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Botanical, Phytochemical and Pharmacological Properties of *Hedychium* (Zingiberaceae) - A Review

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Abstract

Zingiberaceae is one of the most widely distributed plants in tropic and subtropic area, about 19 genus and 375 species weredistributed in Indonesia. Based on empirical data, some of the plants were used traditionally to treat various diseases. Nowadays, Zingiberaceae plants are extensively studied for their phytochemistry and pharmacological properties included genus *Hedychium*. The various bioactive compounds were isolated from these plants and they were known to have the pharmacological effect. This review showed that *Hedychium* plants were prospective as a natural product medicine.

Peer-review under responsibility of the School of Pharmacy, Bandung Institute of Technology

*Keywords:*Zingiberaceae, *Hedychium,* Ginger lilly, pharmacological activity, volatile oils

1. Introduction

Various species of Zingiberaceaefamily were widely distributed in tropical and subtropical areas, which were about 47 genus and 1400 species. The member of Zingiberaceaewere Alpinia (225 species), *Globba* (100 species), *Amomum* (90 species), *Zingiber* (80 species), *Renealmia*(70 species), *Curcuma* (54 species), *Boesenbergia* (50 species) and *Hedychium* (40 species)[1].

Previous researches ofdifferent part from Zingiberaceae plants (rhizomes, leaves, flowers or fruits) were carried out. Nevertheless, the spread of those plants that commonly grow as wild type in the forest makes this family interesting to study. The focuses were mainly about their phytochemical and pharmacological aspects. In order to know the progress of research on Zingiberaceae plants, data collection by Scopus indexed was carried out.

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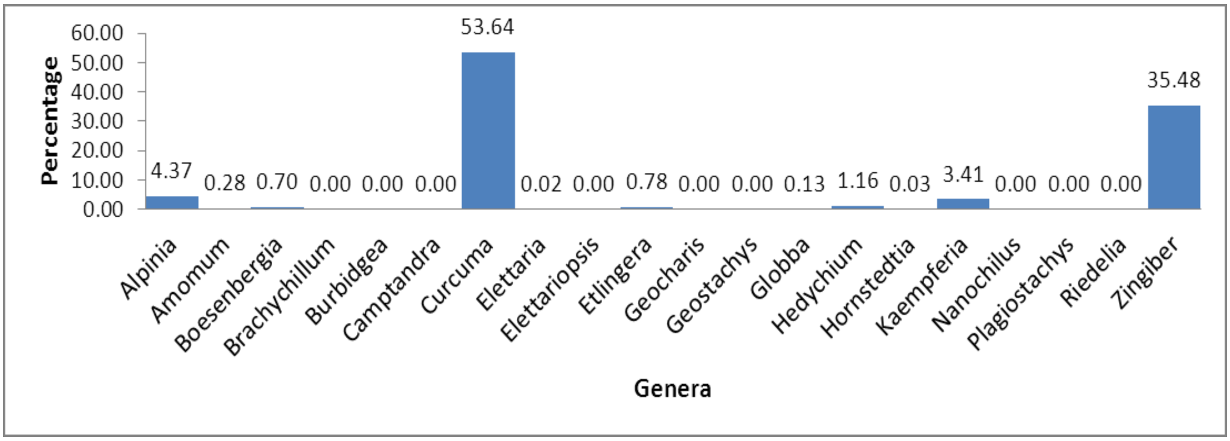

Fig. 1. Percentage of Scopus indexed researches of Zingiberaceaeplants distributed in Indonesia.

The data showed that there were various species of the Zingiberaceae plants were prospective as natural product medicine to be explored.

The *Hedychium* genus consists of 80 species in worldwide[2]. There are 29 species that were distributed in the tropical and sub-tropical regions of China and 40 species growin Indonesia[1, 3]. The essential oils can be extracted from leaves, flowers and rhizomes of these plants. It is well documented that these oils have many medicinal efficacies, including cercaricidal properties[3]. Various species were used in traditional medicines for treatment of asthma, bronchitis, blood purification, gastric diseases, and as anti-emetics, especially among the hill tribes of Uttarakhand, as well as for eye diseases in Nagaland[4-6]. In addition, Hedychiumspecies were widely cultivated for their perfume essences, and the aerial stems constitute is a useful raw material for manufacturing paper. Moreover, some species were developed for their edible flowers[2].

The target characters for *Hedychium* cultivating include aroma, bracts arrangement, flower color, flowering phase and potted period. Zhang et al, 2007 analyzed the aroma ingredients were consist of 13 compounds and concluded that α-pinene; ocimene; 1,8-cineole; L-linalool; caryophyllene and farnesenewere responsible for the characteristic aroma components in *Hedychium*[7].

2. Botanical Aspect

The *Hedychium* species were characterized by beautiful foliage, showy and fragrant flowers[2]. Based on the morphological characteristics, the species were clearly differentiated [8]. *H. aurantiacum* Wall., the rhizome is well develoved, robust; the leaves are lanceolate, narrow gradually to the base, glabrous beneath; the spike is 15-30 cm; the flower is peach-colouredwhile the seed is red in colour, aril fibrous[9]. *H. coccineum* Ham. Ex Sm. is commonly known as Scarlet Ginger Lily. It is a medium-sized plant with pseudostems of 1.5-2 m [10]. The leaves arelanceolate, base rather rounded, narrowed gradually from the middle to the point; the spike islong[9]. The bisexual flower has a bilateral symmetry[10]. Moderately dense flowered; the bracts are oblong; the flowers are red; calyx are not longer than the bract; corolla segments is linearandreflexing; the staminode is bright red; the lip is orbicular, distinctly clawed, deeply bifid; the stamen is longer than lip[9]. The stem is grey and glaucus[8].

H. coronarium Konig.,is commonly known as Butterfly Ginger Lily. The leaves are oblong to oblong-lanceolate; the spike is dense flowered; the bracts are large, oblong imbicate 3-4 flowered; the flowers are white or tinged with yellow patch in the centre; the staminodesare oblong or oblong-lanceolate, the lip are broad shallowly bifid distinctly clawed; the stamen is as long as or rather longer than the lip; filament orange colored or white; capsule oblong, glabrous[9]. The stem is bright green[8]. *H. elatum* R.Brown., the leaves are pubescent underneath, dark green; sweetly scented flowers, pink with reddish patch; green stem[8].

H. flavescens Carey ex Rosc., the leaves are oblong or oblong-lanceolate, usually pubescent beneath; spike dense-flowered; the flowers are fragrant, sulfur yellow; calyx green, cylindric, shorter than the bract; corolla segment linear, reflexing, half as long the tube; staminodes oblong or oblong-lanceolate; the lip is broad shallowly bifid distinctly clawed; the stamen is as long as or rather longer than the lip, the filament is white; the capsule is oblong, glabrous[9]. The stem is green, pubescent[8].

H. gracillimum Rao et Verma., the rhizome are cylindrical upright; the leaves are oblong-lanceolate, glabrous on both the surfaces, ligule reddish, pubescent; inflorescence spike, peduncle curved a bit upward, terminal, pubescent, green; bract green, glabrous on both the surfaces, single flowered; the flower are small, mildly scented, cream-yellow; calyx 3-lobed, cream-yellow; corolla-lobes 3, linear, margins roll up, cream-yellow; the staminodes differentiated into distinct claw and limb; lip of the same length and color as that of the staminodes, very shallowly bifid; the filament is cream-yellow, getting darker towards the apex, longer than the corolla lobes; anther orange-colored, connective appendage absent[9].

H. marginatum Clarke., the leaves are pubescent with dirty green colors. The flowers are orange-yellow uniformly with linear staminodes; sweetly scented[8].

H. maximum Rosc., commonly known as Giant Butterfly Ginger Lily. The leaves are oblong or oblong-lanceolate; spike dense-flowered; bracts large oblong imbricate 3-4 flowered; the flowers are pure white, larger; staminodes are broad, oblong or oblong lanceolate, lip broad shallowly bifid distinctly clawed; stamen as long as or rather longer than the lip; the filament is white; capsule oblong, glabrous[9].

*H. gardnerianum*is a rhizomatus herb that grows to a height of 1-2 m; ovate-elliptic leaveas; inflorescences are erect and produce numerous seeds in late fall and winter[11].

H. rubrum A. S.Rao et Verma., the leaves are lanceolate, glabrous and mossy green. The flowers are orbicular, red and unfragrant. The stem is reddish[8].

H. urophyllum Lod., the leaves are pubescent underneath, bright green; glabrous stem with reddish colors[8].

H. stenopetalum Lodd., the leaves are pubescent underneath with dark green colors. The flowers are uniformly white sometimes greenish patch at base, slightly scented. The stem is pubescent with green colors[8].

H. thrysiforme Ker- Gawl., the leaves are pubescent underneath; white flowers, small obcordate with linear staminodes, slightly aroma; bright green stem and pubescent[8].

H. villosum Wall., the leaves are pubescent underneath with dark green colors. The flowers are scented, white with red stamens[8].

3. Phytochemical Properties

3.1. Volatile oil

Volatile oils are widely used in soaps, cosmetics, toilet products, pharmaceuticals, parfumes and food[12]. Plant organs that contain natural volatile oils are flowers, leaves, barks, roots, seeds, fruits, rhizomes and gums or oleoresin exudate. This component can be accumulated on oils cells, secretion ducts or glandular hairs of plants, modified parenchymal cells, resin canals, oil tubes called vittae, lysigenous cavities, schizogenous passages or gum canals[12, 13]. The rhizomes of Zingiberaceaeplants, included the genus of *Hedychium*, are the volatile oils sources. The major constituents of volatile oils that were presented in all samples of *Hedychium* species examined were myrcene, limonene, p-cymene, camphene and γ-terpinene[14].

Medeiros et al, 2003 identified the compositions of the volatile oils from leaves and flowers of H. gardnerianum by GC-MS(Table.1)[15].

The volatile oils from *H. coronarium* flower were extracted by enfleurage method with whale's fat-palm oil (1:1) as the solvent[13]. The result showed that the scent of the volatile oils obtained from enfleurage method was the closest to fresh flowers.The chemical compositions were identified by GC-MS as ethyl hexadecanoate, tetradecanol, benzyl alcohol, α-farnesene and linalool. The composition of the rhizome volatile oils from different *Hedychium* species (*H. ellipticum, H. aurantiacum, H. spicatum and H.coronarium* from India) were analyzed by GC-MS method[16].

Table 1.PercentageComposition (w/w) of the Volatile Oils of *H. gardnerianum* Leaves and Flowers[15]

Compound	Leaves				Flowers		
	N	P	R	M	N	P	R
Dihydro-cis-α-copaene-8-ol	0.93	1.28	1.23	0.87	0.4	–	–
Aromadendrene	1.88	1.71	1.62	1.32	0.87	0.84	T
α-Cadinol	6.42	14.59	12.54	8.73	12.54	5.76	26.22
δ –Cadinol	0.93	1.93	1.8	1.54	1.29	t	2.66
τ-Cadinol	3.16	5.76	5.2	4.06	3.28	1.26	7.05
β-Cadinene	0.94	0.93	0.96	0.91	7.5	4.81	9.2
δ-Cadinene	7.88	4.89	8.76	7.68	t	t	T
γ-Cadinene	0.74	0.92	0.66	0.69	0.45	0.65	T
Calamenene	0.21	0.56	0.47	0.21	t	–	–
Camphene	Tb	t	t	t	t	t	T
(E)-3(10)-Caren-4-ol	–	t	–	–	–	–	–
2-Carene	–	–	–	–	0.85	1.79	T
Caryophyllene	8.89	8.18	7.04	7.66	4.17	5.49	4.95
Isocaryophyllene	–	t	–	–	0.39	t	T
α-Copaene	0.22	t	0.13	t	t	t	T
α-Cubebene	0.2	t	0.11	–	t	t	T
β-Cubebene	2.58	2.85	2.86	2.26	1.47	0.76	2.35
Cubenol	0.83	1.08	1.35	0.88	0.38	–	–
p-Cymene	0.21	–	0.14	t	7.4	8.16	3.85
EBCPc	1.23	t	1.9	1.3	0.91	t	T
β-Elemene	0.15	t	0.43	0.18	–	–	–
γ-Elemene	–	–	–	–	1.19	0.87	1.55
Eucalyptol	t	t	t	t	t	t	T
Eudesmene	0.92	1.52	1.34	0.84	0.77	–	T
α-Farnesene	5.67	1.25	7.92	7.14	2.72	2.97	2.74
Germacrene B	2.93	3.04	4.94	2.39	1.9	0.93	2.68
β-Guaiene	6.11	5.49	4.94	4.84	3.39	1.04	4.2
α-Gurjunene	0.25	t	0.18	t	–	–	–
γ-Gurjunene	0.14	t	0.19	t	t	t	T
Limonene	0.75	0.97	0.44	0.77	1.01	1.92	T
Linalool	t	t	t	t	0.57	1.89	T
Longifolenaldehyde	1.51	1.86	1.68	1.43	1.4	0.8	2.13
α-Muurolene	0.4	0.48	0.49	0.39	t	t	T
γ-Muurolene	0.38	t	0.36	–	0.26	–	T
τ-Muurolol	2.64	5.86	4.9	3.84	4.11	1.78	8.72
β-Myrcene	0.2		0.44	0.24	0.38	0.78	T
Nerolidol	–	–	–	–	1.24	0.74	T
Patchoulene	3.91	1.41	9.81	4.42	–	–	–

γ-Phellandrene	t	t	t	t	1.16	2.6	T
α-Pinene	17.51	14.19	8.38	18.13	9.75	18.37	4.43
α-Pinene oxide	–	t	–	t	t	–	–
β-Pinene	9.93	11.99	5.06	11	6.4	14.53	3.12
Spathulenol	0.57	0.41	0.39	0.27	0.32	t	T
β-Terpinene	0.92	0.91	0.59	0.91	0.34	t	T
γ-Terpinene	–	–	0.08	t	6.7	14.43	3.15
Thujol	–	t	–	–	t	t	–
Valencene	1.42	2.05	1.48	1.5	1.14	0.73	1.94
Total	93.56	96.1	95.36	96.4	86.65	93.9	90.94

Place of sampling: N = Nordeste; P=Povoacao; R = Ribeira Grande; M = Mosteiros, EBPC = epibicyclosesquiphellandrene.

3.2. Diterpenes

Nowadays, more than 10 compounds were known as the labdanediterpenes type from the rhizomes of *H. coronarium* J. Koenig. Suresh et al, 2010 had characterized two new labdane-type diterpenes isolate[17].They were 6-oxo-7,11,13-labdatrien-17-al-16,15-olide and 7,17-dihydroxy-6-oxo-7,11,13-labdatrien-16,15-olide. The others known constituents were (E)-labda-8(17),12-diene-15,16-dial; (E)-15,16-bisnorlabda-8(17),11-dien-13-one; coronain B; coronarin D; coronarin C; coronarin D methyl ether; C-14 eimers of isocoronarin D; ethoxycoronarin D (obtained as epimeric mixture had been isolated from ethanolic extract); coronarin F; eicosyl; docosyl-(E)-ferulates; cryptomeridiol; hedychenone; 6-oxo-7,11,13-labdatriene-16,15-olide; 9-hydroxy,15,16-epoxy-7,11,13(16)14-labdatetraen-6-one; pacovatin A; 4-hydroxy3-methoxycinnamaldehyde; 4-hydroxy-3-methoxy ethyl cinnamate[17-25].

Table 2. Composition of the Rhizome Volatile Oils of Different *Hedychium* Species[16]

Compound	HE	HA	HC	HS		
				I	II	III
Borneol (3)		3.3	0.8	tr	0.1	0.6
Bornyl acetate (4)		7.6				
γ-Cadinene (5)		1.2	0.1			
α-Cadinol (6)	0.1			2.9	3.3	1.2
Camphene (12)			3.1	0.4	0.3	0.1
Carvacrol (15)			0.5			
Caryophyllene oxide (17)	1					
β-Caryophyllene (18)	5.6		0.3			
β-Cedrene (20)			0.5			
1,8-Cineole (29)	33	0.1	0.1	42.8	45.7	4.3
Cubebol (44)	Tr			0.8	0.8	
β-Curcumene (45)			Tr	1.1	0.6	1
ar-Curcumene (46)			0.2			
Curzerene (47)				0.5	0.2	1.2
p-Cymene (48)	0.6	8.2	Tr	tr	tr	0.7
Dehydroaromadendrane (50)			0.6			
10-epi-γ-Eudesmol (58)	Tr	0.5	0.7	12.4	12	1.2

β-Eudesmol (59)	0.1	0.5	0.2			
(*E*)-β-Farnesene (60)	0.5		0.1	2	1.3	
Geraniol (63)			1.5			
Germacrene D (65)		2.1				
Germacrene D-4-ol (66)				2	1.1	
α-Gurjunene (68)			0.2			
α-Humulene (81)	1.5		0.1	0.5	0.4	
Humulene epoxide (82)	0.2					
Limonene (89)	0.9	0.4	1.6	tr	tr	0.2
Linalool (90)	3.3	1.8	21.7	6.4	0.6	2.1
para-Mentha-3,8-diene (92)			0.7			
trans-meta-Mentha-2,8-diene (93)			25.2			
β-Myrcene (97)	0.1		1	0.3	0.4	8.7
γ-Muurolene (95)			0.2			
(*E*)-Nerolidol (98)	0.3	1.5	Tr			
α-Phellandrene (102)	Tr		0.2			
α-Pinene (103)	0.5	2.8	4	1.8	2.8	5.7
β-Pinene (104)	1.8	3.1		4	5.3	5.9
Sabinene (106)	22.2	2		0.1	tr	13
trans-Sabinol (107)	0.4					
α-Selinene (108)	1.3			0.1	0.3	1.4
β-Selinene (109)		1		6.8	3.9	1.3
Spathulenol (111)			0.5			
Terpin-4-ol (115)	14.3	24.8	4.1	0.9	1.1	19.5
Terpinolene (116)	0.7		0.2			
α-Terpinene (117)	1.8		0.2			
γ-Terpinene (119)	5.3		3.6			
α-Terpineol (120)	2	2.4	10.9	1.6	1.7	0.1
α-Thujene (121)	tr[d])	0.2		0.1	0.1	5.8
trans-Verbenol (124)	0.3					
Total [%]	97.8	63.5	83.1	87.5	82	69

HE = H. ellipticum; HA = H. aurantiacum; HC = H. coronarium; HS = Spicatum (from Jageshwar (I), Shimla (II) and Bhowali (III)

Diterpenes constituents also had been isolated from methanolicextract,they were 15-methoxylabda-8(17),13-dien-16,15-olide (coronarin G); coronarin H and coronarin I (3β,7β,14-trihydroxy-15,16-epoxylabda-8(17),12Z-dien and hedyforrestin C[26]. Matsuda et al, 2002 successfully characterized the labdane-type diterpenes compound from methanolic extract of *H. coronarium*, there were hedychilactones A; B and C, and six known labdane-type diterpenescoronarin D; coronarin D methyl ether; coronarin E; labda-8(17),13(14)-dien-15,16-olide, hedychenone; 7-hydroxyhedychenone [27].

Two diterpenes were isolated from the stems of *H. villosum* Wall, they were characterized as villosinandcoronarin E [28]. Whereas the chemical constituents from the rhizomes of *H. spicatum*led to the isolation of two new labdane-type diterpenes which were characterized as 7-hydroxy hedichinal and spicatanoic acid and six known compounds thatwereyunnacoronarin D; coronarin E; 8(12) drimene; 4-methoxy ethyl cinnamate; ethyl cinnamate and chrysin[29]. In addition, another labdane-type diterpenes was successfully isolated from $CHCl_3$ extract of *H. Spicatum*. Theywere characterized as hedychilactone D; 9-hydroxy hedychenone; yunnacoronarin A; hedychilactone B and hedychilactone C [25].

3.3. Sesquiterpenes

The present of sesquiterpenes compound were identified from methanolic extract of *H.coronarium*. Matsuda et al (2002) had isolated (+)-nerolidol; hedychiols A and hedychiol B 8,9-diacetate from *H. coronarium*[27].

3.4. Sterols

The rhizome of *H. coronarium* had been known consist of β-sitosterol; daucosterol and stigmasterol[26].

3.5. Flavonoid

The flavonoid compounds were presented in the methanolic extract of *H. coronarium* rhizome. Matsuda et al, 2002, had isolated flavonoid compound which was characterized as 5-hydroxy-3,7,4'-trimethoxyflavone[27]. Whereas the flavonoid from the rhizome of *H. spicatum* were identified as chrysin and teptochrysin[25].

Table 3. Phytochemical Content of *Hedyhcium* Species

No	Compound	Sources	References
	Diterpene		
1	(E)-15,16-Bisnorlabda-8(17),11-dien-13-one	*H. coronarium* (Rhizomes)	Itokawa, 1980
2	(E)-Labda-8(17),12-diene-15,16-dial	*H. coronarium* (Rhizomes)	Morita and Itokawa, 1988
3	4-Hydroxy-3-methoxy ethyl cinnamate	*H. coronarium* (Rhizomes)	Suresh et al, 2010
4	4-Hydroxy3-methoxycinnamaldehyde	*H. coronarium* (Rhizomes)	Suresh et al, 2010
5	6-Oxo-7,11,13-labdatrien-17-al-16,15-olide	*H. coronarium* (Rhizomes)	Suresh et al, 2010
6	6-Oxo-7,11,13-labdatriene-16,15-olide	*H. coronarium* (Rhizomes)	Suresh et al, 2010
7	7,17-Dihydroxy-6-oxo-7,11,13-labdatrien-16,15-olide	*H. coronarium* (Rhizomes)	Suresh et al, 2010
8	7-Hydroxyhedychenone	*H. coronarium* (Rhizomes)	Matsuda et al, 2002
9	Isocoronarin D	*H. coronarium* (Rhizomes)	Taveira et al, 2005
10	Benzoyl eugenol	*H. coronarium* (Rhizomes)	Taveira et al, 2005
11	Coronarin A	*H. coronarium* (Rhizomes)	Kiem et al, 2011
12	Coronain B	*H. coronarium* (Rhizomes)	Itokawa, 1988a
13	Coronarin C	*H. coronarium* (Rhizomes)	Taveira et al, 2005
14	Coronarin D	*H. coronarium* (Rhizomes)	Matsuda et al, 2002; Chinmoi, 2008
15	Coronarin D methyl ether	*H. coronarium* (Rhizomes)	Taveira et al, 2005; Matsuda et al, 2002
16	Coronarin E	*H. coronarium* (Rhizomes), *H. spicatum* (Rhizomes)	Matsuda et al, 2002; Reddy et al, 2009a
17	Coronarin F (36)	*H. coronarium* (Rhizomes)	Itokawa 1988b
18	Coronarin G (15-Methoxylabda-8(17),13-dien-16,15-olide)	*H. coronarium* (Rhizomes)	Kiem et al, 2011
19	Coronarin H	*H. coronarium* (Rhizomes)	Kiem et al, 2011

20	Coronarin I (3β,7β,14-Trihydroxy-15,16-epoxylabda-8(17),12Z-dien	*H. coronarium* (Rhizomes)	Kiem et al, 2011
21	Cryptomeridiol	*H. coronarium* (Rhizomes)	Suresh et al, 2010
22	Docosyl-(E)-ferulates	*H. coronarium* (Rhizomes)	Jayaprakasam et al, 2006
23	Eicosyl	*H. coronarium* (Rhizomes)	Jayaprakasam et al, 2006
24	Ethoxycoronarin D	*H. coronarium* (Rhizomes)	Taveira et al, 2005
25	Hedychenone	*H. coronarium* (Rhizomes)	Matsuda et al, 2002; Suresh et al, 2010
26	Hedychilactones A	*H. coronarium* (Rhizomes)	Matsuda et al, 2002
27	Hedychilactones B	*H. coronarium* (Rhizomes), *H. spicatum* (Rhizomes)	Matsuda et al, 2002; Reddy et al, 2009a
28	Hedychilactones C	*H. coronarium* (Rhizomes), *H. spicatum* (Rhizomes)	Matsuda et al, 2002; Reddy et al, 2009a
29	Hedyforrestin C	*H. coronarium* (Rhizomes)	Kiem et al, 2011
30	Labda-8(17),13(14)-dien-15,16-olide	*H. coronarium* (Rhizomes)	Matsuda et al, 2002
31	Pacovatin A	*H. coronarium* (Rhizomes)	Suresh et al, 2010
32	Villosin (along with coronarin E)	*H. villosum(Stems)*	Xiao et al, 2001
33	7-Hydroxy hedichinal	*H. spicatum* (Rhizomes)	Reddy et al, 2009a
34	8(12)Drimene, 4-methoxy ethyl cinnamate	*H. spicatum* (Rhizomes)	Reddy et al, 2009a
35	7-Hydroxy hedychenone	*H. coronarium* (Rhizomes)	Matsuda et al, 2002
36	9-Hydroxy hedychenone	*H. spicatum* (Rhizomes)	Reddy et al,, 2009b
37	Ethyl cinnamate	*H. spicatum* (Rhizomes)	Reddy et al, 2009a
38	Hedychilactone D	*H. spicatum* (Rhizomes)	Reddy et al,, 2009b
39	Spicatanoic acid	*H. spicatum* (Rhizomes)	Reddy et al, 2009a
40	Yunnacoronarin A	*H. spicatum* (Rhizomes)	Reddy et al,, 2009b
41	Yunnacoronarin D	*H. spicatum* (Rhizomes)	Reddy et al, 2009a
42	7-Hydroxy,6-oxo-7,11,13-labdatrien-16,15-olide	*H. coronarium* (Rhizomes)	Kiem et al, 2011
43	15-Methoxylabda-8(17),11*E*,13-trien-16,15-olide (Hedycoronens A)	*H. coronarium* (Rhizomes)	Kiem et al, 2011
44	Labda-8(17),11,13-trien-16,15-olide	*H. coronarium* (Rhizomes)	Kiem et al, 2011
45	16-Methoxylabda-8(17),11*E*,13-trien-15,16-olide (Hedycoronens B)	*H. coronarium* (Rhizomes)	Kiem et al, 2011
46	16-Hydroxylabda-8(17),11,13-trien-15,16-olide	*H. coronarium* (Rhizomes)	Kiem et al, 2011
	<u>Sesquiterpene</u>		
47	(+)-Nerolidol	*H. coronarium* (Rhizomes)	Matsuda et al, 2002
48	Hedychiol A	*H. coronarium* (Rhizomes)	Matsuda et al, 2002
49	Hedychiol B 8,9-diacetate	*H. coronarium* (Rhizomes)	Matsuda et al, 2002
	<u>Sterol</u>		
50	Daucosterol	*H. coronarium* (Rhizomes)	Kiem et al, 2011
51	Stigmasterol	*H. coronarium* (Rhizomes)	Kiem et al, 2011
52	β-Sitosterol	*H. coronarium* (Rhizomes)	Kiem et al, 2011
	<u>Flavonoid</u>		
53	5-Hydroxy-3,7,4'-trimethoxyflavone	*H. coronarium* (Rhizomes)	Matsuda et al,, 2002

54	Chrysin	*H. spicatum (Rhizomes)*	Reddy et al, 2009a
55	Teptochrysin	*H. spicatum (Rhizomes)*	Reddy et al,, 2009b

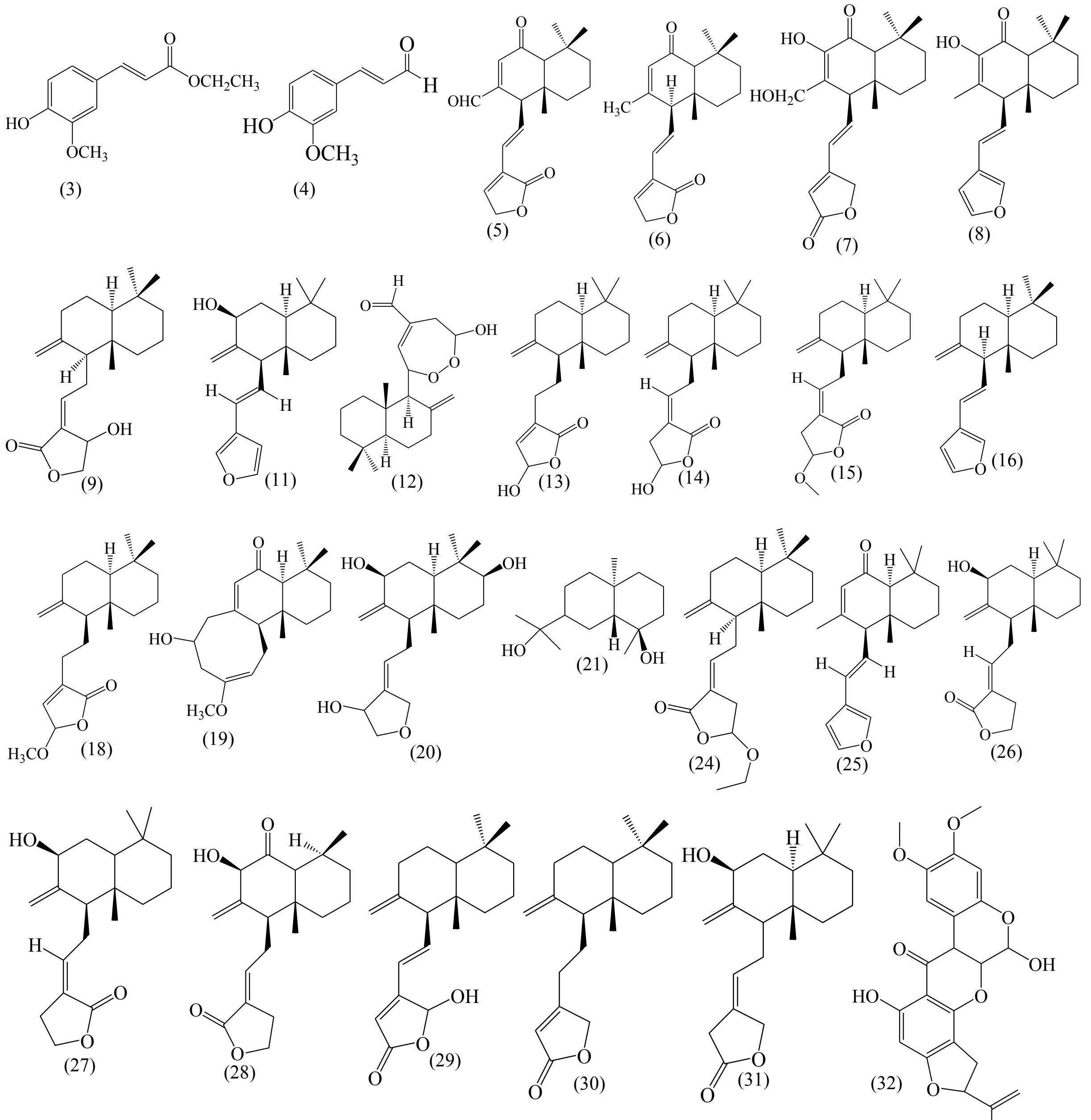

Fig. 2.The chemical constituents of *Hedychium* species.

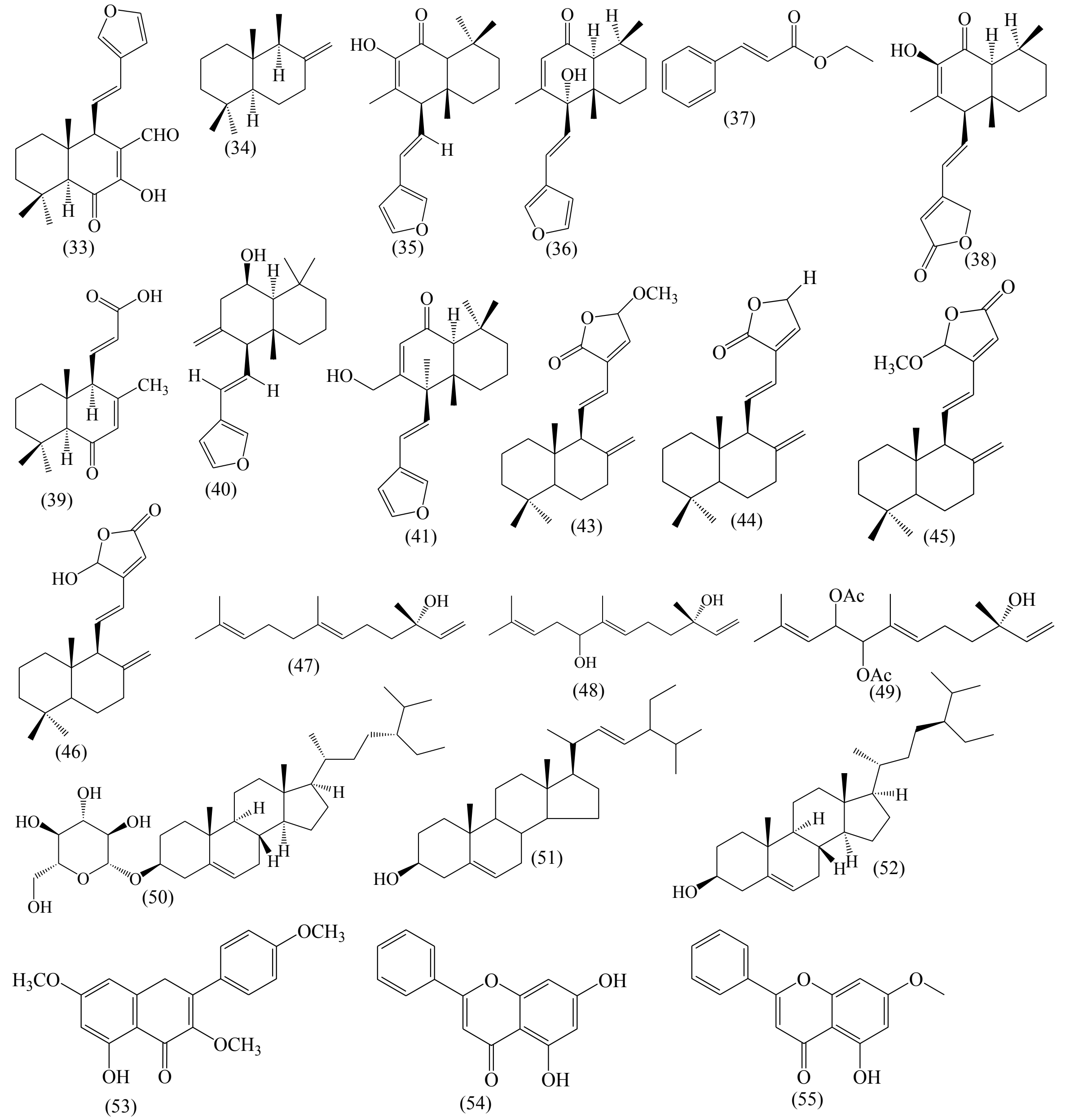

Fig. 2. The chemical constituents of *Hedychium* species. (Continued).

4. Pharmacological Properties

4.1. Antimicrobial

The essential oils of *H. aurantiacum, H. ellipticum*and *H. coronarium*showed broadspectrumactivity of antimicrobial. It was determined by the disc-difussion method that exhibited inhibition zone against *Staphylococcusaureus, Shigellaflexneri, Pateurellamultocida, Escherichia coli* and*Samonella enterica*[16]. By the same method, the essential oils, petroleum ether and chloroform extract of *H. spicatum* showed inhibitory activity against Gram positive and Gram negative bacterial cultures[30]. Methanolic extract of *H. coronarium* exhibited strong inhibition against *S.enterica*and *S. aureus* (MIC 0.05 mg/mL) and did not showed activity against *E. coli* and *Vibrio parahaemolyticus*[31].

The activity of leaves oil of *H. coronarium* Koenig. was observed against *Candida glabrata*, *Malassezia furfur* and *Candida albicans*, whereas the strongest activity of rhizome oil of *H. coronarium* Koenig. was observed against *C. glabrata* followed by *C. albicans* and *M. furfur*. All methanoland aqueous extracts (leaves andrhizome) showed weak or no activity[32]. The essential oils from *H. gardnerianum* leaves (30 µL) showed antimicrobial activity against *S. aureus* and *S. epidermidis* but not against *P. aeruginosa*[15]. Whereas fungitoxic activity of essential oils from *H. spicatum* rhizome against the toxigenic strain of *Aspergillusflavus* showed MIC 2.5 µL/mL and MFC 6.0 µL/mL[33].

4.2. Antioxidant

Antioxidant capacity of *H. coronarium* Koenig rhizome was 89.6 ± 11.6%. In DPPH scavenging activity, methanolic extract of *H. coronarium*Koening rhizome exhibited 90.1 ± 7.2% reducing power[31]. The most active free radical scavengers were methanolic leaves extracts, leaves aqueous, rhizome methanolic and rhizome aqueous extracts showed 97.8%; 98.1%; 95.5% and 92.9% inhibition respectively[32].

Antioxidant activity of the methanolic extract of *H. spicatum*Buch. Ham. Ex. D. Don rhizome from some population sites in India were analized, 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay and the result showed the IC_{50} values is0.549-1.059 mM AAE per 100 g dry weight[34]. Whereas antioxidant activity of the essential oils were analyzed by DPPH assay exhibited the IC_{50} values at 21.67±0.22 µL/mL[33]. This results showed that methanolic rhizome extract and essential oils of *H. spicatum* quite potential as an antioxidant sources.

4.3. Cytotoxicity

The *in vitro* cytotoxicity of labdane-type diterpenes from *H. coronarium* on some cancer cell lines was identified by MTT assays. Isocoronarin D (C-14 epimers) was shown to be the most active against all cancer cell lines, with the IC_{50} was 4 µg/mL, except for S102 cell line[35].

All compounds that were isolated from hexane extract of *H. coronarium* were examined their cytotoxic properties against the A-549, SK-N-SH, MCF-7 and HeLa cancer cell lines by using sulforhodamine B (SRB) assay. Based on the results, structural differences of the compounds significantly affected in anticancer activity. The 4-hydroxy-3-methoxy ethyl cinnamate;4-hydroxy-3-methoxycinnamaldehyde; hedy-chenone; coronarin C and coronarin D exhibited potent cytotoxic activity against A-549 cell line with the LC_{50} value ranging from 1.26 to 8.0 µM. Two compounds, 6-oxo-7,11,13-labdatrien-17-al-16,15-olide and 7,17-dihydroxy-6-oxo-7,11,13-labdatrien-16,15-olide, showed moderate cyctotoxicity on the test[17].

The cytotoxic activity of the isolates of *H. spicatum*were evaluated against THP-1, HL-60, A-375 and A-549 cell lines with the procedure was based on the standard MTT assay. Among the test compound, 7-hydroxy hedichinal showed potent activity and spicatanoic acid exhibited moderate activity[29]. In addition, *in vitro* cytotoxicity test of the isolates from $CHCl_3$ extract of *H. spicatum* were investigated against Colo-205, A-431, MCF-7, A-549 and CHO cell lines. The compound was characterized as hedychilactone D showed significant activity on Colo-205, A-431, MCF-7 and CHO cell lines. Another labdane-type diterpene was identified as 9-hydroxy-hedychenone exhibited moderate activity against Colo-205,A-431 and potent activity against CHO cell lines[29].

Synthesized derivatives of hedychenone and their cytotoxic activity were examined. Based on the results, epoxidation of hedychenone enhanced the activity against CHO cell lines. Whereas the compounds which were derived by allelic oxidation and ozonolysis showed weak activity against the test cell lines. The potent cytotoxic activity had been shown by the compounds which were derived by dimerization of hedychenone[36].

4.4. Anti-inflammatory activity

The rhizomes of *H. coronarium* were traditionally used for the treatment of arthritis, diabetes, headache and hypertension[37]. The inhibitory effect on the pro-inflammatory cytokines production is the parameter to examine the inflammatory activity. The test ofh the isolates from *H. coronarium* as the anti-inflammatory agent were evaluated by Kiem et al, 2011[26]. The result showed that the hedyforrestin C potently inhibited IL-6 and IL-12 production LPS-stimulated BMDCs. Inhibition activity of TNF-α, IL-6 and IL-12 in LPS-stimulated exhibited by the three of isolates from *H. coronarium*, coronarin G, coronarin H and hedyforrestin C[27].

Inhibitory effects of extract, fraction and isolates from *H. coronarium* were examined by determination the inhibitory effects on the vascular permeability acetic acid-induced in mice and also nitric oxide (NO) production in LPS-activated mouse peritoneal macrophages. Among to the test, the methanolic extracts (IC_{50} 45 μg/mL) and AcOEt-soluble fraction (IC_{50} 13 μg/mL) showed inhibition of NO production in LPS-stimulated mouse peritoneal macrophages. In addition, hedychilactone A (IC_{50} 18 μM), coronarins D (IC_{50} 16 μM), coronarin D methyl ether (IC_{50} 21 μM), labda-8(17),13(14)-dien-15,16-olide (IC_{50} 15 μM) and hedychenone (IC_{50} 7.9 μM)[27].

The effect on iNOS induction also had been examined by Matsuda *et al*., The results exhibited that hedychilactone A, coronarin D, labda-8(17),13(14)-dien-15,16-olide and hedychenone inhibited the NO production due to their inhibitory activities against induction of iNOS in LPS-activated macrophages[27].

The development of the increase in vascular permeability induced by acetic acid had been known to correspond to the early exudative stage of inflammation, one of the most important processes in inflammatory pathology[38]. The methanolic extract, coronarin D and coronarin D methyl ether from *H. coronarium* showed increasing in vascular permeability on the acetic acid-induced in mice[27].

The ethanolic extract of *H. spicatum* at the dose of 2 g/100 g body weight showed anti-inflammatory activity with 55.54% inhibition of edema carageenan-induced in Wistar rats[39].

4.5. Analgetic

The methanolic extract of *H. coronarium* significantly showed analgetic effect. At the dose of 100, 100 and 400 mg/kg body weight produced a significant increase in pain threshold in tail immersion methods in a dose dependent manner in acetic acid-induced writhing test, the extract at 400 mg/kg body weight dose showed a maximum of 73.12% writhing inhibition compared to the control, comparable to 75.78% inhibition of writhing by standard drug sodium diclofenac (25 mg/kg body weight)[40].

4.6. Larvacidal activity

Mosquito larvicidal activity against *Aedesaegypti*(L.) was carried out on the essential oil of the leaves and rhizomes of *H. coronarium*. The leaves oil exhibited larvicidal activity during 2 h and 24 h, the LC_{50} values were 111 and 90 ppm respectively while the rhizome oil exhibited larvicidal activity during 2 h and 24 h, the LC_{50} values were 86 and 47 ppm. It had been reported that α-pinene, β-pinene and 1,8-cineole present larvicidal effects (LC_{50} values 15.4, 12.1 and 57.2 ppm, respectively) on *A. aegypti*larvae. *H. coronarium*essential oil could be considered as a contribution to the search for new biodegradable larvicides of natural origin[32].

5. Conclusions

The scientific information of *Hedychium* genera is still limited. Based on the previous research of some of *Hedychium* plants could be concluded that the others plants from *Hedychium* genera are potential to be explored as a natural product resources.

References

1.Riswan S, Setyowati FM. Ethnobotanical Study On Zingiberaceae In Indonesia. *Proc 2nd Symp Fam Zingiberaceae South China Inst Bot* 1996; 196-218.

2. He EY. Study on *Hedychium coronarium* Koenig's edibility and its pharmacological experiments. *Lishizhen Med Medica Res* 2000; **11** (1): 1077–78.

3. Warren KS & Peters PA. Cercariae of *Schistosoma mansoni* and plants: attempt to penetrate *Phaseolus vulgaris* and *Hedychium coronarium* produces a cercaricide. *Nature* 1968; **217** (5129): 647–8.

4. Sharma PK, Dhyani SK, Shanker V. Some useful and medicinal plants of the district Dehradun and Siwalik. *J Sci Res Plant Med* 1979; **1**: 17-43.

5. Malhotra CL and Balodi B. Wild medicinal plants in the use of Johari tribe. *J Econ Tax Bot* 1984; **5**(4): 841-7.

6. Megoneisto, Rao RR. Ethnobotanical studies in Nagaland: Sixty two medicinal plants used by the Angami Nagas. *J Econ Tax Bot* 1983; 4: 167-72.

7. Zhang, W. Study on crossbreeding and analysis on the aroma components in *Hedychium*. [MastersThesis] South China Agricultural University 2007.

8. Sarangthem N, Talukdar NC, Thogam B. Collection and evaluation of *Hedychium* species of Manipur. *Genet Resour Crop Evol* 2013; **60**: 13-21.

9. Sharma GJ, Chirangini P, Kishor R. Gingers of Manipur: diversity and potentials as bioresources. *Genet Resour Crop Evol* 2011; **58**: 753–67

10. Kong SJJ, Xia YM, Li QJ. Inflorescence and flower development in the Hedychieae (Zingiberaceae): *Hedychium coccineum*. *Protoplasma* 2010; **247**: 83–90.

11. Wagner WL, Herbst DR, Sohmer SH. Manual of the flowering plants of Hawai'i.Honolulu:Bernice P. Bishop Museum; 1999.

12. Handa SS, Khanuja SPS, Longo G, Rakesh DD (eds). Extraction technologies for medicinal and aromatic plants. Trieste: UNIDO; 2008.

13. Paibon W, Yinmoi CA, Tembab N, Boonlue W, Jampachaisri K, Nuengchamnong N, Waranuch N, Ingkaninan K. Comparison and evaluation of volatile oils from three different extraction methods for some Thai fragrant flowers. *Int J Cosmetic Sci* 2011; **33**: 150–6.

14. Weyerstahl P, Marschall H, Thefeld K, Subba GC. Constituents of the essential oil from the rhizomes of *Hedychium gardnerianum* Roscoe. *Flavour Frag* J 1998; **13**: 377– 88.

15. Medeiros JR, Camposb LB, Mendon cab SC, Davinc LB, Lewisc NG. Composition and antimicrobial activity of the essential oils from invasive species of the Azores, *Hedychium gardnerianum* and *Pittosporum undulatum*. *Phytochemistry* 2003; **64**(2): 561-5.

16. Joshi S, Chanotiva CS, Agarwala G, Prakasha O, Panta AK, Mathelab CS. Terpenoid compositions, and antioxidant and antimicrobial properties of the rhizome essential oils of different *Hedychium* species. *Chem Biodivers* 2008; **5**(2): 299-309.

17. Suresh G, Reddy P, Suresh Babu K , Shaik TB, Kalivendi SV. Two new cytotoxic labdane diterpenes from the rhizomes of *Hedychium coronarium*. *Bioorg Med Chem Lett* 2010; **20**: 7544–48.

18. Morita H, Itokawa H. Cytotoxic and antifungal diterpenes from the seeds of *Alpinia galangal*. *Planta Med* 1988; **54**: 117–20.

19. Itokawa H, Morita M, Mihashi S. Labdane and bisnorlabdane type diterpenes from *Alpinia speciosa* K. Schum. *Chem Pharm Bull* 1980; **28**: 3452–54.

20. Itokawa H, Morita H, Katou I, Takeya K, Caval heiro A. J, Oliveira RCB, Ishige M, Moti dome M. Cytotoxic diterpenes from the rhizomes of *Hedychium coronarium*. *Planta Med* 1988; **54**: 311–5.

21. Chimnoi N, Pisutjaroenpong S, Ngiwsara L, Dechtrirut D, Chokchaichamnankit D, Khunnawutmanotham N, Mahidol C, Techasakul S. Labdane diterpenes from the rhizomes of *Hedychium coronarium*. *Nat Prod Res* 2008; **22**(14): 1255–62.

22. Taveira FN, Oliveira AB, Souza Filho JD, Braga FC. Epimers of labdane diterpenes from the rhizomes of *Hedychium coronarium.* J. Koenig. *Rev Bras Pharmacog 2005*; **15**: 55–9.

23. Itokawa H, Morita H, Takeya K, Motidome M. Diterpenes from rhizomes of *Hedychium coronarium.Chem Pharm Bull* 1988;**36**: 2682–4.

24. Jayaprakasam B, Vanisree M, Zhang Y, Dewitt DL, Nair MG. Impact of alkyl esters of caffeic and ferulic acids on tumor cell proliferation, cyclooxygenase enzyme, and lipid peroxidation. *J Agric Food Chem* 2006; **54**: 5375–81.

25. Reddy PP, Rao RR, Rekha K, Babu SK, Shashidar J, Shashikiran G, Lakshmi VV, Rao JM.. Two new cytotoxic diterpenes from the rhizomes of *Hedychium spicatum*. *Bioorg Med Chem Lett* 2009; **19**: 192-5.

26. Kiem PV, Kim Thuy NT, Tuan Anh HL, Nhiem NX, Minh CV, Yen PH, Ban NK, Hang DT, Tai BH Tuyen NV, Mathema VB, Koh YS, Kim YH. Chemical constituents of the rhizomes of *Hedychium coronarium* and their inhibitory effect on the pro-inflammatory cytokines production LPS-stimulated in bone marrow-derived dendritic cells. *Bioorg Med Chem Lett* 2011; **21**: 7460–65.

27. Matsuda H, Morikawa T, Sakamoto Y, Toguchida I, Yoshikawa M. Labdane-type Diterpenes with Inhibitory Effects on increase in vascular permeability and nitric oxide production from *Hedychium coronarium*. *Bioorg Med Chem* 2002; **10**: 2527-34.
28. Xiao P, Sun C, Zahid M, Ishrud O, Pan Y. New diterpene from *Hedychium villosum*. *Fitoterapia* 2001; **72**: 837-8.
29. Reddy PP, Rao RR, Shashidhar J, Sastry BS, Rao JM, Babu KS. Phytochemical investigation of labdane diterpenes from the rhizomes of *Hedychium spicatum* and their cytotoxic activity. *Bioorg Med Chem Lett* 2009; **19**: 6078-81.
30. Bisht GS, Awasthi AK, Dhole TN. Antimicrobial activity of *Hedychium spicatum*. *Fitoterapia* 2006; **77**: 240-2.
31. Chen IN, Chang CC, Ng CC, Wang CY, Shyu YT, Chang TL. Antioxidant and antimicrobial activity of Zingiberaceae plants in Taiwan. Plant *Foods Hum Nutr* 2008; **63**: 15-20.
32. Ho JC. Antimicrobial, mosquito larvicidal and antioxidant properties of the leaf and rhizome of *Hedychium coronarium. J Chin Chem Soc* 2011; **58**: 563-7.
33. Prakash B, Singh P, Kedia A, Dubey NK. Assessment of some essential oils as food preservatives based on antifungal, antiaflatoxin, antioxidant activities and in vivo efficacy in food system. *Food Res Int* 2012; **49**: 201–8.
34. Rawat S, Bhatt ID, Rawal RS. Total phenolic compounds and antioxidant potential of *Hedychium spicatum* Buch. Ham. ex D. Don in west Himalaya. *India. J Food Compos Anal* 2011; **24**: 574–9.
35. Chinmoi N, Sarasuk C, Khunnawutmanotham N, Intachote P, Seangsai S, Saimanee B, Pisutjaroenpong S, Mahidol C, Techasakul S. Phytochemical reinvestigation of labdane-type diterpenes and their cytotoxicity from the rhizomes of *Hedychium coronarium*. *Phytochem Lett* 2009; **2**: 184–7.
36. Reddy PP, Lavekar AG, Babu KS, Rao RR, Shashidhar J, Shashikiran G, Rao JM. Synthesis, cytotoxic activity and structure-activity relationships of hedychenone analogues. *Bioorg Med Chem Lett* 2010; **20**: 2525–28.
37. Jain SK, Fernandes VF, Lata S. and Ayub A. Indo- Amazonian ethnobotanicconnections - Similar uses of some common plants. *Ethnobotany* 1995; **7**:29-37.
38. Whittle BA. The Use of Changes in Capillary Permeability in Mice to Distinguish Between Narcotic and Non-narcotic Analgesics. *Br J Pharmacol Chemother* 1964; **22**: 246-53
39. Chachad D and Shimpi S. Anti-Inflammatory activity of ‘Kapurkachari’. *Elect J Pharm & Ther* 2008; **1**: 25 -7.
40. Dash PR, Nasrin M, Saha MR. Evaluation of analgesic and neuropharmacological activities of methanolic rhizome extract of *Hedychium coronarium*. *Int J Pharm Sci Res* 2011; **2**(4): 979-84.