stem	(H. K. Yang *et al*., 2007)
	D. rotundatum	Whole plant	(Majumder & Pal, 1992)
Plicatol A [**130**]	*D. nobile*	Stem	(H. K. Yang *et al*., 2007)
	D. plicatile	Stem	(Honda & Yamaki, 2000)
Plicatol B [**131**]	*D. plicatile*	Stem	(Honda & Yamaki, 2000)
2,3,5-Trihydroxy-4,9-dimethoxyphenanthrene [**132**]	*D. nobile*	Stem	(Yang, Sung and Kim., 2007)
3,4,8-Trimethoxy phenanthrene-2,5-diol [**133**]	*D. nobile*	Stem	(Hwang et al., 2010)
Aphyllone A [**134**]	*D. aphyllum*	Stem	(Yang et al., 2015)

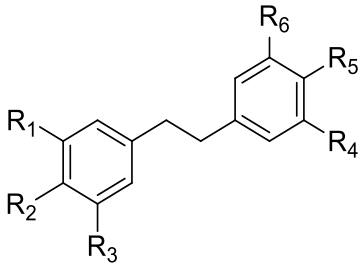
Stilbenoids	Plant	Plant part	Reference
(*S*)-2,4,5,9-Tetrahydroxy-9,10-dihydro phenanthrene [**135**]	*D. fimbriatum*	Stem	(Xu et al., 2014)
1,5,7-Trimethoxy phenanthren-2-ol [**136**]	*D. nobile*	Stem	(Kim *et al*., 2015)
1,5-Dihydroxy-3,4,7-trimethoxy-9,10-dihydrophenanthrene [**137**]	*D. moniliforme*	Whole plant	(Zhao *et al.*, 2016)
2,5,9*S*-Trihydroxy-9,10-dihydro phenanthrene-4-*O*-β-D-glucopyranoside [**138**]	*D. primulinum*	Whole plant	(Ye *et al.*, 2016)
Loddigesiinol G [**139**]	*D. loddigesii*	Stem	(Lu *et al.*, 2014)
Loddigesiinol H [**140**]	*D. loddigesii*	Stem	(Lu *et al.*, 2014)
Loddigesiinol I [**141**]	*D. loddigesii*	Stem	(Lu *et al.*, 2014)
Loddigesiinol J [**142**]	*D. loddigesii*	Stem	(Lu *et al.*, 2014)
Dendrowillol A [**143**]	*D. williamsonii*	Whole plant	(M. Yang *et al.*, 2018)
Dendrocandin P1 [**144**]	*D. officinale*	Stem	(G. Y. Zhao *et al.*, 2018)
Dendrocandin P2 [**145**]	*D. officinale*	Stem	(G. Y. Zhao *et al.*, 2018)
Orchinol [**146**]	*D. officinale*	Stem	(G. Y. Zhao *et al.*, 2018)
2,4,7-Trihydroxy-9,10-dihydro-phenanthrene [**147**]	*D. officinale*	Stem	(G. Y. Zhao *et al.*, 2018)
4-Methoxy-5,9*R*-dihydroxy-9,10-dihydro phenanthrene 2-*O*-β-D-glucopyranoside [**148**]	*D. nobile*	Stem	(Zhou *et al.*, 2017)
Dihydroresveratrol [**149**]	*D. aphyllum*	Stem	(D. Yang *et al.*, 2015)
Aphyllone B [**150**]	*D. aphyllum*	Stem	(D. Yang *et al.*, 2015)
Aphyllal C [**151**]	*D. aphyllum*	Stem	(D. Yang *et al.*, 2015)
	D. loddigesii	Stem	(R. J. Ma *et al.*, 2019)

Stilbenoids	Plant	Plant part	Reference
Aphyllal D [152]	*D. aphyllum*	Stem	(D. Yang *et al*., 2015)
Aphyllal E [153]	*D. aphyllum*	Stem	(D. Yang *et al*., 2015)
(–)-dendroparishiol [**154**]	*D. parishii*	Whole plant	(Kongkatitham *et al*., 2018a)
(*R*)-4,5,4'-trihydroxy-3,3',α-trimethoxybibenzyl [**155**]	*D. loddigesii*	Stem	(R. J. Ma *et al*., 2019)
Dendrofindlaphenol A [**156**]	*D. findlayanum*	Stem	(D. Yang *et al*., 2018)
6″-de-O-methyldendrofindlaphenol A [**157**]	*D. findlayanum*	Stem	(D. Yang *et al*., 2018)
Dendrofindlaphenol B [**158**]	*D. findlayanum*	Stem	(D. Yang *et al*., 2018)
Dendrofindlaphenol C [**159**]	*D. findlayanum*	Stem	(D. Yang *et al*., 2018)
Dendrodevonin A [**160**]	*D. devonianum*	Stem	(Wu *et al*., 2019)
Dendrodevonin B [**161**]	*D. devonianum*	Stem	(Wu *et al*., 2019)



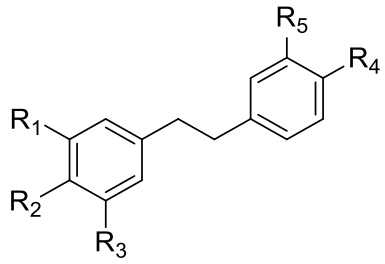
	R_1	R_2	R_3	R_4	R_5	R_6
[**1**] Aloifol I	OMe	OH	OMe	OH	H	H
[**2**] Amoenylin	OMe	OH	OMe	H	OMe	H
[**3**] Batatasin	OMe	H	H	OH	H	OH
[**4**] Batatasin III	OH	H	OMe	H	H	OH
[**5**] Brittonin A	OMe	OMe	OMe	OMe	OMe	OMe
[**6**] Chrysotobibenzyl	OMe	OMe	OMe	OMe	OMe	H
[**7**] Chrysotoxine	OMe	OH	OMe	OMe	OMe	H
[**8**] Crepidatin	OMe	OMe	OMe	OMe	OH	H
[**9**] Cumulatin	OMe	OMe	OH	OH	OMe	OMe
[**10**] 4,5 Dihydroxy-3,3'-dimethoxybibenzyl	OH	OH	OMe	H	H	OMe
[**11**] 3,3′-Dihydroxy-4,5-dimethoxybibenzyl	OMe	OMe	OH	H	H	OH
[**12**] 3,4′-Dihydroxy-5-methoxybibenzyl	OH	H	OMe	H	OH	H
[**13**] 3,4′-Dihydroxy-5,5′-dimethoxydihydrostilbene	OH	H	OMe	OMe	OH	H

Figure 3. Structures of stilbenoids from *Dendrobium*

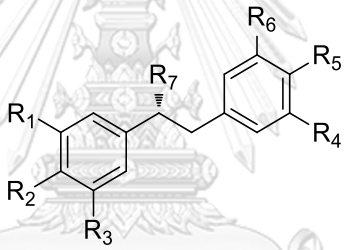


	R_1	R_2	R_3	R_4	R_5	R_6
[**14**] 4,5-Dihydroxy-3,3′-dimethoxybibenzyl						
	OMe	OH	OH	H	H	OMe
[**15**] Erianin	OMe	OMe	OMe	H	OMe	OH
[**16**] Gigantol	OMe	H	H	H	OH	OMe
[**17**] 4-Hydroxy-3,5,3′-trimethoxybibenzyl						
	OMe	OH	OMe	H	H	OMe
[**18**] 5-Hydroxy-3,4,3′,4′,5′-pentamethoxybibenzyl						
	OMe	OMe	OH	OMe	OMe	OMe
[**19**] Isoamoenylin	OMe	OMe	OMe	H	H	OH
[**20**] Moniliformine	OH	OH	OMe	H	OMe	H
[**21**] Moscatilin	OMe	OH	OMe	H	OH	OMe
[**22**] 3,3′,4-Trihydroxybibenzyl	OH	OH	H	H	H	OH
[**23**] 3,3′,5-Trihydroxybibenzyl	OH	H	OH	H	H	OH
[**24**] 3,5,4′-Trihydroxybibenzyl	OH	H	OH	H	OH	H

Figure 3. Structures of stilbenoids from *Dendrobium* (continued)

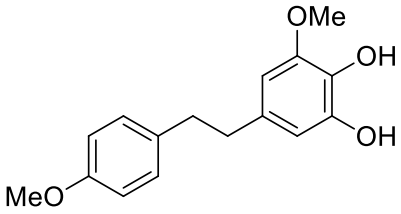


	R_1	R_2	R_3	R_4	R_5
[**25**] 4,5,4′-Trihydroxy-3-3′-dimethoxybibenzyl	OMe	OH	OH	OH	OMe
[**26**] Tristin	OH	H	OH	OH	OMe
[**27**] Dendromoniliside E	OGlc	OGlc	OMe	OMe	H
[**28**] 5,4′-Dihydroxy-3,4,3′-trimethoxybibenzyl	OH	OMe	OMe	OH	OMe
[**29**] 4,3′,4′-trihydroxy-3,5-dimethoxybibenzyl	OMe	OH	OMe	OH	OH

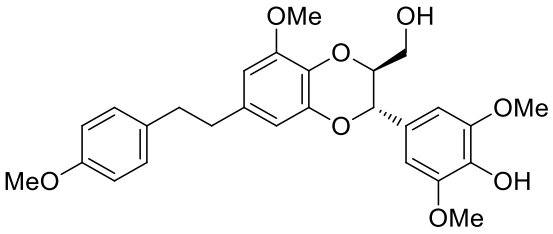


	R_1	R_2	R_3	R_4	R_5	R_6	R_7
[**30**] Dendrophenol	OMe	OH	OMe	OH	OH	H	H
[**31**] 3,4-Dihydroxy-5,4′-dimethoxybibenzyl	OH	OH	OMe	H	OMe	H	H
[**32**] 4,4′-Dihydroxy-3,5-dimethoxybibenzyl	OMe	OH	OMe	H	OH	H	H
[**33**] Loddigesiinol C	OMe	OH	OMe	H	OH	OMe	OMe
[**34**] 3-*O*-Methylgigantol	OMe	H	OH	OMe	OMe	H	H

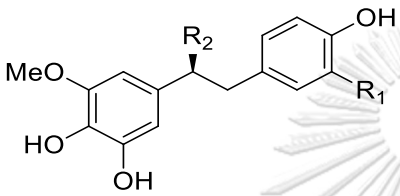
Figure 3. Structures of stilbenoids from *Dendrobium* (continued)



[**35**] Dendrocandin A



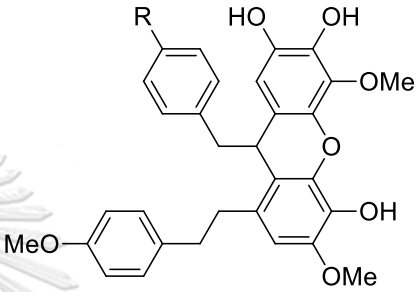
[**36**] Dendrocandin B



[**37**] Dendrocandin C R_1 = H R_2 = OMe

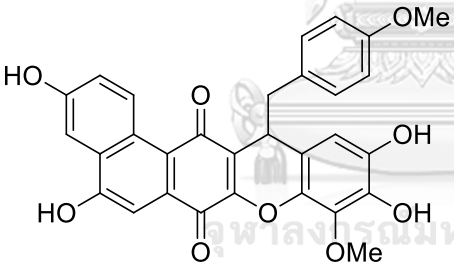
[**38**] Dendrocandin D R_1 = H R_2 = OEt

[**39**] Dendrocandin E R_1 = OH R_2 = H

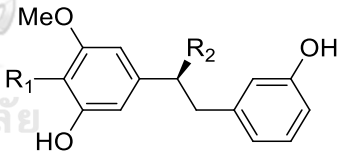


[**40**] Dendrocandin F R = OMe

[**41**] Dendrocandin G R = OH



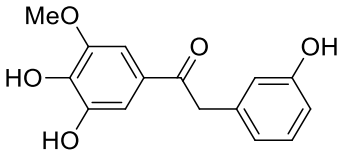
[**42**] Dendrocandin H



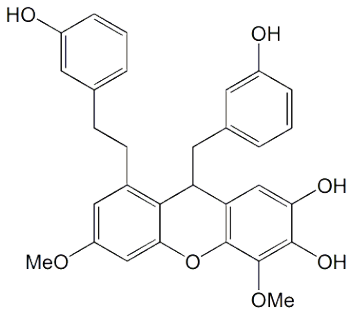
[**43**] Dendrosinen A R_1 = OMe R_2 = OH

[**44**] Dendrosinen B R_1 = OH R_2 = H

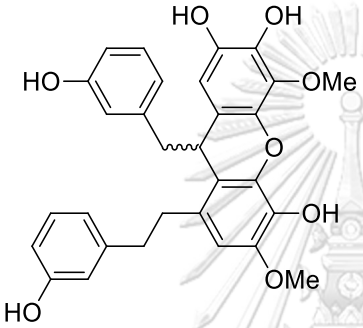
Figure 3. Structures of stilbenoids from *Dendrobium* (continued)



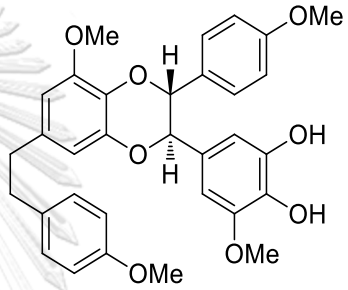
[**45**] Dendrosinen C



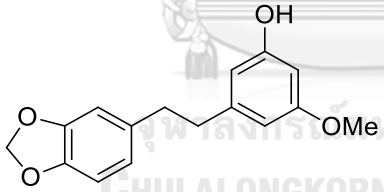
[**46**] Dendroscabrol B



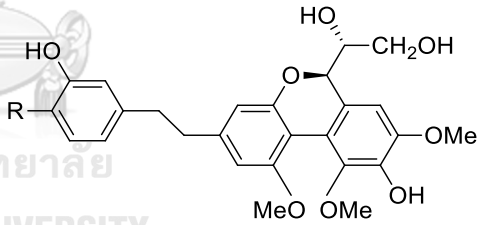
[**47**] Dendrosinen D



[**48**] Dendrocandin I



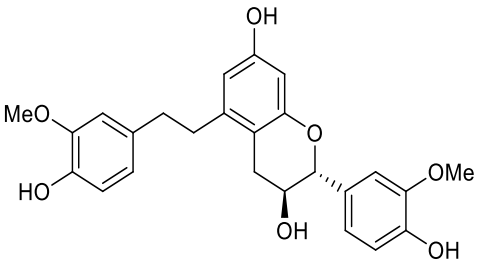
[**49**] Densiflorol A



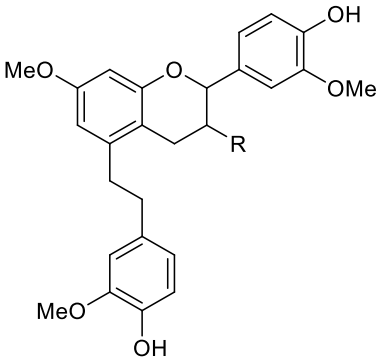
[**50**] Longicornuol A R = H

[**51**] Trigonopol A R = OMe

Figure 3. Structures of stilbenoids from *Dendrobium* (continued)

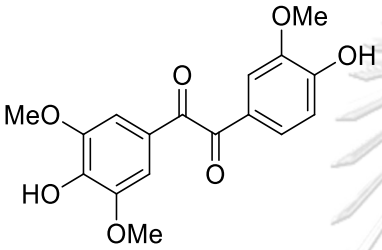


[**52**] Trigonopol B

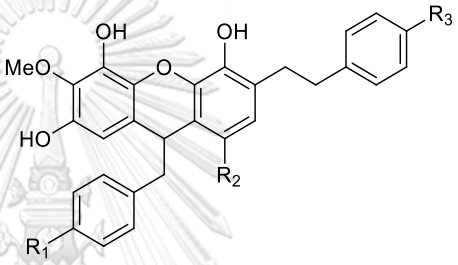


[**53**] Crepidatuol A R = H

[**54**] Crepidatuol B R = OH

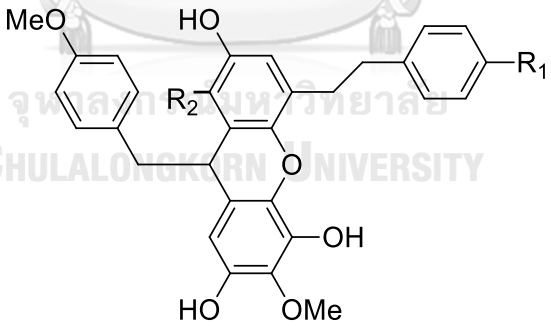


[**55**] Loddigesiinol D



[**56**] Dencryol A R_1 = OMe R_2 = R_3 = OH

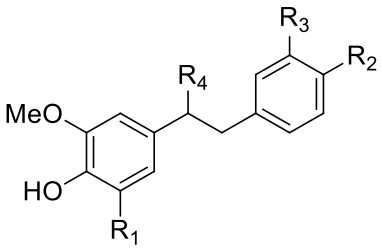
[**57**] Dencryol B R_1 = OH R_2 = R_3 = OMe



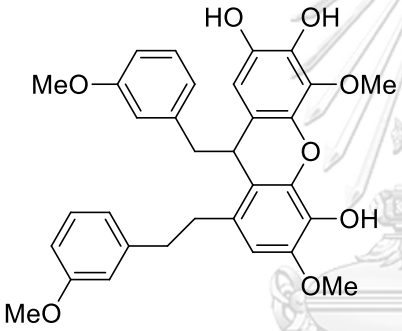
[**58**] Dengraol A R_1 = R_2 = OH

[**59**] Dengraol B R_1 = R_2 = OMe

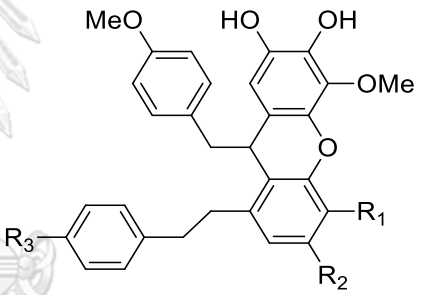
Figure 3. Structures of stilbenoids from *Dendrobium* (continued)



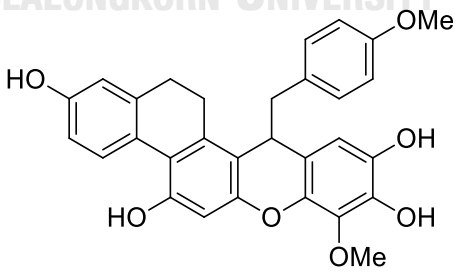
	R_1	R_2	R_3	R_4
[**60**] 4-[2-(3-Hydroxyphenol)-1-methoxyethyl]-2,6-dimethoxyphenol	OMe	H	OH	OMe
[**61**] Nobilin A	OH	H	OMe	OMe
[**62**] Nobilin B	OMe	OH	OMe	OMe
[**63**] Nobilin C	OMe	OMe	OMe	OMe
[**64**] Nobilin D	OMe	OH	OMe	OH



[**65**] Nobilin E

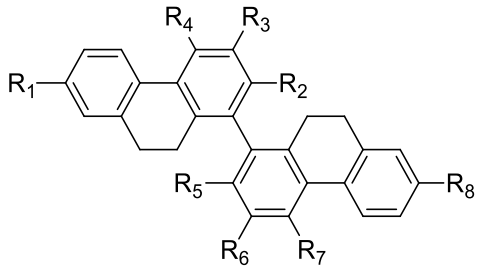


[**66**] Dendrofalconerol A	R_1 = OH	R_2 = R_3 = OMe
[**67**] Dendrofalconerol B	R_1 = H	R_2 = R_3 = OH

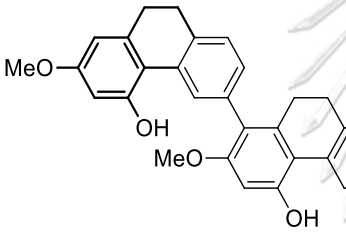


[**68**] Dendrosignatol

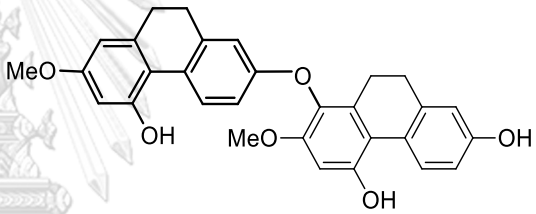
Figure 3. Structures of stilbenoids from *Dendrobium* (continued)



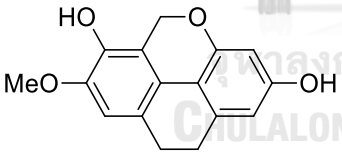
	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8
[**69**] 2,2′-Dihydroxy-3,3′,4,4′,7,7′-hexa methoxy-9,9′,10,10′-tetrahydro-1,1′-biphenanthrene	OMe	OH	OMe	OMe	OH	OMe	OMe	OMe
[**70**] 2,2′-Dimethoxy-4,4′,7,7′-tetrahydroxy-9,9′,10,10′-tetrahydro-1,1′-biphenanthrene	OH	OMe	H	OH	OMe	H	OH	OH
[**71**] Flavanthrin	OH	OH	H	OMe	OH	H	OMe	OH



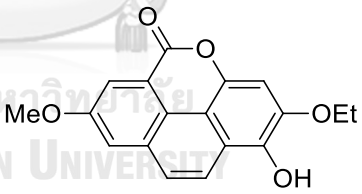
[**72**] Phoyunnanin C



[**73**] Phoyunnanin E

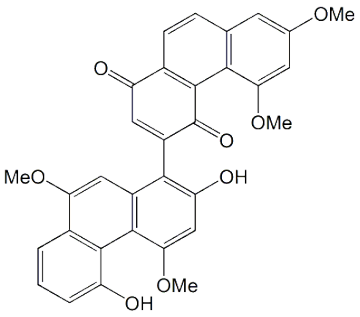


[**74**] Amoenumin

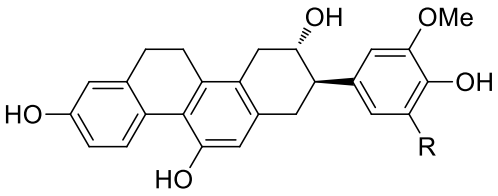


[**75**] Crystalltone

Figure 3. Structures of stilbenoids from *Dendrobium* (continued)

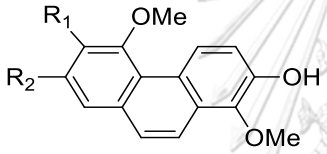


[**76**] Dendropalpebrone



[**77**] Chrysotoxol A R = H

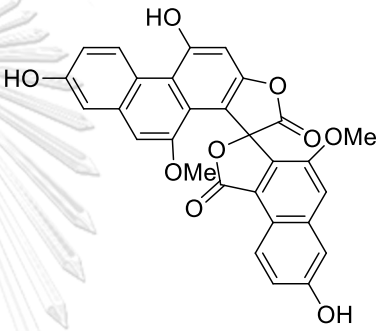
[**78**] Chrysotoxol B R = OMe



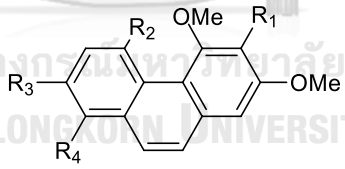
[**79**] Confusarin R_1 = OMe R_2 = OH

[**80**] 2,6-Dihydroxy-1,5,7-trimethoxyphenanthrene

R_1 = OH R_2 = OMe

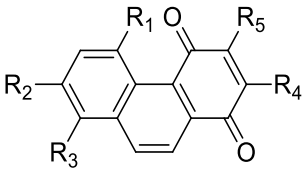


[**81**] Dendrochrysanene

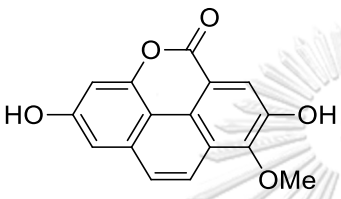


	R_1	R_2	R_3	R_4
[**82**] Bulbophyllanthrin	OH	OH	H	H
[**83**] 5-Hydroxy-2,4-dimethoxy phenanthrene	H	OH	H	H
[**84**] 3-Hydroxy-2,4,7-trimethoxy phenanthrene	OH	H	OMe	H

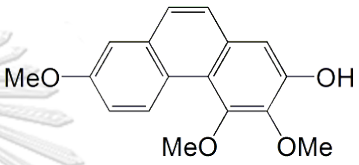
Figure 3. Structures of stilbenoids from *Dendrobium* (continued)



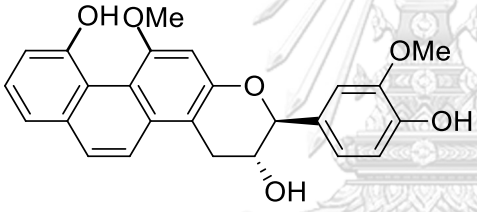
	R_1	R_2	R_3	R_4	R_5
[**85**] Cypripedin	H	OH	OMe	OMe	H
[**86**] Densiflorol B	H	OH	H	OMe	H
[**87**] Denbinobin	OH	OMe	H	H	OMe



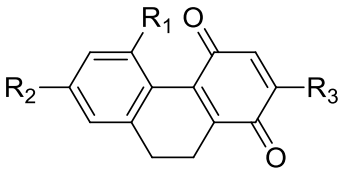
[**88**] Fimbriatone



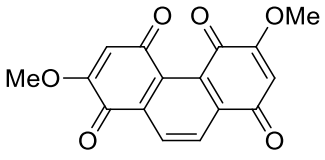
[**89**] Dendroscabrol A



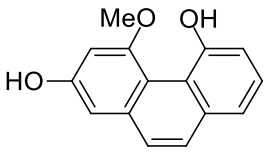
[**90**] Loddigesiinol B



	R_1	R_2	R_3
[**91**] Dendronone	OH	OMe	H
[**92**] Ephemeranthoquinone	H	OH	OMe
[**93**] 5-Methoxy-7-hydroxy-9,10-dihydro-1,4-phenanthrenequinone	OMe	OH	H

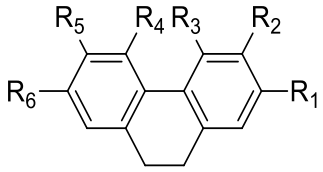


[**94**] Moniliformin



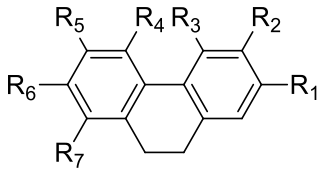
[**95**] Moscatin

Figure 3. Structures of stilbenoids from *Dendrobium* (continued)



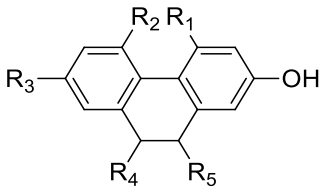
	R_1	R_2	R_3	R_4	R_5	R_6
[**96**] Coelonin	OH	H	OMe	H	H	OH
[**97**] 9,10-Dihydromoscatin	H	H	OH	OMe	H	OH
[**98**] 9,10-Dihydrophenanthrene-2,4,7-triol	OH	H	OH	H	H	OH
[**99**] 4,5-Dihydroxy-2,3-dimethoxy-9,10-dihydrophenanthrene	OMe	OMe	OH	OH	H	H
[**100**] 4,5-Dihydroxy-2,6-dimethoxy-9,10-dihydrophenanthrene	OMe	H	OH	OH	OMe	H
[**101**] 4,5-Dihydroxy-3,7-dimethoxy-9,10-dihydrophenanthrene	H	OMe	OH	OH	H	OMe
[**102**] 4,5-Dihydroxy-2-methoxy-9,10-dihydrophenanthrene	OMe	H	OH	OH	H	H
[**103**] Lusianthridin	OMe	H	OH	H	H	OH

Figure 3. Structures of stilbenoids from *Dendrobium* (continued)

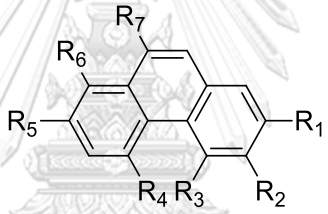


	R_1	R_2	R_3	R_4	R_5	R_6	R_7
[**104**] 2,7-Dihydroxy-3,4,6-trimethoxy-9,10-dihydrophenanthrene	OH	OMe	OMe	H	OMe	OH	H
[**105**] 2,8-Dihydroxy-3,4,7-trimethoxy-9,10-dihydrophenanthrene	OH	OMe	OMe	H	H	OMe	OH
[**106**] 4,7-Dihydroxy-2,3,6-trimethoxy-9,10-dihydrophenanthrene	OMe	OMe	OH	H	OMe	OH	H
[**107**] Ephemeranthol A	OH	H	H	OH	OMe	OMe	H
[**108**] Ephemeranthol C	OH	OH	OMe	OH	H	H	H
[**109**] Erianthridin	OH	OMe	OMe	H	H	OH	H
[**110**] Flavanthridin	OH	H	H	OMe	OH	OMe	H
[**111**] Hircinol	OH	H	OMe	OH	H	H	H
[**112**] 3-Hydroxy-2,4,7-trimethoxy-9,10-dihydro-phenanthrene	OMe	OH	OMe	H	H	OMe	H
[**113**] 7-hydroxy-2,3,4-trimethoxy-9,10-dihydrophenanthrene	OH	H	H	OMe	OMe	OMe	H
[**114**] Dendroinfundin A	OMe	OMe	OH	H	H	OMe	H
[**115**] Dendroinfundin B	OMe	OMe	OH	OH	H	H	OMe
[**116**] 3,4-Dimethoxy-1-(methoxymethyl)-9,10-dihydrophenanthrene-2,7-diol	OH	H	H	OMe	OMe	OH	$-CH_2OMe$

Figure 3. Structures of stilbenoids from *Dendrobium* (continued)

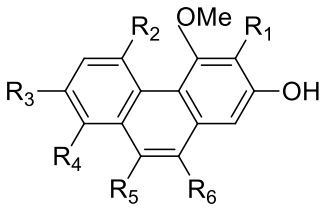


	R_1	R_2	R_3	R_4	R_5
[**117**] 2-Hydroxy-4,7-dimethoxy-9,10-dihydrophenanthrene	OMe	H	OMe	H	H
[**118**] 7-Methoxy-9,10-dihydrophenanthrene-2,4,5-triol	OH	OH	OMe	H	H
[**119**] 2,5,7-Trihydroxy-4-methoxy-9,10-dihydrophenanthrene	OMe	OH	OH	H	H
[**120**] Plicatol C	H	OMe	OH	H	OMe
[**121**] Rotundatin	H	OMe	OH	H	OH

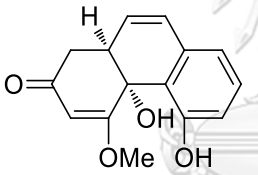


	R_1	R_2	R_3	R_4	R_5	R_6	R_7
[**122**] 2,5-Dihydroxy-3,4-dimethoxyphenanthrene	OH	OMe	OMe	OH	H	H	H
[**123**] 2,5-Dihydroxy-4,9-dimethoxyphenanthrene	OH	H	OMe	OH	H	H	OMe
[**124**] 2,8-Dihydroxy-3,4,7-trimethoxyphenanthrene	OH	OMe	OMe	H	OMe	OH	H
[**125**] Epheranthol B	H	H	OMe	OH	OMe	H	H
[**126**] Fimbriol B	OH	OMe	OH	H	H	H	H
[**127**] Flavanthrinin	H	H	OMe	H	OH	H	H

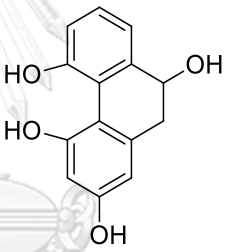
Figure 3. Structures of stilbenoids from *Dendrobium* (continued)



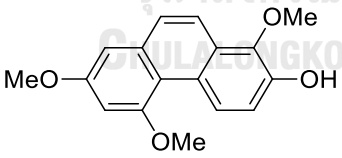
	R_1	R_2	R_3	R_4	R_5	R_6
[**128**] Loddigesiinol A	H	OMe	H	H	OH	H
[**129**] Nudol	OMe	H	OH	H	H	H
[**130**] Plicatol A	H	OH	H	H	OMe	OMe
[**131**] Plicatol B	H	OH	H	H	H	H
[**132**] 2,3,5-Trihydroxy-4,9-dimethoxyphenanthrene	OH	OH	H	H	OMe	H
[**133**] 3,4,8-Trimethoxyphenanthrene-2,5-diol	OMe	OH	H	OMe	H	H



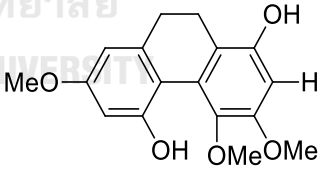
[**134**] Aphyllone A



[**135**] 2,4,5,9*S*-Tetrahydroxy-9,10-dihydrophenanthrene

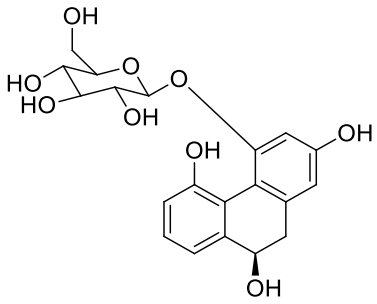


[**136**] 1,5,7-Trimethoxyphenanthren-2-ol

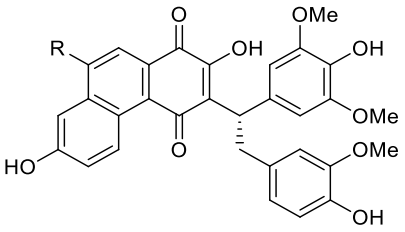


[**137**] 1,5-Dihydroxy-3,4,7-trimethoxy-9,10-dihydrophenanthrene

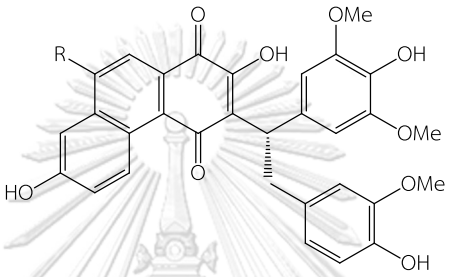
Figure 3. Structures of stilbenoids from *Dendrobium* (continued)



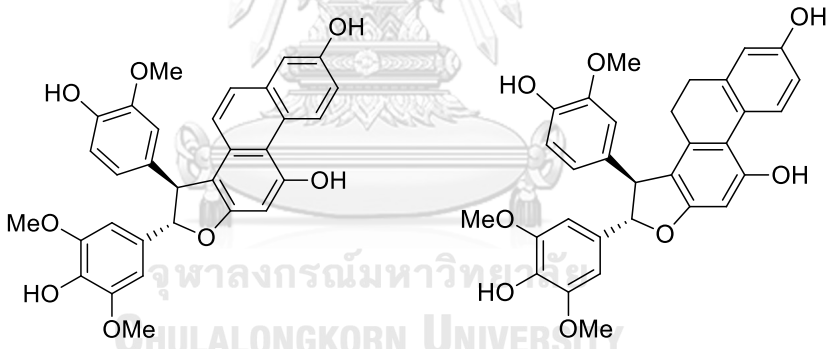
[**138**] 2,5,9*S*-Trihydroxy-9,10-dihydrophenanthrene -4-*O*-β-D-glucopyranoside



[**139**] Loddigesiinol G R = H

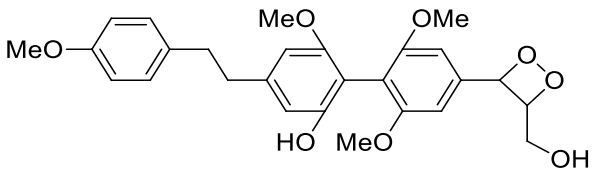


[**140**] Loddigesiinol H R = OH



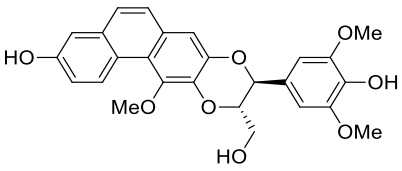
[**141**] Loddigesiinol I

[**142**] Loddigesiinol J

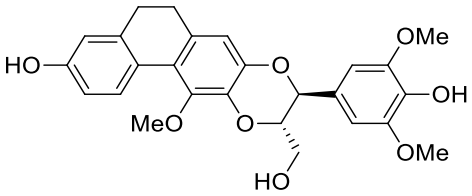


[**143**] Dendrowillol A

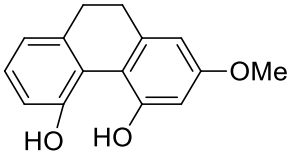
Figure 3. Structures of stilbenoids from *Dendrobium* (continued)



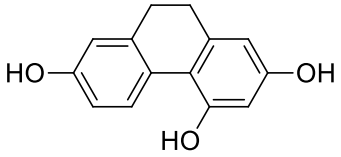
[**144**] Dendrocandin P1



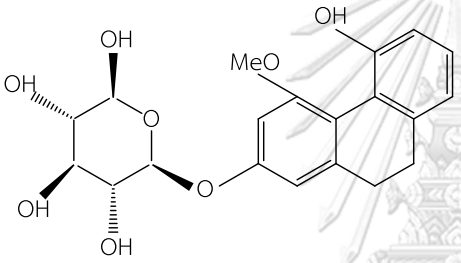
[**145**] Dendrocandin P2



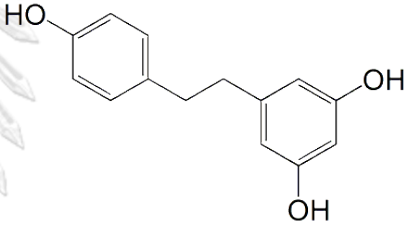
[**146**] Orchinol



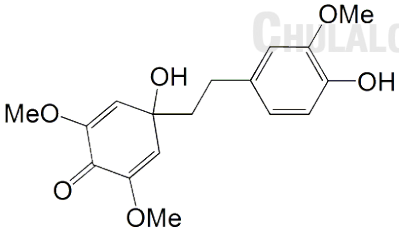
[**147**] 2,4,7-Trihydroxy-9,10-dihydrophenanthrene



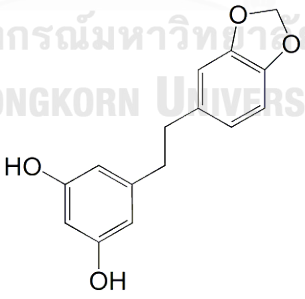
[**148**] 2,5-dihydroxy-4-methoxy-phenanthrene 2-O-β-D-glucopyranoside



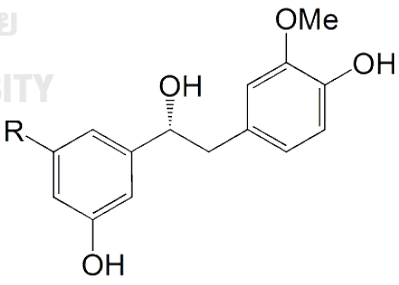
[**149**] Dihydroresveratrol



[**150**] Aphyllone B



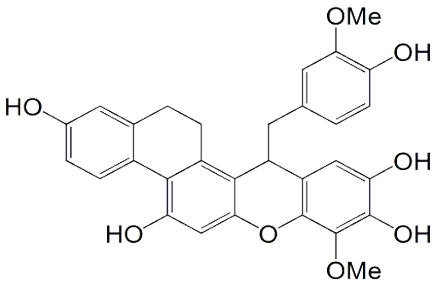
[**151**] Aphyllal C



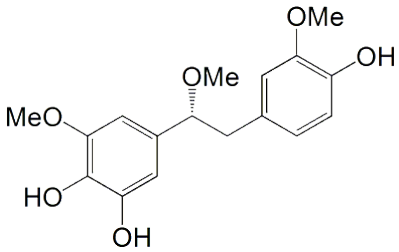
[**152**] Aphyllal D R = OH

[**153**] Aphyllal E R = Ome

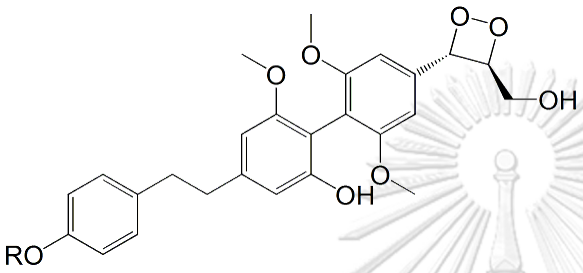
Figure 3. Structures of stilbenoids from *Dendrobium* (continued)



[**154**] (–)-dendroparishiol

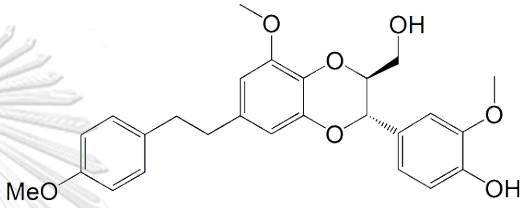


[**155**] (*R*)-4,5,4'-trihydroxy-3,3',α-trimethoxybibenzyl

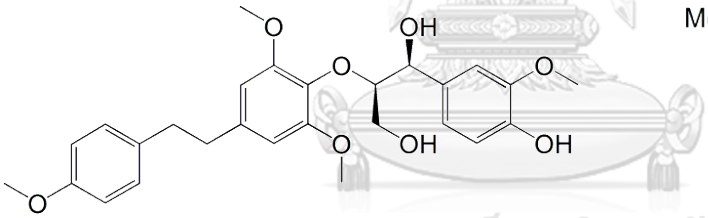


[**156**] 6″-de-O-methyldendrofindlaphenol A R = Me

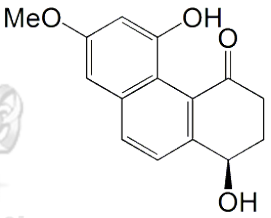
[**157**] 6″-de-O-methyldendrofindlaphenol A R = H



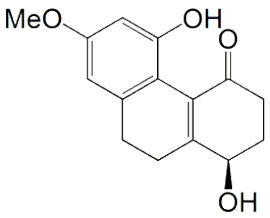
[**158**] Dendrofindlaphenol B



[**159**] Dendrofindlaphenol C



[**160**] Dendrodevonin A



[**161**] Dendrodevonin B

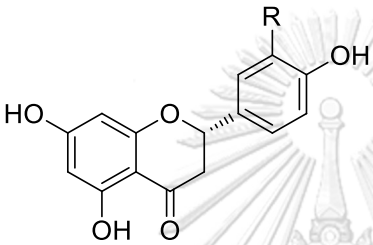
Figure 3. Structures of stilbenoids from *Dendrobium* (continued)

Table 2. Flavonoids from genus *Dendrobium*

Flavonoids	Plant	Plant part	Reference
(2*S*)-Homoeriodictyol [**162**]	*D. densiflorum*	Stem	(C. Fan *et al*., 2001)
	D. ellipsophyllum	Whole plant	(Tanagornmeatar *et al*., 2014)
Naringenin [**163**]	*D. aurantiacum* var. *denneanum*	Stem	(L. Yang, Wang, *et al*., 2006)
	D. densiflorum	Stem	(C. Fan *et al*., 2001)
	D. longicornu	Stem	(Hu *et al*., 2008a)
(2*S*)-Eriodictyol [**164**]	*D. trigonopus*	Stem	(Hu *et al*., 2008b)
	D. ellipsophyllum	Whole plant	(Tanagornmeatar *et al*., 2014)
	D. tortile	Whole plant	(Limpanit *et al*., 2016)
Vicenin-2 [**165**]	*D. aurantiacum* var. *denneanum*	Stem	(Xiong *et al*., 2013)
Apigenin [**166**]	*D. crystallinum*	Stem	(L. Wang *et al*., 2009)
	D. williamsonii	Whole plant	(Rungwichaniwat *et al*., 2014)
5,6-Dihydroxy-4′-methoxyflavone [**167**]	*D. chrysotoxum*	Stem	(Hu *et al*., 2012)
Chrysoeriol [**168**]	*D. ellipsophyllum*	Whole plant	(Tanagornmeatar *et al*., 2014)
Luteolin [**169**]	*D. aurantiacum* var. *denneanum*	Whole plant	(Liu *et al*., 2009)
	D. ellipsophyllum	Whole plant	(Tanagornmeatar *et al*., 2014)
6-*C*-(a-Arabino pyranosyl)-8-*C*-[(2-*O*-a-rhamnopyranosyl)-β-galactopyranosyl] apigenin [**170**]	*D. huoshanense*	Aerial part	(C. C. Chang *et al*., 2010)

Flavonoids	Plant	Plant part	Reference
6-*C*-(a-Arabinopyranosyl)-8-*C*-[(2-*O*-a-rhamnopyranosyl)-β-glucopyranosyl] apigenin [**171**]	*D. huoshanense*	Aerial part	(C. C. Chang *et al*., 2010)
6‴-Glucosyl-vitexin [**172**]	*D. crystallinum*	Stem	(L. Wang *et al*., 2009)
Isoschaftoside [**173**]	*D. huoshanense*	Aerial part	(C. C. Chang *et al*., 2010)
Isoviolanthin [**174**]	*D. crystallinum*	Stem	(L. Wang *et al*., 2009)
6-*C*-[(2-*O*-a-Rhamno pyranosyl)-β-gluco pyranosyl]-8-*C*-(a-arabinopyranosyl) apigenin [**175**]	*D. huoshanense*	Aerial part	(C. C. Chang *et al*., 2010)
6-*C*-(β-Xylopyranosyl)-8-*C*-[(2-*O*-a-rhamnopyranosyl)-β-gluco pyranosyl]apigenin [**176**]	*D. huoshanense*	Aerial part	(C. C. Chang *et al*., 2010)
Kaempferol [**177**]	*D. aurantiacum* var. *denneanum*	Stem	(L. Yang, Wang, *et al*., 2006)
Kaempferol-3-*O*-a-L rhamnopyranoside [**178**]	*D. secundum*	Stem	(Phechrmeekha *et al*., 2012)
Kaempferol-3,7-*O*-di-a-L-rhamnopyranoside [**179**]	*D. secundum*	Stem	(Phechrmeekha *et al*., 2012)
Kaempferol-3-*O*-a-L-rhamnopyranosyl-(1⟶2)-β-D-gluco pyranoside [**180**]	*D. capillipes*	Stem	(Phechrmeekha *et al*., 2012)
Kaempferol-3-*O*-a-L-rhamnopyranosyl-(1⟶2)-β-D-xylopyranoside [**181**]	*D. capillipes*	Stem	(Phechrmeekha *et al*., 2012)
Quercetin-3-*O*-a-L-rhamnopyranoside [**182**]	*D. secundum*	Stem	(Phechrmeekha *et al*., 2012)
Quercetin-3-*O*-a-L-rhamnopyranosyl-(1⟶2)-β-D-xylopyranoside [**183**]	*D. capillipes*	Stem	(Phechrmeekha *et al*., 2012)

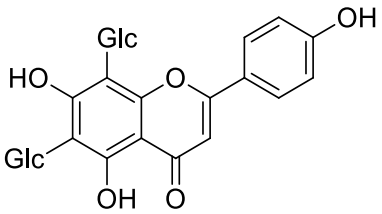
Flavonoids	Plant	Plant part	Reference
5-Hydroxy-3-methoxy-flavone-7-*O*-[β-D-apiosyl-(1⟶6)]-β-D-glucoside [**184**]	*D. devonianum*	Stem	(Sun *et al*., 2014)
Isorhamnetin-3-*O*-β-D-rutinoside [**185**]	*D. nobile*	Stem	(Zhou *et al*., 2017)
(*S*)-5,5′,7-trihydroxy-3′,4′-dimethoxyflavanone [**186**]	*D. loddigesii*	Stem	(R. J. Ma *et al*., 2019)



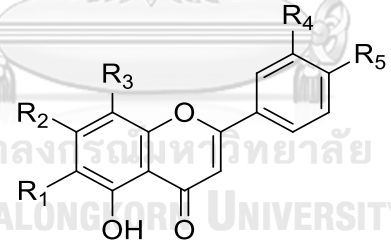
[**162**] (2*S*)-Homoeriodictyol R = OMe

[**163**] Naringenin R = H

[**164**] (2*S*)-Eriodictyol R = OH

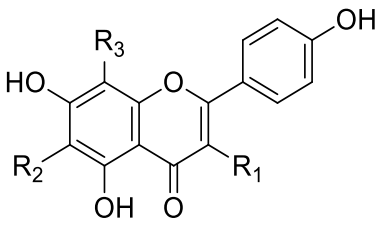


[**165**] Vicenin-2

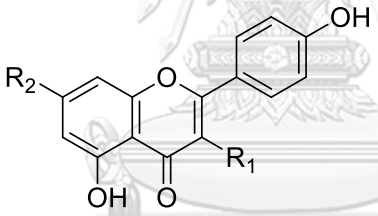


	R_1	R_2	R_3	R_4	R_5
[**166**] Apigenin	H	OH	H	H	OH
[**167**] 5,6-Dihydroxy-4′-methoxyflavone	OH	H	H	H	OMe
[**168**] Chrysoeriol	H	OH	H	OMe	OH
[**169**] Luteolin	H	OH	H	OH	OH
[**170**] 6-*C*-(a-Arabinopyranosyl)-8-*C*-[(2-*O*-a-rhamnopyranosyl)-β-galactopyranosyl]apigenin	-Ara	OH	-Gal-Rha	H	OH
[**171**] 6-*C*-(a-Arabinopyranosyl)-8- *C*-[(2-*O*-a-rhamnopyranosyl)-β-glucopyranosyl]apigenin	-Ara	OH	-Glc-Rha	H	OH

Figure 4. Structures of flavonoids from *Dendrobium*

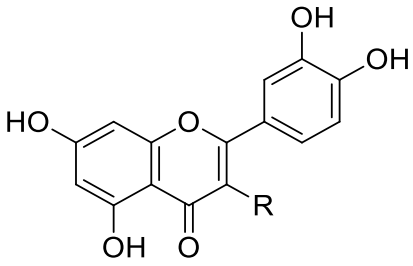


	R_1	R_2	R_3
[**172**] 6‴-Glucosyl-vitexin	H	H	-Glc
[**173**] Isoschaftoside	H	-Ara	-Glc
[**174**] Isoviolanthin	H	-Rha	-Glc
[**175**] 6-*C*-[(2-*O*-a-Rhamnopyranosyl)-β-glucopyranosyl]-8-*C*-(a-arabinopyranosyl)apigenin	H	-Glc-Rha	-Ara
[**176**] 6-*C*-(β-Xylopyranosyl)-8-*C*-[(2-*O*-a-rhamnopyranosyl)-β-glucopyranosyl]apigenin	H	-Xyl	-Glc-Rha
[**177**] Kaempferol	OH	H	H



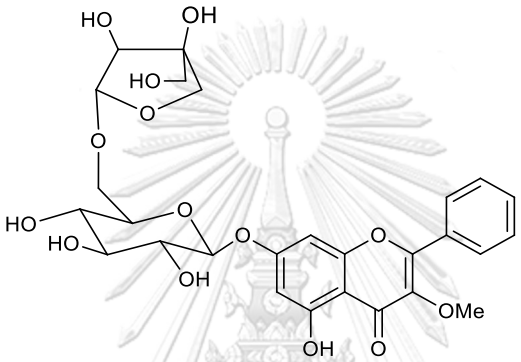
	R_1	R_2
[**178**] Kaempferol-3-*O*-a-L-rhamnopyranoside	O-Rha	OH
[**179**] Kaempferol-3,7-*O*-di-a-L-rhamnopyranoside	O-Rha	O-Rha
[**180**] Kaempferol-3-*O*-a-L-rhamnopyranosyl-(1→2)-β-D-glucopyranoside	O-Glc-Rha	OH
[**181**] Kaempferol-3-*O*-a-L-rhamnopyranosyl-(1→2)-β-D-xylopyranoside	O-Xyl-Rha	OH

Figure 4. Structures of flavonoids from *Dendrobium* (continued)

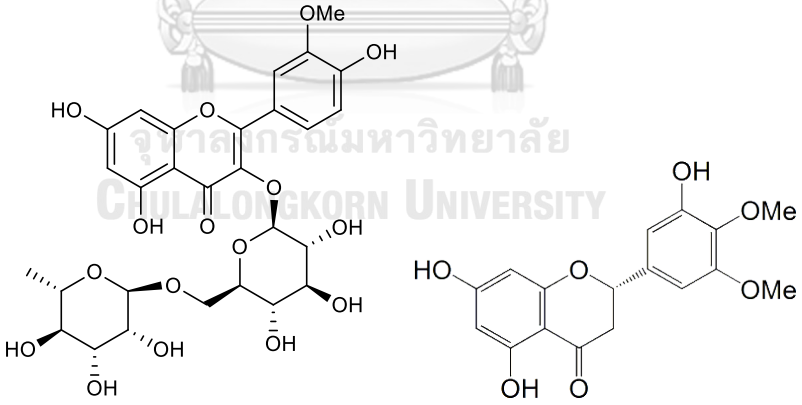


[**182**] Quercetin-3-*O*-a-L-rhamnopyranoside R = O-Rha

[**183**] Quercetin-3-*O*-a-L-rhamnopyranosyl-(1→2)-β-D-xylopyranoside R = O-Xyl-Rha



[**184**] 5-Hydroxy-3-methoxy-flavone-7-*O*-[β-D-apiosyl-(1→6)]-β-D-glucoside



[**185**] Isorhamnetin-3-*O*-β-D-rutinoside [**186**] (*S*)-5,5′,7-trihydroxy-3′,4′-dimethoxyflavanone

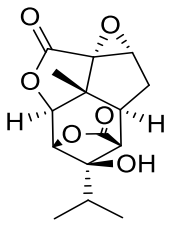
Figure 4. Structures of flavonoids from *Dendrobium* (continued)

Table 3. Terpenoids from *Dendrobium*

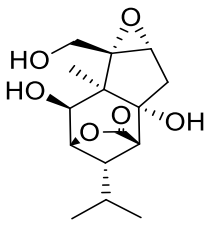
Terpenoids	Plant	Plant part	Reference
Aduncin [**187**]	*D. aduncum*	Whole plant	(Gawell & Leander, 1976)
Amoenin [**188**]	*D. amoenum*	Whole plant	(Dahmen & Leander, 1978; Majumder *et al*., 1999)
Amotin [**189**]	*D. amoenum*	Whole plant	(Dahmen & Leander, 1978; Majumder *et al*., 1999)
asiatic acid [**190**]	*D. parishii*	Whole plant	(Klongkumnuankarn *et al*., 2015)
a-Dihydropicrotoxinin [**191**]	*D. moniliforme*	Stem	(Bi *et al*., 2004)
Dendrobane A [**192**]	*D. nobile*	Stem	(X. Zhang, H. Gao, *et al*., 2007)
Dendronobilin A [**193**]	*D. nobile*	Stem	(Xue Zhang *et al*., 2007)
Dendronobilin B [**194**]	*D. nobile*	Stem	(Xue Zhang *et al*., 2007)
Dendronobilin C [**195**]	*D. nobile*	Stem	(Xue Zhang *et al*., 2007)
Dendronobilin D [**196**]	*D. nobile*	Stem	(Xue Zhang *et al*., 2007)
Dendronobilin E [**197**]	*D. nobile*	Stem	(Xue Zhang *et al*., 2007)
Dendronobilin F [**198**]	*D. nobile*	Stem	(Xue Zhang *et al*., 2007)
Dendronobilin G [**199**]	*D. nobile*	Stem	(Xue Zhang *et al*., 2007)
Dendronobilin H [**200**]	*D. nobile*	Stem	(Xue Zhang *et al*., 2007)
Dendronobilin I [**201**]	*D. nobile*	Stem	(Xue Zhang *et al*., 2007)
	D. findlayanum	Stem	(D. Yang *et al*., 2019)
Dendronobilin J [**202**]	*D. nobile*	Stem	(X. Zhang, H. Gao, *et al*., 2007)
Dendronobilin K [**203**]	*D. nobile*	Stem	(X. Zhang, F. J. Tu, *et al*., 2008)
Dendronobilin L [**204**]	*D. nobile*	Stem	(X. Zhang, F. J. Tu, *et al*., 2008)
Dendronobilin M [**205**]	*D. nobile*	Stem	(X. Zhang, F. J. Tu, *et al*., 2008)
Dendronobilin N [**206**]	*D. nobile*	Stem	(X. Zhang, F. J. Tu, *et al*., 2008)
	D. findlayanum	Stem	(D. Yang *et al*., 2019)

Terpenoids	Plant	Plant part	Reference
Dendrowardol A [**207**]	*D. wardianum*	Stem	(W. W. Fan *et al*., 2013)
Dendrowardol B [**208**]	*D. wardianum*	Stem	(W. W. Fan *et al*., 2013)
Dendrowardol C [**209**]	*D. wardianum*	Stem	(W. W. Fan *et al*., 2013)
Corchoionoside C [**210**]	*D. polyanthum*	Stem	(Hu *et al*., 2009)
Crystallinin [**211**]	*D. crystallinum*	Stem	(L. Wang *et al*., 2009)
	D. findlayanum	Whole plant	(Qin *et al*., 2011)
Findlayanin [**212**]	*D. findlayanum*	Whole plant	(Qin *et al*., 2011)
3-Hydroxy-2-oxodendrobine [**213**]	*D. nobile*	Stem	(H. Wang *et al*., 1985)
Dendrobine [**214**]	*D. nobile*	Stem	(H. Wang *et al*., 1985)
	D. findlayanum	Stem	(D. Yang *et al*., 2018)
2-Hydroxydendrobine [**215**]	*D. findlayanum*	Stem	(D. Yang *et al*., 2018)
Findlayine A [**216**]	*D. findlayanum*	Stem	(D. Yang *et al*., 2018)
Findlayine B [**217**]	*D. findlayanum*	Stem	(D. Yang *et al*., 2018)
Findlayine C [**218**]	*D. findlayanum*	Stem	(D. Yang *et al*., 2018)
Findlayine D [**219**]	*D. findlayanum*	Stem	(D. Yang *et al*., 2018)
Dendromoniliside A [220]	*D. moniliforme*	Stem	(C. S. Zhao *et al*., 2003)
Dendromoniliside B [**221**]	*D. moniliforme*	Stem	(C. S. Zhao *et al*., 2003)
Dendromoniliside C [**222**]	*D. moniliforme*	Stem	(C. S. Zhao *et al*., 2003)
Dendromoniliside D [**223**]	*D. moniliforme*	Stem	(C. S. Zhao *et al*., 2003)
Dendronobiloside A [**224**]	*D. nobile*	Stem	(W. M. Zhao *et al*., 2001); (Ye & Zhao, 2002)
Dendronobiloside B [**225**]	*D. nobile*	Stem	(Ye & Zhao, 2002; W. M. Zhao *et al*., 2001)
Dendronobiloside C [**226**]	*D. nobile*	Stem	(Ye & Zhao, 2002; W. M. Zhao *et al*., 2001)
Dendronobiloside D [**227**]	*D. nobile*	Stem	(Ye & Zhao, 2002; W. M. Zhao *et al*., 2001)
Dendronobiloside E [**228**]	*D. nobile*	Stem	(Ye & Zhao, 2002; W. M. Zhao *et al*., 2001)
Dendroside A [**229**]	*D. moniliforme*	Stem	(C. S. Zhao *et al*., 2003)
	D. nobile	Stem	(W. M. Zhao *et al*., 2001)
		Stem	(Ye & Zhao, 2002)

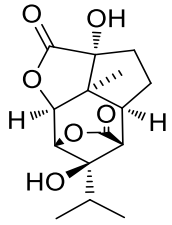
Terpenoids	Plant	Plant part	Reference
	D. findlayanum	Stem	(D. Yang *et al*., 2019)
Dendroside B [**230**]	*D. nobile*	Stem	(Ye & Zhao, 2002)
Dendroside C [**231**]	*D. moniliforme*	Stem	(C. S. Zhao *et al*., 2003)
	D. nobile	Stem	(Ye & Zhao, 2002)
Dendroside D [**232**]	*D. nobile*	Stem	(Ye & Zhao, 2002)
Dendroside E [**233**]	*D. nobile*	Stem	(Ye *et al*., 2002)
Dendroside F [**234**]	*D. moniliforme*	Stem	(Ye *et al*., 2002)
Dendroside G [**235**]	*D. nobile*	Stem	(Ye *et al*., 2002)
Dendrowillin A [**236**]	*D. williamsonii*	Whole plant	(M. Yang *et al*., 2019)
Dendrowillin B [**237**]	*D. williamsonii*	Whole plant	(M. Yang *et al*., 2019)
(–)-Picrotin [**238**]	*D. williamsonii*	Whole plant	(M. Yang *et al*., 2019)
10β,12,14-trihydroxyaromadendrane [**239**]	*D. findlayanum*	Stem	(D. Yang *et al*., 2019)
10β,13,14-trihydroxyaromadendrane [**240**]	*D. findlayanum*	Stem	(D. Yang *et al*., 2019)
Dendrofindlayanoside A [**241**]	*D. findlayanum*	Stem	(D. Yang *et al*., 2019)
Dendrofindlayanoside B [**242**]	*D. findlayanum*	Stem	(D. Yang *et al*., 2019)
Dendrofindlayanoside C [**243**]	*D. findlayanum*	Stem	(D. Yang *et al*., 2019)
Dendrofindlayanobilin [**244**]	*D. findlayanum*	Stem	(D. Yang *et al*., 2019)
(+)-(1R,2S,3R,4S,5R,6S,9R)-3,11,12-trihydroxypicrotoxane-2(15)-lactone [**245**]	*D. nobile*	Stem	(C. Ma *et al*., 2019)
(–)-(1S,2R,3S,4R,5S,6R,9S,12R)-3,11,13-trihydroxypicrotoxane-2(15)-lactone [**246**]	*D. nobile*	Stem	(C. Ma *et al*., 2019)
(+)-(1R,5R,6S,8R,9R)-8,12-dihydroxy-copacamphan-3-en-2-one [**247**]	*D. nobile*	Stem	(C. Ma *et al*., 2019)
Dendroterpene A [**248**]	*D. nobile*	Stem	(P. Wang *et al*., 2019)
Dendroterpene B [**249**]	*D. nobile*	Stem	(P. Wang *et al*., 2019)
Dendroterpene C [**250**]	*D. nobile*	Stem	(P. Wang *et al*., 2019)
Dendroterpene D [**251**]	*D. nobile*	Stem	(P. Wang *et al*., 2019)



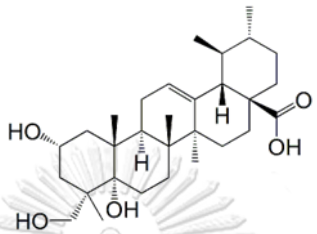
[**187**] Aduncin



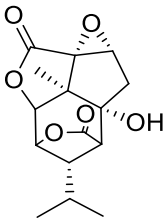
[**188**] Amoenin



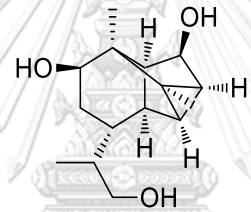
[**189**] Amotin



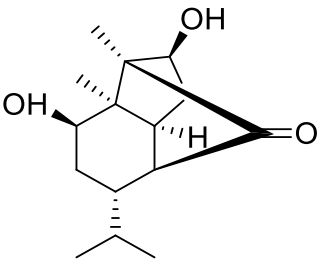
[**190**] Asiatic acid



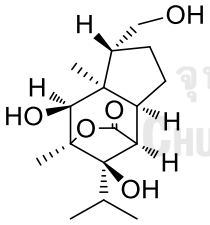
[**191**] a-Dihydropicrotoxinin



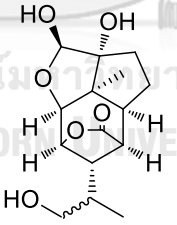
[**192**] Dendrobane A



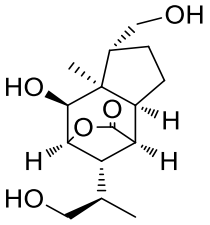
[**193**] Dendronobilin A



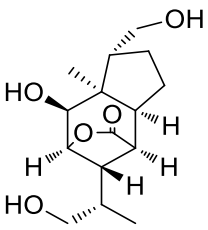
[**194**] Dendronobilin B



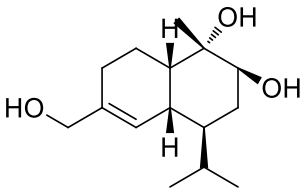
[**195**] Dendronobilin C



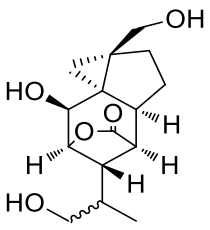
[**196**] Dendronobilin D



[**197**] Dendronobilin E

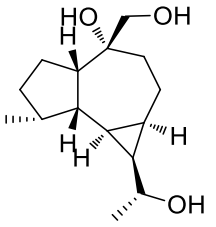


[**198**] Dendronobilin F

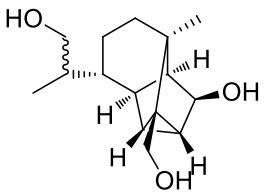


[**199**] Dendronobilin G

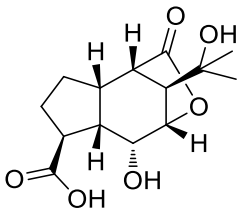
Figure 5. Structures of terpenoids from *Dendrobium*



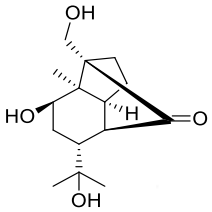
[**200**] Dendronobilin H



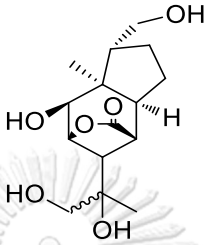
[**201**] Dendronobilin I



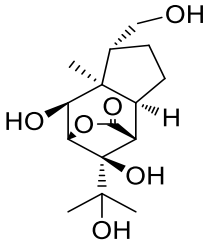
[**202**] Dendronobilin J



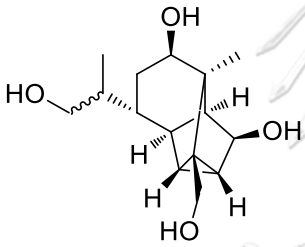
[**203**] Dendronobilin K



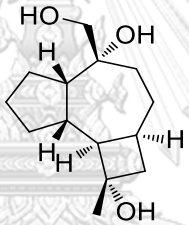
[**204**] Dendronobilin L



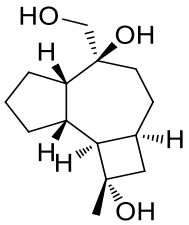
[**205**] Dendronobilin M



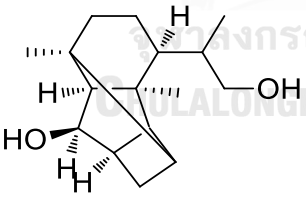
[**206**] Dendronobilin N



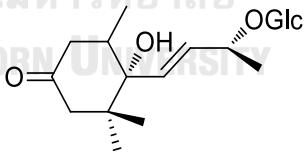
[**207**] Dendrowardol A



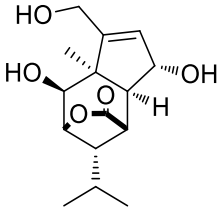
[**208**] Dendrowardol B



[**209**] Dendrowardol C

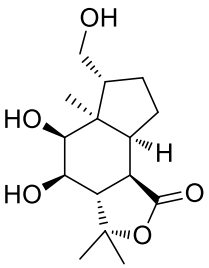


[**210**] Corchoionoside C

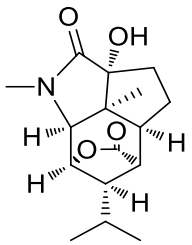


[**211**] Crystallinin

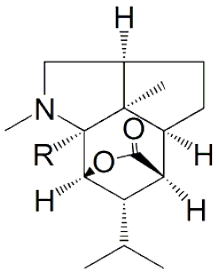
Figure 5. Structures of terpenoids from *Dendrobium* (continued)



[**212**] Findlayanin

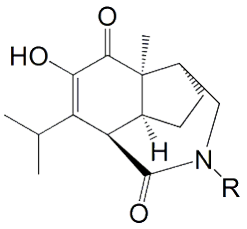


[**213**] 3-Hydroxy-2-oxodendrobine



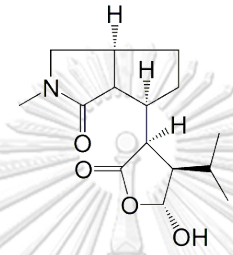
[**214**] Dendrobine: R = H

[**215**] 2-Hydroxydendrobine: R = OH

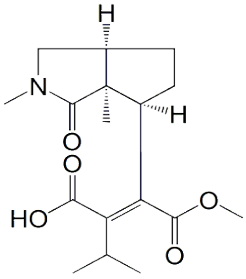


[**216**] Findlayine A R = Me

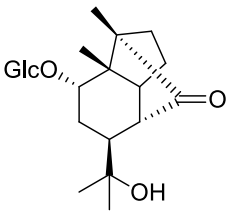
[**217**] Findlayine B R = H



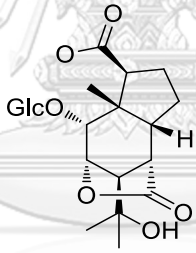
[**218**] Findlayine C



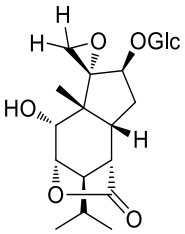
[**219**] Findlayine D



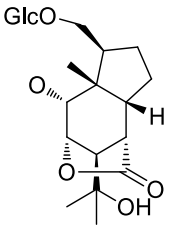
[**220**] Dendromoniliside A



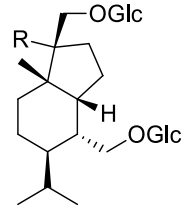
[**221**] Dendromoniliside B



[**222**] Dendromoniliside C

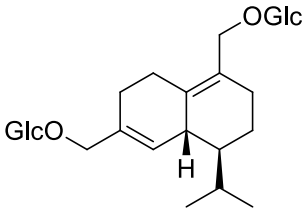


[**223**] Dendromoniliside D



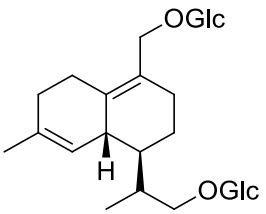
[**224**] Dendronobiloside A R = H

[**225**] Dendronobiloside B R = OH

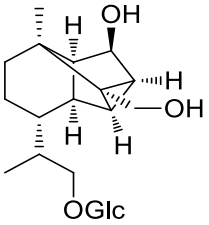


[**226**] Dendronobiloside C

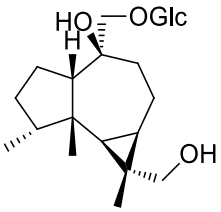
Figure 5. Structures of terpenoids from *Dendrobium* (continued)



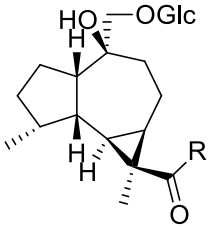
[**227**] Dendronobiloside D



[**228**] Dendronobiloside E

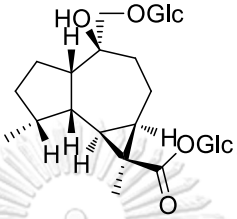


[**229**] Dendroside A

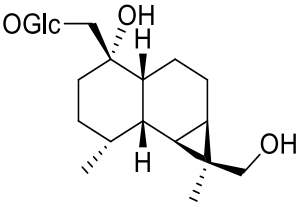


[**230**] Dendroside B R = OGlc

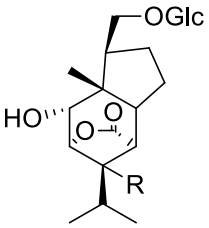
[**231**] Dendroside C R = OH



[**232**] Dendroside D

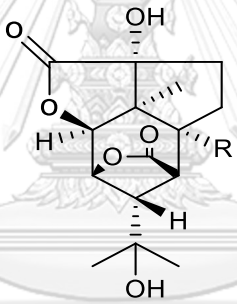


[**233**] Dendroside E



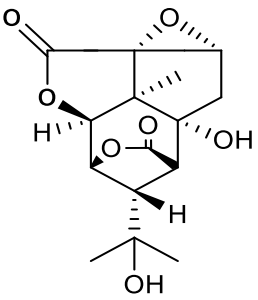
[**234**] Dendroside F R = H

[**235**] Dendroside G R = OH

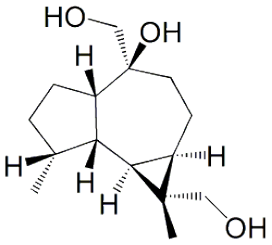


[**236**] Dendrowillin A R = OH

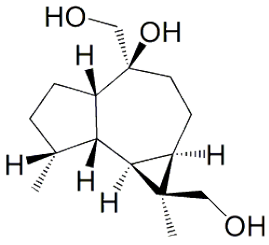
[**237**] Dendrowillin B R = H



[**238**] (–)-Picrotin

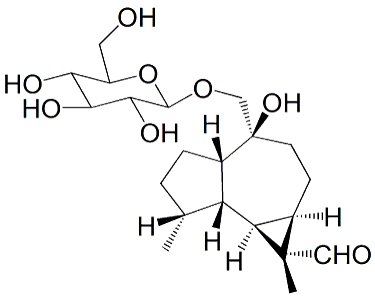


[**239**] 10β, 12, 14-trihydroxyaromadendrane

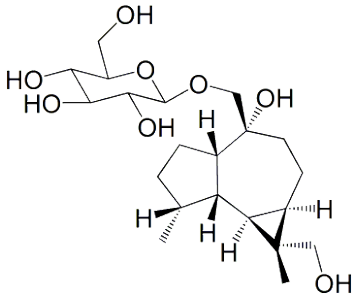


[**240**] 10β, 13, 14-trihydroxyaromadendrane

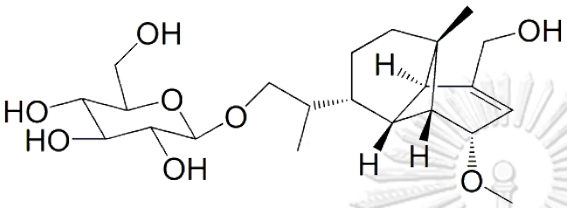
Figure 5. Structures of terpenoids from *Dendrobium* (continued)



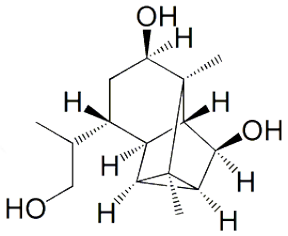
[**241**] Dendrofindlayanoside A



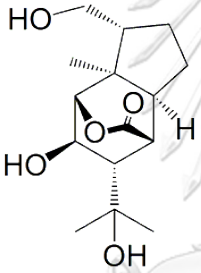
[**242**] Dendrofindlayanoside B



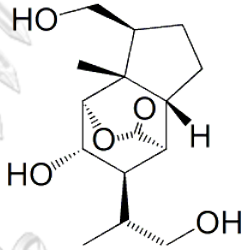
[**243**] Dendrofindlayanoside C



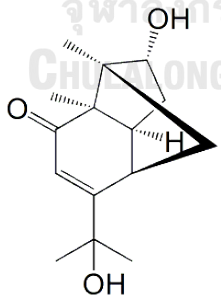
[**244**] Dendrofindlayanobilin



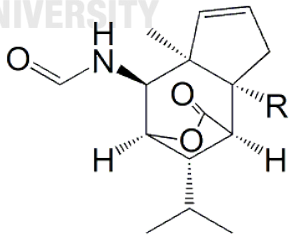
[**245**] (+)-(1R,2S,3R,4S,5R,6S,9R)-3,11,12-trihydroxypicrotoxane-2(15)-lactone



[**246**] (–)-(1S,2R,3S,4R,5S,6R,9S,12R)-3,11,13-trihydroxypicrotoxane-2(15)-lactone



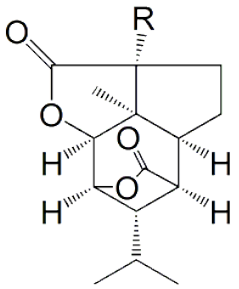
[**247**] (+)-(1R,5R,6S,8R,9R)-8,12-dihydroxy copacamphan-3-en-2-one



[**248**] Dendroterpene A: R = H

[**249**] Dendroterpene B: R = OH

Figure 5. Structures of terpenoids from *Dendrobium* (continued)



[**250**] Dendroterpene C R = H

[**251**] Dendroterpene D R = OH

Figure 5. Structures of terpenoids from *Dendrobium* (continued)

Table 1 Miscellaneous compounds from *Dendrobium*

Categories and compounds	Plant	Plant part	Reference
Aliphatic acid derivatives			
Aliphatic acids [**252**]	*D. clavatum* var. *aurantiacum*	Stem	(S. J. Chang *et al.*, 2001)
Aliphatic alcohols [**253**]	*D. clavatum* var. *aurantiacum*	Stem	(S. J. Chang *et al.*, 2001)
Malic acid [**254**]	*D. huoshanense*	Aerial part	(C. C. Chang *et al.*, 2010)
Dimethyl malate [**255**]	*D. huoshanense*	Aerial part	(C. C. Chang *et al.*, 2010)
(-)-Shikimic acid [**256**]	*D. fuscescens*	Whole plant	(Talapatra *et al.*, 1989)
	D. huoshanense	Aerial part	(C. C. Chang *et al.*, 2010)
	D. longicornu	Stem	(Hu *et al.*, 2008a)
	D. pulchellum	Stem	(Chanvorachote *et al.*, 2013)
Isopentyl butyrate [**257**]	*D. huoshanense*	Aerial part	(C. C. Chang *et al.*, 2010)
Dendrodevonic acid A [**258**]	*D. devonianum*	Stem	(Wu *et al.*, 2019)
Dendrodevonic acid B [**259**]	*D. devonianum*	Stem	(Wu *et al.*, 2019)
Benzoic acid derivatives and phenolic compounds			
3-Hydroxy-2-methoxy-5,6-dimethylbenzoic acid [**260**]	*D. crystallinum*	Stem	(L. Wang *et al.*, 2009)
Salicylic acid [**261**]	*D. huoshanense*	Aerial part	(C. C. Chang *et al.*, 2010)

Categories and compounds	Plant	Plant part	Reference
	D. williamsonii	Whole plant	(M. Yang *et al.*, 2018)
Vanilloside [**262**]	*D. denneanum*	Stem	(Pan *et al.*, 2012)
	D. moniliforme	Stem	(C. S. Zhao *et al.*, 2003)
Gallic acid [**263**]	*D. longicornu*	Whole plant	(J. T. Li *et al.*, 2009)
Syringic acid [**264**]	*D. crystallinum*	Stem	(L. Wang *et al.*, 2009)
Vanillic acid [**265**]	*D. chrysotoxum*	Whole plant	(Y. P. Li *et al.*, 2009)
	D. williamsonii	Whole plant	(Rungwichaniwat *et al.*, 2014)
Antiarol [**266**]	*D. chrysotoxum*	Stem	(Hu *et al.*, 2012)
Ethylhaematommate [**267**]	*D. longicornu*	Whole plant	(J. T. Li *et al.*, 2009)
p-Hydroxy benzaldehyde [**268**]	*D. devonianum*	Whole plant	(Sun *et al.*, 2014)
	D. falconeri	Stem	(Sritularak & Likhitwitayawuid, 2009)
	D. tortile	Whole plant	(Limpanit *et al.*, 2016)
	D. williamsonii	Whole plant	(M. Yang *et al.*, 2018)
Methyl β-orsellinate [**269**]	*D. longicornu*	Stem	(Hu *et al.*, 2008a)
Tachioside [**270**]	*D. denneanum*	Stem	(Pan *et al.*, 2012)
Alkyl 4′-hydroxy-*trans*-cinnamates [**271**]	*D. clavatum* var. *aurantiacum*	Stem	(S. J. Chang *et al.*, 2001)
Alkyl *trans*-ferulate [**272**]	*D. clavatum* var. *aurantiacum*	Stem	(S. J. Chang *et al.*, 2001)
	D. scabrilingue	Whole plant	(Sarakulwattana *et al.*, 2018)
Defuscin [**273**]	*D. fuscescens*	Whole plant	(Talapatra *et al.*, 1989)
	D. aurantiacum var. *denneanum*	Stem	(L. Yang, Wang, *et al.*, 2006)
n-Octacosyl ferulate [**274**]	*D. aurantiacum var. denneanum*	Stem	(L. Yang, Wang, *et al.*, 2006)
	D. moniliforme	Stem	(Bi *et al.*, 2004)
n-Triacontyl *p*-hydroxy-cis-cinnamate [**275**]	*D. moniliforme*	Stem	(Bi *et al.*, 2004)

Categories and compounds	Plant	Plant part	Reference
Tetratriacontanyl-*trans*-*p*-coumarate [**276**]	*D. williamsonii*	Whole plant	(Rungwichaniwat *et al.*, 2014)
p-hydroxyphenethyl-*trans*-ferulate [**277**]	*D. loddigesii*	Stem	(R. J. Ma *et al.*, 2019)
n-Docosyl *trans*-ferulate [**278**]	*D. longicornu*	Whole plant	(J. T. Li *et al.*, 2009)
	D. williamsonii	Whole plant	(Rungwichaniwat *et al.*, 2014)
trans-Tetracosyl ferulate [**279**]	*D. tortile*	Whole plant	(Limpanit *et al.*, 2016)
cis-Hexacosanoyl ferulate [**280**]	*D. tortile*	Whole plant	(Limpanit *et al.*, 2016)
Ferulaldehyde [**281**]	*D. longicornu*	Whole plant	(J. T. Li *et al.*, 2009)
Ferulic acid [**282**]	*D. secundum*	Stem	(Sritularak, Duangrak*, et al.*, 2011)
2-(*p*-Hydroxyphenyl) ethyl *p*-coumarate [**283**]	*D. falconeri*	Stem	(Sritularak & Likhitwitayawuid, 2009)
Dihydroconiferyl dihydro-*p*-coumarate [**284**]	*D. formosum*	Whole plant	(Inthongkaew *et al.*, 2017)
	D. loddigesii	Stem	(R. J. Ma *et al.*, 2019)
	D. devonianum	Stem	(Wu *et al.*, 2019)
	D. hainanense	Aerial part	(Y. Y. Zhang *et al.*, 2019)
1-[4-(β-D-Glucopyranosyloxy)-3,5-dimethoxyphenyl]-1-propanone [**285**]	*D. aurantiacum* var. *denneanum*	Stem	(Xiong *et al.*, 2013)
3-Hydroxy-1-(4-hydroxy-3,5-dimethoxyphenyl)-1-propanone [**286**]	*D. williamsonii*	Whole plant	(M. Yang *et al.*, 2018)

Categories and compounds	Plant	Plant part	Reference
2-Hydroxy-3-(4-hydroxy-3-methoxyphenyl)-3-methoxypropyl-3-(4-hydroxylphenyl)-propanoate [**287**]	*D. hainanense*	Aerial part	(Y. Y. Zhang *et al.*, 2019)
Coniferyl alcohol [**288**]	*D. trigonopus*	Stem	(Hu *et al.*, 2008b)
(*E*)-Coniferyl aldehyde [**289**]	*D. hainanense*	Aerial part	(Y. Y. Zhang *et al.*, 2019)
Sinapicaldehyde [**290**]	*D. hainanense*	Aerial part	(Y. Y. Zhang *et al.*, 2019)
Decumbic acid A [**291**]	*D. nobile*	Stem	(Zhou *et al.*, 2016)
Decumbic acid B [**292**]	*D. nobile*	Stem	(Zhou *et al.*, 2016)
(−)-Decumbic acid [**293**]	*D. nobile*	Stem	(Zhou *et al.*, 2016)
(+)-Dendrolactone [**294**]	*D. nobile*	Stem	(Zhou *et al.*, 2016)
4-(3-Hydroxyphenyl)-2-butanone [**295**]	*D. nobile*	Stem	(Zhou *et al.*, 2016)
3-Hydroxy-1(3-methoxy-4-hydroxyphenyl)-propan-1-one [**296**]	*D. nobile*	Stem	(Zhou *et al.*, 2016)
3′,4′,5′-Trimethoxy cinnamyl acetate [**297**]	*D. nobile*	Stem	(Zhou *et al.*, 2016)
Alatusol A [**298**]	*D. hainanense*	Aerial part	(Y. Y. Zhang *et al.*, 2019)
p-Hydroxyphenyl propionic methyl ester [**299**]	*D. aphyllum*	Whole plant	(Yegao Chen *et al.*, 2008)
Phloretic acid [**300**]	*D. ellipsophyllum*	Whole plant	(Tanagornmeatar *et al.*, 2014)
Dihydroconiferyl alcohol [**301**]	*D. longicornu*	Stem	(Hu *et al.*, 2008a)
Salidrosol [**302**]	*D. chrysotoxum*	Stem	(Hu *et al.*, 2012)
Shashenoside I [**303**]	*D. aurantiacum* var. *denneanum*	Stem	(Xiong *et al.*, 2013)
Syringin [**304**]	*D. aurantiacum* var. *denneanum*	Stem	(Xiong *et al.*, 2013)

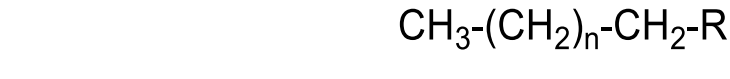
Categories and compounds	Plant	Plant part	Reference
Tetracosyl(*Z*)-*p*-coumarate [**305**]	*D. falconeri*	Whole plant	(Sritularak & Likhitwitayawuid, 2009)
(7*S*,8*R*)-Dehydrodiconiferyl alcohol 9′-β-D-glucopyranoside [**306**]	*D. nobile*	Stem	(Zhou *et al.*, 2017)
Koaburaside [**307**]	*D. nobile*	Stem	(Zhou *et al.*, 2017)
Juniperoside [**308**]	*D. nobile*	Stem	(Zhou *et al.*, 2017)
Dehydrodiconiferyl alcohol-4-β-D-glucoside [**309**]	*D. nobile*	Stem	(Zhou *et al.*, 2017)
(3*R*,3′*S*,4*R*,4′*S*)-3,3′,4,4′-Tetrahydro-6,6′-dimethoxy[3,3′-bi-2*H*-benzopyran]-4,4′-diol [**310**]	*D. williamsonii*	Whole plant	(M. Yang *et al.*, 2018)
threo-7-*O*-ethyl-9-*O*-(4-hydroxyphenyl) propionyl-guaiacyl glycerol [**311**]	*D. loddigesii*	Stem	(Ma, R. J., *et al.*, 2019b)
Coumarins			
Ayapin [**312**]	*D. densiflorum*	Stem	(Fan *et al.*, 2001)
Coumarin [**313**]	*D. aurantiacum* var. *denneanum*	Stem	(L. Yang, Wang, *et al.*, 2006)
	D. clavatum var. *aurantiacum*	Stem	(S. J. Chang *et al.*, 2001)
Denthyrsin [**314**]	*D. thyrsiflorum*	Stem	(G. N. Zhang *et al.*, 2005)
Scoparone [**315**]	*D. densiflorum*	Stem	(Fan *et al.*, 2001)
	D. thyrsiflorum	Stem	(G. N. Zhang *et al.*, 2005)
	D. williamsonii	Whole plant	(M. Yang *et al.*, 2018)
	D. palpebrae	Whole plant	(Kyokong *et al.*, 2019)
Scopoletin [**316**]	*D. densiflorum*	Stem	(Fan *et al.*, 2001)
Lignans and neolignans			
Episyringaresinol [**317**]	*D. chrysotoxum*	Stem	(Hu *et al.*, 2012)
	D. longicornu	Stem	(Hu *et al.*, 2008a)
	D. nobile	Stem	(X. Zhang *et al.*, 2008)

Categories and compounds	Plant	Plant part	Reference
Episyringaresinol 4″-*O*- β-D-glucopyranoside [**318**]	*D. moniliforme*	Stem	(C. S. Zhao *et al.*, 2003)
(-)-(7*S*,8*R*,7′*E*)-4-Hydroxy -3,3′,5,5′-tetramethoxy-8,4′-oxyneolign-7′-ene- 7,9′-bis-*O*-β-D-glucopyranoside [**319**]	*D. aurantiacum* var. *denneanum*	Stem	(Xiong *et al.*, 2013)
Lyoniresinol [**320**]	*D. chrysanthum*	Stem	(Ye *et al.*, 2004)
(-)-Syringaresinol-4,4′-bis-*O*-β–D- glucopyranoside [**321**]	*D. aurantiacum* var. *denneanum*	Stem	(Xiong *et al.*, 2013)
Syringaresinol-4-*O*-D-monoglucopyranoside [**322**]	*D. aurantiacum* var. *denneanum*	Stem	(Xiong *et al.*, 2013)
Dendrocoumarin [**323**]	*D. nobile*	Stem	(Zhou *et al.*, 2018)
Itolide A [**324**]	*D. nobile*	Stem	(Zhou *et al.*, 2018)
(-)-Medioresinol [**325**]	*D. loddigesii*	Whole plant	(Ito *et al.*, 2010)
	D. nobile	Stem	(X. Zhang *et al.*, 2008)
(-)-Pinoresinol [**326**]	*D. loddigesii*	Whole plant	(Ito *et al.*, 2010)
	D. nobile	Stem	(X. Zhang *et al.*, 2008)
(+)-Pinoresinol [**327**]	*D. devonianum*	Stem	(Wu *et al.*, 2019)
Erythro-1-(4-*O*-β-D-glucopyranosyl-3-methoxyphenyl)-2-[4-(3-hydroxypropyl)-2,6-dimethoxyphenoxy]-1,3-propanediol [**328**]	*D. longicornu*	Stem	(Hu *et al.*, 2008a)
Syringaresinol [**329**]	*D. nobile*	Stem	(X. Zhang *et al.*, 2008)
	D. secundum	Stem	(Sritularak, Duangrak, *et al.*, 2011)
	D. williamsonii	Whole plant	(M. Yang *et al.*, 2018)
Acanthoside B [**330**]	*D. chrysanthum*	Stem	(Ye *et al.*, 2004)

Categories and compounds	Plant	Plant part	Reference
Liriodendrin [**331**]	*D. brymerianum*	Whole plant	(Chen *et al.*, 2014)
	D. pulchellum	Stem	(Chanvorachote *et al.*, 2013)
(-)-(8*R*,7′*E*)-4-Hydroxy-3,3′,5,5′-tetramethoxy-8,4′-oxyneolign-7′-ene-9,9′-diol 4,9-bis-*O*-β-D-glucopyranoside [**332**]	*D. auranticum* var. *denneanum*	Stem	(Li *et al.*, 2014)
(-)-(8*S*,7′*E*)-4-Hydroxy-3,3′,5,5′-tetramethoxy-8,4′-oxyneolign-7′-ene-9,9′-diol 4,9-bis-*O*-β-D-glucopyranoside [**333**]	*D. auranticum* var. *denneanum*	Stem	(Li *et al.*, 2014)
(-)-(8*R*,7′*E*)-4-Hydroxy-3,3′,5,5′,9′-penta methoxy-8,4′-oxyneolign-7′-ene-9-ol 4,9-bis-*O*-β-D-glucopyranoside [**334**]	*D. auranticum* var. *denneanum*	Stem	(Li *et al.*, 2014)
Fluorenones			
Denchrysan B [**335**]	*D. brymerianum*	Whole plant	(Klongkumnuankarn *et al.*, 2015)
Denchrysan A [**336**]	*D. chrysotoxum*	Whole plant	(Y. P. Li *et al.*, 2009)
Dendroflorin [**337**]	*D. aurantiacum* var. *denneanum*	Stem	(L. Yang, Wang, *et al.*, 2006)
	D. brymerianum	Whole plant	(Klongkumnuankarn *et al.*, 2015)
	D. palpebrae	Whole plant	(Kyokong *et al.*, 2019)
Dengibsin [**338**]	*D. aurantiacum var. denneanum*	Stem	(L. Yang, Wang, *et al.*, 2006)
	D. chrysanthum	Stem	(L. Yang, Qin, *et al.*, 2006)
	D. chrysotoxum	Whole plant	(Y. P. Li *et al.*, 2009)

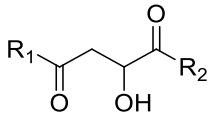
Categories and compounds	Plant	Plant part	Reference
Nobilone [**339**]	*D. brymerianum*	Whole plant	(Klongkumnuankarn *et al.*, 2015)
	D. nobile	Stem	(X. Zhang *et al.*, 2007)
	D. palpebrae	Whole plant	(Kyokong *et al.*, 2019)
1,4,5-Trihydroxy-7-methoxy-9*H*-fluoren-9-one [**340**]	*D. chrysotoxum*	Whole plant	(Y. P. Li *et al.*, 2009)
2,4,7-Trihydroxy-1,5-dimethoxy-9-fluorenone [**341**]	*D. chrysotoxum*	Stem	(H. Yang *et al.*, 2004)
Others			
3,6,9-Trihydroxy-3,4-dihydroanthracen-1-(2*H*)-one [**342**]	*D. chrysotoxum*	Stem	(Hu *et al.*, 2012)
Palmarumycin JC2 [**343**]	*D. crystallinum*	Stem	(L. Wang *et al.*, 2009)
Dehydrovomifoliol [**344**]	*D. loddigesii*	Whole plant	(Ito *et al.*, 2010)
2,6-Dimethoxy Benzoquinone [**345**]	*D. chryseum*	Stem	(Ma *et al.*, 1998)
4-(2-Hydroxypropyl)- 2(5*H*)-furanone [**346**]	*D. tortile*	Whole plant	(Limpanit *et al.*, 2016)
5,7-Dihydroxy chromen-4-one [**347**]	*D. ellipsophyllum*	Whole plant	(Tanagornmeatar *et al.*, 2014)
Balanophonin [**348**]	*D. williamsonii*	Whole plant	(M. Yang *et al.*, 2018)
Ergosta-8(9),22-diene-3,5,6,7-tetraol [**349**]	*D. williamsonii*	Whole plant	(M. Yang *et al.*, 2018)
Stigmast-4-en-3a, 6β-diol [**350**]	*D. williamsonii*	Whole plant	(M. Yang *et al.*, 2018)
3β-Hydroxy-5a,8a-epidioxyergosta-6,9,22-triene [**351**]	*D. williamsonii*	Whole plant	(M. Yang *et al.*, 2018)
β-Sitosterol [**352**]	*D. williamsonii*	Whole plant	(M. Yang *et al.*, 2018)
Daucosterol [**353**]	*D. williamsonii*	Whole plant	(M. Yang *et al.*, 2018)

Categories and compounds	Plant	Plant part	Reference
Anosmine [**354**]	*D. parishii*	Whole plant	(Hemscheidt & Spenser, 1991)
di-*p*-hydroxyphenylpropionic acidic-*p*-coumaric acid lactone [**355**]	*D. chrysanthum*	Whole plant	(Cai *et al.*, 2018)
RF-3192C [**356**]	*D. scabrilingue*	Whole plant	(Sarakulwattana *et al.*, 2018)
Crepidatumine C [**357**]	*D. crepidatum*	Stem	(Xu *et al.*, 2019)
Crepidatumine D [**358**]	*D. crepidatum*	Stem	(Xu *et al.*, 2019)
Crepidine [**359**]	*D. crepidatum*	Stem	(Xu *et al.*, 2019)
Isocrepidamine [**360**]	*D. crepidatum*	Stem	(Xu *et al.*, 2019)
Crepidamine [**361**]	*D. crepidatum*	Stem	(Xu *et al.*, 2019)



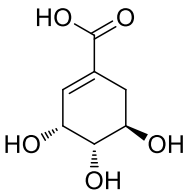
[**252**] Aliphatic acids R = COOH n = 19-31

[**253**] Aliphatic alcohol R = OH n = 22-32

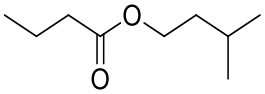


[**254**] Malic acid $R_1 = R_2 = OH$

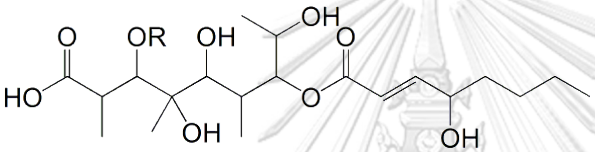
[**255**] Dimethyl malate $R_1 = R_2 = OMe$



[**256**] (-)-Shikimic acid

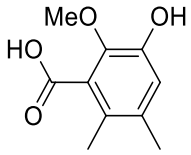


[**257**] Isopentyl butyrate

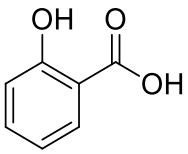


[**258**] Dendrodevonic acid A R = H

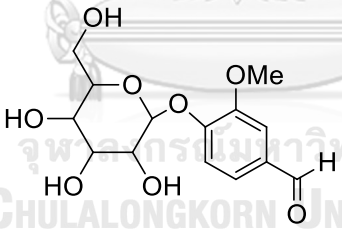
[**259**] Dendrodevonic acid B R = acetyl



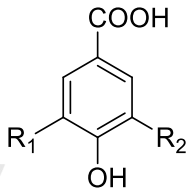
[**260**] 3-Hydroxy-2-methoxy-5,6-dimethylbenzoic acid



[**261**] Salicylic acid



[**262**] Vanilloside

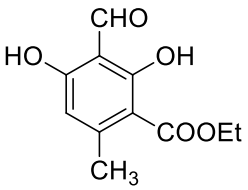


[**263**] Gallic acid $R_1 = OH$ $R_2 = OH$

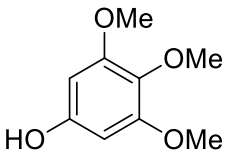
[**264**] Syringic acid $R_1 = OMe$ $R_2 = OMe$

[**265**] Vanillic acid $R_1 = H$ $R_2 = OMe$

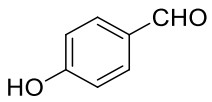
Figure 6. Structures of miscellaneous compounds from *Dendrobium*



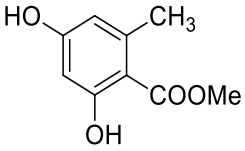
[**266**] Antiarol



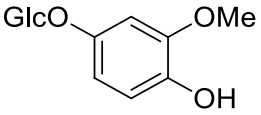
[**267**] Ethylhaematommate



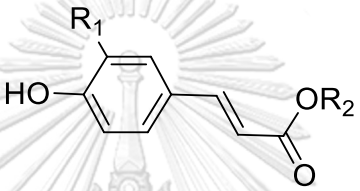
[**268**] *p*-Hydroxybenzaldehyde



[**269**] Methyl β-orsellinate

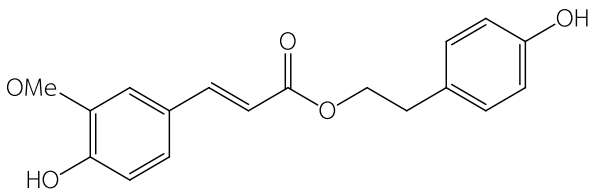


[**270**] Tachioside

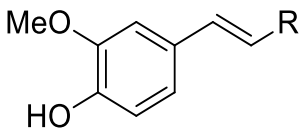


[**271**] Alkyl 4′-hydroxy-*trans*-cinnamates	R_1 = H	$R_2 = C_nH_{2n+1}$ n =22-32
[**272**] Alkyl *trans*-ferulate	R_1 = OMe,	$R_2 = C_nH_{2n+1}$ n = 18-28, 30
[**273**] Defuscin	R_1 = OMe	$R_2 = (CH_2)_{27}CH_3$
[**274**] *n*-Octacosyl ferulate	R_1 = OMe	$R_2 = (CH_2)_{28}CH_3$
[**275**] *n*-Triacontyl *p*-hydroxy-*cis*-cinnamate	R_1 = H	$R_2 = C_{30}H_{61}$
[**276**] Tetratriacontanyl-*trans*-*p*-coumarate	R_1 = H	$R_2 = (CH_2)_{33}CH_3$

Figure 6. Structures of miscellaneous compounds from *Dendrobium* (continued)



[**277**] *p*-hydroxyphenethyl-*trans*-ferulate



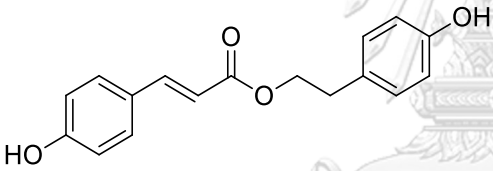
[**278**] *n*-Docosyl *trans*-ferulate: R = $COOCH_2(CH_2)_{20}CH_3$

[**279**] *trans*-Tetracosyl ferulate R = $COOCH_2(CH_2)_{22}CH_3$

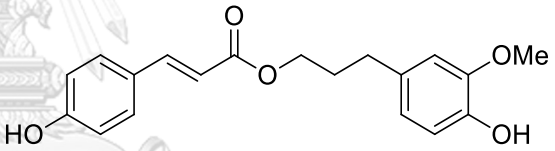
[**280**] *cis*-Hexacosanoyl ferulate R = $COOCH_2(CH_2)_{24}CH_3$

[**281**] Ferulaldehyde R = CHO

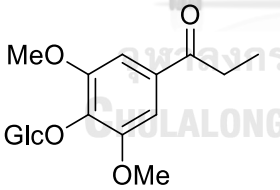
[**282**] Ferulic acid R = COOH



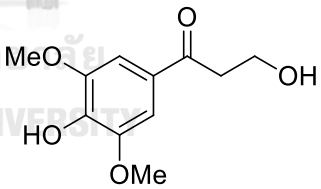
[**283**] 2-(*p*-Hydroxyphenyl) ethyl *p*-coumarate



[**284**] Dihydroconiferyl dihydro-*p*-coumarate

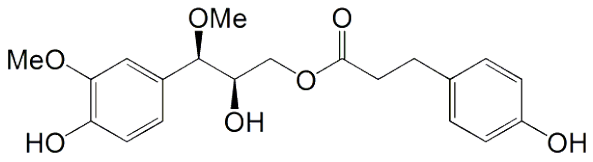


[**285**] 1-[4-(β-D-Glucopyranosyloxy)-3,5-dimethoxyphenyl]-1-propanone

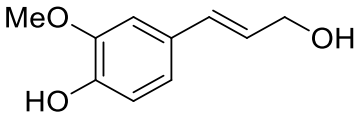


[**286**] 3-Hydroxy-1-(4-hydroxy-3,5 dimethoxyphenyl)-1-propanone

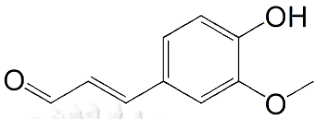
Figure 6. Structures of miscellaneous compounds from *Dendrobium* (continued)



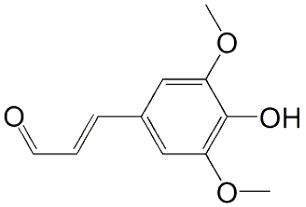
[**287**] 2-Hydroxy-3-(4-hydroxy-3-methoxyphenyl)-3-methoxypropyl-3-(4-hydroxylphenyl)propanoate



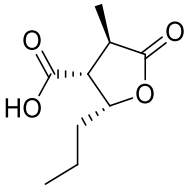
[**288**] Coniferyl alcohol



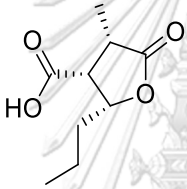
[289] (*E*)-Coniferyl aldehyde



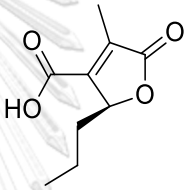
[**290**] Sinapicaldehyde



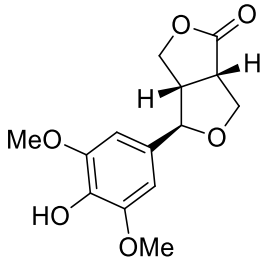
[**291**] Decumbic acid A



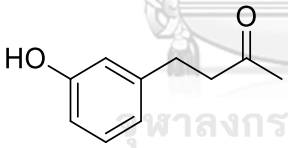
[**292**] Decumbic acid B



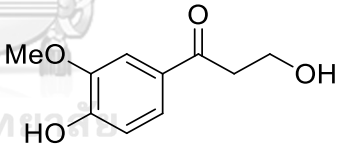
[**293**] (–)-Decumbic acid



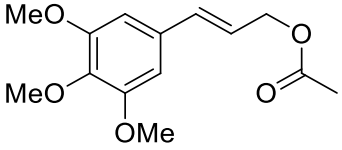
[**294**] (+)-Dendrolactone



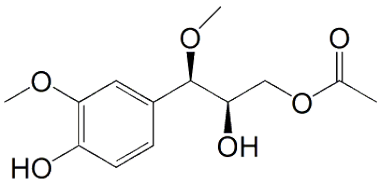
[**295**] 4-(3-Hydroxyphenyl)-2-butanone



[**296**] 3-Hydroxy-1(3-methoxy-4-hydroxyphenyl)-propan-1-one

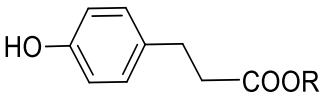


[**297**] 3′,4′,5′-Trimethoxy cinnamyl acetate



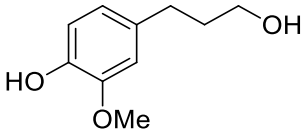
[**298**] Alatusol A

Figure 6. Structures of miscellaneous compounds from *Dendrobium* (continued)

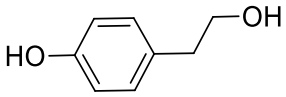


[**299**] *p*-Hydroxyphenyl propionic methyl ester R = CH_3

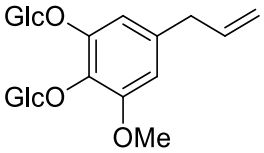
[**300**] Phloretic acid R = OH



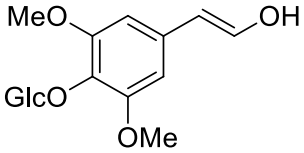
[**301**] Dihydroconiferyl alcohol



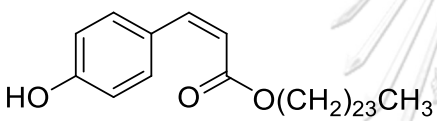
[**302**] Salidrosol



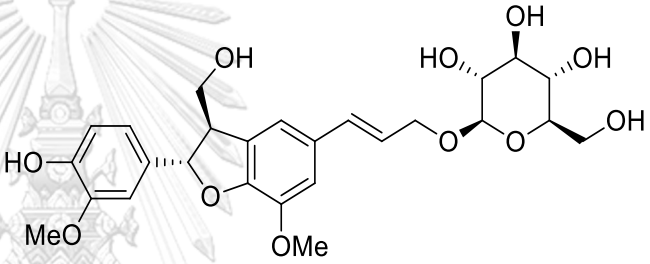
[**303**] Shashenoside I



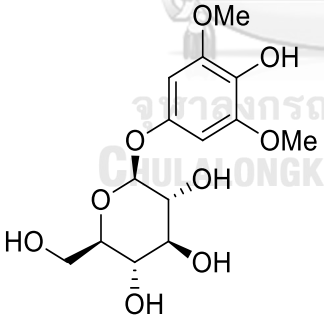
[**304**] Syringin



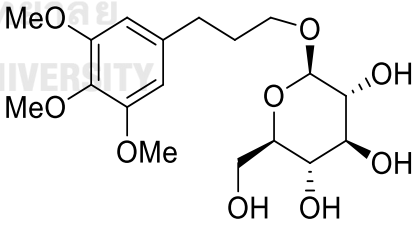
[**305**] Tetracosyl (*Z*)-*p*-coumarate



[**306**] (7*S*,8*R*)-Dehydrodiconiferyl alcohol 9′-β-D-glucopyranoside

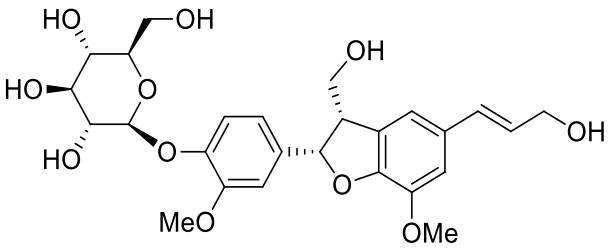


[**307**] Koaburaside

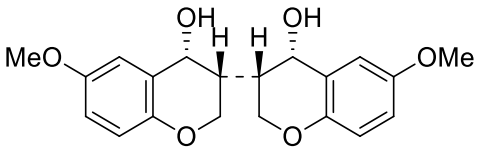


[**308**] Juniperoside

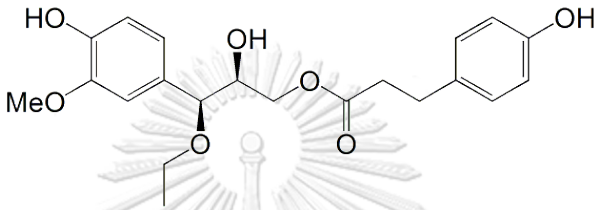
Figure 6. Structures of miscellaneous compounds from *Dendrobium* (continued)



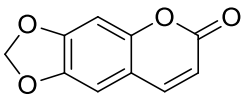
[**309**] Dehydrodiconiferyl alcohol-4-β-D-glucoside



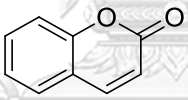
[**310**] (3*R*,3′*S*,4*R*,4′*S*)-3,3′,4,4′-Tetrahydro-6,6′-dimethoxy[3,3′-bi-2*H*-benzopyran]-4,4′-diol



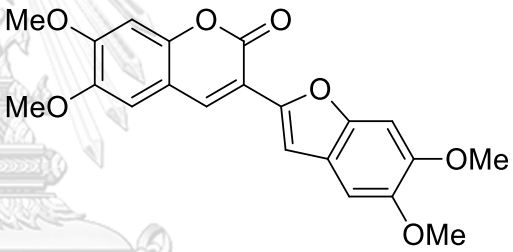
[**311**] *threo*-7-*O*-ethyl-9-*O*-(4-hydroxyphenyl) propionyl-guaiacyl glycerol



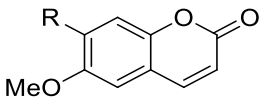
[**312**] Ayapin



[**313**] Coumarin

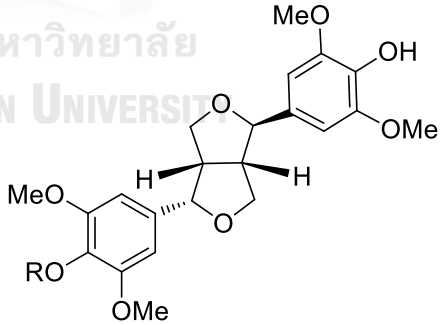


[**314**] Denthyrsin



[**315**] Scoparone R = OMe

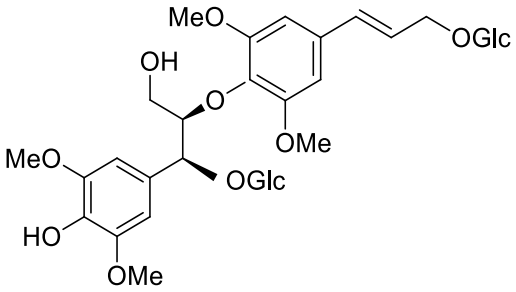
[**316**] Scopoletin R = OH



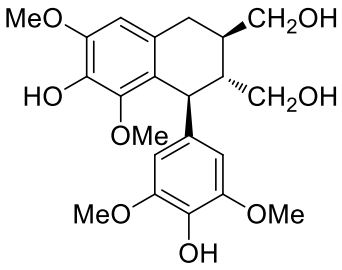
[**317**] Episyringaresinol R = H

[**318**] Episyringaresinol 4″-*O*-β-D-glucopyranoside R = β-D-glucose

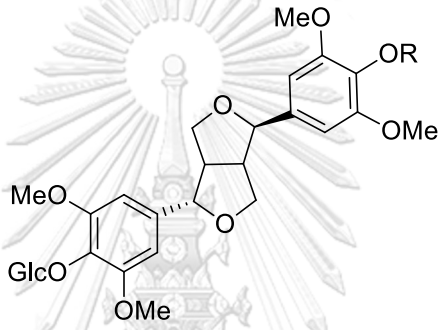
Figure 6. Structures of miscellaneous compounds from *Dendrobium* (continued)



[**319**] (-)-(7*S*,8*R*,7′*E*)-4-Hydroxy-3,3′,5,5′-tetramethoxy-8,4′-oxyneolign-7′-ene-7,9′-bis-*O*-β-D-glucopyranoside

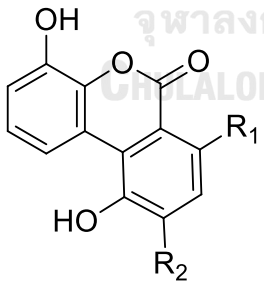


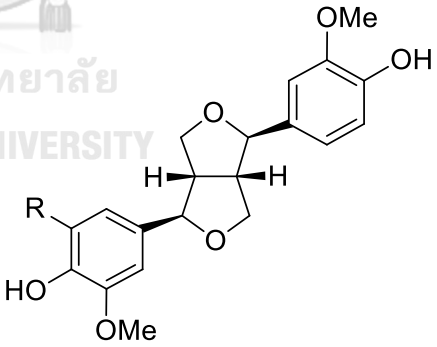
[**320**] Lyoniresinol



[**321**] (-)-Syringaresinol-4,4′-bis-*O*-β–D-glucopyranoside R = Glc

[**322**] Syringaresinol-4-*O*-D-monoglucopyranoside R = H





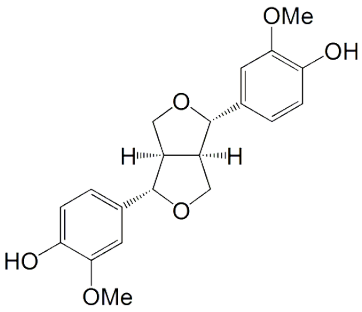
[**323**] Dendrocoumarin R_1 = H R_2 = OH

[**324**] Itolide A R_1 = OH R_2 = H

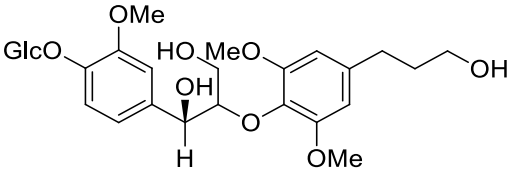
[**325**] (-)-Medioresinol R = OMe

[**326**] (-)-Pinoresinol R = H

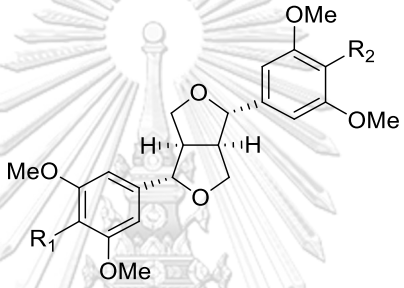
Figure 6. Structures of miscellaneous compounds from *Dendrobium* (continued)



[**327**] (+)-Pinoresinol

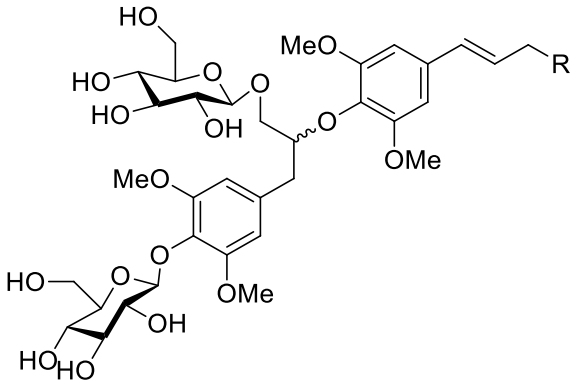


[**328**] Erythro-1-(4-*O*-β-D-glucopyranosyl-3-methoxyphenyl)-2-[4-(3-hydroxypropyl)-2,6-dimethoxyphenoxy]-1,3-propanediol



	R_1	R_2
[**329**] Syringaresinol	OH	OH
[**330**] Acanthoside B	OGlc	OH
[**331**] Liriodendrin	OGlc	OGlc

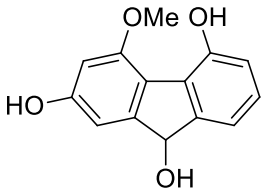
Figure 6. Structures of miscellaneous compounds from *Dendrobium* (continued)

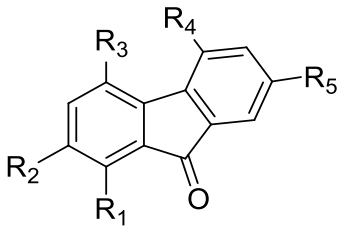


[**332**] (-)-(8*R*,7′*E*)-4-Hydroxy-3,3′,5,5′-tetramethoxy-8,4′-oxyneolign-7′-ene-9,9′-diol 4,9-bis-O-β-D-glucopyranoside R = OH; 8*R*

[**333**] (-)-(8*S*,7′*E*)-4-Hydroxy-3,3′,5,5′-tetramethoxy-8,4′-oxyneolign-7′-ene-9,9′-diol 4,9-bis-O-β-D-glucopyranoside R = OH; 8*S*

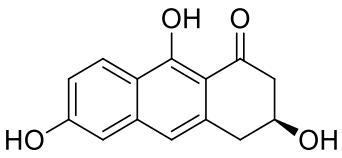
[**334**] (-)-(8*R*,7′*E*)-4-Hydroxy-3,3′,5,5′,9′-pentamethoxy-8,4′-oxyneolign-7′-ene-9-ol 4,9-bis-O-β-D-glucopyranoside R = OMe; 8*R*



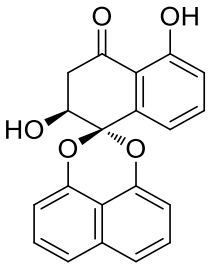


	R_1	R_2	R_3	R_4	R_5
[**335**] Denchrysan B					
[**336**] Denchrysan A	H	OH	OH	OMe	OH
[**337**] Dendroflorin	OH	H	OH	OMe	OH
[**338**] Dengibsin	H	OH	OMe	OH	H
[**339**] Nobilone	H	OH	H	OMe	OH
[**340**] 1,4,5-Trihydroxy-7-methoxy-9*H*-fluoren-9-one	OH	H	OH	OH	OMe
[**341**] 2,4,7-trihydroxy-1,5-dimethoxy-9-fluorenone	OMe	OH	OH	OMe	OH

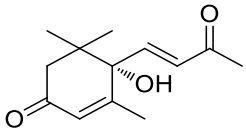
Figure 6. Structures of miscellaneous compounds from *Dendrobium* (continued)



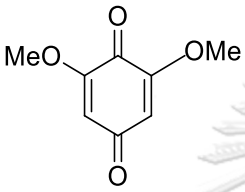
[**342**] 3,6,9-Trihydroxy-3,4-dihydroanthracen-1-(2*H*)-one



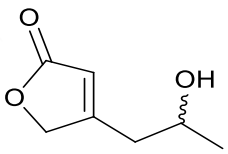
[**343**] Palmarumycin JC2



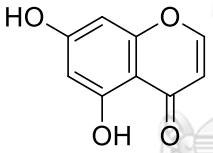
[**344**] Dehydrovomifoliol



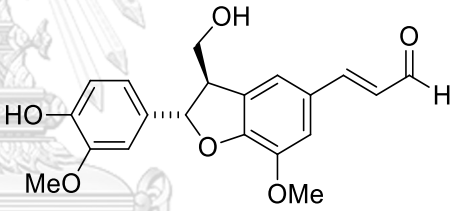
[**345**] 2,6-Dimethoxybenzoquinone



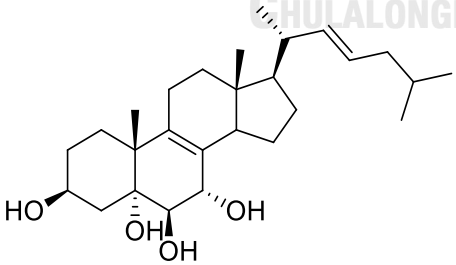
[**346**] 4-(2-Hydroxypropyl)-2(5*H*)-furanone



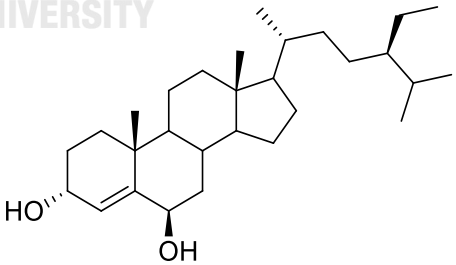
[**347**] 5,7-Dihydroxy chromen-4-one



[**348**] Balanophonin

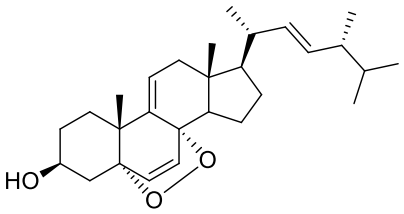


[**349**] Ergosta-8(9),22-diene-3,5,6,7-tetraol

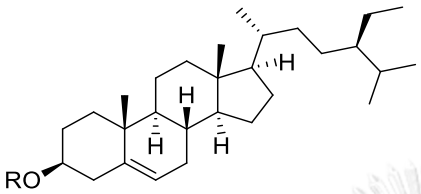


[**350**] Stigmast-4-en-3a, 6β-diol

Figure 6. Structures of miscellaneous compounds from *Dendrobium* (continued)

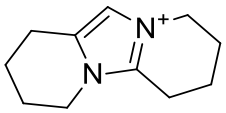


[**351**] 3β-Hydroxy-5a,8a-epidioxyergosta-6,9,22-triene

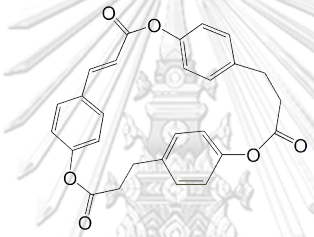


[**352**] β-Sitosterol R = H

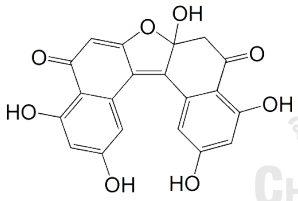
[**353**] Daucosterol R = Glc



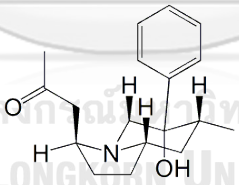
[**354**] Anosmine



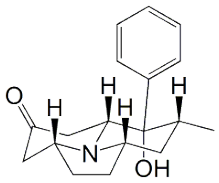
[**355**] di-*p*-hydroxyphenylpropionic acidic-*p*-coumaric acid lactone



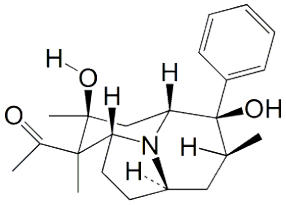
[**356**] RF-3192C



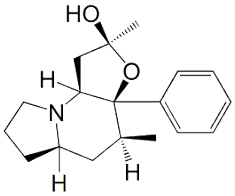
[**357**] Crepidatumine C



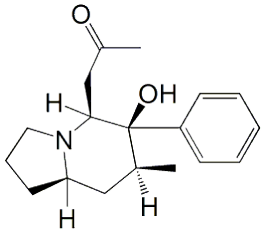
[**358**] Crepidatumine D



[**359**] Crepidine



[**360**] Isocrepidamine



[**361**] Crepidamine

Figure 6. Structures of miscellaneous compounds from *Dendrobium* (continued)

2. Alpha-glucosidase inhibitory activity of *Dendrobium* species

One of the largest genera of Orchidaceae is the *Dendrobium* genus. Thousands of species of *Dendrobium* can be found all over the world. Dozens of species, such as *D. officinale*, *D. nobile*, *D. huoshanense,* and *D. chrysanthum*, are grown in China. Among all of these *Dendrobium* species, *D. officinale* is one of the most widely known due to its functions in Traditional Chinese Medicine (TCM), like tonifying the stomach, promoting fluid, nourishing yin, and clearing heat. The fresh stem of *D. officinale* can be orally consumed directly and used as a soup stock or tea too. On the other hand, modern pharmacology research has shown some beneficial bioactivities of *D. officinale*, like anti-oxidant, anti-tumor, hypoglycemic activities as well as gastrointestinal regulatory functions (Zhou, C., Xie, Z., et. al., 2018).

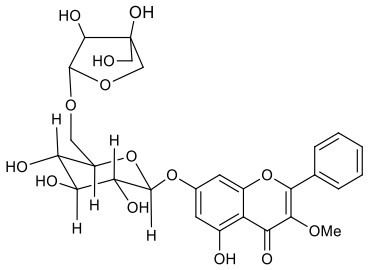
Alpha-glucosidase inhibitors (AGIs) are a class of Oral Hypoglycemic Agents (OHAs) for the treatment of DM II. The mechanism of AGIs is to inhibit binding the active centers of α-glucosidase enzyme with oligosaccharides. The treatment of DM II patients can use AGIs as drugs that inhibit the absorption of carbohydrates from the gut. Because of their nitrogen component, AGIs can block the enzymatic reaction of α-glucosidase (Joshi *et. al*., 2015). Acarbose, miglitiol and voglibose are drugs that include AGIs (Patel *et al.,* 2012). Among the AGIs, acarbose has the most robust evidence base for the treatment of DM II. It is the most studied drug with proven efficacy in lowering insulin dose in postprandial hyperglycemia (PPHG) and improving insulin resistance/secretion and dyslipidemia in patients with DM II (Joshi *et al*., 2015).

The inhibitory effect of α-glucosidase in type 2 diabetes can be used to absorb postprandial glucose. α-Glucosidase has a role in carbohydrates into glucose conversion. By inhibiting α-glucosidase, blood glucose levels can be returned within the normal range (Van de Laar, 2008).

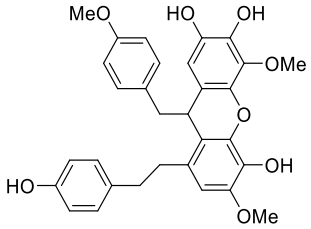
In previous reports, several compounds from *Dendrobium* spp. have been found to possess α-glucosidase effect. Table 5 showed examples of α-glucosidase inhibitors from *Dendrobium* spp.

Table 5. Examples of α-glucosidase inhibitors from *Dendrobium* spp.

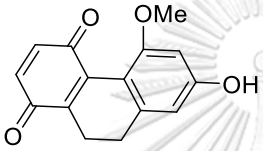
Structure name	Plant	Plant part	Parts
Flavonoids			
5-Hydroxy-3-methoxy-flavone-7-*O*-[β-D-apiosyl-(1⟶6)]-β-D-glucoside **[363]**	*D. devonianum*	(Sun *et al*., 2014)	whole plant
Bisbibenzyls			
Dendrofalconerol A **[364]**	*D. tortile*	(Limpanit *et al*., 2016)	whole plant
Phenanthrene Quinones			
5-Methoxy-7-hydroxy-9,10-dihydro-1,4-phenanthrenequinone **[365]**	*D. formosum*	(Inthongkaew *et al*., 2017)	stem
Bibenzyl derivatives			
Loddigesiinol J **[366]**	*D. loddigesii*	(Lu *et al*., 2014)	stem
3,4-Dihydroxy-5,4′-dimethoxybibenzyl **[367]**	*D. tortile*	(Limpanit *et al*., 2016)	whole plant



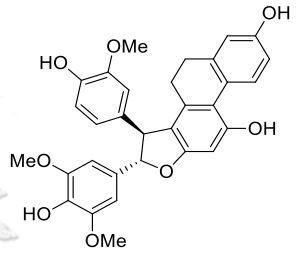
[363] 5-Hydroxy-3-methoxy-flavone-7-*O*-[β-D-apiosyl-(1⟶6)]-β-D-glucoside



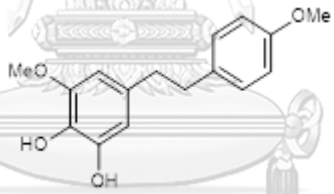
[364] Dendrofalconerol A



[365] 5-Methoxy-7-hydroxy-9,10-dihydro-1,4-phenanthrenequinone



[366] Loddigesiinol J



[367] 3,4-Dihydroxy-5,4′-dimethoxybibenzyl

Figure 7. Structures of α-glucosidase inhibitors from *Dendrobium* spp.

CHAPTER III

EXPERIMENTAL

1. Source of plant materials

1.1 *Dendrobium braianense* (เอื้องคำป๊อกลาว)

Dendrobium braianense samples were bought from Chatuchak market, Bangkok, in March 2018. This plant was identified by Mr. Yanyong Punpreuk, Department of Agriculture, Bangkok. Voucher specimens (BS-DB-032561) has been saved at the herbarium of the Department of Pharmacognosy and Pharmaceutical Botany, Faculty of Pharmaceutical Sciences, Chulalongkorn University.

1.2 *Dendrobium kentrophyllum* (เอื้องก้างปลาใหญ่)

Dendrobium kentrophyllum samples were purchased from an orchid farm, Suphanburi, in August 2018. They were identified by Mr. Yanyong Punpreuk, Department of Agriculture, Bangkok. Voucher specimens (BS-DK-072561) have been saved at the herbarium of the Department of Pharmacognosy and Pharmaceutical Botany, Faculty of Pharmaceutical Sciences, Chulalongkorn University.

2. General Techniques

2.1 Analytical thin-layer chromatography (TLC)

2.1.1 Normal phase thin-layer chromatography

Technique	One-dimension ascending
Absorbent	Silica gel 60 F254 precoated plate (E. Merck)
Temperature	Laboratory temperature (30-35 ºC)
Detection	1. Ultraviolet light at wavelengths of 254 and 365 nm.

2. Spraying with anisaldehyde reagent (p-anisaldehyde 15 g in ethanol 250 mL and concentrated sulfuric acid 2.5 mL) and heating at 105 ºC for 10 minutes.

2.1.2 Reverse phase thin-layer chromatography

Technique One-dimension ascending

Absorbent RP C-18 precoated on aluminum sheet (Anal Tech)

Temperature Laboratory temperature (30-35 ºC)

Detection Ultraviolet light at wavelengths of 254 and 365 nm.

2.2 Column chromatography (CC)

2.2.1 Vacuum liquid chromatography (VLC)

Adsorbent Silica gel 60 (No. 107734), size 0.063-0.200 mm (E. Merck)

Packing method Dry packing

Sample loading The sample was dissolved in a small volume of organic solvent, triturated with a slight amount of the adsorbent, dried, and then gradually put on the top of the column.

Detection Each fraction was studied by TLC under UV light at the wavelengths of 254 and 365 nm.

2.2.2 Flash column chromatography (FCC), normal phase

Adsorbent Silica gel 60 (No. 109385), size 0.040-0.063 mm (E. Merck)

Packing method Wet packing

Sample loading The sample was dissolved in a minor volume of organic solvent, triturated with a small amount of the adsorbent, dried, and then gradually put on the top of the column.

Detection Fractions were studied as described in section 2.2.1

2.2.3 Flash column chromatography (FCC), reverse phase

Adsorbent C-18 (No. 113900), size 40-63 μm (E. Merck)

Packing method Wet packing

Sample loading The sample was dissolved with a little volume of organic solvent, and then gradually loaded on the top of the column.

Detection Fractions were studied as described in section 2.2.1

2.2.4 Gel filtration chromatography

Gel filter Sephadex LH-20, particle size 25-100 μm (GE Healthcare)

Packing method The gel filter was suspended in an appropriate solvent, left standing for about 24 hours, and then poured into the column and left to set tightly.

Sample loading It was liquefied in a little volume of the eluent and then gradually dispensed on the top of the column.

Detection Fractions were studied as described in section 2.2.1.

2.2.5 Semi-preparative high pressure liquid chromatography (HPLC)

Column COSMOSIL 5C18-AR-II (10ID x 250 mm)

Flow rate 3 ml/min

Mobile phase Isocratic 50% methanol in water

Sample preparation It was liquefied in a little volume of the eluent and filtered through Millipore filter paper before it was injected.

Injection volume 1 ml

Pump LC-8A (Shimadzu)

Detector SPD-10A UV-Vis Detector (Shimadzu)

Recorder C-R6A Chromatopac (Shimadzu)

Temperature Room temperature

2.3 Spectroscopy

2.3.1 Mass spectra

Mass spectra (MS) were recorded using a Bruker micro TOF mass spectrometer (Department of Chemistry, Faculty of Science, Mahidol University).

2.3.2 Proton and carbon-13 nuclear magnetic resonance (^{1}H and ^{13}C-NMR) spectra

^{1}H NMR (300 MHz) and ^{13}C NMR (75 MHz) spectra were recorded utilizing a Bruker Avance DPX-300 FT-NMR spectrometer (Faculty of Pharmaceutical Sciences, Chulalongkorn University). ^{1}H NMR (500 MHz) and ^{13}C NMR (125 MHz) spectra were recorded on a Bruker Avance III HD 500 NMR spectrometer (Scientific and Technology Research Equipment Center, Chulalongkorn University).

Solvents for NMR spectra constituted deuterated acetone (acetone-d_6), deuterated dimethyl sulfoxide (DMSO-d_6), or deuterated chloroform ($CDCl_3$). Chemical shifts were described in ppm scale using the chemical shift of the solvent as the reference signal.

2.4 Solvents

All organic solvents used throughout this work were of commercial grade and were redistilled before being used.

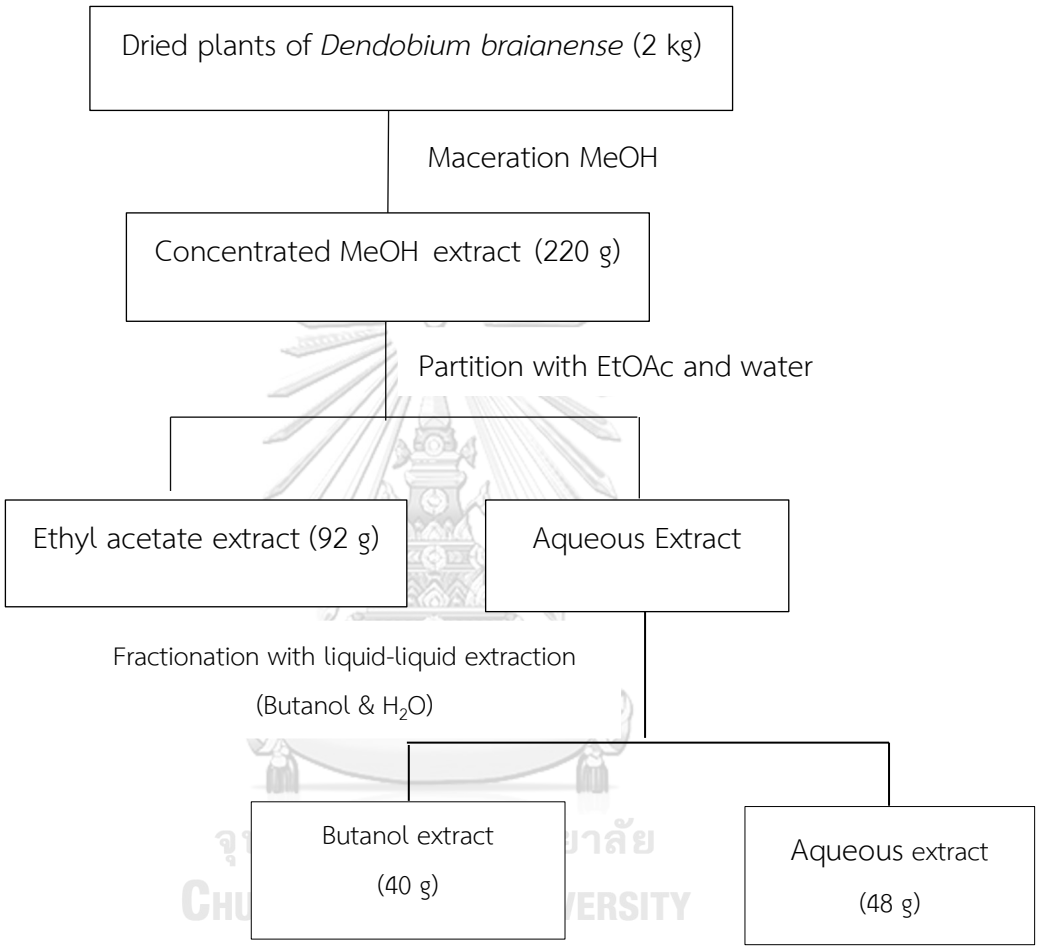
3. Extraction and isolation

3.1 Extraction and isolation of compounds from *Dendrobium braianense*

3.1.1 Extraction

The dried whole plant of *Dendrobium braianense* (2 kg) was ground into a powder then mixed with MeOH solvent at room temperature. After three days the liquid extracts were taken and filtered to the flask. Then the extracts were evaporated to remove the solvent with a rotary evaporator at 40°C to get concentrated MeOH extract. This process was repeated 3 times with the same

volume of solvent. Finally, the extracts were weighed and stored in the fridge till their usage in the different tests **(Scheme 1)**.



Scheme 1. Extraction steps for *Dendrobium braianense*

3.1.2 Isolation

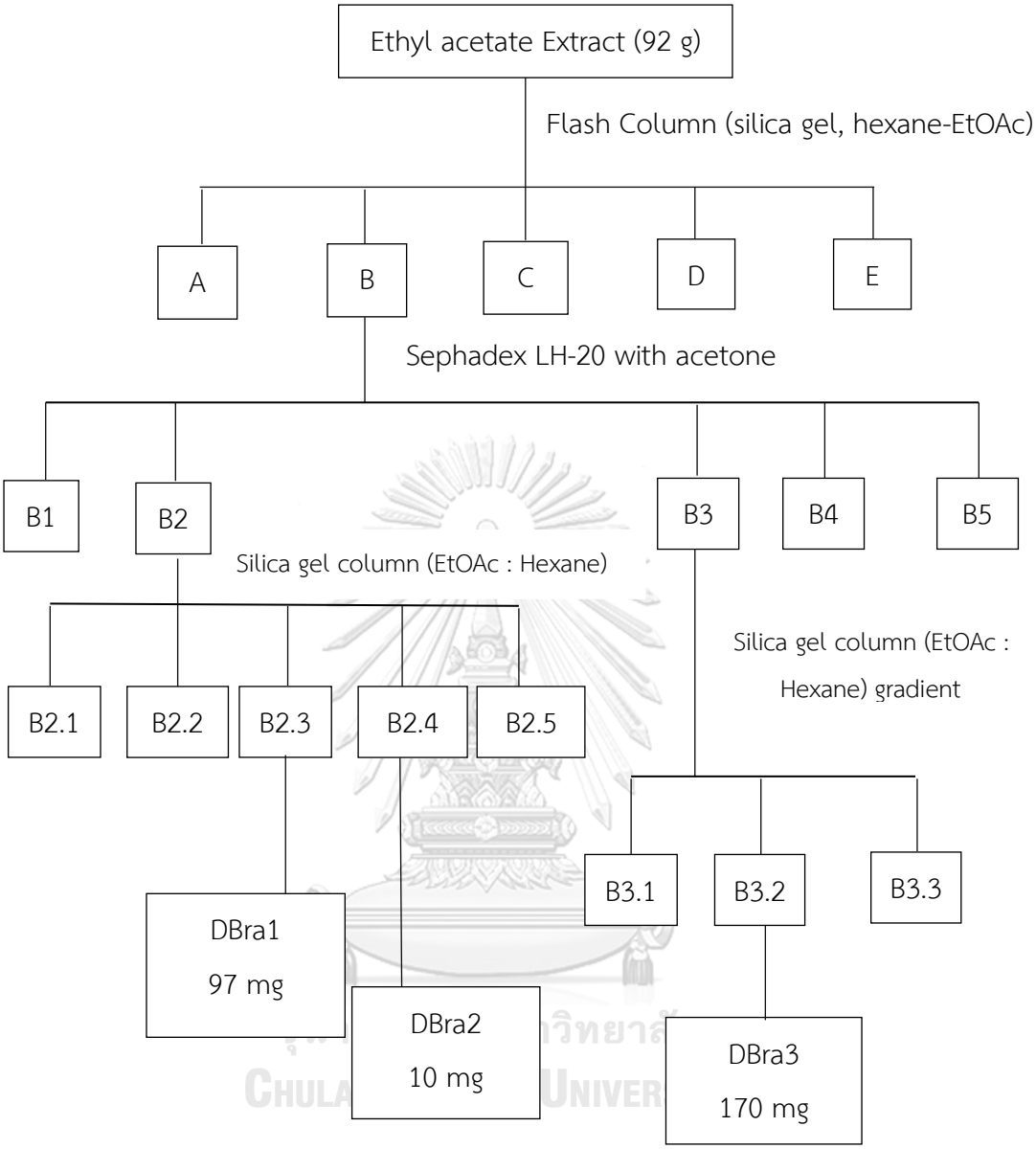
3.1.2.1 Isolation of compound DBra1 (Chrysotoxine) and compound DBra2 (Moscatilin)

Ethyl acetate extract (92 g) was initially divided using vacuum liquid chromatography (silica gel, hexane-EtOAc) to give five fractions (A to E). Fraction B was isolated with Sephadex LH-20 with acetone to give five fractions (B1 – B5). Fraction B2 was divided by silica gel column (EtOAc: Hexane) gradient to give five fractions B2.1 – B2.5 **(Scheme 2).**

Fraction B2.3 after drying gave compound DBra1 (97 mg) as a white powder. Compound DBra1 was later identified as chrysotoxine. Fraction B2.4 after drying gave compound DBra2 (10 mg) as brown amorphous. Compound DBra2 was then known to be moscatilin.

3.1.2.2 Isolation of compound DBra3 (Gigantol)

Fraction B3 (2.38 g) was subjected to column chromatography (CC) on a silica gel column (hexane-EtOAc) **(Scheme 2)**. Three subfractions (B3.1 to B3.3) were obtained. Fraction B3.2 gave brown amorphous after being left standing at room temperature overnight. The precipitates were collected, washed with EtOAc, and dried to give Compound DBra3 (170 mg). This compound was identified as gigantol**.**

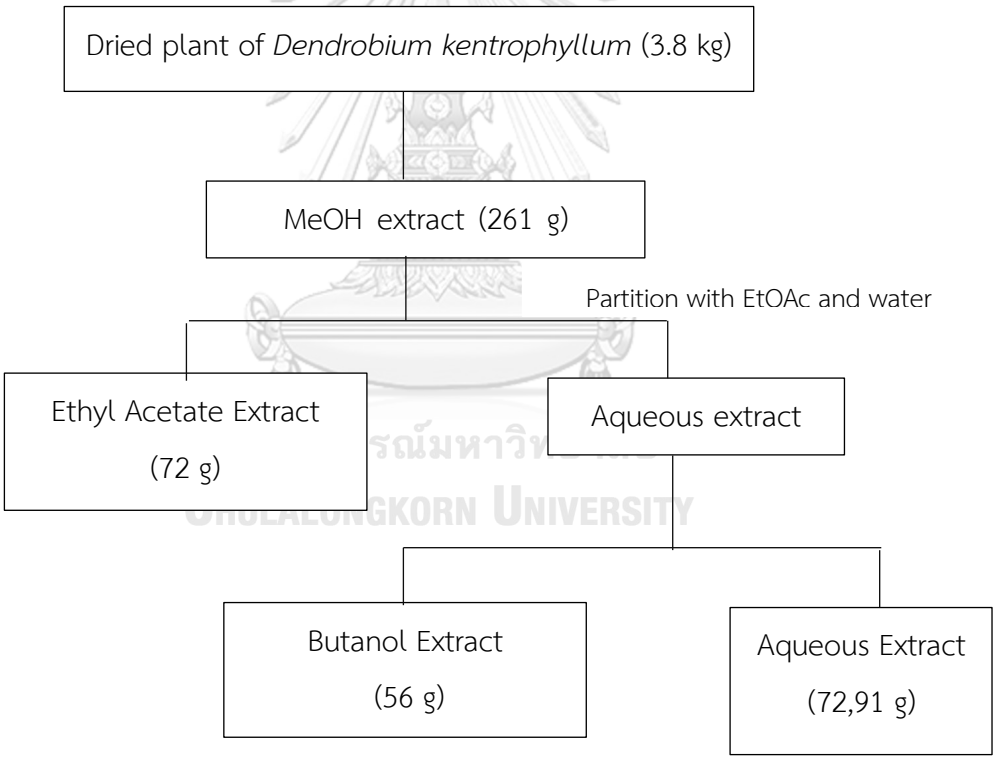


Scheme 2. Isolation of compounds from ethyl acetate extract of *Dendrobium braianense*

3.2 Extraction and isolation of compounds from *Dendrobium kentrophyllum*

3.2.1 Extraction

The dried whole plant of *Dendrobium kentrophyllum* (3.8 kg) was ground into powder then macerated with MeOH solvent at room temperature. After three days the liquid extracts were taken and filtered to the flask. Then the extracts were evaporated to remove the solvent with a rotary evaporator at 40°C to get concentrate MeOH extract. This process was repeated 3 times with the same volume of solvent. Finally, the extracts were weighed and stored in the fridge till their usage in the different tests **(Scheme 3)**.



Scheme 3. Extraction steps for *Dendrobium kentrophyllum*

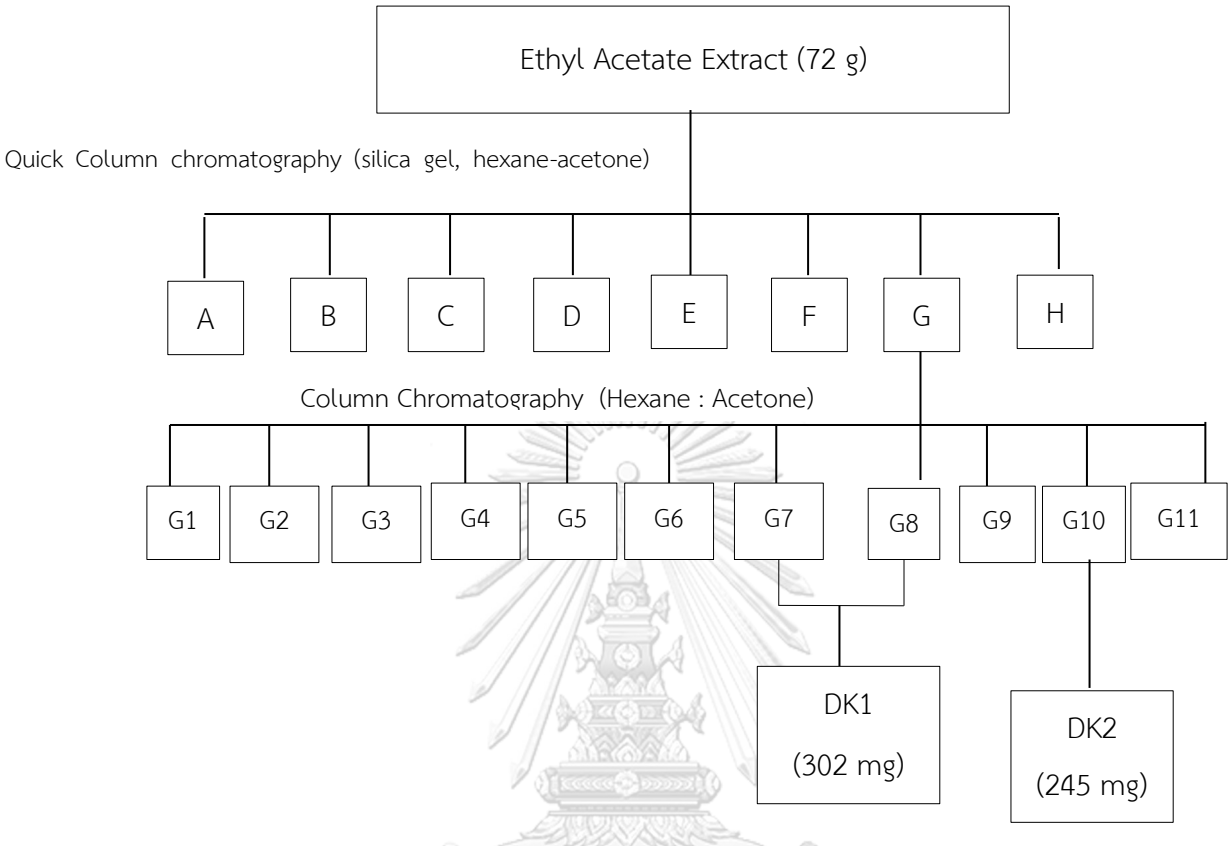
3.2.2 Isolation

3.2.2.1 Isolation of compound DK 1 (Kaempferol) and compound DK 2 (Quercetin)

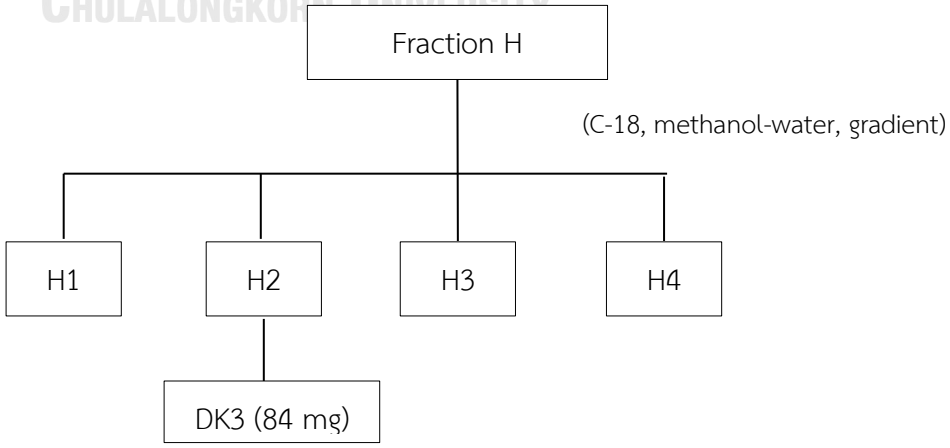
The ethyl acetate extract (72 g) was separated by vacuum-liquid chromatography (silica gel, hexane-acetone gradient) to give 7 fractions (A-H). Fraction G (27 g) was fractionated by column chromatography over silica gel (acetone-hexane, gradient) to give 11 fractions (G1-G11) (**Scheme 4**). Compound DK 1 (302 mg) was obtained from fractions G7 and G8 as a yellow powder and identified as kaempferol. Fraction G10 (1 g) was further divided by column chromatography (silica gel, toluene) to yield compound DK 2 (245 mg) as a yellow powder and identified as quercetin.

3.2.2.2 Isolation of compound DK3 (Rutin)

Fraction H (2 g) was purified by column chromatography (C-18, methanol-water, gradient) to give 4 fractions (H1 – H4) (**Scheme 5).** Compound DK3 (84 mg) was obtained from H2 as a yellow powder and identified as rutin.



Scheme 4. Isolation of compounds from EtOAc extract of *Dendrobium kentrophyllum*



Scheme 5. Isolation of compounds from fraction H of *Dendrobium kentrophyllum*

4. Physical and spectral data of isolated compounds

4.1 Compound DBra 1 (Chrysotoxine)

Compound **DBra 1** was gained as a white powder (97 mg, 0.00485% based on dried weight of plant). It was soluble in acetone.

^{1}H NMR δ ppm, 300 MHz, in acetone-d_6; **Table 7**

^{13}C NMR δ ppm, 75 MHz, in acetone-d_6; **Table 7**

4.2 Compound DBra 2 (Moscatilin)

Compound **DBra 2** was gained as brown amorphous (10 mg, 0.0005% based on the dried weight of the plant. It was soluble in acetone.

^{1}H NMR δ ppm, 300 MHz, in acetone-d_6; **Table 8**

^{13}C NMR δ ppm, 75 MHz, in acetone-d_6; **Table 8**

4.3 Compound DBra 3 (Gigantol)

Compound DBra 3 was gained as white crystals (170 mg, 0.0085% based on dried weight of root). It was soluble in acetone.

^{1}H NMR δ ppm, 300 MHz, in acetone-d_6; **Table 9**

^{13}C NMR δ ppm, 75 MHz, in acetone-d_6; **Table 9**

4.4 Compound DK 1 (Kaempferol)

Compound **DK 3** was gained as a yellow powder (302 mg, 0.00795% based on dried weight of plant). It was soluble in acetone.

^{1}H NMR δ ppm, 300 MHz, in acetone-d_6; **Table 10**

^{13}C NMR δ ppm, 75 MHz, in acetone-d_6; **Table 10**

4.5 Compound DK 2 (Quercetin)

Compound **DK 2** was gained as a yellow powder (245 mg, 0.00645% based on dried weight of plant). It was soluble in acetone.

^{1}H NMR δ ppm, 300 MHz, in acetone-d_6; **Table 11**

^{13}C NMR δ ppm, 75 MHz, in acetone-d_6; **Table 11**

4.6 Compound DK 3 (Rutin)

Compound **DK 3** was gained as a yellow powder (84 mg, 0.00221% based on dried weight of plant). It was soluble in acetone-d_6.

^{1}H NMR δ ppm, 300 MHz, in DMSO-d_6; **Table 12**

^{13}C NMR δ ppm, 75 MHz, in acetone-d_6; **Table 12**

5. Assay for α-glucosidase inhibitory activity

The *in vitro* α-glucosidase inhibition assay was performed by spectrophotometric method, involving hydrolysis of substrate *p*-nitrophenyl α-D-glucopyranoside (Srianta *et al*., 2013).

In this research, α-glucosidase inhibitory activity was assessed using the spectrophotometric measurement of the amount of *p*-nitrophenol (pNP) discharged from the hydrolytic reaction of *p*-nitrophenyl-α-D-glucopyranoside (p-NPG) catalyzed by α-glucosidase enzyme. p-NPG is a synthetic substrate representing the α-linked terminal glucose of polysaccharides. The experiment was conducted at microscale *in vitro* in a 96-well plate following established protocols (Inthongkaew *et al.*, 2017).

5.1 Materials and instruments

- *p*-Nitrophenyl-α-D-glucopyranoside (p-NPG) (Sigma-Aldrich, USA)
- α-Glucosidase enzyme (Sigma-Aldrich, USA)
- Na_2CO_3 (Sigma-Aldrich, USA)
- DMSO (Sigma-Aldrich, USA)
- Acarbose (Sigma-Aldrich, USA)
- Vortex mixer (Vortex-Genie2, Scientific Industries)
- Incubator (BM500, Memmert)
- Microplate reader (Perkin Elmer, BMG LABTECH)

5.2 Determination of α-glucosidase inhibitory activity

Prepare the sample 1 mg in 1 ml of 50% DMSO. Briefly, 10 µl of the test samples and 40 µL of α-glucosidase solution (0.1 U/ml) were mixed in 96 well microplates. Incubate 96-well plate at 37°C for 10 minutes. After pre-incubation, 50 µL of 20 Mm *p*-nitrophenol-α-D-glucopyranoside (p-NPG) in 50 M phosphate buffer (pH 6.8) was added to each well and incubated at 37 ℃ for 20 minutes. Finally, Na_2CO_3 (100 µL, 1 Mm) was added to each well to stop the reaction. The mixture was measured with a microplate reader at 405 nm. The α-glucosidase inhibitory activity was shown to be the percentage of inhibition and was calculated as follows :

$$\%\ \text{Inhibition} = \frac{(Neg - Neg') - \left(\frac{S}{A} - \frac{S'}{A'}\right)}{(Neg - Neg')}$$

Neg' = Buffer 40 µL + 50% DMSO 10 µL	**Neg = Enzyme 40 µL + 50% DMSO 10 µL**
A' = Buffer 40 1µL + Acarbose 10 µL	**A = Enzyme 40 µL + Acarbose 10 µL**
S' = Buffer 40 µL + Sample 10 µL	**S = Enzyme 40 µL + Sample 10 µL**
Neg = Negative Control	**S = Sample**
A = Acarbose	**' = blank (no enzyme)**

CHAPTER IV

RESULTS AND DISCUSSION

In this research, the extracts were prepared from *Dendrobium braianense* and *D. kentrophyllum.* They were found to have significant α-glucosidase inhibitory potential and thus were subjected to further research to identify the active principles. This chapter is divided into four main sections. Each section describes the results and discussion on the phytochemical and biological studies of each plant.

1. Preliminary biological activity evaluation of *D. braianense* and *D. kentrophyllum*

Dendrobium braianense crude extract was prepared by maceration of the dried powdered whole plants with methanol. The MeOH extract was evaluated for α-glucosidase inhibitory activity and found to show 64.7% inhibition at a concentration of 50µg/ml.

The MeOH extract was divided using ethyl acetate, butanol, and water to give ethyl acetate and butanol extracts. These extracts were then assessed for their α-glucosidase inhibitory property. The ethyl acetate extract was found to show a strong α-glucosidase inhibitory effect with 82.1% inhibition at a concentration of 100 µg/ml, whereas the butanol extract exhibited 68.6% inhibition (**Table 6**). Therefore the ethyl acetate extract was chosen for further chemical research.

Dendrobium kentrophyllum crude extract was prepared by maceration of the dried powdered whole plants with methanol. The MeOH extract was assessed for α-glucosidase inhibitory activity and had 69.7 % inhibition at a concentration of 50 µg/ml. The MeOH extract was divided using ethyl acetate, butanol, and water to give ethyl acetate and butanol extracts. These extracts were then assessed for their α-glucosidase inhibitory property. The ethyl acetate extract was found to show a strong α-glucosidase inhibitory effect with 76.4% inhibition at a concentration of 50 µg/ml,

whereas the butanol extract exhibited 12.74 % inhibition (**Table 6**). Therefore the ethyl acetate extract was chosen for further chemical research.

Table 6. α-glucosidase inhibitory activity of crude extracts from *D. braianense* and *D. kentrophyllum*

***Dendrobium* spp.**	**Extracts (100 µg/ml)**	**% Inhibition**
D. braianense	Methanol Extract	64.7
	Ethyl acetate Extract	82.1
	Butanol Extract	68.6
D. kentrophyllum	Methanol Extract	69.7
	Ethyl acetate Extract	76.4
	Butanol Extract	12.7
Acarbose (positive control)		74.8

2. Structure determination of isolated compounds from *D. braianense*.

2.1 Identification of compound DBra1 (Chrysotoxine)

Compound DBra1 was detached as a white powder. It's HR-ESI-MS (**Appendix 1.1**) showed an $[M+Na]^+$ ion at *m/z* 341.1389 (calcd. For $C_{18}H_{22}O_5Na$, 341.1364) and the molecular formula $C_{18}H_{22}O_5$. The ^1H NMR spectrum (**Appendix 1.2** and **Table 7**) showed a characteristic signals of bibenzyl for five aromatic protons [δ 6.49 (2H, br s, H-2, H-6), 6.71 (1H, dd, *J* = 8.1, 1.8 Hz, H-6′), 6.82 (1H, br s, H-2′), 6.83 (1H, d, *J* = 8.1 Hz, H-5′)], four methoxy groups at δ 3.77 (9H, s) and 3.76 (3H, s), and four methylene protons at δ 2.82 (4H, br s, H_2-α and H_2-α'). It was confirmed by the presence of twelve aromatic carbons and two methylene carbons at δ 38.0 (C-α) and δ (C-α') in ^{13}C NMR and HSQC spectrum (**Appendix 1.3** and **1.4**). The position of H-2 and H-6 were assigned based on their HMBC correlations with C-α (**Appendix 1.7**). The assignments of H-2′ and H-6′ were based on their HMBC correlations with C-α'. The substitution of two symmetric methoxyls at C-3 and C-5 was confirmed by their NOESY correlations with H-2 and H-6 (**Appendix 1.9**). The other two methoxyls were located at C-3′ and C-4′, as shown by their NOESY interactions with H-2′ and H-5′, respectively. Compound DBra1 was known to be chrysotoxine based on the above spectral data. Its ^1H and ^{13}C NMR properties are in line with previously reported values (**Table 7**) (Ono *et al*., 1995).

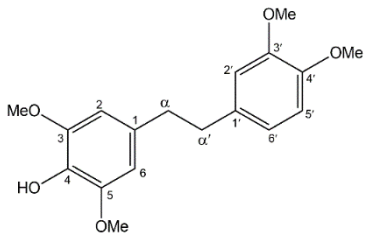


Figure 8. Chrysotoxine

Table 7. ^{1}H NMR (300 MHz) and ^{13}C NMR (75 MHz) spectral data of compound DBra1 in acetone-d_6 and ^{1}H NMR (300 MHz) and ^{13}C NMR (75 MHz) of chrysotoxine in $CDCl_3$

Position	Compound DBra1		Chrysotoxine[a]	
	δ_H (mult., *J* in Hz)	δ_C	δ_H (mult., *J* in Hz)	δ_C
1	-	132.2	-	132.8
2, 6	6.49 (s)	106.0	6.36 (s)	105.2
3, 5	-	147.6	-	146.8
4	-	134.1	-	132.8
α	2.82 (br s)	38.0	2.83 (s)	38.3
α	2.82 (br s)	37.6	2.83 (s)	37.8
1′	-	134.7	-	134.3
2′	6.82 (br s)	112.7	6.66 (d, 1.8)	111.9
3′	-	147.8	-	147.2
4′	-	149.3	-	148.7
5′	6.83 (d, 8.1)	112.0	6.79 (d, 8.1)	111.2
6′	6.71 (dd, 8.1, 1.8)	120.4	6.70 (dd, 1.8, 8.1)	120.4
MeO-3, MeO-5	3.77 (s)	55.7	3.84 (s)*	56.2
MeO-3′	3.77 (s)	55.3*	3.85 (s)*	55.9*
MeO-4′	3.76 (s)	55.1*	3.84 (s)*	55.8*

[a] (Ono *et al*., 1995) * Value in the same column are interchangeable.

2.2 Identification of compound DBra2 (Moscatilin)

Compound DBra2 was gained as a brown amorphous solid. The HR-ESI-MS of this compound showed an $[M+Na]^+$ ion at *m/z* 327.1216 (calcd. for $C_{17}H_{20}O_5Na$, 327.1208), corresponding to the molecular formula $C_{17}H_{20}O_5$. (**Appendix 2.1**). The ^1H and ^{13}C NMR spectrum (**Appendix 2.2**, **2.3** and **Table 8**) of compound DBra2 were similar to compound DBra1, except for the substitution of a hydroxyl instead of a methoxyl at C-4′. The ^1H NMR revealed the signals of five aromatic protons at δ 6.49 (2H, br s, H-2, H-6), 6.65 (1H, dd, *J* = 8.1, 1.5, H-6′), 6.72 (1H, d, *J* = 8.1 Hz, H-5′), 6.79 (1H, d, *J* = 1.5 Hz, H-2′), three methoxyls at 3.77 (6H, s, MeO-3,5) and 3.79 (3H, s, MeO-3′), and two methylene protons at δ 2.79 (4H, br s, H_2-α and H_2-α'). The ^{13}C NMR spectrum (**Appendix 2.3**) exhibited 14 carbon signals of 17 carbons.

Compound DBra2 was identified as moscatilin based on the above spectral evidence and by comparing it with prior reported data (**Table 8**) (Klongkumnuankarn *et al*., 2015).

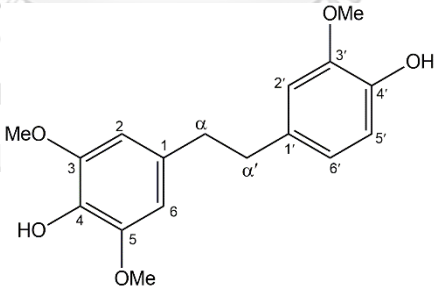


Figure 9. Moscatilin

Table 8. ^{1}H NMR (300 MHz) and ^{13}C NMR (75 MHz) spectral data of compound DBra2 in acetone-d_6 and ^{1}H NMR (300 MHz) and ^{13}C NMR (75 MHz) of moscatilin in acetone-d_6

Position	Compound DBra2		Moscatilin [a]	
	δ_H (mult., *J* in Hz)	δ_C	δ_H (mult., *J* in Hz)	δ_C
1	-	132.3	-	133.1
2, 6	6.49 (br s)	106.0	6.48 (s)	106.7
3, 5	-	147.6	-	148.3
4	-	134.1	-	134.8
α	2.79 (br s)	38.2	2.78 (m)	38.3
α′	2.79 (br s)	37.6	2.78 (m)	38.8
1′	-	133.3	-	134.1
2′	6.79 (d, 1.8)	112.1	6.78 (d, 2.0)	112.9
3′	-	147.2	-	147.9
4′	-	144.7	-	145.3
5′	6.72 (d, 7.8)	114.7	6.75 (d, 8.0)	115.4
6′	6.65 (dd, 8.1, 1.8)	120.8	6.64 (dd, 8.0, 2.0)	121.6
MeO-3, MeO-5	3.77 (s)	55.7	3.75 (s)	56.5
MeO-3′	3.79 (s)	55.3	3.76 (s)	56.1

[a] (Klongkumnuankarn *et al*., 2015)

2.3 Identification of compound DBra3 (Gigantol)

Compound DBra3, a brown amorphous solid, possesses a molecular formula $C_{16}H_{18}O_4$, as suggested by an $[M+Na]^+$ ion at *m/z* 297.1113 (calcd. For $C_{16}H_{18}O_4Na$, 297.1102) in the HR-ESI-MS (**Table 9**). The ^1H NMR (**Appendix 3.2**, **Table 9**) showed signals for two methylene protons at δ 2.76 (4H, br s, H_2-α and H_2-α'). The ^1H NMR also displayed six aromatic proton signals at δ 6.26 (1H, br d, J = 2.1 Hz, H-4), 6.31 (1H, br s, H-2), 6.33 (1H, br s, H-6), 6.66 (1H, dd, J = 8.1, 1.5 Hz, H-6′), 6.74 (1H, d, J = 8.1 Hz, H-5′) and 6.80 (1H, d, J = 1.5 Hz, H-2′), and two methoxyl protons at δ 3.70 (3H, s, MeO-3) and 3.79 (3H, s, MeO-3′). The ^{13}C (**Appendix 3.3**) exhibited 16 carbon signals, corresponding to six quaternary carbons, six methines, two methylenes, and two methoxyls (**Appendix 3.3**).

This compound was identified as gigantol based on above spectral evidence. Its ^1H and ^{13}C NMR data are in line with previously reported data (**Table 9**) (Klongkumnuankarn *et al*., 2015).

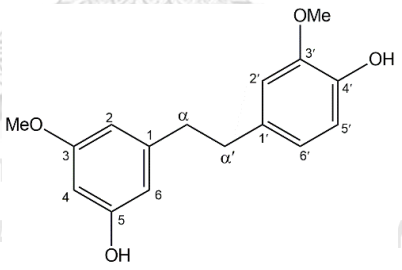


Figure 10. Gigantol

Table 9. ^{1}H NMR (300 MHz) and ^{13}C NMR (75 MHz) spectral data of compound DBra3 in acetone-d_6 and ^{1}H NMR (300 MHz) and ^{13}C NMR (75 MHz) of gigantol in acetone-d_6

Position	Compound DBra3		Gigantol[a]	
	δ_H (mult., *J* in Hz)	δ_C	δ_H (mult., *J* in Hz)	δ_C
1	-	144.6	-	145.4
2	6.31 (br s)	108.1	6.22 (t, 2.0)	108.8
3	-	160.9	-	159.1
4	6.26 (t, 2.1)	98.9	6.28 (t, 2.0)	99.6
5	-	158.4	-	161.7
6	6.33 (br s)	105.4	6.30 (t, 2.0)	106.2
α	2.76 (s)	38.2	2.78 (m)	39.0
α′	2.76 (s)	37.1	2.78 (m)	37.9
1′	-	133.3	-	134.0
2′	6.80 (d, 1.5)	112.0	6.79 (d, 1.5)	115.4
3′	-	147.2	-	147.9
4′	-	144.3	-	145.1
5′	6.74 (d, 8.1)	114.7	6.69 (d, 8.0)	112.8
6′	6.66 (dd, 8.1, 1.5)	120.7	6.64 (dd, 8.0, 1.5)	121.5
MeO-3	3.70 (3H, s)	54.4	3.69 (s)	55.2
MeO-3′	3.79 (3H, s)	55.3	3.78 (s)	56.0

[a] (Klongkumnuankarn *et al*., 2015)

3. Structure determination of isolated compounds from *D. kentrophyllum*

3.1 Identification of compound DK1 (Kaempferol)

Compound DK1 was gained as a yellow powder. The molecular formula of $C_{15}H_{10}O_6$ was analyzed from its $[M+H]^+$ ion at 287.0545 (calcd. for $C_{15}H_{11}O_6$ 287.0555) in the HR-APCI-MS. The ^1H and ^{13}C NMR spectra (**Appendix 4.1** & **4.2**) of this compound exhibited the characteristics of flavonoid nucleus by a sharp singlet proton signal at δ 12.17 (chelated hydroxyl) and the carbon signal at δ 175.7 (C-4). The ^1H NMR showed two doublets at δ 6.26 (1H, d, *J* = 1.8 Hz) and δ 6.52 (1H, d, *J* = 1.8 Hz) assignable to H-6 and H-8 of ring A, respectively. The assignment of H-6 was based on the HMBC of H-6 with C-5 (δ 161.4) (**Appendix 4.6**). It also showed a pair of doublets, 2H each at δ 7.02 (2H, d, *J* = 9.0 Hz, H-3′ and H-5′) and 8.14 (2H, d, *J* = 9.0 Hz, H-2′ and H-6′), suggesting the *para*-hydroxyl substitution of ring B. The ^{13}C NMR and HSQC spectra (**Appendix 4.2** & **4.4**) displayed 13 signals corresponding to 15 carbons including nine quaternary carbons and six methines. By comparing the above spectroscopic data with reported values (Lin *et al*., 2016). Thus, compound DK1 was known to be kaempferol (**Table 10**).

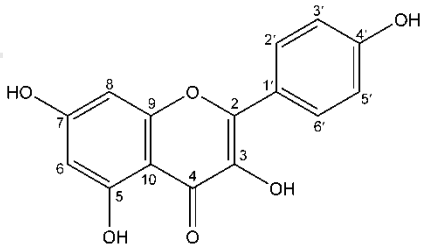


Figure 11. Kaempferol

Table 10. ^{1}H NMR (300 MHz) and ^{13}C NMR (75 MHz) spectral data of DK1 in acetone-d_6 and ^{1}H NMR (600 MHz) and ^{13}C NMR (150 MHz) of kaempferol in DMSO-d_6

Position	Compound DK1		Kaempferol[a]	
	δ_H (mult., *J* in Hz)	δ_C	δ_H (mult., *J* in Hz)	δ_C
2	-	146.1	-	146.8
3	-	135.7	-	135.6
4	-	175.7	-	175.9
5	-	161.4	-	160.7
6	6.26 (d, 1.8)	98.3	6.19 (d, 1.8)	98.2
7	-	164.1	-	164.9
8	6.52 (d, 1.8)	93.6	6.44 (d, 1.8)	93.5
9	-	156.9	-	156.2
10	-	103.3		103.0
1′	-	122.4	-	121.7
2′	8.14 (d, 9.0)	129.6	8.04 (d, 9.0)	130.5
3′	7.02 (d, 9.0)	115.4	6.92 (d, 9.0)	115.4
4′	-	159.3	-	159.2
5′	7.02 (d, 9.0)	115.4	6.92 (d, 9.0)	115.4
6′	8.14 (d, 9.0)	129.6	8.04 (d, 9.0)	130.5
HO-5	12.17 (s)	-	-	-

[a] Lin LJ, Huang XB, Lv ZC. Isolation and identification of flavonoids components from *Pteris vittata* L. 2016; 5: 1649.

3.2 Identification of compound DK2 (Quercetin)

Compound DK2 was detached as a yellow powder. The molecular formula was $C_{15}H_{10}O_7$ by HR-APCI-MS of its $[M+H]^+$ ion at 303.0492 (calcd. for $C_{15}H_{11}O_7$ 303.0504). The ^1H and ^{13}C NMR data were the same as those of **1**, except for the presence of a hydroxyl group at C-3′ of ring B. This was confirmed by the presence of the ABM spin system of ^1H NMR spectrum at δ 7.00 (1H, d, *J* = 8.4 Hz, H-5′), δ 7.69 (1H, dd, *J* = 8.4, 2.1 Hz, H-6′) and 7.82 (1H, d, *J* = 2.1 Hz, H-2′). The ^1H NMR also exhibited two doublets of H-6 (1H, *J* = 1.8 Hz) and H-8 (1H, *J* = 1.8 Hz), and a sharp singlet of 5-OH at δ 12.17. The ^{13}C NMR (Appendix 5.2) displayed 15 signals corresponding to ten quaternary carbons and five methines. Compound DK2 was identified to be quercetin by comparing with prior reported data (**Table 11**) (Lin *et al*., 2016).

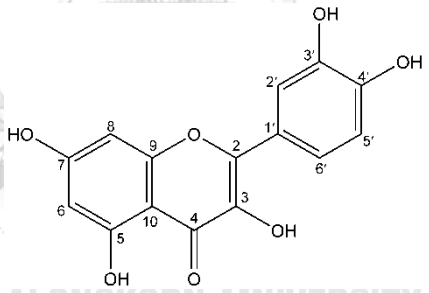


Figure 12. Quercetin

Table 11. ^{1}H NMR (300 MHz) and ^{13}C NMR (75 MHz) spectral data of compound DK2 in acetone-d_6 and ^{1}H NMR (600 MHz) and ^{13}C NMR (150 MHz) of quercetin in DMSO-d_6

Position	Compound DK2		Quercetin[a]	
	δ_H (mult., *J* in Hz)	δ_C	δ_H (mult., *J* in Hz)	δ_C
2	-	146.1	-	146.7
3	-	135.9	-	135.6
4	-	175.7	-	175.8
5	-	161.4	-	160.4
6	6.26 (d, 1.8)	98.3	6.19 (d, 1.8)	98.1
7	-	164.1	-	163.8
8	6.51 (d, 1.8)	93.6	6.40 (d, 2.4)	93.3
9	-	156.9	-	156.1
10	-	103.2		102.9
1′	-	122.8	-	121.8
2′	7.82 (d, 2.1)	114.8	7.67 (d, 2.4)	114.9
3′	-	144.9	-	144.9
4′	-	147.5	-	147.6
5′	7.00 (d, 8.4)	115.3	6.88 (d, 8.4)	115.5
6′	7.69 (dd, 8.4, 2.1)	120.6	7.54 (dd, 8.4, 2.4)	119.9
HO-5	12.17 (s)	-	-	-

[a] Lin LJ, Huang XB, Lv ZC. Isolation and identification of flavonoids components from *Pteris vittata* L. 2016; 5: 1649.

3.3 Identification of compound DK3 (Rutin)

Compound DK3, a yellow powder, showed its $[M+Na]^+$ ion at 633.1436 (calcd. for $C_{27}H_{30}O_{16}Na$ 633.1431) in the HR-ESI-MS, suggesting a molecular formula $C_{27}H_{30}O_{16}$. The ^1H NMR spectrum (**Appendix 6.1**) showed the presence of the ABM splitting system of ring B at δ 7.52 (1H, br s, H-2′), δ 7.54 (1H, br d, *J* = 8.7 Hz, H-6′) and δ 6.82 (1H, d, *J* = 8.7 Hz, H-5′) and two broad singlets of H-6 and H-8 at δ 6.18 and δ 6.37. In addition, the appearance of two anomeric proton signals at δ 5.33 (1H, d, *J* = 6.9 Hz, H-1″) and δ 4.37 (1H, s, H-1‴), which revealed HSQC correlations with the carbon at δ 101.6 (C-1″) and δ 101.2 (C-1‴), respectively, suggest that this compound should be a diglycoside of compound DK2. The ^{13}C NMR and HSQC spectra (**Appendix 6.5**) exhibited 12 carbon signals of sugar carbons and 15 carbon signals of the quercetin nucleus. The sugars were identified as rutinose (α-rhamnopyranosyl-β-glucopyranose) by comparison with reported values (Sintayehu *et al*., 2012). The connection of glucose and rhamnose was maintained by the HMBC correlations of C-1‴ with H-6″ (**Appendix 6.8**). The rutinose was located at C-3 of quercetin based on the HMBC correlations of C-3 (δ 133.7) with H-1″. Compound DK3 was determined as quercetin-3-*O*-rutinoside or rutin by comparing with prior reported data (**Table 9**) (Sintayehu *et al*., 2012).

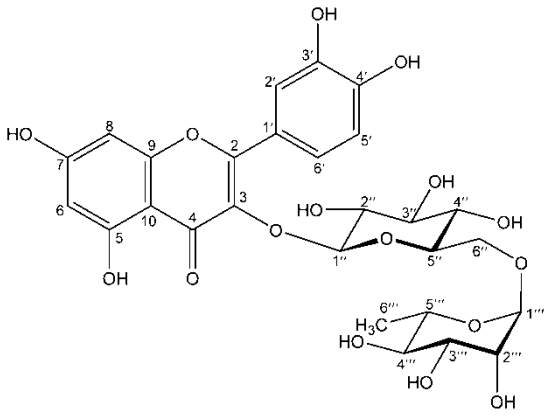


Figure 13. Rutin

Table 12. ^{1}H NMR (300 MHz) and ^{13}C NMR (75 MHz) spectral data of compound DK3 in acetone-d_6 and ^{1}H NMR (400 MHz) and ^{13}C NMR (100 MHz) of rutin in DMSO-d_6

Position	Compound DK3		Rutin[a]	
	δ_H (mult., *J* in Hz)	δ_C	δ_H (mult., *J* in	δ_C
2	-	156.9	-	157.1
3	-	133.7	-	133.7
4	-	177.8	-	177.8
5	-	161.7	-	161.6
6	6.18 (br s)	99.1	6.20 (d, 1.6)	99.1
7	-	164.6	-	164.5
8	6.37 (br s)	94.0	6.39 (d, 1.6)	94.1
9	-	157.0	-	156.9
10	-	104.4	-	104.4
1′	-	121.6	-	121.6
2′	7.52 (br s)	116.7	7.52 (s)	115.7
3′	-	145.2	-	145.2
4′	-	148.9	-	148.8
5′	6.82 (d, 8.7)	115.7	6.85 (d, 8.4)	116.7
6′	7.54 (br d, 8.7)	122.0	7.55 (d, 8.4)	122.1
HO-5	12.59 (s)	-	12.56 (s)	-
1″	5.33 (d, 6.9)	101.6	5.33 (d)	101.6
2″	3.22-3.28 (m)	74.5	3.32-3.81	74.5
3″	3.22-3.28 (m)	76.9	3.32-3.81	76.9
4″	3.22-3.28 (m)	71.0	3.32-3.81	71.1
5″	3.22-3.28 (m)	76.4	3.32-3.81	76.3
6″	3.68, 3.29 (m)	67.4	3.32-3.81	67.4
1‴	4.37 (s)	101.2	4.38 (s)	101.2
2‴	3.22-3.28 (m)	70.8	3.32-3.81	70.8
3‴	3.03-3.09 (m)	70.4	3.32-3.81	70.4
4‴	3.03-3.09 (m)	72.3	3.32-3.81	72.3
5‴	3.22-3.28 (m)	68.7	3.32-3.81	68.7
6‴	0.98 (d, 6.0)	18.2	1.11 (d, 6.0)	18.2

[a] Sintayehu B, Asres K, Raghavendra Y. Radical scavenging activities of the leaf extracts and a flavonoid glycoside isolated from *Cineraria abyssinica* Sch. Bip. Exa. Rich. Journal of Applied Pharmaceutical Science. 2012; 2: 44-49.

4. Biological activity of isolated compounds of *Dendrobium braianense* and *Dendrobium kentrophyllum*

In this study, the isolated compounds were assessed for α-glucosidase inhibitory activity (**Table 13**). Chrysotoxine and moscatilin did not possess α-glucosidase inhibitory activity (28.71% and 14.44 % inhibition at 100 µg/ml), in line with prior research (Inthongkaew, *et al*., 2013). Gigantol exhibited a stronger inhibitory effect (IC_{50} 349 µM) than acarbose (IC_{50} 532.4 µM). These findings show that those compounds have α-glucosidase inhibitory activity compared with earlier reported values. Gigantol (IC_{50} 79.87 µM) than acarbose (IC_{50} 724.74 µM) (San, H. T., *et al*., 2011). Kaempferol (IC_{50} 42.59 µM) and Quercetin (IC_{50} 30,67 µM), than acarbose (IC_{50} 177,5 µM) (Habtemariam, S., 2011). Rutin did not possess α-gluco sidase inhibitory activity which is in agreement with a previous report (Habtemariam, S., 2011). Kaempferol and quercetin exhibited strong inhibitory effects with IC_{50} of 87.5 and 109.1 µM compared with acarbose. These findings were in agreement with previously reported values (Habtemariam, S., 2011).

Table 13. α-Glucosidase inhibitory activity of *D. braianense* and *D. kentrophyllum*

compounds	**IC_{50} (µM)**
DBra 1 (Chrysotoxine)	NA
DBra 2 (Moscatilin)	NA
DBra 3 (Gigantol)	349.0 ± 9.3
DK 1 (Kaempferol)	87.5 ± 6.2
DK 2 (Quercetin)	109.1 ± 7.6
DK 3 (Rutin)	NA
Acarbose	532.4 ± 19.6

CHAPTER V

CONCLUSION

The ethyl acetate extracts prepared from the whole plant of *Dendrobium braianense* and *D. kentrophyllum* exhibited α-glucosidase inhibitory activity 82.1% and 76.4%, respectively, at a concentration of 100 µg/mL. Phytochemical research of the ethyl acetate extract of *D. braianense* led to the isolation of three bibenzyls, which included chrysotoxine, moscatilin, and gigantol. Chromatographic separation of the ethyl acetate extract of *Dendrobium kentrophyllum* led to the isolation of three flavonoids, namely kaempferol, quercetin, and rutin. The structures of these isolates were determined utilizing the analysis of their ^{1}H NMR, ^{13}C NMR, and MS data and compared with the prior reported values. All the isolated compounds were assessed for their α-glucosidase inhibitory activity. Gigantol, kaempferol, and quercetin were found to exhibit strong α-glucosidase inhibitory activity with IC_{50} 349.0, 87.5, and 109.1 µM, respectively, in comparison with positive control acarbose (IC_{50} 532.4 µM). These findings show that those compounds have α-glucosidase inhibitory activity compared with earlier reported values. Gigantol (IC_{50} 79.87 µM) than acarbose (IC_{50} 724.74 µM) (San, H. T., *et al*., 2011). Kaempferol (IC_{50} 42.59 µM) and Quercetin (IC_{50} 30,67 µM), than acarbose (IC_{50} 177,5 µM) (Habtemariam, S., 2011).

Chrysotoxine, moscatilin, and rutin were devoid of activity. Finally, the writer suggest for further experiments to broaden scientific information.

APPENDICES

Appendix 1: The spectral data of compound DBra 1

1.1 Mass spectrum of compound DBra 1

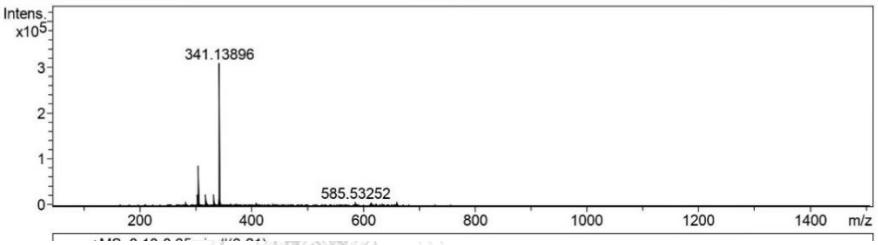
Mass Spectrum List Report

Analysis Info

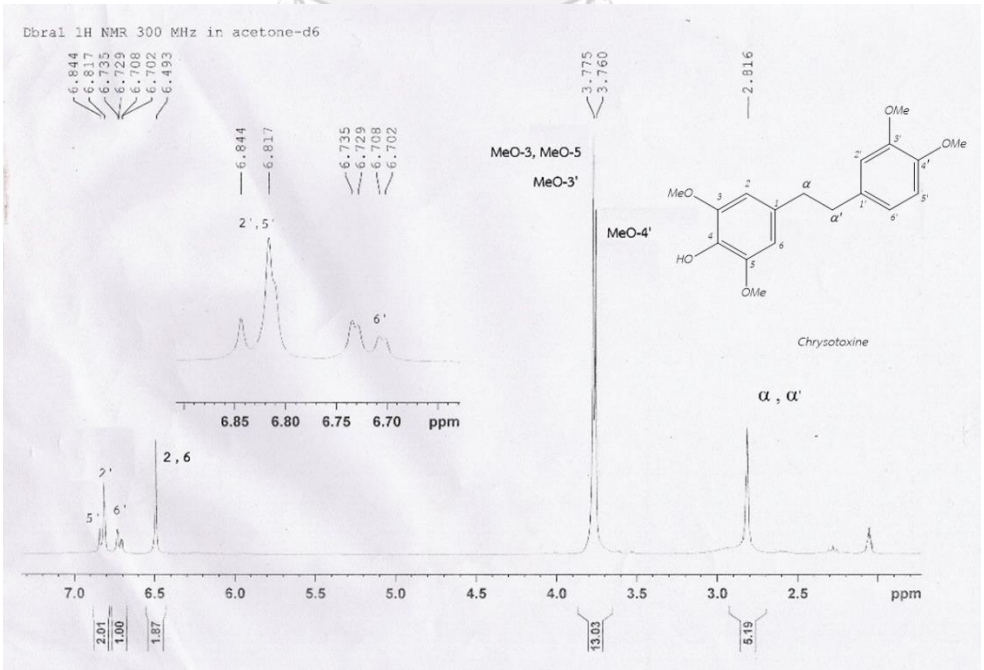
Analysis Name	D:\Data\Data Service\200720\D bra 1_RD1_01_4097.d	Acquisition Date	7/20/2020 6:17:37 PM
Method	nv_pos_6min_profile_wguardcol_50-1500_191021.m	Operator	CU.
Sample Name	D bra 1	Instrument / Ser#	micrOTOF-Q II 10335
Comment			

Acquisition Parameter

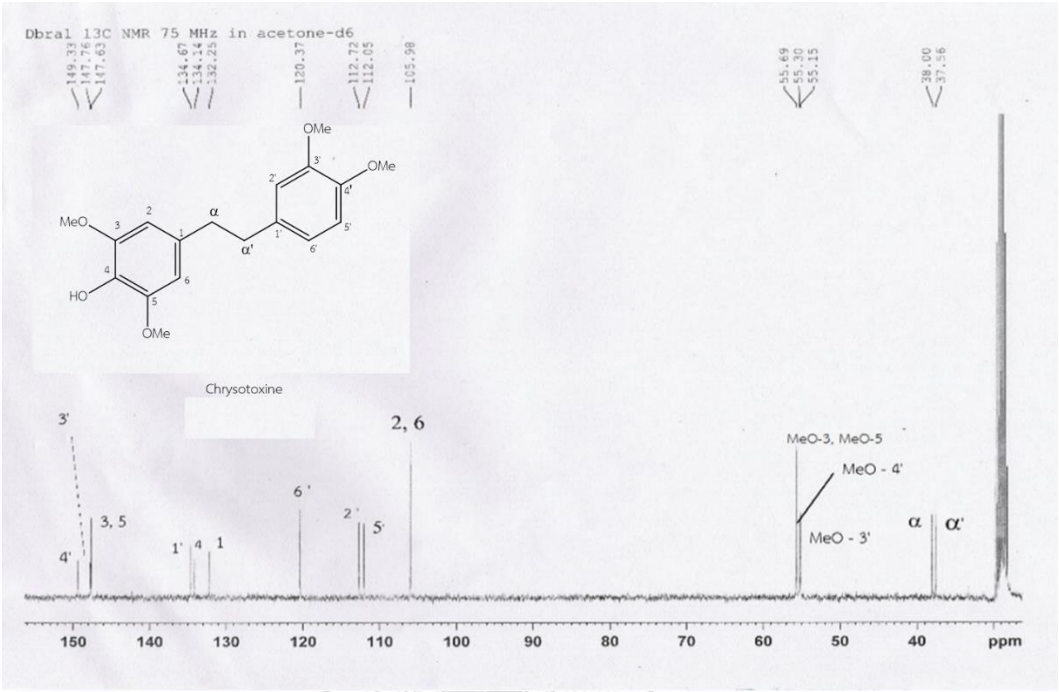
Source Type	ESI	Ion Polarity	Positive	Set Nebulizer	3.0 Bar
Focus	Not active	Set Capillary	4000 V	Set Dry Heater	200 ℃
Scan Begin	50 m/z	Set End Plate Offset	-500 V	Set Dry Gas	8.0 l/min
Scan End	1500 m/z	Set Collision Cell RF	250.0 Vpp	Set Divert Valve	Waste



1.2 ^{1}H-NMR (300 MHz) spectrum of compound DBra 1 (Acetone-d_6)

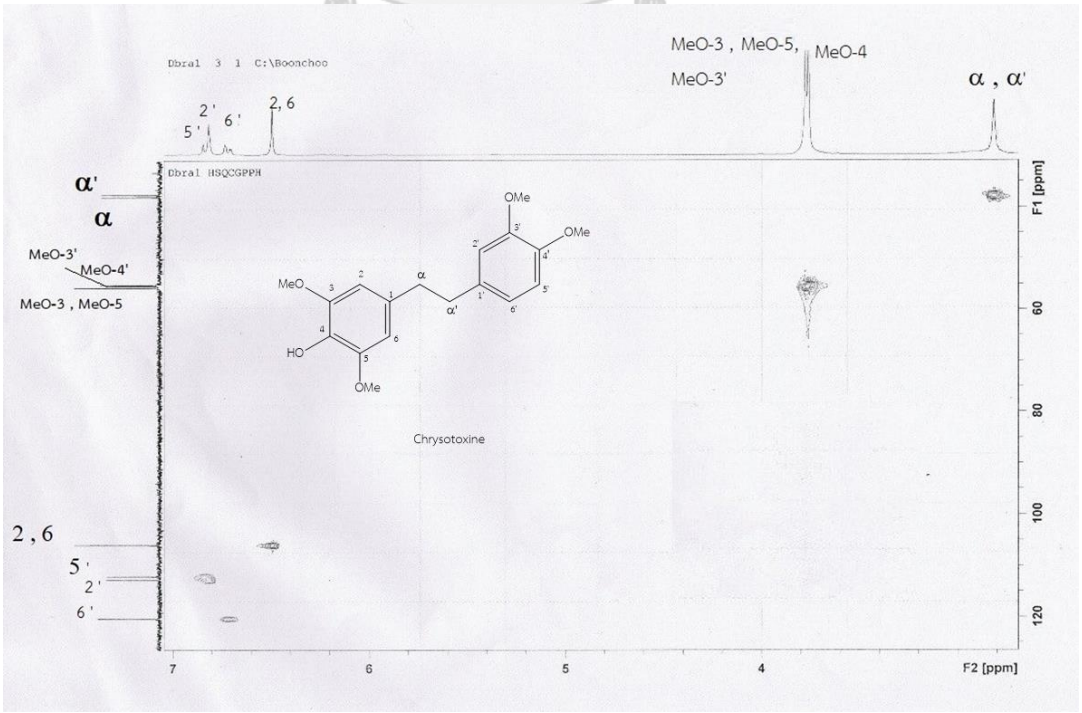


1.3 ^{13}C-NMR (75 MHz) spectrum of compound DBra 1 (Acetone-d_6)



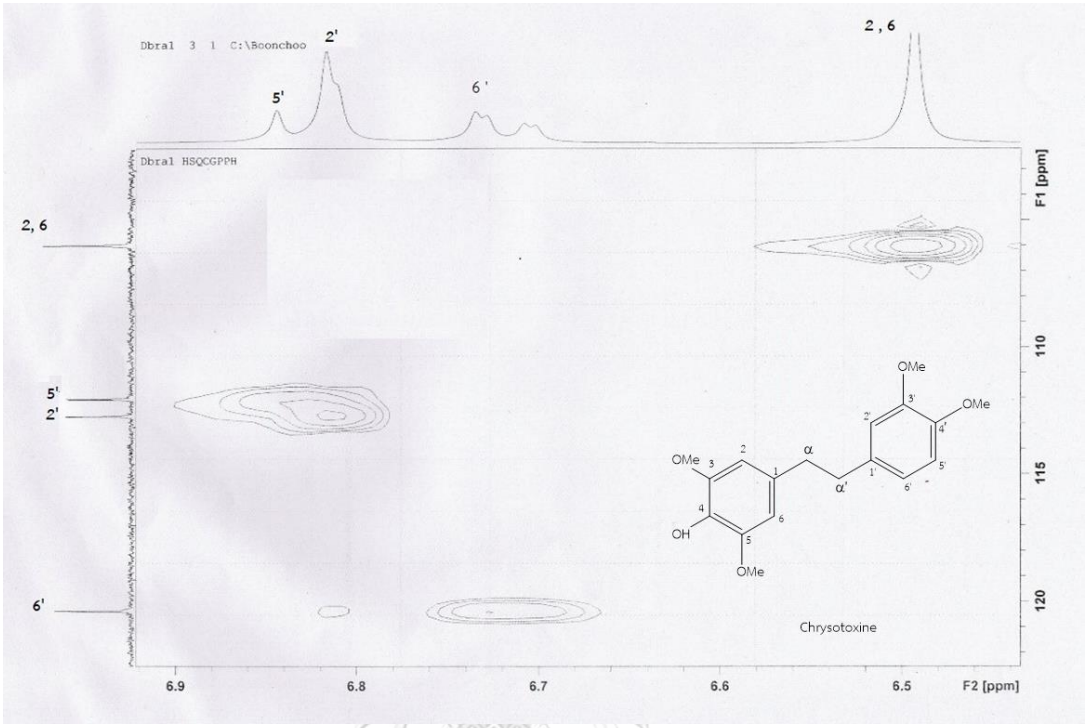
1.4 HSQC spectrum of compound DBra 1 (Acetone-d_6)

expansion [δH 2.82 – 6.83 ppm, δC 37.6 – 120.4]



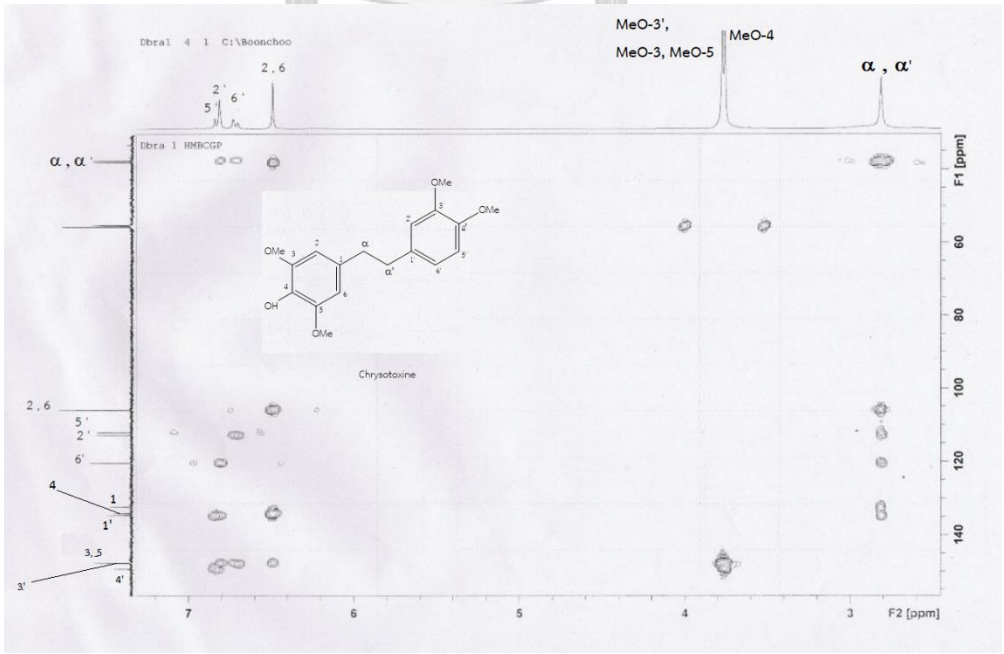
1.5 HSQC spectrum of compound DBra 1 (Acetone-d_6)

expansion [δH 6.49 – 6.83 ppm, δC 106.0 – 120.4]



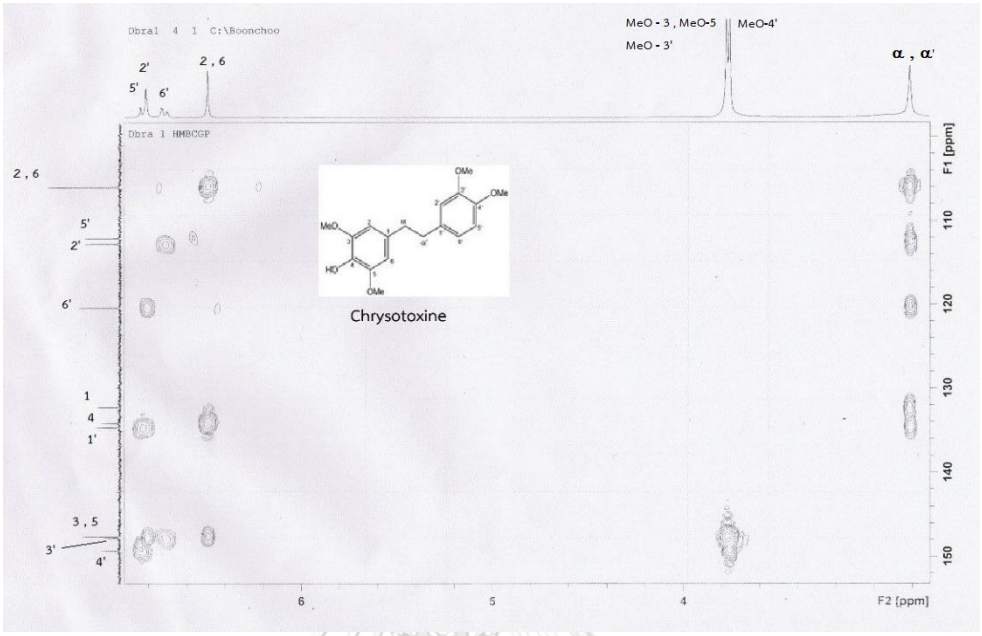
1.6 HMBC spectrum of compound DBra 1 (Acetone-d_6)

expansion [δH 2.82 – 6.83 ppm, δC 37.6 – 149.3 ppm]



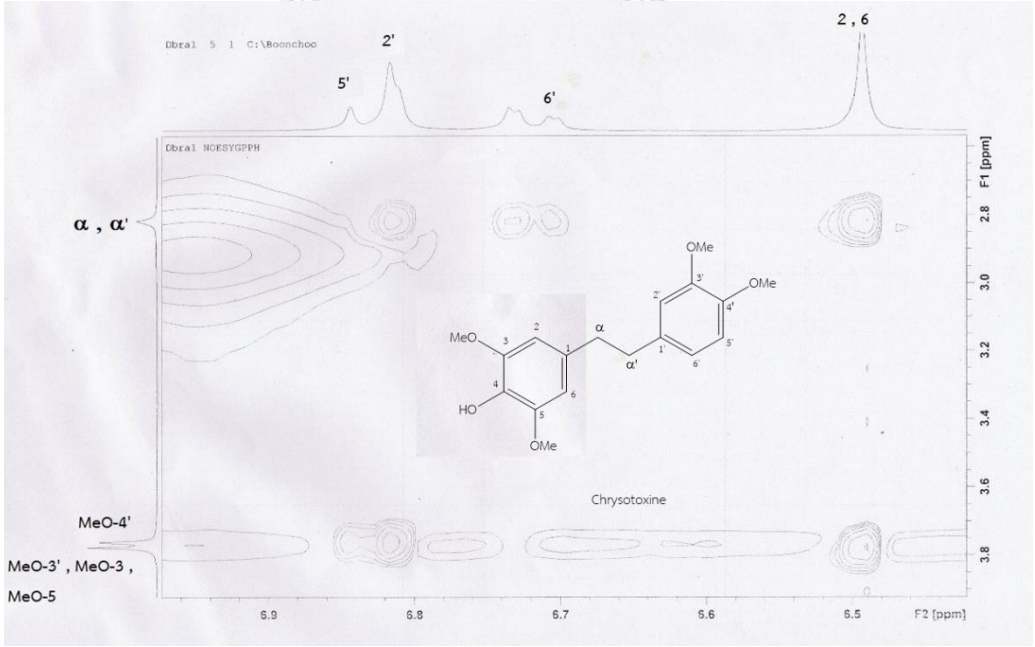
1.7 HMBC spectrum of compound DBra 1 (Acetone-d_6)

expansion [δH 2.82 – 6.83 ppm, δC 106.0 – 149.3 ppm]



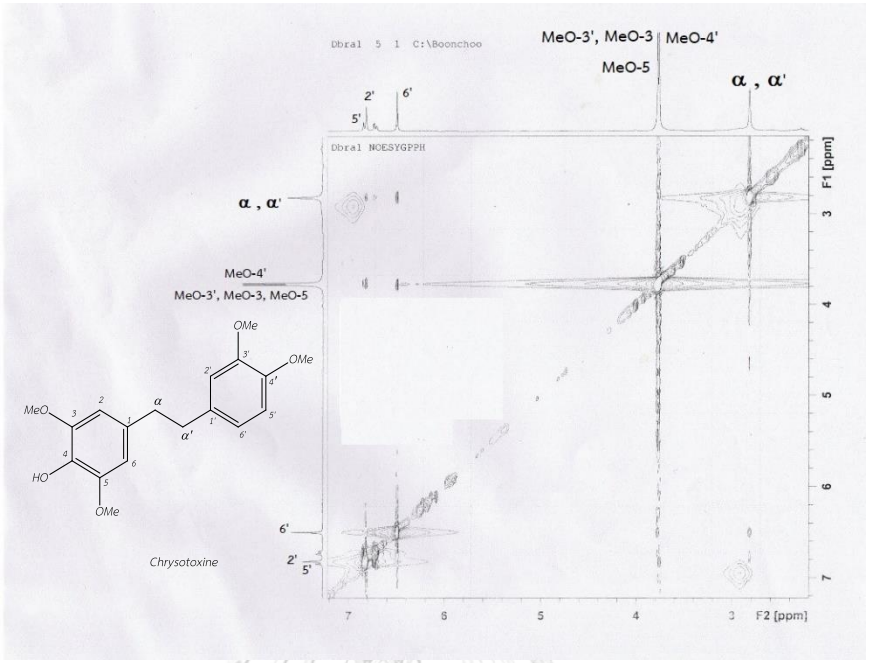
1.8 NOESY spectrum of compound DBra 1 (Acetone-d_6)

expansion [δH 2.82 – 3.77 ppm (F1), δH 6.49 – 6.83 ppm (F2)]



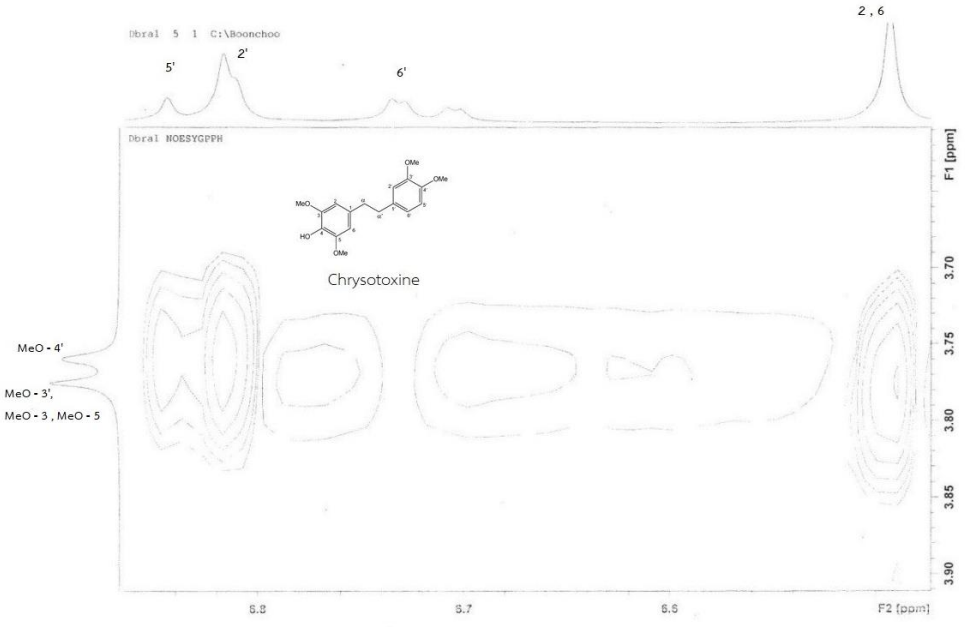
1.9 NOESY spectrum of compound DBra 1 (Acetone-d_6)

expansion [δH 2.82 – 6.83 ppm]



1.10 NOESY spectrum of compound DBra 1 (Acetone-d_6)

expansion [δH 6.49 – 6.83 ppm]

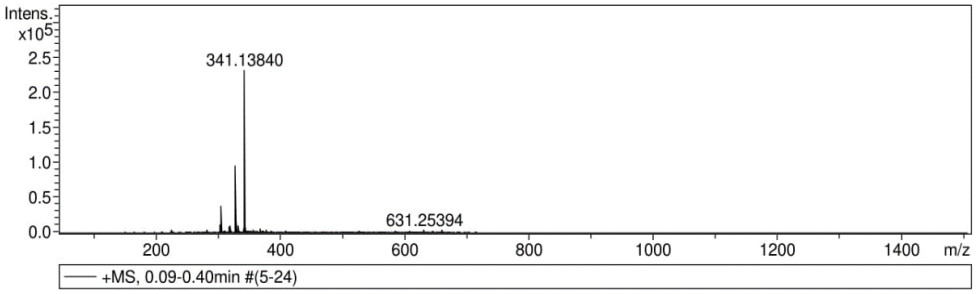


Appendix 2: The spectral data of compound DBra 2

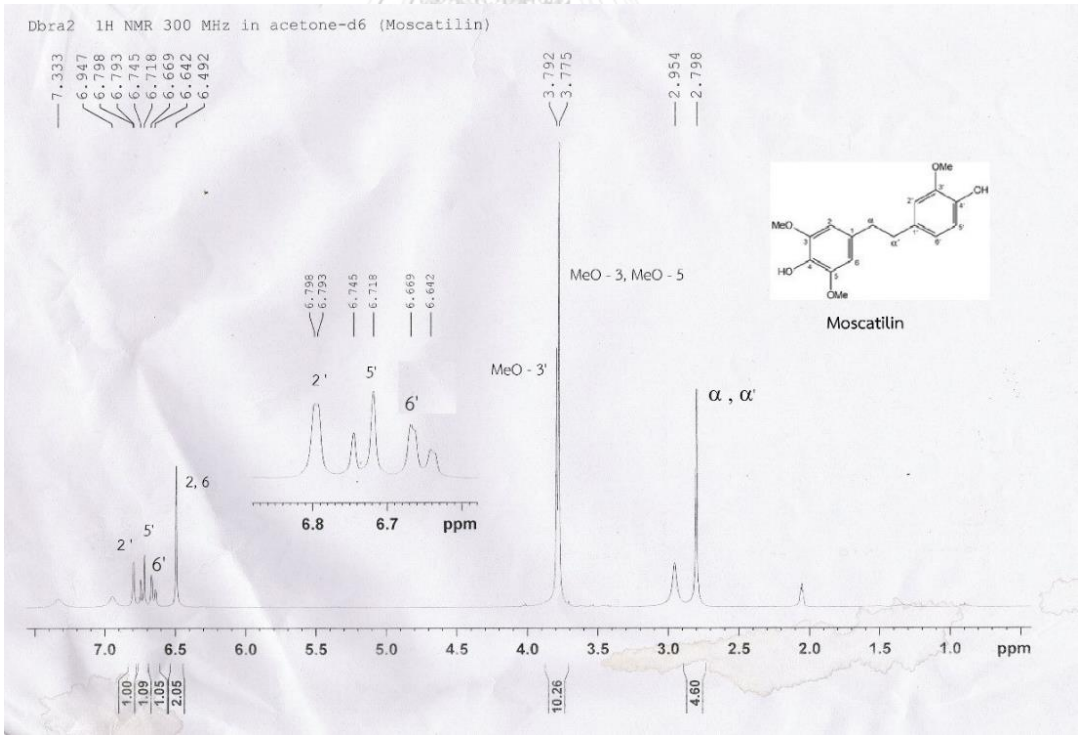
2.1 Mass spectrum of compound DBra 2

Acquisition Parameter

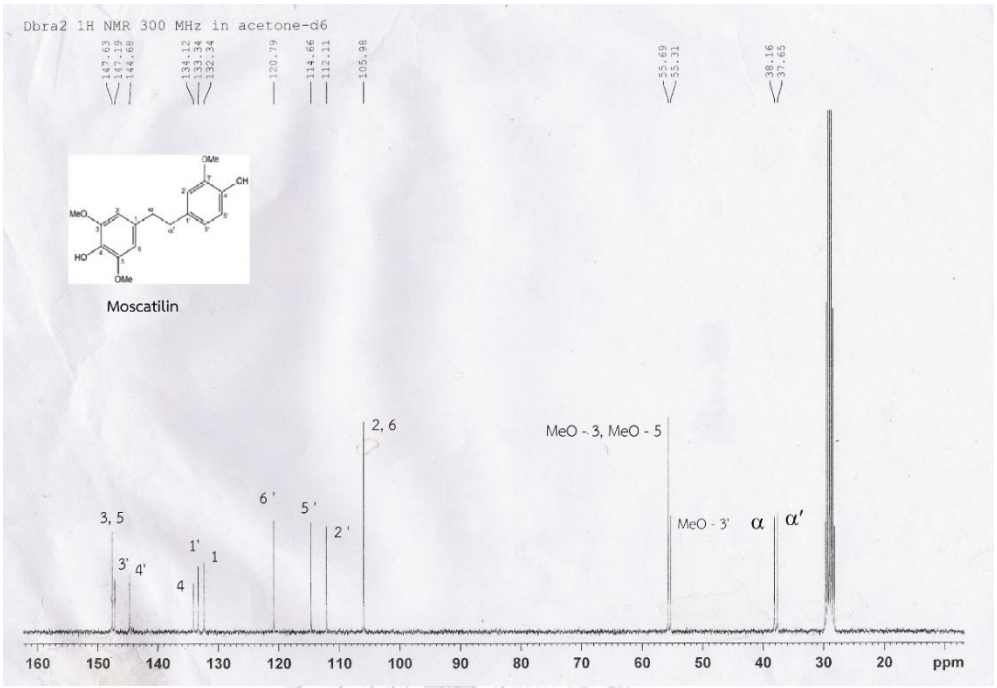
Source Type	ESI	Ion Polarity	Positive	Set Nebulizer	3.0 Bar
Focus	Not active	Set Capillary	4000 V	Set Dry Heater	200 ℃
Scan Begin	50 m/z	Set End Plate Offset	-500 V	Set Dry Gas	8.0 l/min
Scan End	1500 m/z	Set Collision Cell RF	250.0 Vpp	Set Divert Valve	Waste



2.2 ^{1}H-NMR (300 MHz) spectrum of compound DBra 2 (Acetone-d_6)

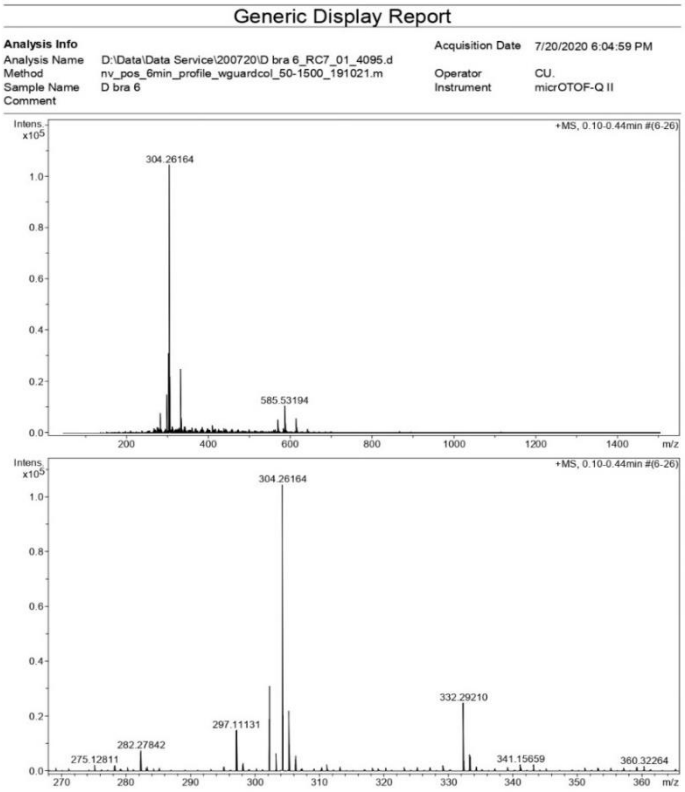


2.3 ^{13}C-NMR (75 MHz) spectrum of compound DBra 2 (Acetone-d_6)

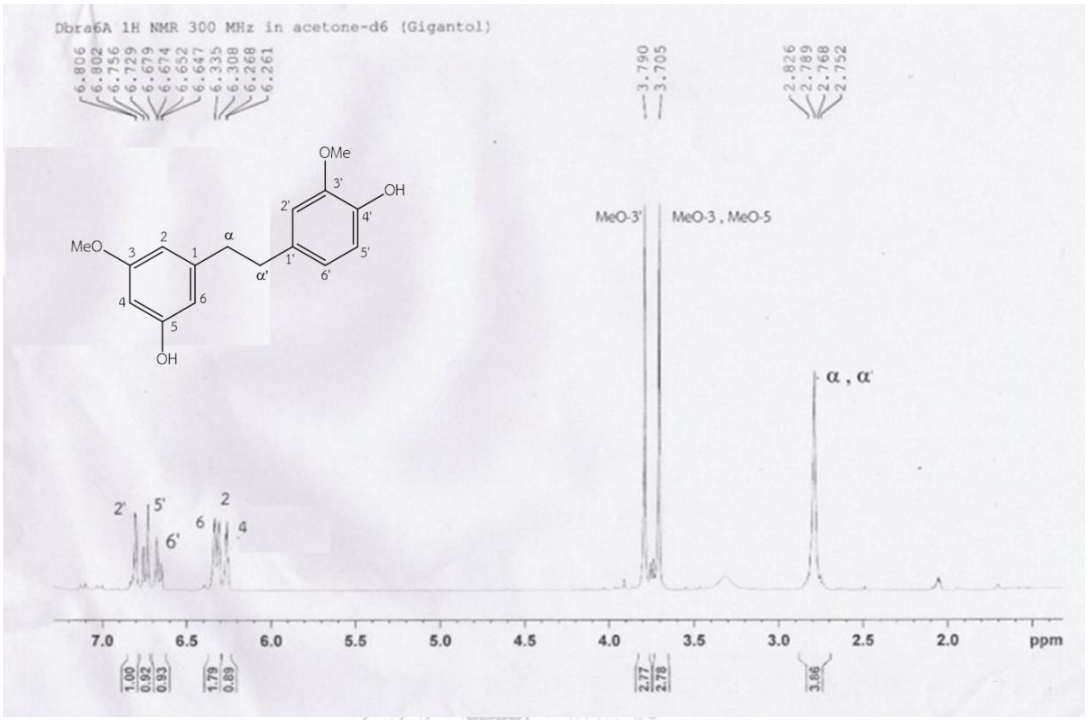


Appendix 3: The spectral data of compound DBra 3

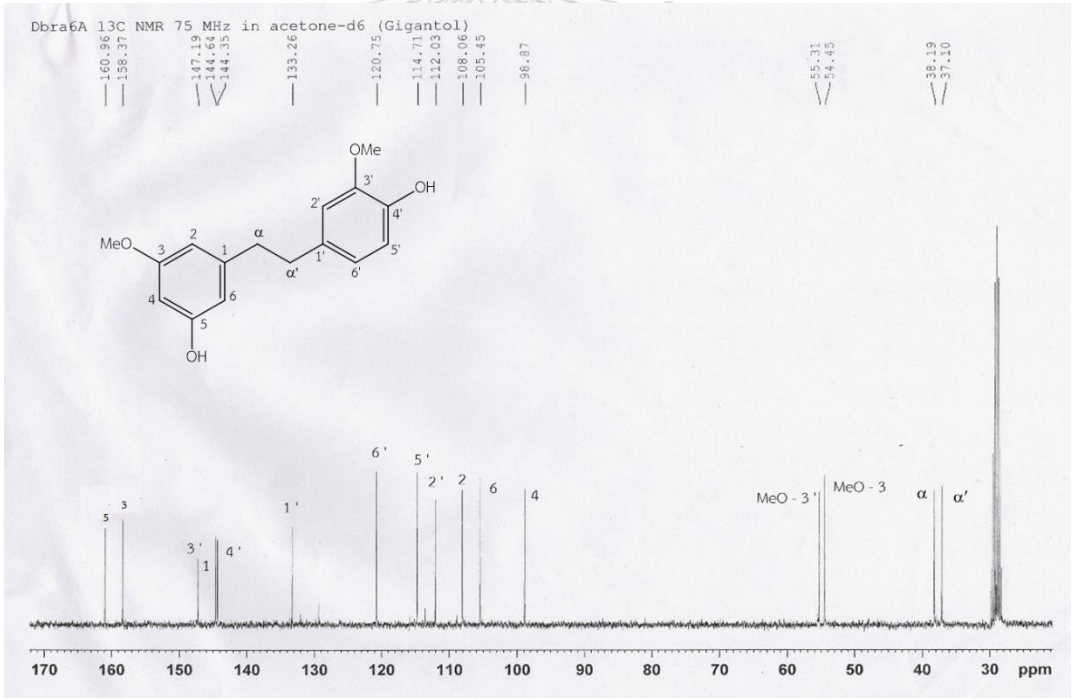
3.1 Mass spectrum of compound DBra 3



3.2 ^{1}H-NMR (300 MHz) spectrum of compound DBra 3 (Acetone-d_6)

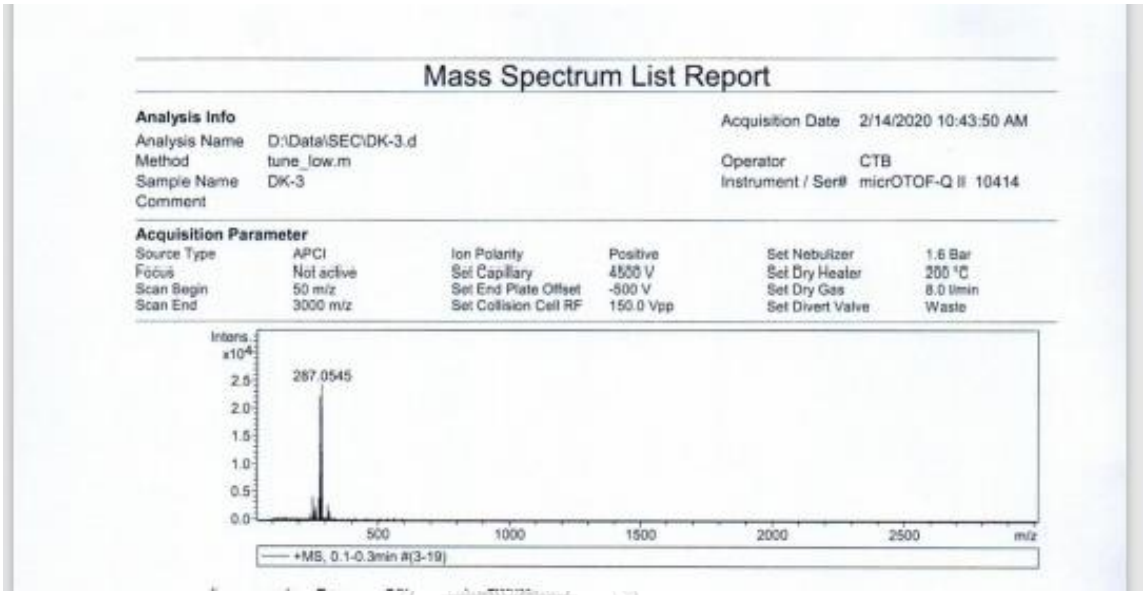


3.3 ^{13}C-NMR (75 MHz) spectrum of compound DBra 3 (Acetone-d_6)

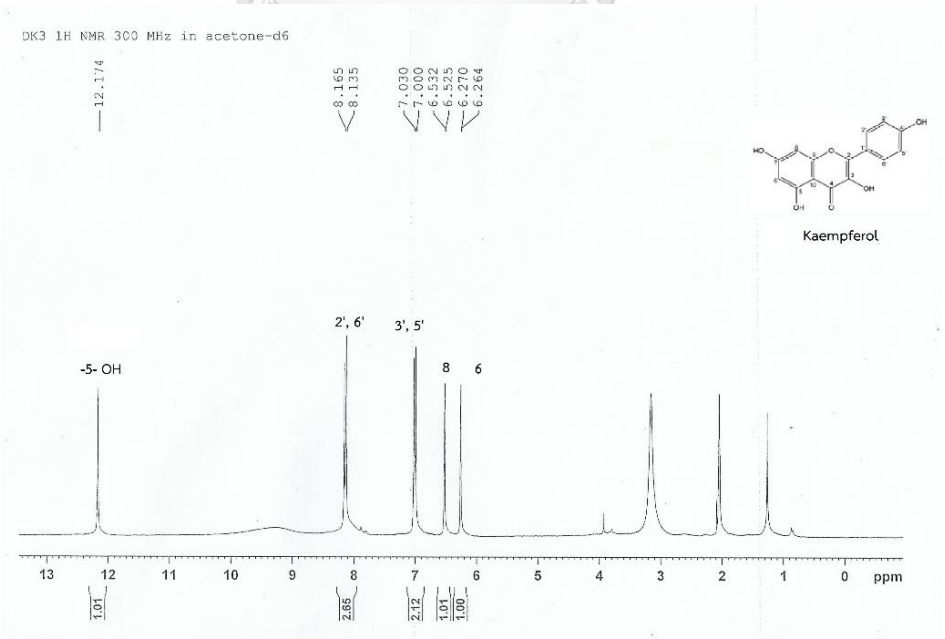


Appendix 4: The spectral data of compound DK 1

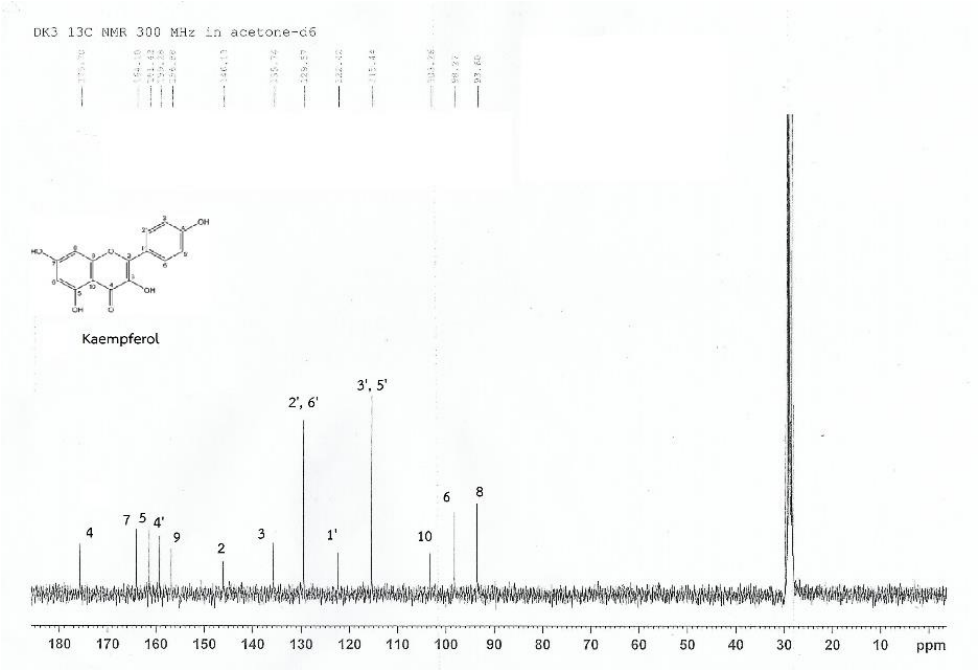
4.1. Mass spectrum of compound DK 1



4.2 ^{1}H-NMR (300 MHz) spectrum of compound DK 1 (Acetone-d_6)

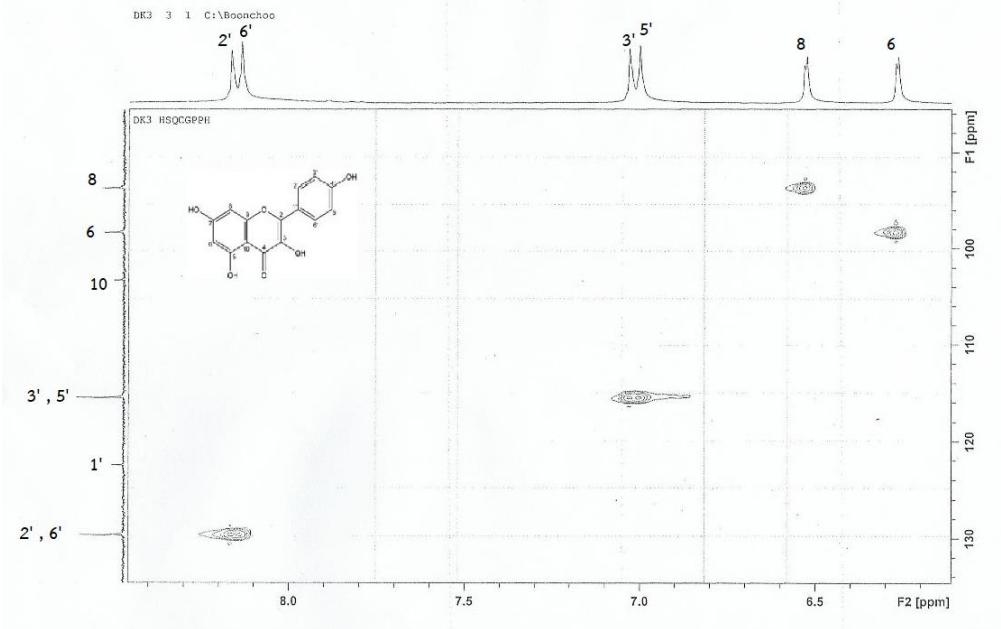


4.3 ^{13}C-NMR (300 MHz) spectrum of compound DK 1 (Acetone-d_6)



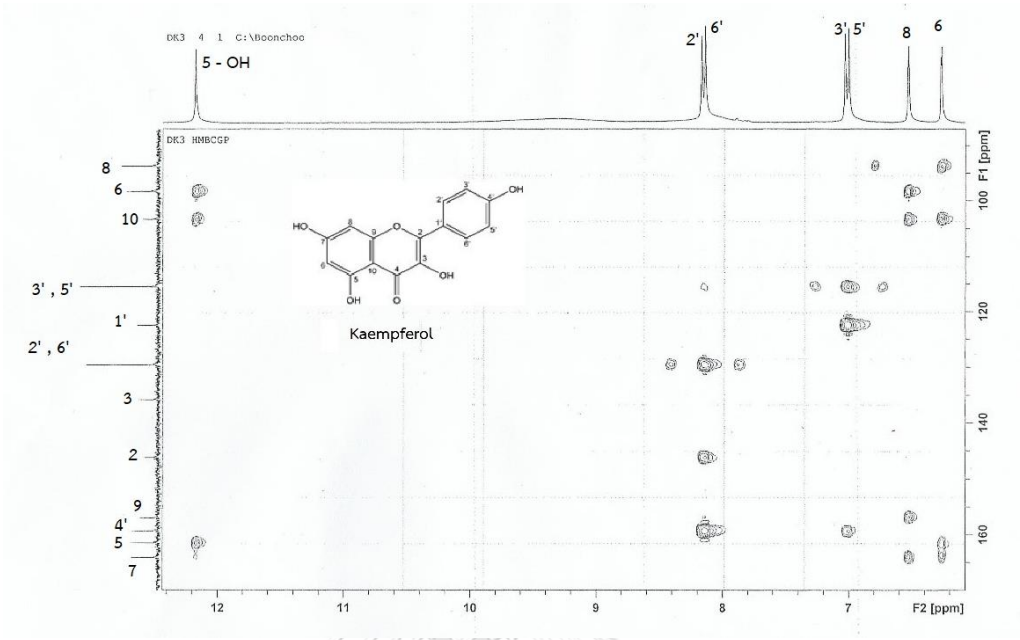
4.4 HSQC NMR spectrum of compound DK 1 (Acetone-d_6)

expansion [δH 6.26 – 8.14 ppm, δC 93.6 – 129.6 ppm]



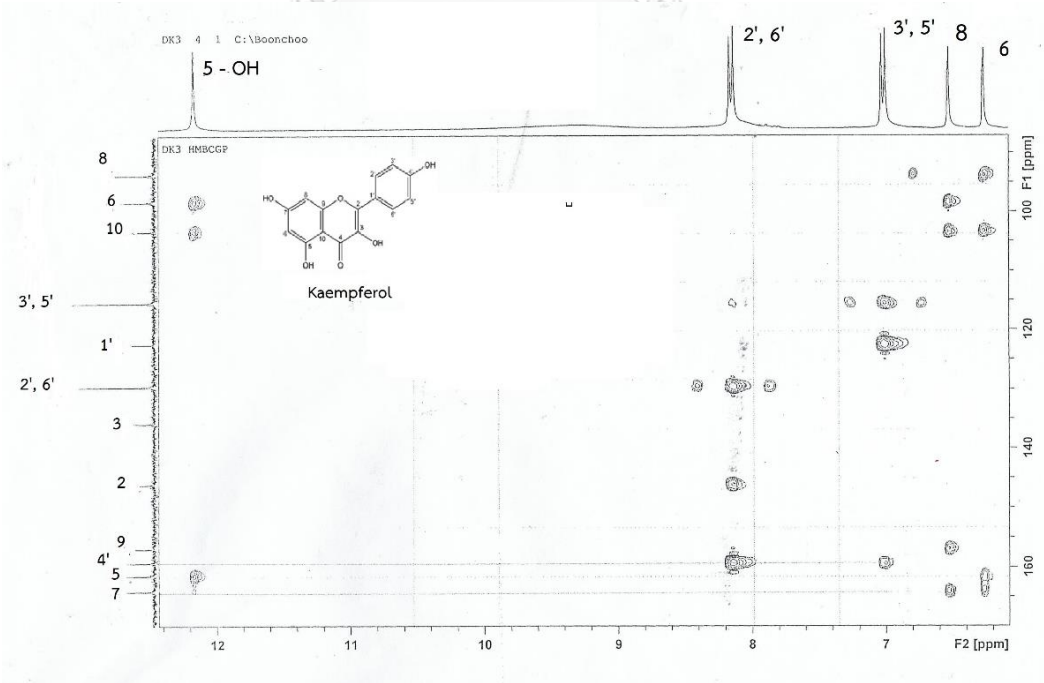
4.5 HMBC NMR spectrum of compound DK 1 (Acetone-d_6)

expansion [δH 6.26 – 12.17 ppm, δC 93.6 – 164.1 ppm]



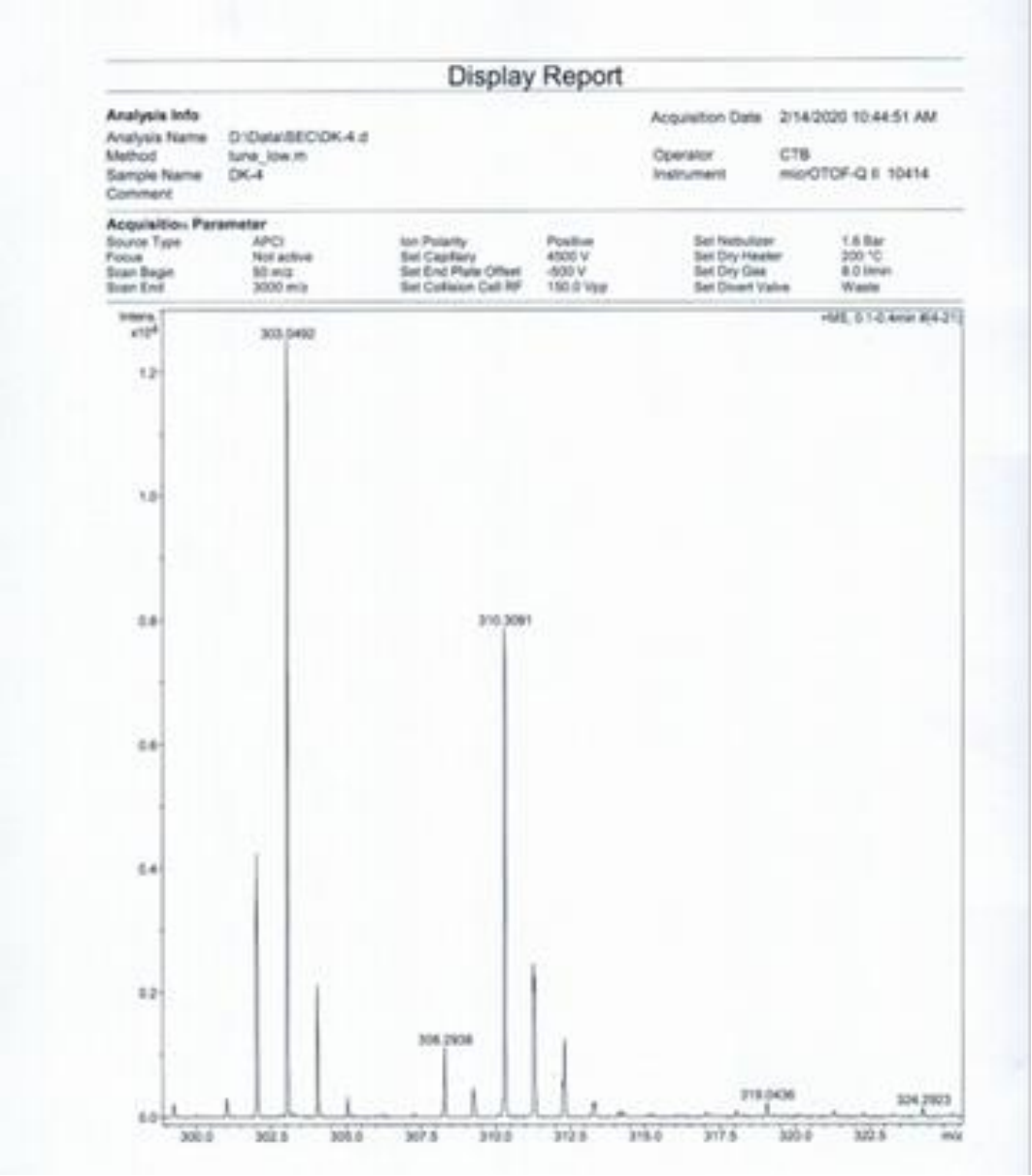
4.6 HMBC NMR spectrum of compound DK 1 (Acetone-d_6)

expansion [δH 6.26 – 12.17 ppm, δC 93.6 – 164.1 ppm]

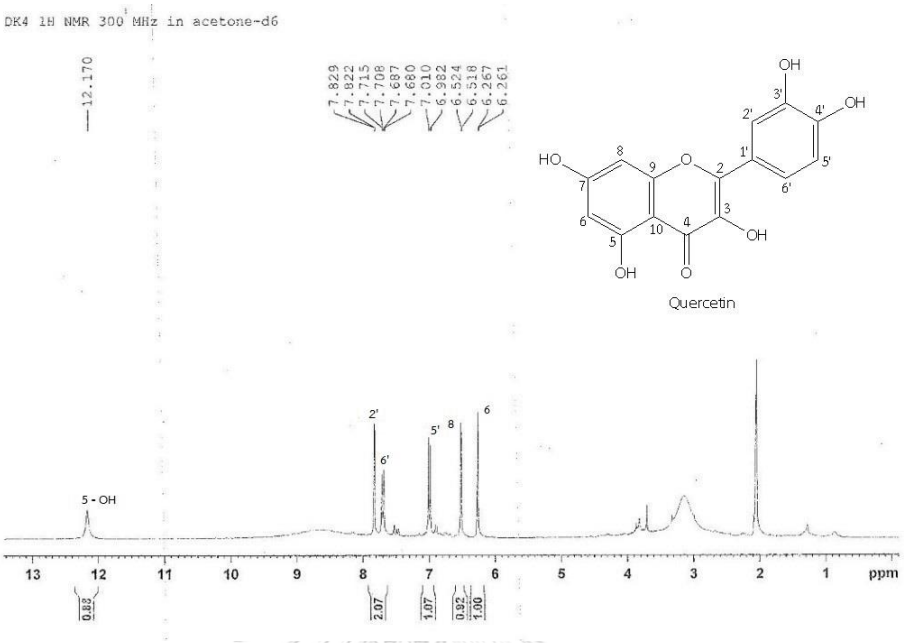


Appendix 5: The spectral data of compound DK 2

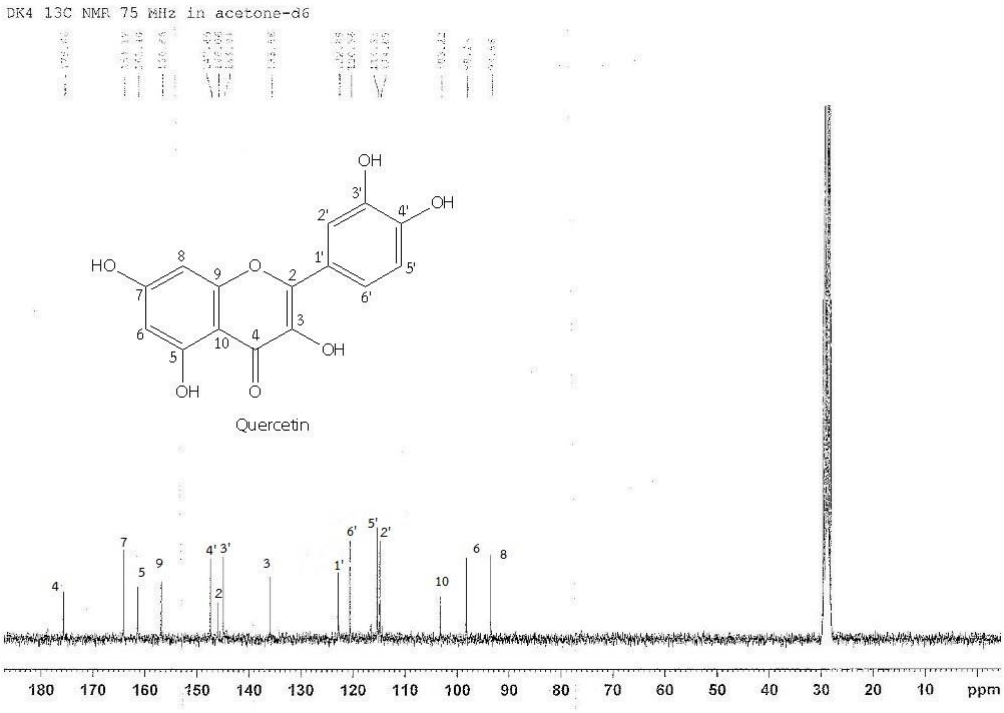
5.1 Mass spectrum of compound DK 2



5.2 ^{1}H-NMR (500 MHz) spectrum of compound DK 2 (Acetone-*d6*)

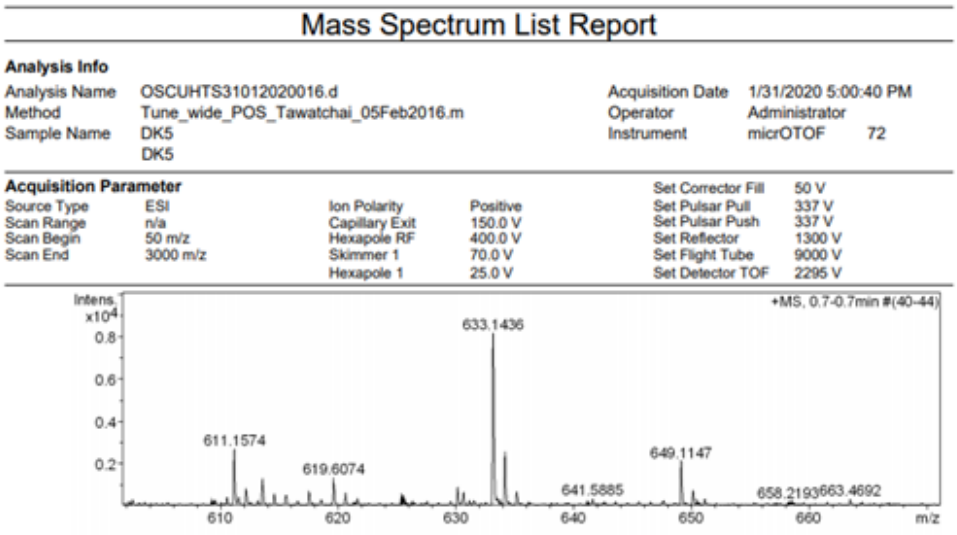


5.3 ^{13}C-NMR (75 MHz) spectrum of compound DK 2 (Acetone-*d6*)



Appendix 6: The spectral data of compound DK 3

6.1 Mass spectrum of compound DK 3



Mass Spectrum List Report

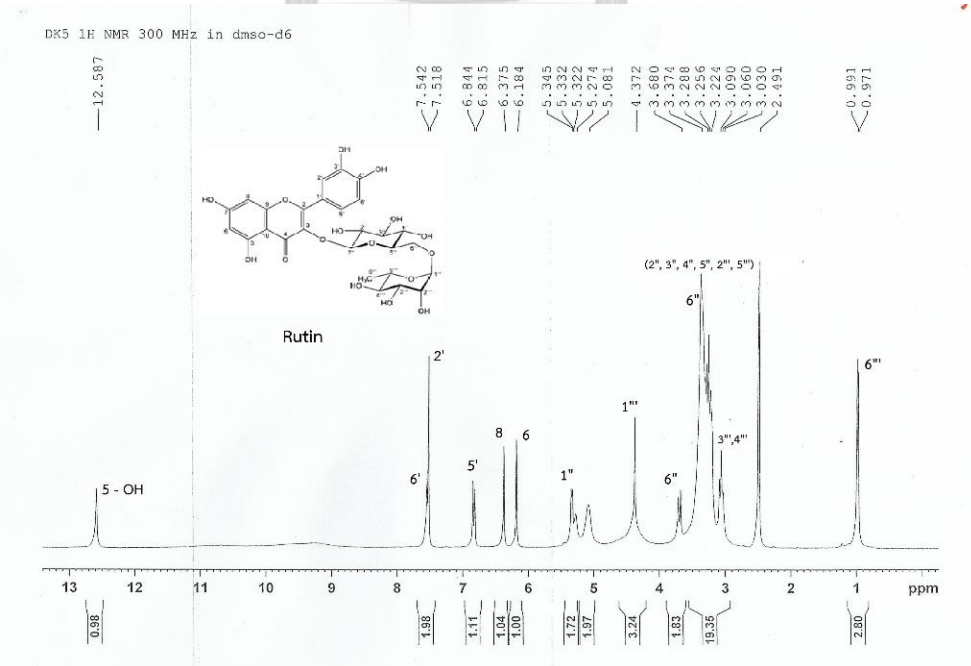
Analysis Info

Analysis Name	OSCUHTS31012020016.d	Acquisition Date	1/31/2020 5:00:40 PM
Method	Tune_wide_POS_Tawatchai_05Feb2016.m	Operator	Administrator
Sample Name	DK5	Instrument	micrOTOF 72
	DK5		

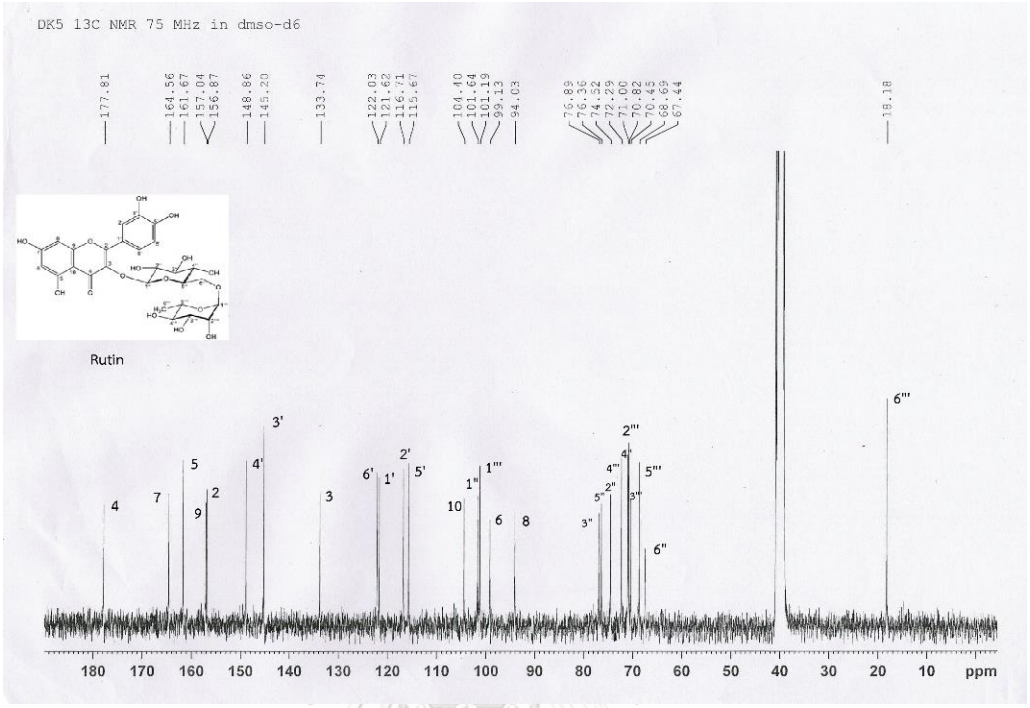
Acquisition Parameter

Source Type	ESI	Ion Polarity	Positive	Set Corrector Fill	50 V
Scan Range	n/a	Capillary Exit	150.0 V	Set Pulsar Pull	337 V
Scan Begin	50 m/z	Hexapole RF	400.0 V	Set Pulsar Push	337 V
Scan End	3000 m/z	Skimmer 1	70.0 V	Set Reflector	1300 V
		Hexapole 1	25.0 V	Set Flight Tube	9000 V
				Set Detector TOF	2295 V

6.2 ^{1}H-NMR (300 MHz) spectrum of compound DK 3 (DMSO-d_6)

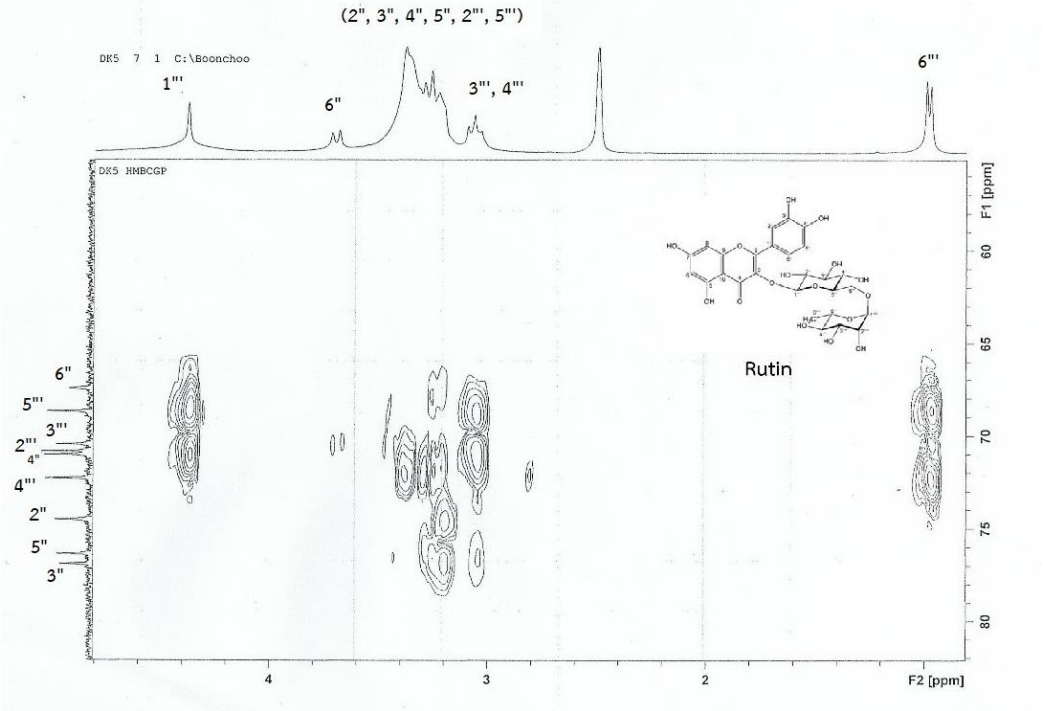


6.3 ^{13}C-NMR (300 MHz) spectrum of compound DK 3 (DMSO-d_6)

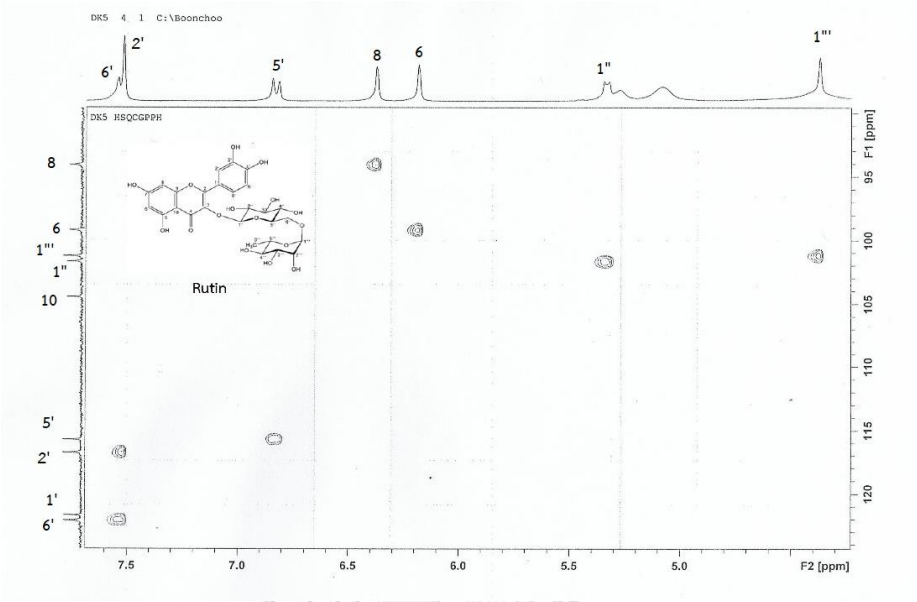


6.4 HSQC spectrum of compound DK 3 (Acetone-d_6)

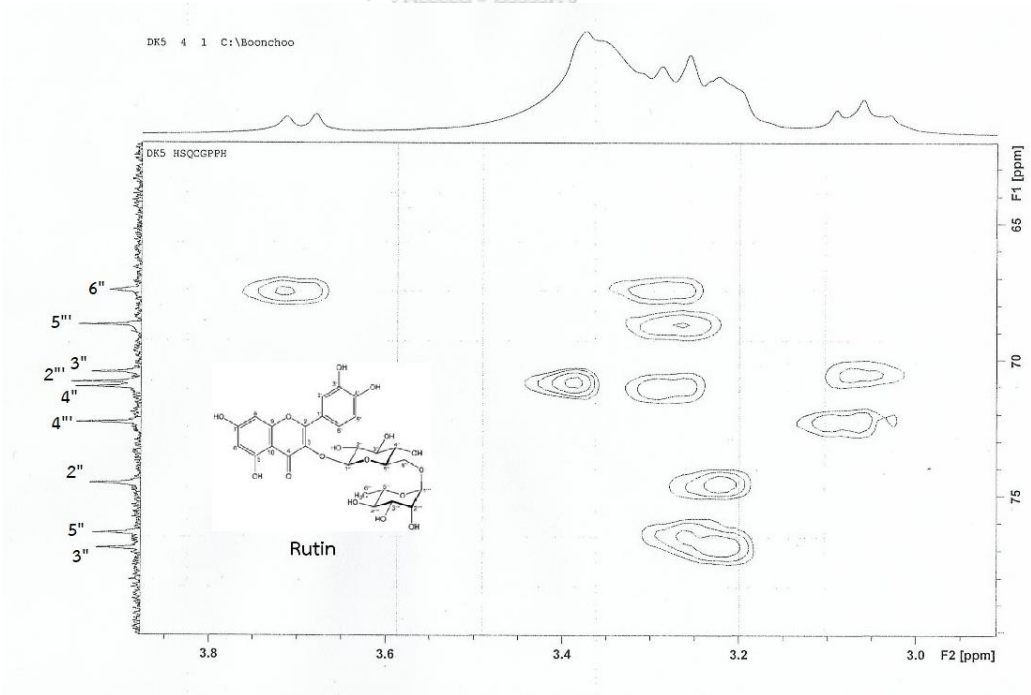
expansion [δH 0.98 – 4.37 ppm, δC 67.4 – 76.9 ppm]



6.5 HSQC spectrum of compound DK 3 (Acetone-d_6) expansion [δH 4.37 – 7.54 ppm, δC 94.0 – 122.0 ppm]

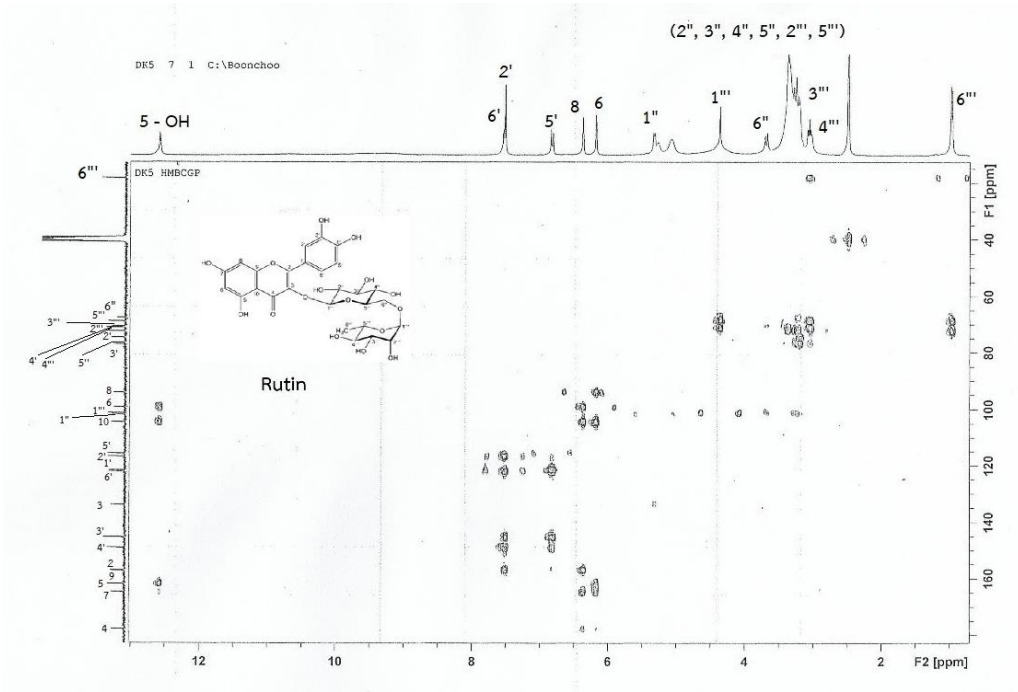


6.6 HSQC spectrum of compound DK 3 (Acetone-d_6) expansion [δH 67.4 – 76.9 ppm]



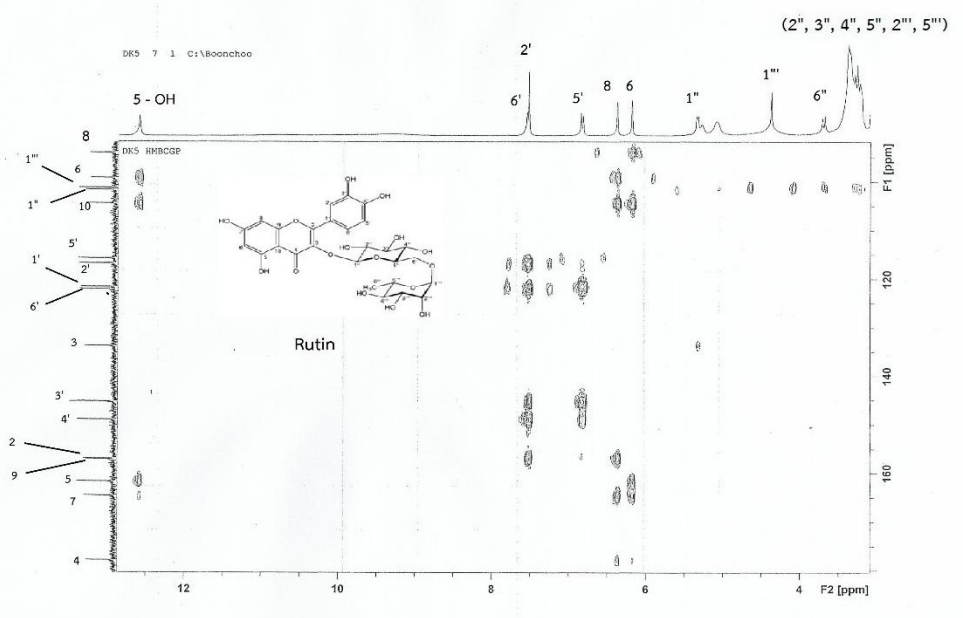
6.6 HMBC spectrum of compound DK 3 (Acetone-d_6)

expansion [δH 0.98 – 12.59 ppm, δC 18.2 – 177.8 ppm]



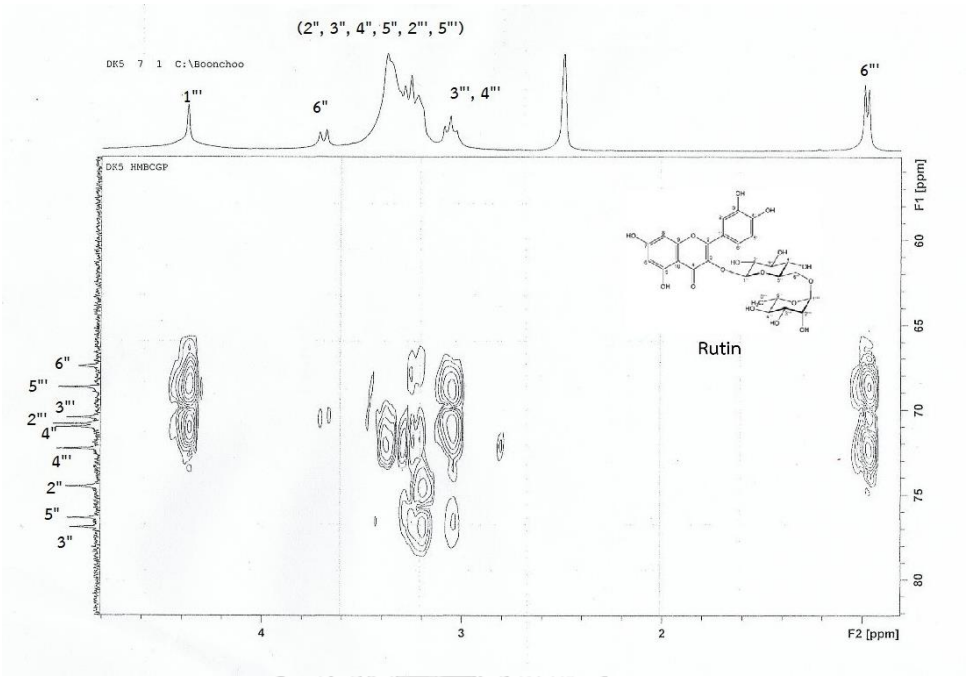
6.7 HMBC spectrum of compound DK 3 (Acetone-d_6)

expansion [δH 3.22 – 12.59 ppm, δC 94.0 – 177.8 ppm]



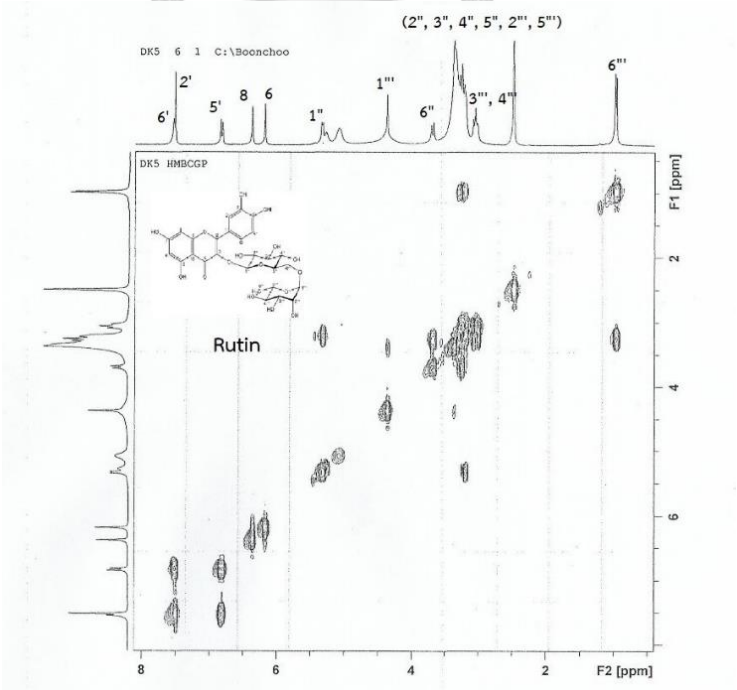
6.8 HMBC spectrum of compound DK 3 (Acetone-d_6)

expansion [δH 0.98 – 4.37 ppm, δC 67.4 – 76.9 ppm]



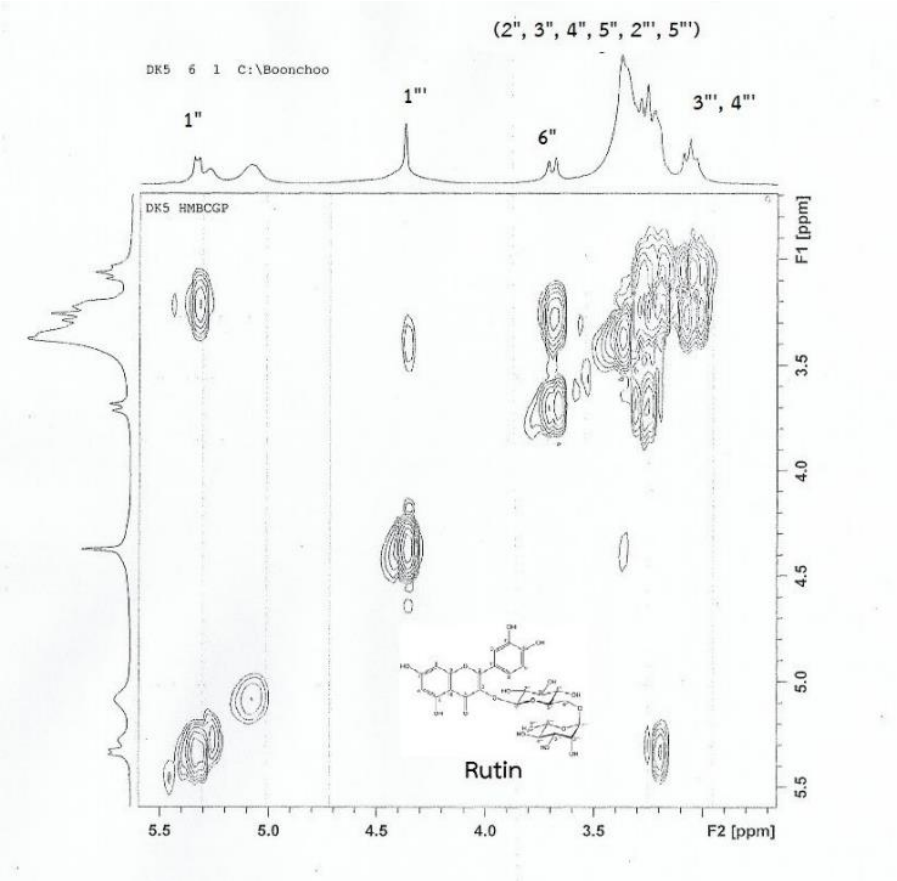
6.9 HMBC spectrum of compound DK 3 (Acetone-d_6)

expansion [δH 0.98 – 7.54 ppm]



6.10 HMBC spectrum of compound DK 3 (Acetone-d_6)

expansion [δH 3.03 – 5.33 ppm]



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