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Mini Review

Bioactivity studies and chemical constituents of *Murraya paniculata* (Linn) Jack

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Abstract

Murraya paniculata (Linn) Jack (Orange Jasmine), known as "Kemuning Putih" in Malaysia, has been widely used as food flavor additive in cuisine by local residences. This is due to the strong fragrances of the leaves which make it suitable to be used in Indian and Malay dishes. Besides as a flavoring, leaves, branches, stem barks and roots of the plant are used in folk medicine to treat dysentery and morning sickness. Flowers of the plants are used in cosmetics. Since 1970's, flavonoids and coumarins were isolated from *Murraya paniculata*, but no further bioactivity has been tested from the isolated compounds. The aim of this paper is to review and update the research related to chemical constituents and bioactivities of *Murraya paniculata* (L) Jack.

Introduction

Asia has been well known as "Land of spices" since ancient where places like Maluku Island, Indonesia (Spices Island), Sumatera (Spice Isle) and Melaka (Spice City) were popular as the spice markets. In ancient, people not merely use spices to add flavour to foods and beverages, but also as medicines, disinfectants, incenses, stimulants and aphrodisiac agents. Spices were used to cure, relax and excite human being and greatly influence their daily life (Chomchalow, 1996).

Spices are known as non-leafy parts such as bud, fruit, seed, bark, rhizome and bulb of plants that as flavoring or seasoning where some of them may also used as herb medicinal. While the similar phase "herb" used to distinguish the same plant parts which derived from leafy or soft flowering (Chomchalow, 1996). In Malaysia, one of the most commonly used herbs in Malaysia cuisines is *Murraya paniculata* which is commonly known as "kemuning putih". Malaysians commonly use *M. paniculata* leaves in preparing soup, fish and meat. Recently, it has also been used to prepare spicy chicken dishes in one of the most popular fast food restaurant in Malaysia.

Among the 14 species under the genus of *Murraya*, *Murraya paniculata* (Linn) Jack and *Murraya koenigi* (L) Spreng are the most popular natural flavor with the potential bioactivities. Since both are closely related species, they were named as "curry leaves" in Malaysia. However, *M. paniculata* is often found in Peninsular Malaysia (Kedah, Pulau Pinang, Kelantan, Perak, Melaka, Johor) and Singapore (Table 1), whilst *M. koenigi* was grown natively in Thailand (Table 1). *M. paniculata* is an 8 to 12 feet high medium-sized shrub with white, fragrance flowers blooming all the year round and the leaves are green obovated in shape, with less than 2 inches of blade length, alternately arranged on the branch (Gilman, 1999). Another widespread species, *Murraya exotica* which was previously thought as synonym with *M. paniculata* has smaller, obovated leaflets compare to

Table 1. Differences between *M. paniculata*, *M. koenigii* and *M. exotica* (Gilman, 1999)

	Murraya paniculata (L) Jack	*Murraya koenigii* (L) Spreng	*Murraya exotica* (L)
Leaves	Pinnate, with 3-7 leaflets	Pinnate, with 12-23 leaflets	Foliolate, with 3-7 short leaflets
Flowers	Whitetish	Small, white, fragrance	White oblong, fragrance
Fruits	Small berry dotted with oil cells, bright red in colour	small black shiny berries	Not known
Habitat	Peninsular Malaysia and Singapore	Grown native in Thailand	Widespread in tropical and subtropical areas
Local name	"Kemuning putih"	"Kari"	Previously known as Kemuning putih

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M. paniculata. Taxonomic divergent has then resolved by using cumulative data for three Single Primer Amplification Reaction methods (ITS, RAPD and AMD), to compute pair-wide distances, where wide range in distances reported between *M. paniculata* and *M. exotica*. This also has been congruent through comparing the morphological findings suggesting both plants came from different taxa (Verma *et al*., 2009).

Due to the rapid development of Western therapeutic, interest in applying medicinal plants were faded. However, the awareness of potential source of new drug discoveries from plant world rose past few years. Researches included crude extract isolation, bioactivities studies and also structure elucidation of isolated compounds. Herbal medicines are being emphasised with their ready availability and minimal side effects compared to synthetic drugs (Ho *et al*., 2009; Yeap *et al*., 2010). In many cases, crude drugs are found more potent than synthetic drugs on the biological activity with lower toxic effect because of the synergistic effect of other presented compounds. Since *M. paniculata* are not well studied as *M. koenigii*, this review was aimed to give an overview on the current studies on the bioactivities of *M. paniculata* and thus gives some insights into future research and commercial value of this plant.

Activities of Murraya paniculata (Linn) Jack

"Kemuning" is a plant under the family of Rutaceae where an anti-implantation agent named yuehchukene was isolated (Kong *et al*., 1986). With a single dosage or single day of 3 mg/ kg on 2nd day pregnancy rats after successful mating, Yuehchukene extracted from roots of *M. paniculata* was reported 100% active in anti-fertility ability (Kong *et al*., 1985). In one chemotaxonomic research, this yuehchukene is potentially found in Murraya species members especially *M. exotica* (2.61 mg/100 g), *M. alata* (2.06 mg/100 g) and *M. paniculata* (1.39 mg/100 g) (Kong *et al*., 1986). Besides, *M. paniculata* was also reported to have antinociceptive effect and toxicity effect on the ethanolic leaf extract. Writhing inhibition 26.67% and 66.67% were reported at 250 mg/ kg and 500 mg/ kg of body weight mice while toxicity towards brine shrimp was determined at LD_{50} 32 µg/mL in the same study (Sharker *et al*., 2009).

Antioxidant activity

Currently, *M. paniculata* with several extraction methods possess antioxidant activity. According to Rohman and Riyanto (2005), ethanolic extract of "kemuning" leaves using linoleic-thiocyanate method showed antioxidant strength in the following sequence of 10% "kemuning" > 1% vitamin E > 5% "kemuning" > 1% of "kemuning" extract. Using 2,2-diphenyl-l-picryl hydrazyl (DPPH) method, the IC_{50} of "kemuning" extract was 126.17 µg/ mL which is 15 times lower than the vitamin E (positive control) 8.27 µg/ mL. In addition, the acetone extraction of *M. paniculata* showed inhibitory effect toward xanthine oxidase (XO), tyrosinase and lipoxygenase (LOX) where 100 µg/ mL of the acetone extract was able to inhibit 10% of XO activity, 62% of LOX activity and at 500 µg/mL, the acetone extract inhibited 72% of tyrosinase activity (Chen *et al*., 2009).

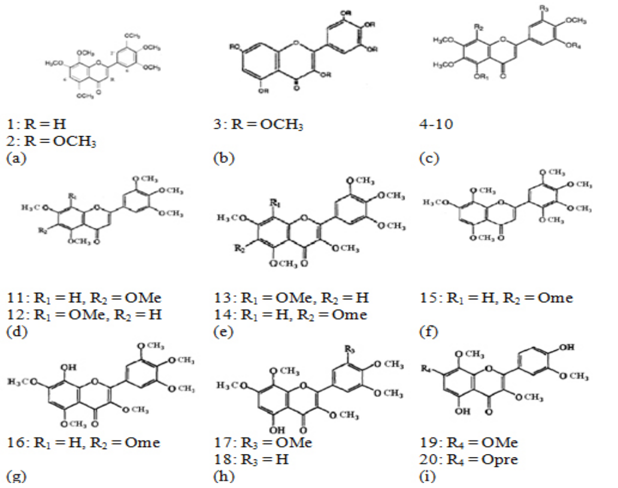

Figure 1. Chemical structures of flavonoids isolated from different parts of *M. paniculata*. (Source: Figure 1(a) Silva et al., 1980 and Yang and Du, 1984; Figure 1(b) Wu *et al*., 1993 ; Figure 1(c) Kinoshita and Firman,1995; Figure 1(d)-(i) Ferracin *et al*., 1998)

Antimicrobial activity

According to Aziz *et al*., (2010), auraptene, trans-gleinadiene,5,7-dimethoxy-8-(3-methyl-2-oxo-butyl) coumarin and toddalenone were isolated from the chloroform, petroleum ether and methanol extract from leaves of *M. paniculata*. Only chloroform extract showed a weak activity against *Bacillus cereus* and *Saccharomyces cerevisiae* with inhibition zone 9 mm and 8 mm respectively. Among the isolated compound, only trans-gleinadiene exhibited a weak antimicrobial activity against *Bacillus cereus* with 8 mm inhibition zone which conclude that trans-gleinadiene, auraptene and 5,7-dimethoxy-8-(3-methyl-2-oxo-butyl) coumarin give synergistic effect towards chloroform extract.

Constituents in Murraya paniculata (Linn) Jack

Flavonoids

Methanolic extract of *M. paniculata* (Jack) leaves was found to contain 3',4',5,5',7,8-hexamethoxyflavone (Figure 1a) and 3,3', 4',5,5',7,8-heptamethoxyflavone (Figure 1a) (Silva *et al*., 1980; Yang and Du, 1984). From the fresh flower

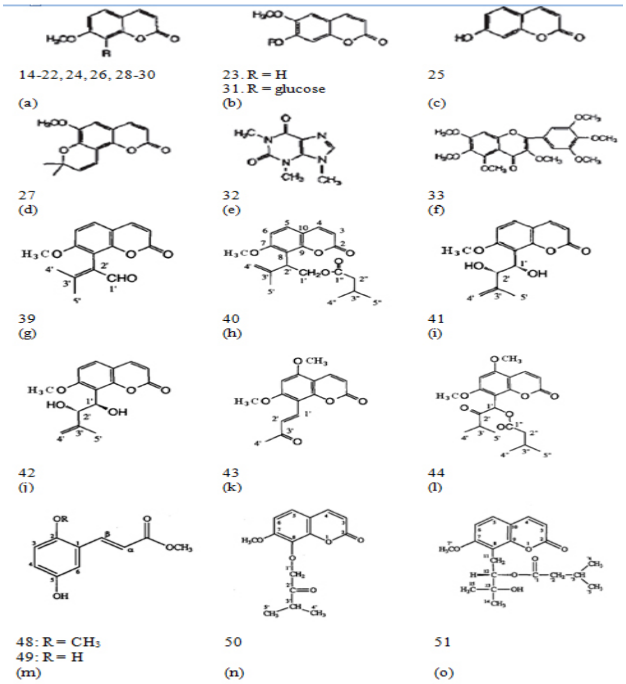

Figure 2. Coumarins isolated from *M. paniculata*. (Source : Figure 2(a)–(f) Lin and Wu, 1994; Figure 2(g)–(l) Kinoshita *et al*.,1996; Figure 2(m)–(o) Rahman *et al*., 1997)

of *M. paniculata*, a flavone named 3,5,7,3',4',5'-hexamethoxyflavone (Figure 1b), was isolated (Wu *et al*., 1994). While in late 1990's, another eight flavonoids (Kinoshita and Firman, 1995) were isolated from leaves and ten flavonoids from the peel and pulp of the fresh ripe fruit of *M. paniculata* (Ferracin *et al*., 1998) as shown in Table 2.

Table 2. Flavonoids isolated from different parts of *M. paniculata* (Silva *et al*., 1980; Yang and Du, 1984; Wu *et al*., 1993; Kinoshita and Firman, 1995; Ferracin *et al*.,1998)

No.	Flavonoids	Mol. Formula	Source	Substituent			
				R_1	R_2	R_3	R_4
1	3',4',5,5',7,8-hexamethoxyflavone	$C_{21}H_{22}O_8$ (Figure 1a)	leaves	H			
2	3,3',4',5,5',7,8-heptamethoxyflavone	$C_{22}H_{24}O_9$ (Figure 1a)	leaves	OCH_3			
3	3,5,7,3',4',5'-hexamethoxyflavone	$C_{21}H_{22}O_8$ (Figure 1b)	Fresh flower	OCH_3			
4	5-hydroxy- 6,7,3',4',5'-pentamethoxyflavone	$C_{20}H_{20}O_8$ (Figure 1c)	Leaves	H	OCH_3	H	CH_3
5	5-hydroxy-6,7,8,3',4',-Hexamethoxyflavone (Gardenin A)	$C_{21}H_{22}O_9$ (Figure 1c)	Leaves	H	OCH_3	OCH_3	CH_3
6	5,3'-dihydroxy-6,7,8,4',5-pentamethoxyflavone	$C_{20}H_{20}O_9$ (Figure 1c)	Leaves	H	OCH_3	OH	CH_3
7	6,7,8,4'-tetramethoxy-5,3',5'- trihydroxyflavone	$C_{19}H_{18}O_8$ (Figure 1c)	Leaves	H	OCH_3	OH	H
8	5-hydroxy-6,7,3',4',5'-pentamethoxyflavone	$C_{20}H_{20}O_8$ (Figure 1c)	Leaves	H	H	OCH_3	CH_3
9	5,3'-dihydroxy-6,7,4',5'-tetramethoxyflavone	$C_{19}H_{18}O_8$ (Figure 1c)	Leaves	H	H	OH	CH_3
10	5,3',5'-trihydroxy-6,7,4'-trimethoxyflavone	$C_{18}H_{18}O_8$ (Figure 1c)	Leaves	H	H	OH	H
11	5,6,7,3',4',5'-hexamethoxyflavone	$C_{21}H_{22}O_8$ (Figure 1d)	Leaves, peel and pulp	CH_3	H	OCH_3	CH_3
12	5,7,8,3',4',5'-hexamethoxyflavone	$C_{21}H_{22}O_8$ (Figure 1d)	peel and pulp	OMe	H		
13	3,5,7,8,3',4',5'-heptamethoxyflavone	$C_{22}H_{24}O_9$ (Figure 1e)	peel and pulp	OMe	H		
14	3,5,6,7,3',4',5'-heptamethoxyilavonol	$C_{22}H_{24}O_9$ (Figure 1e)	peel and pulp	H	OMe		
15	5,7,8,2',3',4',5'-heptamethoxyflavone	$C_{22}H_{24}O_9$ (Figure 1f)	peel and pulp	H	OMe		
16	8-hydroxy-3,5,7,3',4',5'-hexamethoxyflavone	$C_{21}H_{22}O_9$ (Figure 1g)	peel and pulp	H	OMe		
17	5-hydroxy-3,7,8,3',4',5'-hexamethoxyflavone	$C_{21}H_{22}O_9$ (Figure 1h)	peel and pulp			OMe	
18	-hydroxy-3,7,8,3',4'-pentamethoxytlavone	$C_{20}H_{20}O_8$ (Figure 1h)	peel and pulp			H	
19	4',5-dihydroxy-3,3',7,8-tetramethoxyflavone	$C_{19}H_{18}O_8$ (Figure 1i)	peel and pulp				OMe
20	4',5-dihydroxy-3,3',8-trimethoxy-7-(3-methylbut-2-enyloxy)-flavone	$C_{23}H_{24}O_8$ (Figure 1i)	peel and pulp				OPre

Indole alkaloids

Up to date, Yuehcukene, 1β-(3′-indolyl-7,9α,9β-trimethyl-5β,8,9,10β-tetrahydroindano-[2,3-b] indole (Figure 2a) which is an anti-implantation alkaloids was isolated from *M. paniculata* leaves (Kong *et al*., 1986). Besides, two indole alkaloids, murrayacarine (Wu *et al*., 1989) and murrayaculatine (Wu *et al*., 1994) were respectively isolated from root bark and fresh flower of *M. paniculata* (Table 3). However, according to Ito, *et al*., (2006) mahanine, pyrayafoline-D, and murrafoline-I isolated from *M. koenigii* showed cytotoxic effect against HL-60. A decrease of 83.5%, 70.5%, and 52.0% in HL-60 viability compared to untreated (negative control) was observed. These three carbazole alkaloids may also appear in *M. paniculata* since no research have been done in carbazole alkaloids isolation, yet both came from a same genus.

Coumarins

Besides indole alkaloids, coumarins have been found in *M. paniculata* (Table 4). Three coumarins known as meranzin hydrate, murragatin and murpanidin (figure not shown) were obtained from leaves of *M. paniculata* (Yang and Du, 1984). 3-formylindole,omphalocar-pin,5,7-dimethoxy-8-(3'-methyl-2'-oxobutyl) coumarin, coumurrayin, murragleinin, omphamurin, murraol, (-)- murracarpin, (±)-murracarpin, mupanidin, mexoticin, murrangatin, and ferulyl esters were another 13 coumarins that were isolated from root bark of *M. paniculata* (Wu *et al*., 1989). While from the fresh flowers of this plant, yuehgesin-A, yuehgesin-B, yuehgesin-C, and 22 compounds were being characterized (Lin and Wu, 1994) (Table 4). According to Kinoshita *et al*., (1996), nine coumarins including omphamurrayone, murralongin, isomurralonginol isovalerate, murrangatin, minumicrolin (murpanidin), coumurrayin, toddalenone, auraptene and toddasin were identified from acetone extract of the leaves

Table 3. Three indole alkaloids isolated from leaves, root bark and fresh flowers of *M. paniculata* (Kong *et al*., 1986; Wu *et al*., 1989; Wu *et al*., 1993)

No.	Indole alkaloids	Mol. Formula	Source	Substituents
				R
1	Yuehchukene	$C_{26}H_{26}N_2$ (Figure 2a)	Leaves	-
2	Murrayacarine	$C_{14}H_{13}NO_3$ (Figure 2b)	Root bark	-
3	Murrayaculatin	$C_{10}H_9NO_3$ (Figure 2c)	Fresh flower	-

(Figure 2). While methyl 2,5-dihydroxycinnamate and murrayatin (Rahman *et al*., 1997) were reported in the methanolic extract of leaves. Cytotoxic effect of water extracts from leaves and branches of *Philadelphus coronaries* L. (Hydrangeaceae) was investigated on A431 (human skin carcinoma cell line) and MCF-7 (human breast adenocarcinoma cell line). Both leaves and branches extracts gave ED_{50} = 2.19 µg/mL on MCF-7 and ED50 = 27.95 µg/mL on A431 at 24 hours incubation period (Valko *et al*., 2006). This cytotoxic effect on A431 and MCF-7 may due to the presences of coumarins (umbelliferone and scopolin) which also found in *M. paniculata* extract.

Compounds in Murraya paniculata

Composition of Murraya paniculata essential oil:

Besides alkaloids, flavonoids and coumarins, leaves of M. paniculata also contained 60 compounds (Table 5) being identified from volatile and essential oil extracted from the leaves. The major components were γ-elemene (31.7%), perolidol (10%), t-caryophyllene (11.6%), caryaphyllene oxide (16.6%), β-caryophyllene (11.8%), spathulenol (10.2%), β-elemene (8.9%), germacrene D (6.9%) and cyclooctene, 4-methylene-6-(1-propenylidene) (6.4%) (Chowdhury *et al*. 2008; Li *et al*., 1988; Rout *et al*., 2007). According to Chowdhury et al. (2008), 58 compounds were found from the oil of *M. paniculata*. While the major compounds found are (E)-caryophyllene (Table 5) was found to posses cytotoxic against MDA-MB-231 (IC_{50}= 31.6 µg/mL) and Hs 578T (IC_{50}= 78.3 g/mL) human tumor cells (Palazzo *et al*., 2009). Besides, oils extracted from leaves and berries of *Juniperus phoenicea* show similar cytotoxic activity on U251 (0.6 µg/ml), HeLa (5.0 µg/ml) but slightly higher of berry oil compared to leaves against H460 (0.6 and 0.7 µ/ml, respectively), HepG2 (0.7 and 0.9 µg/ml, respectively), MCF-7 (0.8 and 1. µg/ml, respectively) cell lines. These berries and leafs oil from *Juniperus phoenicea* are rich with Monoterpene hydrocarbons (El-Sawi *et al*., 2007) which are also found in *M. paniculata*.

Polysaccharide and others

A water soluble gum polysaccharide was isolated from the fruit of *M. paniculata* (Mondal *et al*.,

Table 4. Coumarins (Wu *et al*., 1989) isolated from the root bark, fresh flowers of *M. paniculata* (Lin and Wu, 1994; Kinoshita *et al*., 1996; Rahman *et al*., 1997)

No.	Coumarins/ Compounds	Mol. Formula	Source	Substituents R
1	3-formyhindole	CH_3O (Not shown)	Root bark	-
2	omphalocar-Pin	$C_{17}H_{22}O_6$ (Not shown)		-
3	5,7-dimethoxy-8-(3'-methyl-2'-oxobutyl) coumarin	$C_{16}H_{18}O_5$ (Not shown)		-
4	coumurrayin	$C_{16}H_{18}O_4$ (Not shown)		-
5	murraglein in	$C_{16}H_{20}O_6$ (Not shown)		-
6	omphamurin	$C_{32}H_{46}O_{16}$ (Not shown)		-
7	murraol	$C_{15}H_{16}O_4$ (Not shown)		-
8	(-)-murracarpin	$C_{16}H_{18}O_5$ (Not shown)		-
9	(k)-mUrraCarpin	$C_{16}H_{18}O_5$ (Not shown)		-
10	murpanidin	$C_{15}H_{16}O_5$ (Not shown)		-
11	mexoticin	$C_{16}H_{20}O_6$ (Not shown)		-
12	murrangatin	$C_{15}H_{16}O_5$ (Not shown)		-
13	feruly l esters	* $C_{31}H_{28}O_{15}$ (Not shown)		-
14	yuehgesin-A	$C_{18}H_{24}O_6$ (Figure 2a)	Fresh flowers	$CH_2CH(OH)C(CH_3)_2OC(CH_2)_2OH$
15	yuehgesin-B	$C_{16}H_{20}O_5$ (Figure 2a)		$CH_2CH(OH)C(CH_3)_2OCH_3$
16	yuehgesin-C	$C_{17}H_{22}O_5$ (Figure 2a)		$CH_2CH(OH)C(CH_3)_2OCH_2CH_3$
17	murracarpin	$C_{16}H_{18}O_5$ (Figure 2a)		$C(OCH_3)H-C(OH)HC(CH_2)=CH_2$
18	murpanidin	$C_{15}H_{16}O_5$ (Figure 2a)		$C(OCH_3)H-C(OH)HCC(CH_2)_2=CH_2$
19	isomeranzin	$C_{15}H_{16}O_4$ (Figure 2a)		$CH_2COCH(CH_3)_2$
20	murralongin	$C_{15}H_{14}O_4$ (Figure 2a)		$C(COH)=C(CH_3)_2$
21	7-methoxy-8-(1'-ethoxy-2'-oxo-3'-methyl-1-butyl) coumarin	Not known (Figure 2a)		$CH(OAc)COCH(CH_3)_2$
22	murrangonon	Not known (Figure 2a)		$CH(OH)COCH(CH_3)_2$
23	Scopoletin	$C_{10}H_8O_4$ (Figure 2b)		H
24	7-methoxy-8-(1'-ethoxy-2'-hydroxy-3'-methyl-3'-butenyl) coumarin	Not known (Figure 2a)		$CH(OEI)CH(OH)C(CH_2)=CH_2$
25	Umbelliferone	Not known (Figure 2c)		-
26	Paniculatin	$C_{27}H_{30}O_{15}$ (Figure 2a)		$CH[OCOCH_2CH(CH_3)_2]COCH(CH_3)$
27	Braylin	$C_{15}H_{14}O_4$ (Figure 2d)		-
28	Auraptenol	Not known (Figure 2a)		$CH_2C(OH)C(CH_3)=CH_2$
29	Meranzin hydrate	$C_{15}H_{18}O_5$ (Figure 2a)		$CH_2C(OH)C(CH_3)_2OH$
30	Minumicrolin (Murpanidin)	$C_{15}H_{16}O_5$ (Figure 2a)		$C(OH)HC(OH)HC(CH_3)=CH_2$
31	Scopolin	$C_{16}H_{18}O_9$ (Figure 2b)		Glucose
32	Caffeine	$C_8H_{10}N_4O_2$ (Figure 2e)		-
33	3,3',4',5,5',6,7-heptamethoxy-flavone	Not known (Figure 2f)		-
34	4-hydroxybenzaldehyde	$C_7H_6O_2$ (Not shown)		-
35	p-hydroxyben-zoic acid	$C_7H_6O_3$ (Not shown)		-
36	Cis-ferullic acid and transferullic acid	Not known (Not shown)		-
37	Cis-methyl ferulate and transferullic acid	$C_{11}H_{12}O_4$ (Not shown)		-
38	Trans-ethylferu-late	Not known (Not shown)		-
39	Murralongin	$C_{15}H_{14}O_4$ (Figure 2g)	Leaves	-
40	Isomurralongniol isovalerate	Not known (Figure 2h)		-
41	Murrangatin	$C_{15}H_{16}O_5$ (Figure 2i)		-
42	Minumicroln	$C_{14}H_{14}O_4$ (Figure 2j)		-
43	Toddalenone	$C_{15}H_{14}O_5$ (Figure 2k)		-
44	Omphamurrayone	Not known (Figure 2l)		-
45	Coumurrayin	$C_{16}H_{18}O_4$ (Not shown)		-
46	Auraptene	$C_{19}H_{22}O_3$ (Not shown)		-
47	Toddasin	Not known (Not shown)		-
48	methyl 2-methoxy-5-hydroxycinnamate	$C_{11}H_{12}O_4$ (Figure 2m)		CH_3
49	methyl 2,5-dihydroxycinnamate	$C_{10}H_{10}O_4$ (Figure 2m)		H
50	8-(2'-exo-3'-methyl) butoxy-7-methoxycoumarin	$C_{15}H_{16}O_5$ (Figure 2n)		-
51	murrayatin	$C_{20}H_{26}O_6$ (Figure 2o)		-

Table 5. Composition of volatile oils (Li *et al*., 1988) and essential oil (Rout *et al*., 2007; Chowdhury *et al*., 2008) isolated from leaves of *M. paniculata*

No.	Components	Mol. Formula	No.	Components	Mol. Formula
1	δ-Elemene	$C_{15}H_{24}$	64	Ethyl palmitate	$C_{18}H_{36}O_2$
2	ß-Elemene	$C_{15}H_{24}$	65	Palmitic acid	$C_{16}H_{32}O_2$
3	t-Caryophyllene	$C_{15}H_{24}$	66	Manool	$C_{20}H_{34}O$
4	t- ß-Farnesene	$C_{15}H_{24}$	67	Methyl linoleate	$C_{19}H_{34}O_2$
5	Eremophilene	$C_{15}H_{24}$	68	Methyl linolenate	$C_{19}H_{32}O_2$
6	Humulene	$C_{15}H_{24}$	69	Methyl stearate	$C_{19}H_{38}O_2$
7	alloaromadendrene	$C_{15}H_{24}$	70	9,12-Octadecadienol	$C_{18}H_{34}O$
8	ß-Cubebene	$C_{15}H_{24}$	71	Docosane	$C_{22}H_{46}$
9	α-Bergamotene	$C_{15}H_{24}$	72	Sabinene	$C_{10}H_{16}$
10	γ-Elemene	$C_{15}H_{24}$	73	3-Hexen-1-ol, formate	$C_7H_{12}O_2$
11	δ-Cardinene	$C_{15}H_{24}$	74	Limonene	$C_{10}H_{16}$
12	Perolidol	Not known	75	Linalool	$C_{10}H_{18}O$
13	Nootkatoon	$C_{15}H_{22}O$	76	Cyclohexene,3,4-diethenyl-3-methyl	$C_{10}H_{16}$
14	Torreyol	$C_{15}H_{26}O$	77	Cyclohexene,5,6-diethenyl-3-methyl	$C_{10}H_{16}$
15	Bulnesol	$C_{15}H_{26}O$	78	Azulene	$C_{10}H_8$
16	Benzaldehyde	C_7H_6O	79	Ocimene	$C_{10}H_{16}$
17	Myrcene	$C_{10}H_{16}$	80	cis-3-Hexenylvalerate	$C_{11}H_{18}O_2$
18	Limonene	$C_{10}H_{16}$	81	2-Cyclohexen-1-one, 2-methyl-5-(1-methylethenyl)	C_6H_8O
19	(Z)-ß-Ocimene	$C_{10}H_{16}$	82	1H-Imidazole 4-methanol,5-methyl	Not known
20	(E)- ß-Ocimene	$C_{10}H_{16}$	83	α-Cubebene	$C_{15}H_{24}$
21	α-Terpinolene	$C_{10}H_{16}$	84	3,9-Dodecadiene	$C_{12}H_{22}$
22	Methyl benzoate	$C_8H_8O_2$	85	β-Caryophylene	$C_{15}H_{24}$
23	Linalool	$C_{10}H_{18}O$	86	Caryophyllene oxide	$C_{15}H_{24}O$
24	Methyl phenylacetate	$C_{12}H_{16}O_2$ $C_6H_5CH_2COOCH_3$	87	Cyclooctene,4-methylene-6-(1-propenylidene)	C_8H_{14}
25	Methyl salicylate	$C_8H_8O_3$	88	Retinal	$C_{20}H_{28}O$
26	Nerol	$C_{10}H_{18}O$	89	α-Caryophylene	$C_{15}H_{24}$
27	2-Phenylethylacetate	$C_{10}H_{12}O_2$	90	β-Humulene	$C_{15}H_{24}$
28	Indole	C_8H_7N	91	Copaene	$C_{15}H_{24}$
29	α-Cubebene	$C_{15}H_{24}$	92	Cubenol	$C_{15}H_{26}O$
30	Cyclosativene	$C_{15}H_{24}$	93	α-Bulnesene	$C_{15}H_{24}$
31	α-Copaene	$C_{15}H_{24}$	94	Calamenene	$C_{15}H_{22}$
32	Phenethylisobutyrate	$C_{12}H_{16}O_2$	95	3-Tetradecynoic acid	$C_{14}H_{24}O_2$
33	(Z)-Jasmone	$C_{11}H_{16}O$	96	Lanceol, cis	$C_{15}H_{24}O$
34	(E)-Caryophylene	$C_{15}H_{24}$	97	β-Vatirenine	Not known
35	Clovene	$C_{15}H_{24}$	98	Nerolidyl acetate	$C_{17}H_{28}O_2$
36	(Z)- ß-Farnesene	$C_{15}H_{24}$	99	Alloaromadendrene oxide	$C_{15}H_{24}O$
37	α-Humulene	$C_{15}H_{24}$	100	Spathulenol	$C_{15}H_{24}O$
38	(E)- ß-Famesene	$C_{15}H_{24}$	101	D-Verbenone	$C_{10}H_{14}O$
38	Muurola-4(14),5-diene	$C_{15}H_{24}$	102	Pyrimidine-2(1H) thione, 3,4-dihydro-6-methyl,4-phenyl	C_5H_5NS
40	Germacrene D	$C_{15}H_{24}$	103	3-Carene	$C_{10}H_{16}$
41	ar-Curcumene	$C_{15}H_{22}$	104	12-Oxabicyclo(9,1,0) dodeca-3,7-diene,1,5,5,8-tetramethyl	$C_{15}H_{24}O$
42	Bicyclogermacrene	$C_{15}H_{24}$	105	Globulol	$C_{15}H_{26}O$
43	α-Zingiberene	$C_{15}H_{24}$	106	Eremophilene	$C_{15}H_{24}$
44	(E,E)- α-Farnesene	$C_{15}H_{24}$	107	2(1H) Naphthalenone, 4a,5,6,7,8,8a-hexahydro,4a,8a-dimethyl	$C_{11}H_{10}O_2$
45	ß-Curcumene	$C_{15}H_{24}$	108	Tau -Muurolol	$C_{15}H_{26}O$
46	δ-Cadinene	$C_{15}H_{24}$	109	Ledol	$C_{15}H_{26}O$
47	Cadina-1,4-diene	$C_{15}H_{24}$	110	Aromadendrene oxide	$C_{15}H_{24}O$
48	Germacrene B	$C_{15}H_{24}$	111	α-Calaconene	Not known
49	(E)-Nerolidol	$C_{15}H_{26}O$	112	Longifolenealdehyde	$C_{15}H_{24}O$
50	Spathulenol	$C_{15}H_{24}O$	113	11-Hexadecyn-1-ol	$C_{16}H_{30}O$
51	Globulol	$C_{15}H_{26}O$	114	Cycloisolongifolene, 8-hydroxy-endo	$C_{15}H_{24}O$
52	Phenyl ethyl tiglate	$C_{13}H_{16}O_2$	115	Longipinocarveol, trans	$C_{15}H_{24}O$
53	1-epi-Cubenol	$C_{15}H_{26}O$	116	Carveol	$C_{10}H_{16}O$
54	epi-α-Muurolol	$C_{15}H_{26}O$	117	1-Cyclohexene-1-ethanol, 2,6,6-trimethyl	Not known
55	α-Cadinol	$C_{15}H_{26}O$	118	1-Methylverbenol	$C_{11}H_{19}O$
56	Patchoulialcohol	$C_{15}H_{26}O$	119	Cyclopropane, 1-bromo-2,2,3,3-tetramethyl-1-prop-1-ynyl	$C_{10}H_{15}Br$
57	ß-Bisabolol	$C_{15}H_{26}O$	120	Corymbolone	$C_{15}H_{24}O_2$
58	Benzyl benzoate	$C_{14}H_{12}O_2$	121	2(4a,8-Dimethyl-1,3,3,4,4a,5,6,7-octahydronaphthalen-2-yl) -prop-2-en-1-ol	Not known
59	Phenethylbenzoate	$C_{15}H_{14}O_2$	122	Ledene alcohol	$C_{15}H_{24}O$
60	Benzyl salicylate	$C_{14}H_{12}O_3$	123	Aristolene oxide	$C_{15}H_{24}O$
61	Methyl palmitate	$C_{17}H_{34}O_2$	124	6-Isopropenyl-4,8a-dimethyl-1,2,3,5,6,7,8,8a-octahydro naphthalen-2-ol	Not known
62	Phytol	$C_{20}H_{40}O$	125	Longifolene-[12]-epoxide	$C_{15}H_{24}O$
63	Phenyl ethyl salicylate	$C_{15}H_{14}O_3$			

2001). The polysaccharide have 1,3-linked ß-D-galactopyranosyl, 1,3,6-linked ß-D-galactopyranosyl, terminal ß-D-galactopyranosyl and terminal α-D-galactopyranosylm1,4-ß-D-galactopyranosyl. Although plenty of compounds were isolated from this plant, but further bioactivities has not been widely investigated yet.

Conclusion

In short, *Murraya paniculata* is rich of various types of active components. However, the bioactivities studies such as antioxidant, antimicrobial, anticancer, anti-diabetic and others have yet to be discovered. This plant should be given more attention since it could be easily obtained in Peninsular Malaysia.

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