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Review Article

A Review on Pharmacognostical Phytochemical and Ethnomedicinal Properties of *Hedychium Coronarium* J. Koenig an Endangered Medicine

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Abstract: *Hedychium coronarium* J. Koenig is a perennial medicinal herb which is distributed in throughout the world and used as traditional medicine since the ancient time. It contains various bioactive compounds including Phenols, Terpenoids, Saponins, Volatile oils, Flavonoids, Glycosides etc. These bioactive compounds made this herb as a valuable potent herbal drug. *Hedychium coronarium* has high ethno medicinal significance in India and China as well. *H. coronarium* is endemic in the Amarkantak area of Central India. Due to over-exploitation of this plant for extraction of crude drug (Eye Tonic), it is rapidly disappearing from its natural habitat at alarming rate and needs urgent protection and conservation. In present article medicinal, pharmacological and other important properties of *Hedychium coronarium* were compiled. Review reveals this plant as potent herbal drug and remedy for many ailments.

Keywords: *H. Coronarium*, Pharmacognosy, Pharmacology, Phytochemical, Ethnomedicine

1. Introduction

Hedychium coronarium is a monocotyledon perennial herb which belongs to family Zingiberaceae. The coronarium species for this genus (Hedychium) was described by Jhon Koenig in 1783. It is commonly known as white ginger or butterfly ginger because its flower looks like a flying butterfly. *Hedychium coronarium* is an aromatic rhizomatous plant which possesses important medicinal properties and its various parts are used in traditional as well as modern medicine (Vaidyaratnam, 2002). The medicinal value of this plant in the therapeutic field is mentioned in Ayurveda, Charaka Samhita and Sushruta Samhita (Tailor and Goyal, 2015). The all parts of this plant are utilized as medicine as well as other daily uses, although its applications varies by region. In the Ayurvedic system of Indian traditional medicine it has used as a febrifuge, tonic and excitant and also used as medicine in the treatment of tonsillitis, infected nostrils and tumor (Bhandary *et al*., 1995; Jain & Prakash 1995).). In Chinese medicine it has been prescribed in treatment of headache, lancinating pain, contusion, inflammatory and intense pain due to rheumatism etc (Mishra *et al*., 2013). *Hedychium coronarium* is also reported for its anti-cancerous, antioxidant, anti-hypertensive, diuretic, and leishmanicidal, anti-malarial activities it is also used in irregular menstruation, piles bleeding and stone in urinary tract. The essential oil extracted from leaves, flowers and rhizome of this plant possesses cercaricidal properties, molluscicidal activity, potent inhibitory action, antimicrobial activities, anti-inflammatory and analgesic effects (Bisht *et al*., 2012). The paste prepared from rhizome is applied externally in cases of snakebite (Ray *et al.*, 2011). The flowers and stems are also stand for Commercial importance as used in the manufacturing of perfume and paper respectively (Chadha 2005). Both the flower and rhizomes are also consumed as vegetables (Sarangthem *et al*., 2012; Mohanty *et al.,* 2013).

Table 1. *Taxonomic classical classification APG IV 2016.*

Domain:	**Eukaryota**	**Kingdom:**	**Plantae**
Kingdom:	Plantae	Clade:	Angiosperms
Phylum:	Spermatophyta	Clade:	Monocots
Subphylum:	Angiosperm	Clade:	Commelinids
Class:	Monocotyledonae	Order:	Zingiberales
Order:	Zingiberales	Family:	Zingiberaceae
Family:	Zingiberaceae	Genus:	Hedychium
Sub Family:	Zingiberoideae	Species:	Coronarium J. Koenig
Genus:	Hedychium		
Species:	Coronarium		

Table 2. *Synonyms and vernacular names.*

Local common Names:	
Hindi:	Gulbakawali, Dolan champa, Kapoor Kachrai
Marathi:	Sontakka
Manipuri:	Takhellei angouba
Kannada:	Surili sugandhi
Malyalam:	Kalvana sauganthikam

Table 3. *International common names.*

English:	**Butterfly lily, Butterfly ginger, White Garland lily, Jasmin**
Brazil:	Borboleta
Cuba:	Flor De Mariposa
China:	Jiang Hua
German:	Garland Blume
Spanish:	Blanca Mariposa
French:	Canne riviere

2. Geographic Distribution

Hedychium coronarium is found at altitudes from sea level to 2500m (Van Valkenburg and Bunyapraphatsara, 2001). Itis cultivated in many parts of the world and widely distributed in tropical and subtropical regions among China, India and South East countries. Hedychium coronarium is considered as Native to Himalayas and southern China (Van Valkenburg and Bunyapraphatsara, 2001). This species appears in shaded or semi-shaded regions subjected to water logging. It is usually occurs in shallow water and along water margins (Joly and Brandle, 1995). It is known as an invasive weed in Brazil, it was brought to country by African slaves during the slavery era there (Souza and Correia, 2007; Kissmann, 1997). It is also known as the National Flower of Cuba where it is known as the 'Flor de Mariposa' or white butterfly. There are 50 species of *Hedychium* in tropical Asia (Kirtikar and Basu 1984), from them 37 species occurs in India and 8 species in Western Himalaya (Giri, and Tamta, 2011). In India it is distributed in Assam, Bihar, Karnataka, Kerala, Maharashtra, Uttar Pradesh, Odisha, Manipurand Sikkim, in Central region of India it is found in Amarkantak region of Madhya Pradesh and Chhattisgarh.

3. Plant Description

Hedychium coronarium or white butterfly or "Gulbakawali" is a perennial, erect herb, growing up to 1-2.5 m. (3-6 ft) height, from the rhizomes. Rhizomes are fleshy, branched and knotty, with many nodes and grows up to 2.5-5 cm in diameter, spreading horizontally under the soil surface. Leaves are lance-shaped and sharp pointed, simple, 2-ranked, alternately disposed, 8-24 in (20-61 cm) long and 2-5 in (5-12.7 cm) wide. Margins are entire, midrib prominent on dorsal face, smooth and glabrous on surfaces, intense green and glossy. From monsoon to winter the stalks are topped with 4-5 cm long, clusters of white flowers that emerge from between the bracts, 2-3 flowers per bract. Flowers are zygomorphic, hermaphrodite, calyx glaberous, less than half the length of the corolla tube, tubuler calyx 4cm long, hidden between the bracts opening obliquely. Corolla are tubular at the lower part, forming three lobes at the apex. Whithin are four petaloid steminoides, two of which are united to form a bilobed labellum; the other two are elliptic-lanceolate and remain separate. The petaloid staminoides are 4-5 cm long, white sometimes with yellow stains. A long white filament arises through the corolla. Fruits are oblong, capsule contains numerous seeds.

4. Phytochemicals

Hedychium coronarium contains a rich variety of biological compounds which plays an important role in medicine, fragrances and flavor etc. These bioalogical compounds belong to secondary metabolites include terpenoids, steroids, flavonoids and alkaloids (Sah *et al*., 2012). Previous studies reported that various labdane-type diterpenes and farnesane-type sesquiterpenes were also isolated from this plant (Matsuda *et al*., 2002; Nakatani *et al.,* 1994; Chimnoi *et al*., 2009). Cytotoxiclabdane-type diterpenoids including coronarins A−D (Itokawa *et al*., 1988) have been reported from therhizome of *Hedychium coronarium*.

Lu *et al*., 2009; Verma and Bansal, 2012, identified the main chemical included hedychicoranarian, peroxycoronarian D, 7β hydroxylcalcaratarin A and E, 7β- hydroxyl-6-oxo-labda-8, 12-diene-15,16-dial from the rhizomes of *Hedychium coronarium*, in which *Hedychium coronarium*, peroxycoronarin D were isolated as optically active colorless oil. The phytochemical screening from the rhizome showed the presence of benzoyl eugenol along with the labdane diterpenes isocoranarin D and ethoxy coronarian D also. According to Chen *et al*., 2013 and Singh *et al.,* 2013 *Hedychium coronarium* contains oils which major contents were β- pinene (20.0%), linalool (15.8%), α-pinene (10.1%), 1,8-cineole (10.7%) and α-terpineol (8.6%) in the leaf while the root consists mainly of β- pinene (23.6%), α- humulene (17.1%), β- caryophyliene (13.0%), α- piene (6.9%) and elemol (6.9%).

The identified sesquiterpenes from *Hedychium coronarium* are Nerolidol and Hedychiol A (Matsuda *et al.,* 2002). Kiem *et al*., 2011 mentioned that the rhizome of *Hedychium coronarium* contains Sterols and flavonoids which are Daucosterol, Stigmasterol, β-Sitosterol. Major flavonoids are 5-Hydroxy-3,7,4'-trimethoxyflavone, Chrysin and Teptochrysin which are studied by Reddy *et al*., 2009. The volatile constituents of *Hedychium coronarium* from whole plant also have been reported (Mishra *et al*., 2013). Reported phytochemicals from *Hedychium coronarium* are given in table no 1 and 2.

Table 4. *Different volatile oils isolated from hedychium coronarium in previous studies.*

No	Compound	Plant part	References
1	Camphene	Rhizome	Joshi *et al.*, 2008
2	Terpin-4-ol	Rhizome	Joshi *et al.*, 2008
3	ϒ-terpinene	Rhizome	Joshi *et al.*, 2008
4	α-terpineol	Rhizome	Joshi *et al*, 2008; Pragadheesh *et al.*, 2015; Van Thanh *et al.*, 2014
5	Linalool	Rhizome and flower	Joshi *et al*, 2008; Pragadheesh *et al.*, 2015; Van Thanh *et al.*, 2014
6	α-pinene	Rhizome and leaf	Joshi *et al.*, 2008; Pragadheesh *et al.*, 2015; Van Thanh *et al.*, 2014
7	α-humulene	Root	Joshi *et al.*, 2008; Van Thanh *et al.,* 2014
8	β-caryophyllene	Root	Joshi *et al.,* 2008; Van Thanh *et al.*, 2014
9	β-pinene	Rhizome and Leaf	Joshi *et al.,* 2008; Pragadheesh *et al.*, 2015; Fraga Miranda *et al.*, 2015
10	Borneol	Stem	Joshi *et al.*, 2008; Pragadheesh *et al.*, 2015
11	1,8-cineole	Rhizome, Flower and leaf	Joshi *et al.,* 2008; Pragadheesh *et al.*, 2015; Fraga Miranda *et al.*, 2015
12	β-ocimene	Flower	Pragadheesh *et al.,* 2015
13	ϒ-Cadinene	Rhizome	Joshi *et al.*, 2008
14	Carvacrol	Rhizome	Joshi *et al.*, 2008
15	β-Cedrene	Rhizome	Joshi *et al.*, 2008
16	*ar*-Curcumene	Rhizome	Joshi *et al.*, 2008
17	Dehydroaromadendrane	Rhizome	Joshi *et al.,* 2008
18	10-epi-γ-Eudesmol	Rhizome	Joshi *et al.,* 2008
19	β-Eudesmol	Rhizome	Joshi *et al.,* 2008
20	(*E*)-β-Farnesene	Rhizome	Joshi *et al.,* 2008
21	Geraniol	Rhizome	Joshi *et al.,* 2008
22	β-Myrcen	Rhizome	Joshi *et al.*, 2008
23	γ-Muurolene	Rhizome	Joshi *et al.*, 2008
24	(*E*)-Nerolidol	Rhizome	Joshi *et al.*, 2008
25	α-Phellandrene	Rhizome	Joshi *et al.,* 2008
26	Spathulenol	Rhizome	Joshi *et al.*, 2008
27	Terpinolene	Rhizome	Joshi *et al.,* 2008
28	α-Terpinene	Rhizome	Joshi *et al.*, 2008

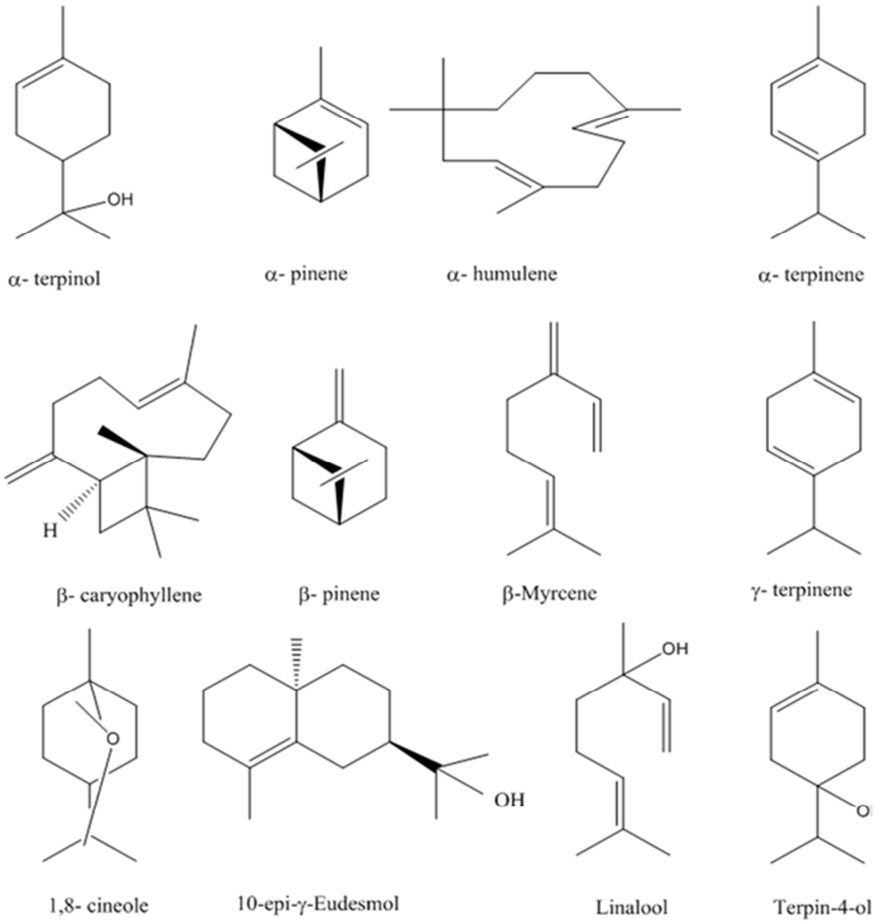

Figure 1. *Different volatile oils isolated from Hedychium coronarium (Joshi et al. 2008).*

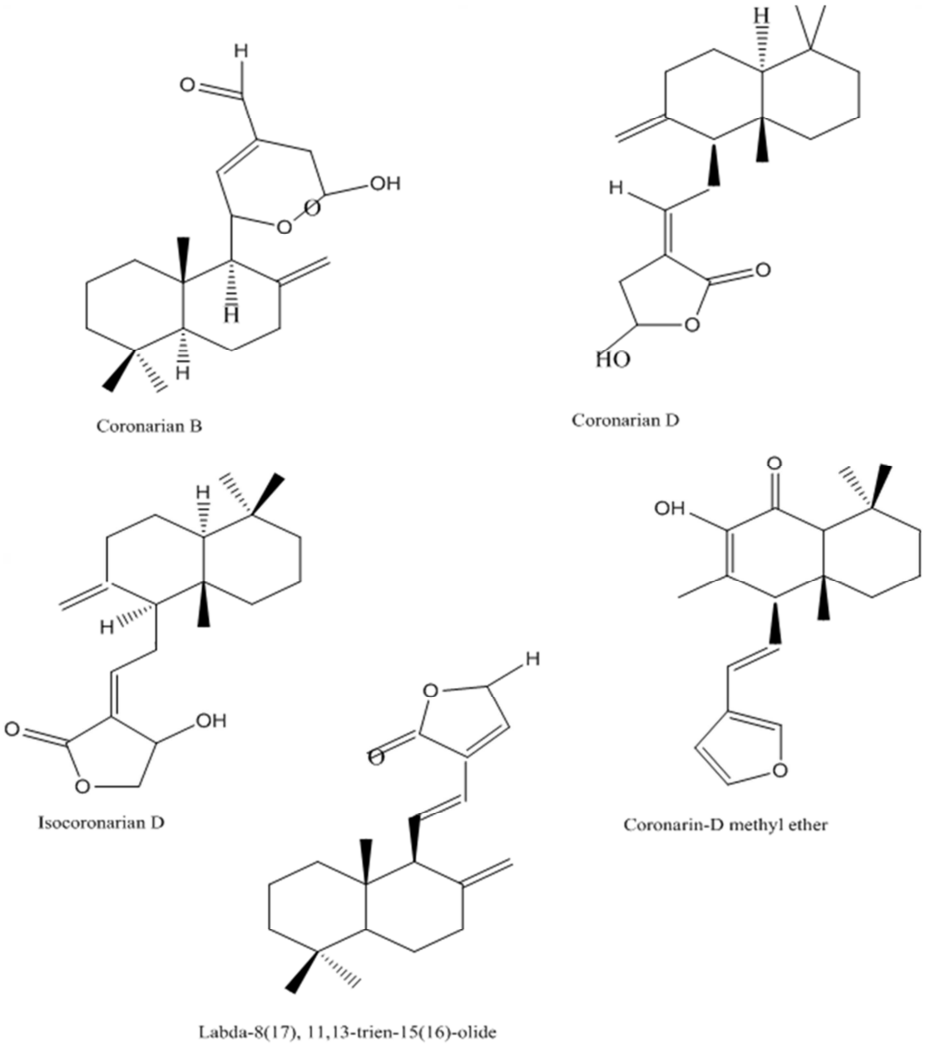

Figure 2a. *Different Diterpenes isolated from Hedychium coronarium (Joshi et al. 2008).*

Table 5. *Different diterpenes isolated from hedychium coronarium in previous studies.*

No	Compound	Plant part	References
1	(E)-15,16-Bisnorlabda-8(17),11-dien-13-one	Rhizome	Itokawa, 1988
2	(E)-Labda-8(17),12-diene-15,16-dial	Rhizome	Itokawa, 1988
3	Coronain B	Rhizome	Itokawa, 1988
4	Coronarin F	Rhizome	Itokawa 1988
5	coronarin -D ethyl ether	Rhizome	Singh S *et al.*, 1991
6	Coronarin –D	Rhizome	Singh S *et al.*, 1991; Matsuda *et al.*, 2002; Chinmoi *et al.,* 2009
7	Isocoronarin-D	Rhizome	Singh S *et al.*, 1991; Nakatani *et al.,* 1994; Taveira *et al.,* 2005
8	Coronarin-D methyl ether	Rhizome	Singh S *et al.*, 1993
9	14,15,16-trinorlabda-8(17),11-(*E*)-dien-13-al	Rhizome	Singh S *et al.,* 1993
10	Labda-8(17), 11,13-trien-15(16)-olide	Rhizome	Nakatani *et al.,* 1994; Kiem *et al.*, 2011
11	7β-hydroxycoronarin B	Rhizome	Nakatani *et al.*, 1994
12	Hedychilactones A	Rhizome	Matsuda *et al.*, 2002
13	Hedychenone	Rhizome	Matsuda *et al.*, 2002; Suresh *et al.,* 2010
14	Labda-8(17),13(14)-dien-15,16-olide	Rhizome	Matsuda *et al.,* 2002
15	7-Hydroxy hedychenone	Rhizome	Matsuda *et al.*, 2002
16	Coronarin E	Rhizome	Matsuda *et al.*, 2002; Reddy *et al.*, 2009
17	Benzoyl eugenol	Rhizome	Taveira *et al.,* 2005; Denise *et al.*, 2014
18	Coronarin C	Rhizome	Taveira *et al.,* 2005
19	Ethoxycoronarin D	Rhizome	Taveira *et al.*, 2005; Denise *et al.*, 2014
20	Docosyl-(E)-ferulates	Rhizome	Jayaprakasam *et al.,* 2006
21	Eicosyl	Rhizome	Jayaprakasam *et al.*, 2006
22	Trans-meta-mentha-2,8-diene	Rhizome	Joshi *et al.,* 2008
23	Pacovatin A	Rhizome	Suresh *et al.,* 2010
24	Cryptomeridiol	Rhizome	Suresh *et al.*, 2010

No	Compound	Plant part	References
25	4-Hydroxy-3-methoxy ethyl cinnamate	Rhizome	Suresh *et al.*, 2010
26	4-Hydroxy3-methoxycinnamaldehyde	Rhizome	Suresh *et al.,* 2010
27	6-Oxo-7,11,13-labdatrien-17-al-16,15-olide	Rhizome	Suresh *et al.*, 2010
28	6-Oxo-7,11,13-labdatriene-16,15-olide	Rhizome	Suresh *et al.,* 2010
29	7,17-Dihydroxy-6-oxo-7,11,13-labdatrien-16,15-olide	Rhizome	Suresh *et al.*, 2010
30	Coronarin A	Rhizome	Kiem *et al.,* 2011
31	Coronarin G (15-Methoxylabda-8(17),13-dien-16,15-olide)	Rhizome	Kiem *et al.,* 2011
32	Coronarin I (3β,7β,14-Trihydroxy-15,16-epoxylabda-8(17),12Z-dien	Rhizome	Kiem *et al.*, 2011
33	Hedyforrestin C	Rhizome	Kiem *et al.,* 2011
34	7-Hydroxy,6-oxo-7,11,13-labdatrien-16,15-olide	Rhizome	Kiem *et al.*, 2011
35	15-Methoxylabda-8(17),11*E*,13-trien-16,15- olide (Hedycoronens A)	Rhizome	Kiem *et al.*, 2011
36	16-Hydroxylabda-8(17),11,13-trien-15,16-olide	Rhizome	Kiem *et al.*, 2011
37	Hedycoronals A and B	Rhizome	Zhan *et al.*, 2012
38	7β-hydroxycalcaratarin A	Rhizome	Chen JJ *et al.*, 2013
39	(*E*)-7β-hydroxy-6-oxo-labda-8(17),12-diene-15,16-dial	Rhizome	Chen JJ *et al.,* 2013
40	Peroxycoronarin D	Rhizome	Chen JJ *et al.*, 2013
41	Hedychicoronarin	Rhizome	Chen JJ *et al.*, 2013
42	Methoxycoronarin D	Rhizome	Denise *et al.*, 2014

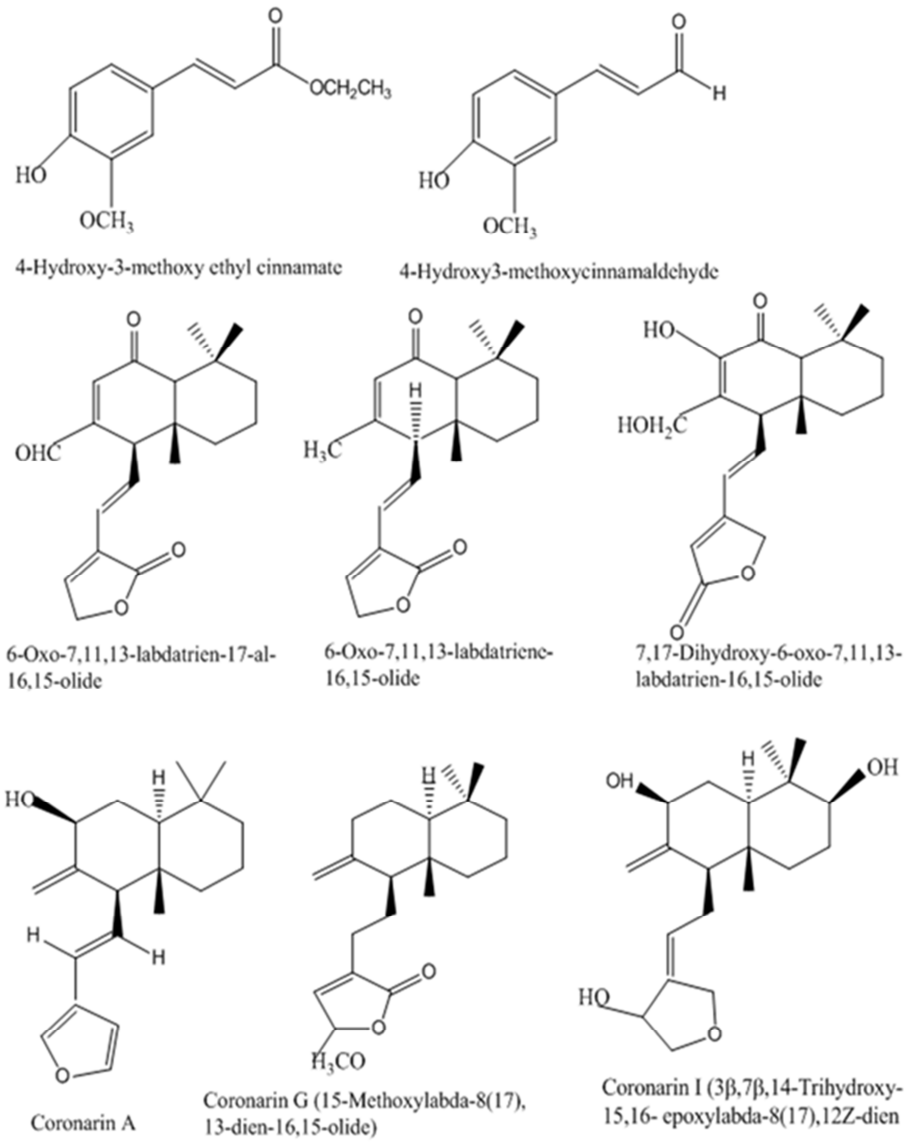

Figure 2b. *Different Diterpenes isolated from Hedychium coronarium (Joshi et al. 2008).*

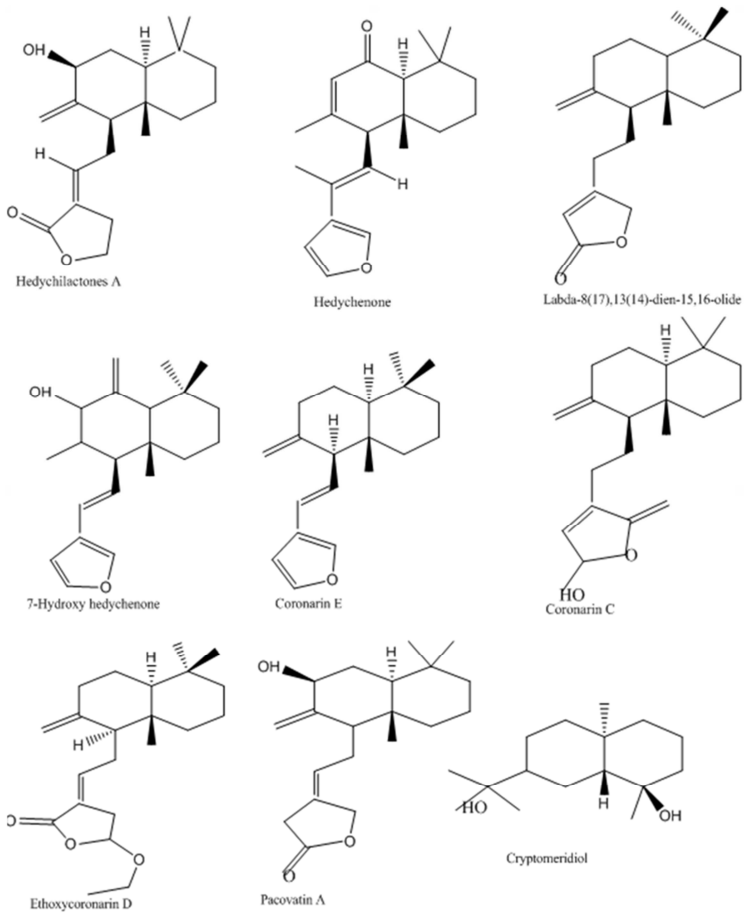

Figure 2c. *Different Diterpenes isolated from Hedychium coronarium (Joshi et al. 2008).*

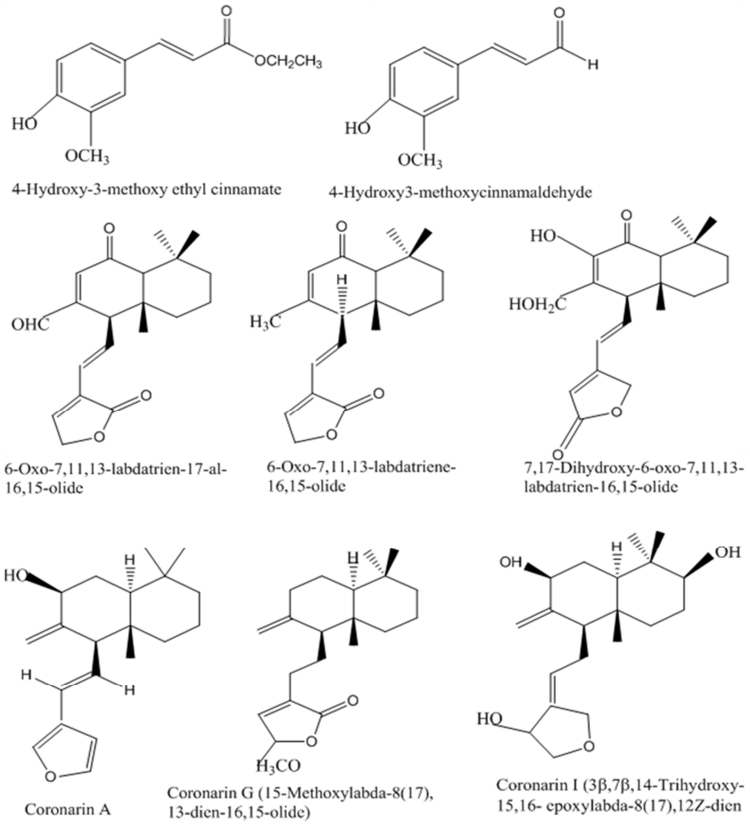

Figure 2d. *Different Diterpenes isolated from Hedychium coronarium (Joshi et al. 2008).*

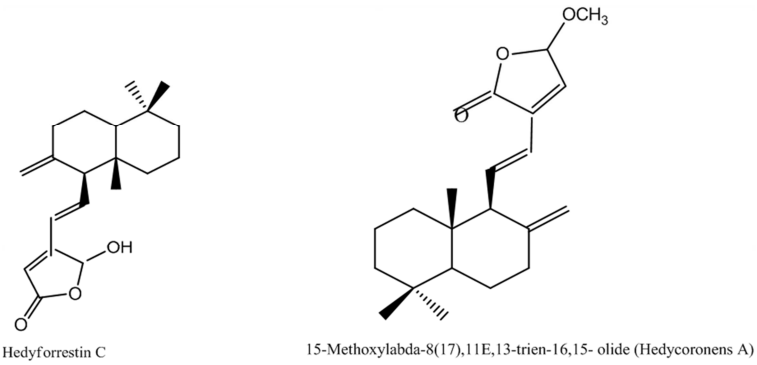

Figure 2e. *Different Diterpenes isolated from Hedychium coronarium (Joshi et al. 2008).*

5. Economic Importance

Hedychium coronarium possesses broad spectrum of applications in different fields, from its various uses it has also important as a source of income. Commercially the aerial stems constitute a useful raw material for making paper. The dried stems contain 43 to 48% cellulose (Bhist *et al*., 2012). It is also highly valued as an ornamental garden plant due to its attractive foliage, showy inflorescence. Its rhizomes are consumes as vegetable by locality of Manipur. *Hedychium* flowers are widely cultivated for their perfume, essence and ethnomedicine (Gopanraj *et al.,* 2005). The native Hawaiians refer to this plant as 'awaphui' (native wild shampoo ginger) and use the juice of mature seed as a hair and skin treatment (Kunnumakkar *et al*., 2008).

6. Ethnomedicinal Uses in India and Other Countries

India is one of the richest ethno botanical traditional Country in the world with more than 7,000 species of plants found in different agro ecosystems used by various indigenous systems in medicine and industries (Joy *et al*., 1998). Zingiberaceae which is also commonly known as gingers family is a vital group of rhizomatous plants well-known for their medicinal and economic significances (Daimei and Kumar, 2014). It used as traditional herbal medicines throughout the world (Sirirugsa *et al.,* 1997). In different region its applications are vary and it is tremendous by different names.

Hedychium coronarium has high ethnomedicinal Significance in India and even local people consume and use its rhizomes as an integral part of cuisines, cultural practices and sacred rituals (Sarangthem *et al*., 2012). The flowers are used in the treatment of fever, arthritis and eye disease (Jain *et al*., 2003). In the Amarkantak region of Madhyapradesh the extract from flowers is known as "Gulbakawali Ark" which is world famous as an eye tonic and prevents "motiabind" (Cataract) (Nath *et al*., 2007).

In Bangladesh *Hedychium coronarium* is used in treatment of Jaundice. The leaf juice of this plant is mixed with leaf juice of *Coccinia grandis* and applied to head for 3 days (Hasan *et al*., 2015). It is commonly used for treating pains, wounds, infections, and rheumatism in Brazil.

Ethno medical uses of *Hedychium coronarium* different region of India are given in table no. 3

Table 6. *Ethanobotanical uses of hedychium coronarium in different region of India.*

Local name	Plant part	Used as	Region	References
Kichchiligadda, Vasa Vasanthi	Rhizome	Antidiabetic	Siddis of Uttara Kannada in the state of Karnataka	Bhandary*et al.,* 1995
Gulbakavali	Flower and rhizome	Flower extracts used to cure Conjunctivitis and rhizome used for rheumatism and swelling	Amarkantak region of Madhya Pradesh	Kumar *et al.,* 2004
Dolon champa	Rhizome	Bodyache	Ziro valley in Arunachal Pradesh	Kala C. P., 2005
Kulphul	Rhizome	Headache	Didayi tribe of Malkangiri district of Orissa	Pattanaik C *et al.,* 2008
Ban haldi	Rhizome	Used in snake bite and liver troubles	East nimar region of Madhya Pradesh	Ray S *et al.*, 2011
Lok-lei	Rhizome	Rhizome cooked and prepared eronba	Manipur state, northeast India	Jain, 1995
Kambui phuanmei, Longnang	Young inflorescence, shoots, rhizome, seeds	Analgesic, vegetables, hair tonic, ornamental	Tamenglong district, Manipur, Northeast India,	Daime Pand Kumar Y 2014
Takhellei angouba	Rhizome	Decoction of the rhizome prescribed orally against fever.	Andro village in imphal east district, Manipur.	Singh T *et al.*, 2014
Loklei	Rhizome	Vomiting	Valley districts of Manipur, Ningombam	Babyrose Devi *et al.*, 2014

7. Pharmacological Properties

Hedychium coronarium shows diverse biological activities (Suresh *et al*., 2010) such as anti-inflammatory (Matsuda *et al*., 1997), anti-tumor (Oh *et al.,* 2006), anti-allergic (Morikawa *et al*., 2002), analgesic (Srimal *et al.,* 1984), antihelmintic (Akhtar *et al*., 2000) and significant cytotoxic effects (Itokawa *et al*., 1988). It contains a rich source of sesquiterpenes, diterpenes with a wide range of biological and pharmacological activities (Demetzos *et al*., 2001). This plant possesses terpenoids viz. coronarin A, B, C, D, E & F (Verma and Bansal 2013). Coronarin A is used to inhibit the proliferation of human umbilical vein, shown to be cytotoxic in tumor cells (Aggarwal, 2004). Coronarin D a labdane diterpene isolated from*Hedychium coronarium* inhibits NF-kB activation induced by different inflammatory stimuli and carcinogenesis. It is also potentiated chemotherapeutic agent for induced apoptosis (Kunnumakkara *et al.,* 2008). Recently a cancer chemoprevention activity is also reported of Labdane diterpenes from rhizomes of *Hedychium coronarium* (Endringera, 2014). Previous reported Pharmacological activities of *Hedychium coronarium* are described below:

7.1. Antimicrobial

Hedychium coronarium shows broad spectrum of antimicrobial activity. Leaf, flower and rhizome extractsof different solvents possess antibacterial and antifungal activities. Methanolic extract of rhizome of *Hedychium coronarium* exhibited strong inhibition against *Staphylococcus enteric* and *Staphylococcus aureus* (MIC 0.05 mg/mL). Leaves and rhizome oil was examined against *Candida glabrata*, *Malassezia furfur*and *Candida albicans* results shows the strongest activity was observed against *Candida glabrata* followed by *Candida albicans* and *Malassezia furfur* (Ho, 2011). Pandya *et al.*, 2014 were determined antifungal activity of flower extract against three fungal strains viz. *Alternaria, Fusarium* and *Aspergillus flavus* the extract were found to be the most effective against *Alternaria*.

Antimicrobial activity of coronarin D from rhizome of *Hedychium coronarium* was performed by Chimnoi *et al*., 2014 against gram positive, gram negative bacteria and fungi, results showed that Coronarin D could inhibit gram-positive bacteria (*Staphylococcus aureus*, *Staphylococcus epidermidis*, *Enterococcus faecalis*, and *Bacillus cereus*) at concentrations ranging from 6.25 to 50 μg/mL, but showed no activity against gram-negative bacteria (*Escherichia coli*, *Pseudomonas aeruginosa*, and *Salmonella typhimurium*) with MIC values over 200 μg/mL. Coronarin D showed noticeable activity against *Bacillus cereus* at MIC value of 6.25 μg/mL, coronarinD also displayed moderate activity at MIC values of 12.5 μg/mL. The MBC values of coronarinD against the tested gram-positive bacteria ranged from 12.5 to 100 μg/mL.

7.2. Antioxidant

Phenolic compounds from plants possess great potential to scavenge free radicals and toxic ROS and referred as antioxidants. According to previous studies the extract of *Hedychium coronarium* showed potent free radical scavenging activity especially against DPPH radicals. DPPH scavenging activity and reducing power of the ethanolic extract of whole plant parts of *Hedychium coronarium* were analyzed, extract exhibited 0.0% and 12.76% at 10 µg/ml and 50 µg/ml (Lock *et al*., 2005). Methanolic extract of rhizome exhibited 90.1% reducing power (Chen *et al*., 2008) and methanolic leaf extract exhibited 81.4% antioxidant activities (Chan EWC *et al.,* 2008). The maximum free radical scavenging potential of methanolic and aqueous extracts of rhizome were 97.8%; 98.1%; 95.5% and 92.9% inhibition respectively (Ho, 2011).

The rhizome essential oil was also tested for their antioxidant potential by different methods, including their metal chelating properties, DPPH scavenging activity, and reducing power, results showed that oil possesses moderate chelating effect (58.11%), moderate scavenging effect against DPPH (43.49%) and the reducing power of essential oil was at absorbance A700=0.242-0.605, results showed concentration-dependent increase in antioxidant activities (Joshi *et al*., 2008).

7.3. Cytotoxicity

Till the present time several labdane diterpens have been isolated from *Hedychium coronarium* some of which showed potent cytotoxic activity. Labdane-type diterpenes isolated from *Hedychium coronarium* evaluated to *in vitro* cytotoxicity against some cancer cell lines by MTT assays. Isocoronarin D (C-14 epimers) was shown to be the most active against all cancer cell lines, with the IC50 was 4 µg/mL, except for S102 cell line 35 (Chinmoi *et al.,* 2009). Compounds isolated from hexane extract of *Hedychium coronarium* were investigated their cytotoxic activities against the A-549, SK-N-SH, MCF-7 and HeLa cancer cell lines by using sulforhodamine B (SRB) assay. Results showed the 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 andcoronarin D exhibited potent cytotoxic activity against A-549 cell line with the LC50 value ranging from 1.26 to 8.0µM. 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 (Suresh G *et al.*, 2010).

Diterpens isolated from ethanol extract showed potential cancer chemo preventive activity assayed by using a battery of *in vitro* tests (inhibition of NF-ķB, COX-1 and -2, ARE induction, and cell proliferation). isocoronarin D activated ARE (EC50 57.6) 2.4 µM), while methoxycoronarin D, ethoxycoronarin D and benzoyl eugenol significantly inhibited NF-ķB (IC50 of 7.3±0.3, 3.2±0.3 and 32.5±4.9 µM, respectively). In addition, methoxycoronarin D and ethoxycoronarin Dselectively inhibited COX-1 (IC50 values

of 0.9 ±0.0 and 3.8 ±0.0 μM, respectively) (*Endringer et al., 2014*).

Inhibitory activities of *Hedychium coronarium* diterpenes against human umbilical vein endothelial cells (HUMECs) proliferation and cytotoxic activities against cancer cell lines, diarylheptanoid exhibited promising inhibitory activities against HUMECs with the IC50 values of 6.4 to 3.3 mm (Zhan *et al*., 2012).

7.4. Anti-Inflammatory

Labdane diteropenes from *Hedychium coronarium* have been reported as an effective anti-inflammatory agent. These compounds were found as able to inhibit the inflammatory mediators including nitric oxide, inflammatory cytokines etc (Berg *et al*., 2002 and Gomez *et al*., 2005). Three isolated form of *Hedychium coronarium*, coronarin G, coronarin H and hedyforrestin C possesses inhibition activity of TNF-α, IL-6 and IL-12 in LPS-stimulated (Matsuda *et al*., 2002). The extract, fraction of *Hedychium coronarium* were studied by determination theinhibitory effects on the vascular permeability acetic acid-induced in mice and also nitric oxide (NO) production in mLPS-activated mouse peritoneal macrophages. Results showed, the methanolic extracts (IC50 45 μg/mL) and AcOEt-soluble fraction (IC50 13 μg/mL) possesses inhibition of NO production in LPS-stimulated mouse peritoneal macrophages. With the addition of hedychilactone A (IC50 18 μM), coronarins D (IC50 16 μM), coronarin D methyl ether (IC50 21 μM), labda-8(17),13(14)-dien-15,16-olide (IC50 15 μM) and hedychenone (IC50 7.9 μM) (Matsuda *et al*., 2002). From labdanediol a series of labdane derivatives were prepared and evaluated as anti-inflammatory agents on lipopolysaccharide (LPS)-treated RAW 264.7 macrophages. Significant results were found from all compounds, they were able to inhibit LPS-induced nitric oxide (NO) (Girón *et al*., 2010). Hedyforrestin C isolated from *Hedychium coronarium* potently inhibited IL-6 and IL-12 production LPS stimulated BMDCs (Kiem *et al*., 2011).

For the response of diverse stimuli, activated neutrophils secrete a series of cytotoxins, such as the superoxide anion radical (O2•−), which is a precursor to other reactive oxygen species (ROS), granule proteases, bioactive lipids, and neutrophil elastase, amajor contributor to destruction of tissue in chronic inflammatory disease (Borregaard N, 1998; Witko-Sarsat *et al*., 2000; Roos *et al.*, 2003). Compounds from the rhizomes of *Hedychium coronarium* were evaluated for the effects on neutrophil pro-inflammatory responses of by suppressing fMet-Leu-Phe/cytochalasin B (fMLP/CB)-induced superoxide anion (O2•−) generation and elastase release by human neutrophils. In results Labdane-Type Diterpenoids viz, 7β-Hydroxycalcaratarin A, calcaratarin A, coronarin A, and (*E*)-labda-8,12-diene-15,16-dial showed potent inhibition (IC50 ≤ 4.52 μg/mL) of superoxide anion generation by human neutrophils in response to fMLP/CB. Above mentioned 4 diterpenes and (*E*)-7β-hydroxy-6-oxo-labda-8(17),12-diene-15,16-dial, and ergosta-4,6,8(14),22-tetraen-3-oneexhibited potent inhibition (IC50 ≤ 6.17 μg/mL) against fMLP-induced elastase release (Chen *et al*., 2013).

7.5. Analgesic

Different extracts of *Hedychium coronarium* were examined for analgesic activity in animal model using acetic acid induced writhing inhibition method and Radiant heat tail-flick method. The chloroform and methanol extracts effectively showed analgesic activity at doses of 400 mg/kg body weight elicited 27.23 and 40.59% inhibition of writhing reflex respectively. Both the chloroform and methanol extracts showed significant elongation of tail flick time (41.15 and 61.32% elongation respectively) at 400 mg/kg body weight. In carrageen an induced rat paw edema test, the chloroform and methanol extracts at a dose of 400 mg/kg body weight showed statistically significant ($P<0.01$) inhibition of paw edema by 27.46 and 32.48%, respectively at the third hour after carrageenan injection (Shrotriya and Bachar, 2007).

The methanolic extract of *Hedychium coronarium* significantly showed analgesic effect. At the dose of 100, 100 and 400mg/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) (Dash *et al*., 2011).

7.6. Larvicidal

Essential oils from leaf and rhizome of *Hedychium coronarium* have been observed to have effective mosquito larvicidal activity. Mosquito larvicidal activity against *Aedes aegypti* (L.) was reported by the essential oils from leaf and rhizome of *Hedychium coronarium*. The leaves oil showed larvicidal activity during 2 h and 24 h, the LC50 values were 111 and 90 ppm respectively while the rhizome oil showed larvicidal activity during 2 h and 24 h, the LC50 values were 86 and 47 ppm (Ho *et al*., 2011). The rhizome oil of was reported to effective larvicidal and pupicidal activities. Rhizome oil was evaluated for larvicidal activity against fourth instar larvae of *A. aegypti* and *C. Quinquefasciatus* results shows that *Hedychium coronarium* essential oils had activity against *C. quinquefasciatus* larvae with LT50 of 1.7 minutes and 100% mortality at 10 minutes, 5 minutes and 15 minutes, respectively and 100% mortality at 60 minutes was found for *Ae. aegypti* (Phukerd and Phukerd, 2013).

7.7. Antiurolithiatic

Roots of *Hedychium coronarium* are found to be effective in the treatment of kidney stones. Alcoholic extracts and aqueous extracts of roots of *Hedychium coronarium* were evaluated for antiurolithiactic by an *invitro* model using calcium oxalate stones. Formulation cystone was used as a reference standard. In results alcoholic extracts obtained from roots part shows highest dissolution of Calcium oxalate

(Kidney Stones) when compared to test extracts at 10 mg concentration. Reference standard formulation Cystone was found to be equally effective (39.12%) when compared to alcoholic extract of roots part (Bahuguna and Neeraj Kumar, 2014). Rhizome extract of *Hedychium coronarium* was also reported for antiurolithiactic activity, ethanolic rhizomes extract showed highest dissolution of stones when compare to standard drug cystone (Tailor and Goyal, 2015).

8. *In Vitro* Culture and Recent Researches on *Hedychium Coronarium*

According to report of Conservation Assessment and Management Plan (CAMP) workshop in 1998, (Prasad and Patnaik, 1998) and Threat Assessment of Medicinal Plant workshop (TAMP) in 2003 at the Indian Institute of Forest Management, Bhopal (M. P) (Ved *et al.,* 2003), *Hedychium coronarium* has reported as a critically endangered species of central India. Due to commercial demand and over harvesting this plant is becoming endangered in its natural habitats. So keeping in view the medicinal properties and rate of disappearance of this plant in central region of India a conservation and mass multiplication is the need of the hour.

For the conservation of *Hedychium coronarium* different protocols have been developed by different previous researchers they used different explants and different combination and concentration of growth regulators and developed successful protocol for conservation of this plant. Bisht *et al.,* (2012) used seedling explants for regeneration of *Hedychium coronarium* by using cytokinin: BAP and Auxin: NAA in different combinations. Verma and Bansal (2012) induced direct regeneration of this plant by using rhizome bud as explants with the growth regulators: 2,4-D (0.5 mg/L), BAP (0.5mg/L) and KN. Parida *et al.*, (2013) developed protocol for large-scale multiplication of *Hedychium coronarium* through Axillary bud proliferation with BAP (3mg/L), KN (3mg/L), TDZ (0.2 mg/L) and IAA (0.5 mg/L). Mohanty (2013) used rhizome bud for regeneration of *Hedychium coronarium* by using BA (2.0 mg/ L) and NAA (0.5 mg /L).

For the last two decades, extensive work has been done to develop new drugs from natural products because of the resistance of microorganisms to the existing drugs. The secondary metabolites present in plants may be responsible for the reduction of silver ions in solution and synthesis of nanoparticles (Ahmad *et al*., 2011). At present days nanoparticles had a broad area of applications such as biological, physical and pharmaceutical. So, keeping in the view of broad applications of nanoparticles the development of rapid and eco-friendly processes for the synthesis of nanoparticles is of great importance in the area of nanotechnology. According to Sinjumol *et al*., (2014) toxicity studies on pathogens open a door for nanotechnology applications in medicine. Sinjumol *et al.,* (2014) successfully synthesized AgNPs using rhizome extract of *Hedychium coronarium* and further tested this AgNPs against different bacteria, results showed good antibacterial properties of AgNPs synthesized from *Hedychium coronarium,* and confirms that this plant is eco friendly, economic and effective alternative for the large scale synthesis of silver nanoparticles in medicinal applications.

9. Conclusion

Studies on pharmacognostical, phytochemical and ethnomedicinal of Hedychium *coronarium* by various researches reveals that it is a valuable potent medicinal herb. In central India *H. coronarium* is endemic in nature and have endangered status due to over exploitation as crude drug for eye drop preparation, hence requires urgent conservation. A little information is available on its natural regeneration and subsequent conservation as per records. The use of this potent plant as established drug requires further medico-clinical research.

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