ISSN:2229-712X

Available online at www.elixirjournal.org

Applied Botany

Elixir Appl. Botany 52 (2012) 11627-11634

Medicinal properties and uses of orchids: a concise review

Siddhartha Singh[1,*], Amit Kumar Singh[1], Sunil Kumar[2], Mukul Kumar[3], Pramod Kumar Pandey[1] and Mayanglambam Chandra Kumar Singh[1]

[1]Department of Basic Science and Humanities, College of Horticulture and Forestry, Central Agricultural University, Pasighat-791102, Arunachal Pradesh, India.

[2]Department of Floriculture, College of Horticulture and Forestry, Central Agricultural University, Pasighat-791102, Arunachal Pradesh, India.

[3]Department of Tree Improvement, Genetics and Plant Breeding, College of Horticulture and Forestry, Central Agricultural University, Pasighat-791102, Arunachal Pradesh, India.

ARTICLE INFO

Article history:
Received: 28 July 2012;
Received in revised form:
19 November 2012;
Accepted: 21 November 2012;

Keywords
Orchids,
Secondary
Metabolites,
Phytochemicals,
Medicinal property.

ABSTRACT

From the primitive period medicinal plants have occupied a distinct place in human's life. They have been the backbone of traditional herbal medicines and have been extensively studied because of their pharmacological importance. Orchids are one of the largest groups of Angiosperms belonging to the family Orchidaceae. A number of constituents obtained from different parts of orchid suggest biological activity. Alkaloids are nitrogenous organic heterocyclic molecules that have pharmacological effects on humans and other animals..In orchids, 214 species in 64 genera contain 0.1% or more alkaloids. Besides alkaloids, they also possess flavanoids, phenanthrenes, terpenoids, bibenzyl derivatives and other biologically active compounds. The present review deals with the phytochemicals present in orchids and their medicinal properties.

Introduction

Orchids are one of the largest and most diverse groups of angiosperms consisting of nearly 25,000 species with more than 850 genera [1, 2]. They are generally cultivated for beautiful flowers and are widely known for their economic importance and very less for their medicinal use. Chinese were the first to present documentary evidence for medicinal uses of orchids. The earliest report for the medicinal use of orchids is from 28th century B.C. when Shen-nung described *Bletilla striata* and a *Dendrobium* species in his *Materia Medica*. The literal meaning of the term orchid (*órkhis*), in Greek is testicles and it was Theophrastus who first coined the term as the anatomy of plant resembles testicles [1]. The Greek myth of Orchis explains the origin of the plants. Orchis, the son of a nymph and a satyr, came upon a festival of Dionysios (Bacchus) in the forest. He drank too much, and attempted to rape a priestess of Dionysios. For his insult, he was torn apart by the Bacchanalians. His father prayed for him to be restored, but the gods instead changed him into a flower. These flowers were previously called *Orchis*, *Satyrion* (*Satyrion feminina*), or "ballockwort". Orchids have been widely used in traditional Chinese medicine and some them have been subjected for phytochemical and pharmacological studies. India is one of the richest habitats of orchid. India comprise of about 2500 species in 167 genera. In India, some orchids like *Eulophia campestris, Orchis latifolia, Vanda roxburgii* have drawn the attention of scientific community because of their medicinal properties [3, 4]. Medicinal orchids mainly belong to genera: *Calanthe, Coelogyne, Cymbidium, Cypipedium, Dendrobium, Ephemerantha, Eria, Galeola, Gastrodia, Gymnadenia, Habenaria, Ludisia, Luisia, Nevilia* and *Thunia* [2, 5]. Certain constituent of orchids such as alkaloids, flavonoids etc. suggest medicinal properties. The present review deals with the phytochemistry and medicinal uses of orchids.

Phytochemicals & Medicinal Properties of Orchids:

A number of phytochemicals such as alkaloids, bibenzyl derivatives, flavonoids, phenanthrenes etc. has been reported from orchids. Presence of these phytochemicals provides antimicrobial, antitumor, anti-inflammatory, antiviral activities, etc. (Table 1 & 2). Various other phytochemicals has been reported from orchid species. 2, 6-Dimethoxy-1, 4-benzoquinone which is reported to have allergic reaction has been isolated from *Cymbidium* sp. [6]. Heptacosane ($C_{27}H_{56}$) and octacosanol ($C_{28}H_{58}O$) which has been found to show marked anti-inflammatory activity in carrageenan induced oedema in rats and mice [7] is reported from *Vanda roxburghii* [8].Calanthoside which showed an activating effect on skin blood flow has been isolated from *Calanthe discolor* and *Calanthe liukiuensis* [9]. Habenariol has been isolated from *Habenaria repens* which inhibits the lipid peroxidation of human low density lipoprotein [10]. Scopoletin and scoparone which exhibit *invitro* ant-platelet aggregation activity has been isolated from *Dendrobium densiflorum* [11]. Gastrol which is reported to have relaxant effects on smooth muscle preparations of guinea pig ileum has been isolated from the rhizomes of *Gastrodia elata* [12]. Nidemin and 9,19-Cyclolanosta-24,24-dimethyl-25-en-3β-yl-trans-p-hydroxycinnamate has been isolated from *Scaphyglottis livida* and *Nidema boothi* [13]. Agrostophyllinol and agrostophyllinone has been isolated from *Agrostoohyllum brevipes* [14]. Alkyl ferulates with

Tele: +91-9402477043
E-mail addresses: siddharthasingh786@gmail.com

antiooxidatve properties has been isolated from methanolic extract of *Dendrobium monoliforme* [15]. Various other antioxidants such as cis & trans-Melilotoside, dihydromelilotoside has been isolated from *Dendrobium sp.* [16]. Cirrhopetalanthrin which has shown cytotoxicity against human colon cancer (HCT-8), human hepatoma (Bel7402), human stomach cancer (BGC-823) human lung adenocarcinoma (A549), human breast cancer (MCF-7) and human ovarian cancer (A2780) cell lines is isolated from *Cremastra appendiculata* [17]. Compounds with anti tumor activities have also been isolated from *Bulbophyllum kwangtungense* [18].CymbidineA with hypotensive and diuretic activities from *Cymbidium goeringii* [19] and Cyclobalanone and 5α-lanosta-24,24-dimethyl-9(11),25-dien-3β-ol which produces dose dependent antinociceptive and anti inflammatory effect from *Scaphyglottislivida* has also been isolated [20].Kinsenoside with significant antihepatotoxic activity has been isolated from *Anoectochilus formosanus* [21].

Antimicrobial Activity:

A number of members of orchid family are used as potent inhibitor against gram positive and gram negative bacteria and also proved to be a potent antimicrobial agent. Gastrodianin, a protein isolated from orchid *Gastrodia elata* have shown *invitro* activity against plant pathogenic fungi [2]. Gastrodianin is homologus to mannose binding proteins of other orchids some of which also displayed *invitro* antifungal activity [22]. The methanolic extract from different parts of orchids has shown antimicrobial activity. The methanolic extract derived from the leaves of *Spiranthus mauritianum* have shown inhibitory effect against gram positive bacteria and also showed anti-inflammatory activity [23]. The methylene chloride extract from the leaves and stem bark of *Galeola foliate* have shown a broad spectrum antibacterial activity against gram positive and gram negative bacteria, however the extract was found to be inactive against moulds [24]. Vanillin, the major flavoring component of vanilla is a membrane active compound which results in dissipation of ion gradients and the inhibition of respiration [25]. Vanillin has shown antimicrobial activity against *Escherichia coli, Lactobacillus plantarum* and *Listeria innocua* [25]. Antimicrobial activity of vanillin and vanillic isolated from *Vanilla planifolia* have been studied against several strains of *Listeria monocytogenes, Listeria innocua,Listeria grayi* and *Listeria seeligeri* and it was found that mixture of vanillin and vanillic acid exhibited additive inhibitory effects particularly at low pH [26]. The herb extract from *Bletilla striata* have shown to possess antioxidant and antimicrobial capacity [27]. The ethanolic extract of seedlings of *Cypripedium macranthos* var. rebunense was found to contain antifungal compounds lusianthrin and chrysin. Lusianthrin maintains the perilous symbiotic association for germination was found to be more potent antifungal compound than chrysin which helps to protect adult plants [28]. The methanolic extract from the leaves of *Acanthephippium bicolor* Lindley was found to have antimicrobial activity against *Staphylococcus aureus, Streptococcus foecalis, Bacillus cereus, Proteus vulgaris, Proteus mirabilis, Pseudomonas aeruginosa, Klebsiella pneumonia, Shigella dysenteriae, Escherichia coli, Microsporum audouinii, Microsporum fulvum, Candida albicans* and *Trichophyton rubrum* [29]. The gram positive bacteria are found to be more sensitive than gram negative bacteria and fungi [29].

Anti-inflammatory Activity:

Several members of orchid family were found to have anti-inflammatory activity. Marked anti-inflammatory activity in carrageenan induced oedema in rats and mice is shown by *Vanda roxburghii.* The anti anrthritic activity was found to be superior to that of phenyl butazone [30]. Heptacosane and octacosanol isolated from *Vanda roxburghii* root was found to have anti-inflammatory activity [31]. The anti-inflammatory activity is due to long chain alkanes and alkanols (ranging C-27 to C-32) which are ubiquitous in plants [31]. The ethanolic extract from the leaves of *Anoectochilus formosanus* have showed delayed onset of anti-inflammatory activity starting from 4 hours post carrageenan administration. *Anoectochilus formosanus* have also produced histological changes. Improvement in inflammatory infiltration of lymphocytes and kupffer cells around the central vein was achieved by the use of this orchid [32]. Several compounds with anti-inflammatory activity were isolated from *Dendrobium monoliforme* [33, 34]. 7-hydroxy-5,6-dimethoxy-1,4-phenanthrenequinone isolated from *Dendrobium moniliforme* have shown inhibitory effect on VHR dual specificity protein tyrosine phosphatase activity [34], whereas Dendroside A, C and vanilloside from the same source have shown stimulatory effect on proliferation of B cells and inhibitory effect on proliferation of T cells [35].

Gastrodia elata has also been a good source of compounds with anti-inflammatory, analgesic and anti-angiogenic activity [36, 37]. Many phenolic compounds such as 4-hydroxybenzaldehyde, 4-hydroxybenzyl alcohol, benzyl alcohol, bis-(4-hydroxyphenyl) methane, 4(4'-hydroxybenzyloxy) benzyl methyl ether, 4-hydroxy-3-methoxybenzyl alcohol, 4-hydroxy-3-methoxybenzaldehyde and 4-hydroxy-3-methoxybenzoic acid with anti-inflammatory as well as analgesic activity has been isolated from *Gastrodia elata* [2]. The ethanolic extract from the rhizomes of *Gastrodia elata* have shown inhibition of angiogenesis in chick chorioallantoic membrane assay, inhibition of acetic acid induced vascular permeability and also exhibited reduction in exudates production, nitric oxide level and leukocyte migration in rat air pouch model [37]. In addition, it inhibits production of nitric oxide and expression of cyclooxygenase-2 and nitric oxide synthase when stimulated by lipopolysaccharide in RAW264.7. Another member of family orchidaceae, *Pholidota chinensis* contains a number of triterpenes, cyclopholidonol and cyclophlidones. The ethyl acetate extract from the pseudobulb of *Pholidota chinensis* have strong inhibitory effect on nitric oxide production in murine macrophage like cell line in RAW264.7 [38].

Antitumor Activity:

Several species of orchids have been studied and a number of compounds with antitumorous activity have been isolated. *Dendrobium nobile* has been a good source of compounds with anti-tumor activity. Denbinobin and 4,7-Dihydroxy-2-methoxy-9,10-dihydrophenanthrene from *Dendrobium nobile* showed cytotoxicity against human lung carcinoma, human ovary adenocarcinoma and humanpromyelocytic leukemia cell lines [39].Dendroside A and dendronobiloside A obtained from the stem of *Dendrobium nobile* showed stimulatory effect on proliferation of murine T and B lymphocytes [40]. Erianin obtained from the stem of *Dendrobium chrysanthum* was found to be a potent inhibitor of proliferation of HL-60 cells and the inhibition might be due to erianin induced apoptosis and altered expression of bcl-2 and bax genes in HL-60 cells [41]. In another study erianin leads to extensive tumor necrosis, growth delay and rapid vascular shutdown in hepatoma Bel7402 and

melanoma A375 [42]. Dendrochrysanene isolated from stems of *Dendrobium chrysanthum* was found to suppress the mRNA level of TNF-alpha, IL8, IL10 and iNOS in murine peritoneal macrophages [43]. Fimbriatone isolated from *Dendrobium fimbriatum* was found to be potent inhibitor of BGC cell line [44]. A number of compounds such as7,8-dihydro-4-hydroxy-12,13-methylenedioxy-11methoxyldibenz[bf]oxepin,7,8dihydro-4-hydroxy-12,13 methylenedioxy11methoxyldibenz[bf]oxepin,7,8-Dihydro5 hydroxy-12,13-methylenedioxy-11-methoxyldibenz[bf]oxepin, cumulating, densiflorol A and plicatol B isolated from *Bulbophyllum kwangtungense* have shown anti tumor activities against Hela and K562 human tumor cell lines [18]. The methanolic extract obtained from *Anoectochilus formosanus* have shown to induce apoptosis of MCF-7 cells [45]. However, the water extract from the same source was found to have potent tumor inhibitor which might is due to its potent immunostimulating effect [46]. It has shown inhibitory effect in BALB/c mice after subcutaneous transplantation of CT-26 murine colon cancer cells by stimulating proliferation of lymphoid tissues and activating the phagocytosis of peritoneal macrophages against *Staphylococcus aureus* [46]. The tuber of *Cremastra appendiculata* yield cirrohopetalanthrin and 2,7,2',7',2''-pentahydroxy-4,4'4''7''-tetramethoxy-1,8,1',1''-triphenanthrene which were found to have moderate cytotoxicity against human colon cancer, human stomach cancer, human hepatoma, human breast cancer, human lung adenocarcinoma and human ovarian cancer cell lines [17,47]. The homoisoflavanone5,7-dihydroxy-3-(3-hydroxy-4 methoxybenzyl)-6-methoxychroman isolated from *Cremastra appendiculata* was found to be a potent inhibitor of angiogenesis [17]. Lonchophylloids A and Lonchophylloids B obtained from the stems of *Ephemerantha lonchophylla* were found to sensitize those cells which have expressed the multidrug resistance phenotype to the toxicity of the anticancer drug doxorubicin [48]. Denbinobin isolated from the same source displayed anticancerous effects in K562 cells by increasing polymerization of tubulin and degranulation of Bcr-Abl signaling [49]. Methanolic extract of *Gastrodia elata* prevents serum deprived apoptosis through activation of serine/threonine kinase-dependent pathway and suppression of JNK activity [50], whereas the ethanolic extract from the rhizomes have shown potent anti tumor activity *invitro* in a dose dependent manner [51]. (2S)-5, 2',6'-trihydroxy-6-lavandulyl-4''-(γ,γ-dimethylallyl)-2'',2''-dimethylpyrano-[5'',6'',7,8]-flavanone, a dihydroflavanoid isolated from *Spiranthes australis* (R. Brown) Lindl inhibits human cancer cells growth including A498, A549, BEL-7402,SGC-7901,MCF-7, HT-29 and K562 cell lines [52]. A phenanthrene derivative 3,7-dihydroxy-2,4,6-trimethoxyphenanthrene from *Bulbophyllum odoratissimum* was found to have cytotoxicity against the human cancer cell lines such as human leukemia cell lines K562 and HL-60, human hepatoma BEL-7402, human lung adenocarcinoma A549 and human stomach cancer cell lines SGC-7901[53].

Antioxidative Property:

Several compounds from orchid family were found to have strong antioxidative property. Ephemeranthone,a dihydrostilbene obtained from the leaf ethanolic extract of *Ephemerantha lonchophylla* was found to have strong antioxidative property for *invitro* inhibition of human low density lipoprotein[54]. Another dihydrostilbene isoamoenylin obtained from the roots of *Dendrobium amoenum* var. denneanum showed moderate antioxidative property [55]. Cis-melilotoside,dihydromelilotoside and trans-melilotoside obtained from stems of *Dendrobium aurantiacum* were found to be potent antioxidants [16]. Antioxidative compounds like alkyl ferulates and quercetin were also isolated from *Dendrobium monoliforme* and *Dendrobium tosaense* [15]. The ethanolic extract of *Dendrobium nobile* was found to exhibit antioxidative property equivalent or higher to ascorbic acid [56].Kinsenone from *Anoectochilus formosanus* was reported to have antioxidative property [57].The aqueous leaf extract from *Anoectochilus formosanus* shows inhibitory effect on proteolytic cleavage of poly(ADP-ribose) polymerase during apoptosis [58]. Several phenolic compounds such as kaempferol-3-*O*-β-D-glucopyranoside (59), kaempferol-7β-D -glucopyranoside (60), isorhamnetin-3-β-D-rutinoside (61), 8-hydroxybenzylquercetin (62), 5- hydroxy-3',4',7-trimethoxyflavonol-3-β-D-rutinoside (63), and, and quercetin-7-*O*-β-D-[6''-*O*-(*trans*-feruloyl)]-glucopyranoside were isolated from *Anoectochilus roxburghii* (Wall.) Lindl that possess scavenging activity of DPPH radicals (64). Hydroxybenzyl alcohol, hydroxybenzaldehyde, vanillin and vanillyl alcohol obtained from leaf methanolic extract of *Gastrodia elata* were reported to possess antioxidative property [65]. Several phenanthrenes isolated from 60% ethanolic extract of air dried plant of *Pholidota yunnanensis* were found to show the DPPH free radical scavenging activity [66].

Other Medicinal Properties:

Ethyl ether obtained from tuber of *Bletilla striata* exhibit *invitro* antihelminthic property against cercaria,excysted metacercaria and adult of *Clonorchis sinensis*[67].Methanolic extract obtained from the rhizomes of *Dendrobium monoliforme* exhibit antipyretic action in rabbits [68]. Fresh stem of *Dendrobium loddigesii* contains shihunidine and shihunine, which possess inhibitory effect on Na^+-K^+ ATPase of rat kidney [69]. Stem of *Dendrobium nobile* contains sesquiterpene glycosides with alooaromadendrane,emmotin and picrotoxane type aglycones which possess immunomodulatory activity[70]. A bibenzyl, moscatilin, obtained from *Dendrobium nobile* possess antimutagenic activity on various mutagens such as UV rays, furylfuramide,4-nitroquinoline-1-oxide, benzo[a]pyrene, aflatoxinB(1) [71]. Methanolic extract from *Calanthe discolour* LINDL. and *Calanthe liukiuensis* SCHLTR contains S,O-bisdesmoside,calanthoside, glucoindican, calalikiuenoside, calaphenanthrenol, tryptanthrin, indirubin, isatin and indicant which exhibits hair restoring and skin blood flow promoting activities [72]. Ethanolic extract from *Vanda roxburghii* possess wound healing property [73]. *Acanthephippium bicolor* Lindley was reported to be one of the best herbal medicine for Urinary Tract Infection and leaves can be used as herbal and scientific medicine throughout the year as there is no seasonal impact [29]. Moscatilin, moscatin and moscatilin diacetate obtained from stem of *Dendrobium loddigesi* exhibits marked antiplatelet aggregation activity [74]. Moscatilin, homoeridictyol ,scoparone, scopoletin and gigantol obtained from the stem of *Dendrobium densiflorum* Lindl. ex Wall were found to possess *in vitro* anti platelet aggregation activity. Out of these scoparone have potent antiplatelet aggregation activity [11]. The methanolic extracts from rhizomes of *Gastrodia elata* also possess a polysachharide with anti platelet aggregation and antithrombosis activity [75]. The aqueous extract from the rhizomes of *Anoectochilus formosanus* possess antihyperglycemic and antioxidant property. The extract reduces fasting blood glucose, fructosamine, triglycerides and total cholesterol in diabetic rats [76].

Table 1. Secondary Metabolites isolated from Orchid

S.No.	Secondary Metabolite	Compound(s)	Source	Activities	Reference(s)
1.	Alkaloid	Dendrobine	*Dendrobium moniliforme*	Antipyretic action	68
2.	Flavonoid	kaempferol-3-*O*-β-D-[glucopyranoside; Kaempferol-7β-D-[glucopyranoside; Isorhamnetin-3-β-D-[rutinoside]; 8-C-p-hydroxybenzylquercetin; Quercetin-7-*O*-β-D-[6"-*O*-(*trans*feruloyl)]-glucopyranoside; 5-Hydroxy-3',4',7-trimethoxyflavonol-3-β-D-[rutinoside]; Isorhamnetin-3-*O* β-D-[glucopyranoside; Isorhamnetin-7-*O*-β-D-[glucopyranoside	*Anoectochilus roxburghii*	Antioxidative activity	59- 64
3.	Alkaloid	Dendrobine	*Dendrobium nobile*	Reduces the β-alanine and taurine induced depolarizations of primary afferent terminals and have little effect upon GABA- and glycine induced depolarizations.	82
4.	Alkaloid	Shihunidine, Shihunine	*Dendrobium loddigesii*	Inhibits Na^+-K^+ ATPase activity of rat kidney	69
5.	Bibenzyl derivative	Moscatilin, Moscatilin diacetato	*Dendrobium loddigesii*	Inhibition of rabbit Platelets aggregation induced by arachidonic acid and collagen. Moscatilin suppresses mutagenicity and Moscatilin diacetato acts as anticancer agent.	71,74,83
6.	Terpenoid	Lonchophylloid A & Lonchophylloid B	*Ephemerantha lonchophylla*	Sensitization of cells that express multi drug resistance phenotype to the toxicity of anticancer drug doxorubicin	48
7.	Bibenzyl derivative	3-Methylgigantol	*Ephemerantha lonchophylla*	Anti-aggregation activity	84
8.	Flavonoid	Homoeriodictyol	*Dendrobium densifiorum*	Anti platelet aggregation activity	11
9.	Terpenoid	Dendroside A; Dendroside D; Dendroside E; Dendroside F; Dendroside G & Dendronobiloside A	*Dendrobium nobile*	Proliferation of murine T and B lymphocytes; Immunomodulatory activity	40, 70
10.	Bibenzyl derivative	Isoamoenylin	*Dendrobium amoneum*	Antioxidative & antibacterial activity	55
11.	Terpenoid	Dendromoniliside A; Dendromoniliside B & Dendromoniliside C	*Dendrobium moniliforme*	Stimulation of proliferation of B cells and inhibition of proliferation of T cells	35
12.	Bibenzyl derivative	Alkyl ferulates	*Dendrobium moniliforme*	Antioxidative activity	15
13.	Bibenzyl derivative	Erianin	*Dendrobium chrysotoxum*	Antiangiogenic activity	42
14.	Bibenzyl derivative	Aloifol	*Nidema boothi*	Spasmolytic acivity	85
21.	Bibenzyl derivative	Cumulatin & Densiflorol A	*Bulbophyllum kwangtungense*	Anti tumor activity	18
22.	Bibenzyl derivative	Gigantol	*Cymbidium goeringii, Scaphyglottis livida*	Inhibits the LPS-induced iNOS and COX-2 expression	20,78
23.	Bibenzyl derivative	Nobilin D, Nobilin E	*Dendrobium nobile*	Antioxidative activity	56
24.	Flavonoid	Chrysin	*Cypripedium macranthos*	Antifungal activity	28
25.	Flavonoid	(2S)-5,2',6'-trihydroxy-6-lavandulyl-4"-(γ, γ -dimethylallyl)-2",2"-dimethylpyrano-[5",6": 7,8]-flavanone	*Spiranthes australis*	Antitumor activity	52
26.	Alkaloid	N^6-(4-hydroxybenzyl) adenine riboside	*Gastrodia elata*	Prevents PC12 cell apoptosis induced by serum deprivation through suppression of JNK pathway	89

Table: 2 Phenanthrenes isolated from Orchids

S. NO.	Source	Compound(s)	Activities	Reference(s)
1.	*Spiranthes sinensis* var amoena	Spiranthesol,Spiranthoquinone, Spiranthol C, Spirasineol B, Sinensol A, Sinensol B, Sinensol C, Sinensol D, Sinensol E, Sinensol F,		90
2.	*Coelogyne ochracea*	Ochrone A		91
3.	*Dendrobium loddigessi*	Moscatin	Inhibition of rabbit Platelets aggregation induced by arachidonic acid and collagen; Anticancerous	74,83
4.	*Dendrobium nobile*	4,7-Dihydroxy-2-methoxy-9,10-dihydrophenanthrene; Denbinobin	Antitumor activity	39
5.	*Agrostophyllum brevipes & Coelogyne flaccida*	Callosinin		92
6.	*Ephemerantha lonchophylla*	Ephemeranthone; Erianthridin	Antioxidative activity; Anti aggregation activity	54,84
7.	*Maxillaria densa*	2,5-Dihydroxy-3, 4-Dimethoxyphenanthrene; 9,10-Dihydro-2,5-dihydroxy-3, 4-Dimethoxyphenanthrene; Nudol; Gymnopusin; Erianthridin; Fimbriol A	spasmolytic activity; inhibition of the tone and amplitude of the spontaneous contractions of the rat ileum; anti-inflammatory activity	20,93-94
8.	*Coelogyne cristata*	Coeloginanthridin, Coeloginanthrin	Activities of phytoalexins and endogenous plant growth regulators	95
9.	*Dendrobium moniliforme*	Moniliformin; 2,6-Dimethoxy-1,4,5,8-Phenanthradiquinone; 7-Hydroxy-5,6-dimethoxy-1,4-phenanthrenequinone	Antiinflammatory activity; Inhibition of VHR dual-specificity protein tyrosine phosphatase (DSPTPase) activity	33-34
10.	*Agrostophyllum callosum*	Callosuminin; Agrostophyllin; Callosumin		14
11.	*Agrostophyllum brevipes*	Imbricatin; Flaccidin		14
12.	*Nidema boothii*	Lusianthridin	Spasmolytic effect	85
13.	*Gymnadenia conopsea*	Gymconopin A; Gymconopin B; Gymconopin D; Dihydroxy-2,6-bis(4-hydroxybenzyl)-5-methoxybibenzyl	Inhibition of antigen-induced degranulation	86
14.	*Epidendrum rigidum*	2,3-Dimethoxy-9,10-dihydrophenathrene-4,7-diol; 3,4,9-Trimethoxyphenanthrene-2,5-diol	Inhibited radicle growth of *Amaranthus hypochondriacus*	88
15.	*Bletilla formosana*	4-Methoxy-9,10-dihydrophenanthrene-1,2,7-triol; 1-(4-Hydroxybenzyl)-4,7-dimethoxy-9,10-dihydrophenanthrene-2-ol; 1,3,6-tri(4-Hydroxybenzyl)-4-methoxydihydrophenanthrene-2,7-diol		96
16.	*Bletilla striata*	3,3'-Dihydroxy-2',6'-bis(p-hydroxybenzyl)-5-methoxybibenzyl; 3',5-Dihydroxy-2-(p-hydroxybenzyl)-3-Methoxybibenzyl; 1-(p-Hydroxybenzyl)-4,8-dimethoxyphenanthrene-2,7-diol; 2,7-Dihydroxy-1,3-bis(p-hydroxybenzyl)-4-methoxy-9,10-dihydrophenanthrene; Blestriarene B; Blestriarene C; Blestrianol A	inhibitory effect of tubulin polymerization	97
17.	*Cremastra appendiculata*	Cirrhopetalanthin; 2,7,2',7',2'-Pentahydroxy-4,4',4",7"-tetramethoxy-1,8,1',1"-triphenanthrene	Cytotoxic activity	47
18.	*Bulbophyllum kwangtungense*	Plicatol B	Anti tumor activity	18
19.	*Dendrobium chrysotoxum*	Dendrochrysanene	Anti inflammatory activity	43
20.	*Cypripedium macranthos*	Lusianthrin	Anti fungal activity	28
21.	*Pholidota yunnanensis*	2,4,7-Trihydroxy-9,10-Dihydrophenanthrene; 3,7-dihydroxy-2,4,8-Trimethoxyphenanthrene; Coelonin; 3,7-Dihydroxy-2,4-dimethoxyphenanthrene	DPPH free radical scavenging activity	66
22.	*Bulbophyllum Odoratissimum*	3,7- Dihydroxy- 2,4,6-trimethoxyphenanthrene	cytotoxicity activity	53

Dendrobium candidum showed antihyperglycemic effect and stimulates secretion of insulin from beta cells and also inhibits secretion of glucagon from cells [77]. Cymbidine A, a monomeric peptidoglycan isolated from *Cymbidium goeringii* ahve shown hypotensive and diuretic activity [19]. Gigantol isolated from the same source have shown potent inhibitory effect on LPS-induced nitric oxide and production of prostaglandin E in RAW 264.7 cells [78]. Kinsenoside obtained from *Anoectochilus formosanus* shows antihepatotoxic activity [21]. It was also found that the aqueous extract of *Anoectochilus formosanus* can lead to reduction of liver fibrinogenesis in rats induced by CCl_4 [79].

Alzheimer's disease is associated with neuronal cell death including hippocampus and is the most common reason of dementia in elderly persons. The ethyl ether extract from the leaves of *Gastrodia elata* Blume possess neuroprotective effect on amyloid beta-peptide induced neuronal cell death in IMR-32 neuroblastoma cells [80]. p-hydroxybenzyl alcohol obtained from the leaves of *Gastrodia elata* provides neuroprotection by preventing brain damage through increased expression of genes encoding antioxidant proteins after transient focal ischemia and may act as a potent neuroprotector at brain's cellular and molecular level [81].

Conclusion:

Orchids are generally known for its beautiful flowers and very less known for its medicinal uses. However, a number of compounds have been isolated from the different parts of the plant which possess medicinal properties. Compounds with antimicrobial, antitumor, anti-inflammatory, antioxidative, antidiabetic, neuroprotective, antiallergic properties have been

isolated and tested on animal models but clinical trials with orchid plant parts have not been a regular practice. Emphasis on the clinical trials will provide a new gateway for treatment of diseases with herbal medicines. The orchid components still requires proper study with full experimental trials which will lead to its acceptance as medical recommendations.

References:

1. Stewart, J & M.,Griffith (1995). Manual of Orchids.Timber Press Portland, Oregon.
2. Gutierrez, R M P (2010). Orchids: A review of uses in traditional medicine, its phytochemistry and pharmacology. Journal of Medicinal Plant Research 4(8):592-638.
3. Stuart, G A (1984). Chinese Materia Medica Taipei, Southern Materials Centre. A translation of an ancient Chinese herbal.
4. Singh, A & Duggal, S (2009). Medicinal Orchids: An Overview. Ethnobotanical Leaflets 13: 351-363.
5. Szlachetko D (2001). Genera et species *Orchidalium.* 1. Polish Bot. J. 46: 11-26.
6. Hausen BM, Shoji A, Jarchow O (1984). Orchid allergy. Archives Dermatol. 120: 1206-1208.
7. Chawla AS, Sharma AK, Handa SS, Dhar KL (1992). Chemical studiesand anti inflammatory activity of *Vanda roxburghii* roots. Indian J. Pharm. Sci. 54: 159-161.
8. Suresh PK, Subramoniam A, Pushpangadan P (2000). Aphodisiac activity of *Vanda tessellata*. Indian J. Pharmacol. 32: 300-304.
9. Yoshikawa M, Murakami T, Kishi A, Sakurama T, Matsuda H, Nomura M, Matsuda H, Kubo M (1998). Novel indole S,O-bisdesmoside, calanthoside, the precursor glycoside of tryptanthrin, indirubin, and isatin, with increasing skin blood flow promoting effects, from two Calanthe species (Orchidaceae). Chem. Pharm. Bull. 46: 886-888.
10. Johnson MK, Alexander KE, Lindquist N, Loo G (1999). A phenolic antioxidant from the freshwater orchid, *Habenaria repens*. Comparative Biochememistry Physiology part C: Pharmacol. Toxicol. Endocrinol. 122: 211-214.
11. Fan C, Wang W, Wang Y, Qin G, Zhao W (2001). Chemical constituents from *Dendrobiu*m *densiflorum.* Phytochemistry 57: 1255-1258.
12. Hayashi J, Sekine T, Deguchi S, Lin Q, Horie S, Tsuchiya S, Yano S, Watanabe K, Ikegami F (2002). Phenolic compounds from *Gastrodia* rhizome and relaxant effects of related compounds on isolated smooth muscle preparation. Phytochemistry 59: 513-519.
13. Estrada S, Acevedo L, Rodríguez M, Toscazo RA, Mata R (2002). New triterpenoids from orchids *Scaphyglottis livida* and *Nidema boothii*. Nat. Prod. Lett. 16: 81-86.
14. Majumder PL, Sen S, Majumder S (2003). Triterpenoids from orchids *Agrostophyllum brevipes* and *Agrostophyllum callosum.* Phytochemistry 62: 591-596.
15. Lo SF, Mulabagal V, Chen CL, Kuo CL, Tsay HS (2004). Bioguided fractionation and isolation of free radical scavenging components from in vitro propagated chinese medicinal plants *Dendrobium tosaense* Makino and *Dendrobium moniliforme* SW. J. Agric. Food Chem. 52: 6916-6919.
16. Yang L, Han H, Nakamura N, Hattori M, Wang Z, Xu L (2007). Bioguided isolation of antioxidants from the stems of *Dendrobium aurantiacum* var. denneanum. Phytotherapy Res. 21: 696-698.
17. Xia WB, Xue Z, Li S, Wang SJ, Yang YC, He DX, Ran GL, Kong LZ, Shi JG (2005). Chemical constituents from tuber of *Cremastra appendiculata.* Zhongguo Zhong Yao Za Zhi. 30: 1827-1830.
18. Wu, B, He, S., Pan, Y.J. (2006). New dihydrodibenzoxepins from *Bulbophyllum kwangtungense*. Planta Medica 72: 1244-1247.
19. Watanabe K, Tanaka R, Sakurai H, Iguchi K, Yamada Y, Hsu CS, Sakuma C, Kikuchi H, Shibayama H, Kawai T (2007). Structure of cymbidine A, a monomeric peptidoglycan-related compound with hypotensive and diuretic activities, isolated from a higher plant, *Cymbidium goeringii* (Orchidaceae). Chemical Pharmaceutic Bulletin 55: 780-783.
20. Déciga-Campos M, Palacios-Espinosa JF, Reyes-Ramírez A, Mata R (2007). Antinociceptive and anti-inflammatory effects of compounds isolated from *Scaphyglottis livida* and *Maxillaria densa* . J. Ethnopharmacol. 114(2):161-168.
21. Wu JB, Lin WL, Hsieh CC, Ho HY, Tsay HS, Lin WC (2007). The hepatoprotective activity of kinsenoside from *Anoectochilus formosanus*. Phytotherapy Res. 21: 58-61.
22. Wang X, Bauw G, Van Damme EJ, Peumans WJ, Chen ZL, Van Montagu M, Angenon G, Dillen W (2001). Gastrodianin-like mannose-binding proteins: a novel class of plant proteins with antifungal properties. Plant J. 25: 651-661.
23. Matu EN, van Staden J (2003). Antibacterial and anti-inflammatory activities of some plants used for medicinal purposes in Kenya. J. Ethnopharmacol. 87: 35-41.
24. Khan MR, Omoloso AD (2004). Antibacterial activity of *Galeola foliata.* Fitoterapia. 75: 494-486.
25. Fitzgerald DJ, Stratford M, Gasson MJ, Ueckert J, Bos A, Narbad A (2004). Mode of antimicrobial action of vanillin against *Escherichia coli, Lactobacillus plantarum and Listeria innocua*. J. Appl. Microbiol. 97. 104-113.
26. Delaquis P, Stanich K, Toivonen P (2005). Effect of pH on the inhibition of *Listeria* spp. by vanillin and vanillic acid. J. Food Protection 68: 1472-1476.
27. Luo H, Lin S, Ren F, Wu L, Chen L, Sun Y (2007). Antioxidant and antimicrobial capacity of Chinese medicinal herb extracts in raw sheep meat. J. Food Protrection 70: 1440-1445.
28. Shimura H, Matsuura M, Takada N, Koda Y (2007). An antifungal compound involved in symbiotic germination of *Cypripedium macranthos* var. rebunense (Orchidaceae). Phytochemistry 68:1442-1447.
29. Kala S and Senthilkumar S (2010). Antimicrobial activity of *Acanthephippium bicolour* Lindley. Malaysian Journal of Microbiology. 6(2):140-148.
30. Prasad DN, Achari G (1966). A study of anti-arthritic action of *Vanda roxburghii* in albino rats. J. Indian Med. Assoc. 46: 234-237.
31. Chawla AS, Sharma AK, Handa SS, Dhar KL (1992). Chemical studiesand anti inflammatory activity of *Vanda roxburghii* roots. Indian J.Pharm. Sci. 54: 159-161.
32. Lin JM, Lin CC, Chiu HF, Yang JJ, Lee SG (1993). Evaluation of the anti-inflammatory and liver-protective effects of *Anoectochilus formosanus, Ganoderma lucidum* and *Gynostemma pentaphyllum* in rats. Am. J. Chin. Med. 21, 59-69.
33. Lin TH, Chang SJ, Chen CC, Wang JP, Tsao LT (2001). Two phenanthraquinones from *Dendrobium moniliforme.* J. Nat. Prod. 64: 1084-1086.
34. Bae EY, Oh H, Oh WK, Kim MS, Kim BS, Kim BY, Sohn CB, Osada H, Ahn JS (2004). A new VHR dual-specificity protein tyrosine phosphatase inhibitor from *Dendrobium moniliforme*. Planta Medica 70:869-870.
35. Zhao C, Liu Q, Halaweish F, Shao B, Ye Y, Zhao W (2003). Copacamphane, picrotoxane, and alloaromadendrane

sesquiterpene glycosides and phenolic glycosides from *Dendrobium moniliforme*. J.Nat. Prod. 66: 1140-1143.
36. Lee JY, Jang YW, Kang HS, Moon H, Sim SS, Kim CJ (2006). Antiinflammatory action of phenolic compounds from *Gastrodia elata* root. Archives Pharm. Res. 29: 849-858.
37. Ahn EK, Jeon HJ, Lim EJ, Jung HJ, Park EH (2007). Anti-inflammatory and anti-angiogenic activities of *Gastrodia elata* Blume. J. Hnopharmacol. 110: 476-482.
38. Wang J, Matsuzaki K, Kitanaka S (2006). Stilbene derivatives from *Pholidota chinensis* and their anti-inflammatory activity. Chem.Pharm. Bulletin. 54: 1216-1218.
39. You HL, Park JD, Baek NI, Kim S, Ahn BZ (1995). *In vitro* and *in vivo* antimural phenanthrenes from the aerial parts of *Dendrobium nobile*. Planta Medica 61: 178-180.
40. Zhao W, Ye Q, Tan X, Jiang H, Li X, Chen K, Kinghorn AD (2001). Three new sesquiterpene glycosides from *Dendrobium nobile* with immunomodulatory activity. Journal Natural Products 64: 1196-2000
41. Li YM, Wang HY, Liu GQ (2001). Erianin induces apoptosis in human leukemia HL-60 cells. Acta Pharmacological Sinica 22: 1018-1022.
42. Gong YQ, Fan Y, Wu DZ, Yang H, Hu ZB, Wang ZT (2004). *In vivo* and *in vitro* evaluation of erianin, a novel anti-angiogenic agent. Eur. J. Cancer 40: 1554-1565.
43. Yang L, Qin LH, Bligh SW, Bashall A, Zhang CF, Zhang M, Wang ZT, Xu LS (2006). A new phenanthrene with a spirolactone from *Dendrobium chrysanthum* and its anti-inflammatory activities. Bioorg. Med. Chem. 14, 3496-3501.
44. Bi ZM, Wang ZT, Xu LS, Xu GJ (2003). Studies on the chemical constituents of *Dendrobium fimbriatum.* Yao Xue Xue Bao 38: 526-529.
45. Shyur LF, Chen CH, Lo CP, Wang SY, Kang PL, Sun SJ, Chang CA, Tzeng CM, Yang NS (2004). Induction of apoptosis in MCF-7 human breast cancer cells by phytochemicals from *Anoectochilus formosanus*. J. Biomed. Sci. 11: 928-939.
46. Tseng CC, Shang HF, Wang LF, Su B, Hsu CC, Kao HY, Cheng KT (2006). Antitumor and immunostimulating effects of *Anoectochilus formosanus* Hayata. Phytomedicine 13: 366-370.
47. Xue Z, Li S, Wang S, Wang Y, Yang Y, Shi J, He L (2006). Mono-, Bi-, and triphenanthrenes from the tubers of *Cremastra appendiculata*. J. Nat. Prod. 69: 907-913.
48. Na GX, Wang TS, Yin L, Pan Y, Guo YL, LeBlanc GA, Reinecke MG, Watson WH, Krawiec M (1998). Two pimarane diterpenoids from *Ephemerantha lonchophylla* and their evaluation as modulators of the multidrug resistance phenotype. J. Nat. Prod. 61: 112-115.
49. Huang Y, Guh J, Teng C (2005). Denbinobin-mediated anticancer effect in human K562 leukemia cells: role in tubulin polymerization and Bcr- Abl activity. J. Biomed. Sci. 12: 113-121.
50. Huang NK, Lin YL, Cheng JJ, Lai WL (2004). *Gastrodia elata* prevents rat pheochromocytoma cells from serum-deprived apoptosis: the role of the MAPK family. Life Sci. 75:1649-1657.
51. Heo JC, Woo SU, Son M, Park JY, Choi WS, Chang KT, Kim SU, Yoon EK, Kim YH, Shin HM, Lee SH (2007). Anti-tumor activity of *Gastrodia elata* Blume is closely associated with a GTP-Ras dependent pathway. Oncol. Reports 8: 849-853.
52. Peng J, Xu Q, Xu Y, Qi Y, Han X, Xu L (2007). A new anticancer dihydroflavanoid from the root of *Spiranthes australis* (R. Brown) Lindl. Nat. Prod. Res. 21: 641-645.
53. Chen Y, Xu J, Yut H, Qin CW, Zhangt Y, Liu Y, Wang J (2007). *Bulbophyllum Odoratissimum* 3,7- Dihydroxy- 2,4,6-trimethoxyphenanthrene. J. Korean Chem. Soc. 51: 352-355.
54. Chen HY, Shiao MS, Huang YL, Shen CC, Lin YL, Kuo YH, Chen CC (1999). Antioxidant principles from *Ephemerantha Ionchophylla*. J. Nat. Prod. 62: 1225-1227.
55. Venkateswarlu S, Raju MS, Subbaraju GV (2002). Synthesis and biological activity of isoamoenylin, a metabolite of *Dendrobium amoenum.* Biosci. Biotechnol. Biochem. 66: 2236-2238
56. Zhang X, Xu JK, Wang J, Wang NL, Kurihara H, Kitanaka S, Yao XS(2007). Bioactive bibenzyl derivatives and fluorenones from *Dendrobium nobile*. J. Nat. Prod. 70: 24-28.
57. Wang SY, Kuo YH, Chang HN, Kang PL, Tsay HS, Lin KF, Yang NS, Shyur LF (2002). Profiling and characterization antioxidant activities in *Anoectochilus formosanus* hayata. J. Agric. Food Chemistry 50:1859-1865.
58. Wang LF, Lin CM, Shih CM, Chen HJ, Su B, Tseng CC, Gau BB, Cheng KT (2005). Prevention of cellular oxidative damage by an aqueous extract of *Anoectochilus formosanus*. Annales. New York Academy of Sciences 1042: 379-386.
59. Markham KR, Ternai B, Stanley R, Geiger H, Mabry TJ (1978). Carbon- 13 NMR studies of flavonosides-III: Naturally occurring flavonoid glycosides and their alylated derivatives. *Tetrahedron* 34: 1389–1397
60. Gong YH (1986). 13C Chemical Shift of Natural Organic Compounds, Tomus 1. Yunnan Science and Technology Press, Kunming pp. 356-359.
61. Victoire, C., Berrurier, M.H., Guth, A.L. (1988). Isolation of flavonol glycosides from *Ginkgo biloba* leaves. Planta Med. 54: 245–247.
62. Merghem RM, Jay M, Viricel MR, Bayet C, Voirin B (1995). Five 8-Cbenzylated flavonoids from *Thymus hirtus*. Phytochemistry *38*: 637–640.
63. Ja CB, Won KC (2002). Studies on the constituents of *Impatiens nolitangere* L. Saengyak Hakhoechi 4: 263–26
64. He C, Wang C, Guo S, Yang J, Xiao P (2006). A Novel Flavonoid Glucoside from *Anoectochilus roxburghii* (Wall.) Lindl. J. Integrative Plant Biol. 48: 359-363.
65. Jung TY, Suh SI, Lee H, Kim IS, Kim HJ, Yoo HS, Lee SR (2007). Protective effects of several components of *Gastrodia elata* on lipid peroxidation in gerbil brain homogenates. Phytother. Res. 21:960
66. Guo XY, Wang J, Wang NL, Kitanaka S, Yao XS (2007). 9, 10- Dihydrophenanthrene derivatives from *Pholidota yunnanensis* and scavenging activity on DPPH free radical. J. Asian Natural Prod. Res.9: 165-174.
67. Rhee JK, Kim PG, Baek BK, Lee SB, Ahan BZ (1982). Isolation of anthelmintic substance on *Clonorchis Sinensis* from tuber of *Bletilla Striata*. Kisaengchunghak Chapchi. 20: 142-146.
68. Chen KK, Chen AL (1935). The alkaloid of Chin-Shih-Hu. J. Biol. Chem. pp. 653-658.
69. Li MF, Hirata Y, Xu GJ, Niwa M, Wu HM (1991). Studies on the chemical constituents of *Dendrobium loddigesii* rolfe. Yao Xue Xue Bao. 26: 307-310
70. Ye Q, Qin G, Zhao W (2002). Immunomodulatory sesquiterpene glycosides from *Dendrobium nobile*. Phytochemistry. 61: 885-890.
71. Miyazawa M, Shimamura H, Nakamura S, Sugiura W, Kosaka H, Kameoka H (1999). Moscatilin from *Dendrobium nobile*, a naturally occurring bibenzyl compound with potential antimutagenic activity. J. Agric. Food Chem. 47: 2163-2167.
72. Yoshikawa M, Murakami T, Kishi A, Sakurama T, Matsuda H, Nomura M, Matsuda H, Kubo M (1998). Novel indole S,O-bisdesmoside, calanthoside, the precursor glycoside of

tryptanthrin, indirubin, and isatin, with increasing skin blood flow promoting effects, from two Calanthe species (Orchidaceae). Chem. Pharm. Bull. 46: 886-888.
73. Nayak BS, Suresh R, Rao AV, Pillai GK, Davis EM, Ramkissoon V, McRae A (2005). Evaluation of wound healing activity of *Vanda roxburghii* R.Br (Orchidacea): a preclinical study in a rat model. Int. J. Lower Extremity Wounds 4: 200-204.
74. Chen CC, Wu LG, Ko FN, Teng CM (1994). Antiplatelet aggregation principles of *Dendrobium loddigesii*. J. Nat. Prod. 57: 1271-1274.
75. Ding CS, Shen YS, Li G, Wei Z, Wei F (2007). Study of a glycoprotein from *Gastrodia elata*: its effects of anticoagulation and antithrombosis. Zhongguo Zhong Yao Za Zhi 32: 1060-1064.
76. Shih CC, Wu YW, Lin WC (2002). Antihyperglycaemic and anti-oxidant properties of *Anoectochilus formosanus* in diabetic rats. Clin. Exp.Pharm. Physiol. 29: 684-668.
77. Wu HS, Xu JH, Chen LZ, Sun JJ (2004). Studies on anti-hyperglycemic effect and its mechanism of *Dendrobium candidum.* Zhongguo Zhong Yao Za Zhi 29: 160-163.
78. Won JH, Kim JY, Yun KJ, Lee JH, Back NI, Chung HG, Chung SA, Jeong TS, Choi MS, Lee KT (2006). Gigantol isolated from the whole plants of *Cymbidium goeringii* inhibits the LPS-induced iNOS and COX- 2 expression via NF-kappaB inactivation in RAW 264.7 macrophages cells. Planta Med. 72: 1181-1187.
79. Shih CC, Wu YW, Lin WC (2005). Aqueous extract of *Anoectochilus formosanus* attenuate hepatic fibrosis induced by carbon tetrachloride in rats. Phytomedicine 12: 453-60.
80. Kim HJ, Lee SR, Moon KD (2003). Ether fraction of methanol extracts of *Gastrodia elata,* medicinal herb protects against neuronal cell damage after transient global ischemia in gerbils. Phytotherapy Res. 17: 909-912
81. Yu SJ, Kim JR, Lee CK, Han JE, Lee JH, Kim HS, Hong JH, Kang SG (2005). *Gastrodia elata* blume and an active component, phydroxybenzyl alcohol reduces focal ischemic brain injury through antioxidant related gene expressions. Biol. Pharm. Bull. 28: 1016-1020.
82. Kudo Y, Tanaka A, Yamada K (1983).Dendrobine, an antagonist of beta-alanine, taurine and of presynaptic inhibition in the frog spinal cord. Brit. J. Pharmacol. 78: 709-715.
83. Ho CK, Chen CC (2003). Moscatilin from the orchid *Dendrobrium loddigesii* is a potential anticancer agent. Cancer Investigation 21: 729-736.
84. Chen CC, Huang YL, Teng CM (2000). Antiplatelet aggregation principles from *Ephemerantha lonchophylla.* Planta Medica 66: 372-374.
85. Hernández-Romero Y, Rojas JI, Castillo R, Rojas A, Mata R (2004). Spasmolytic effects, mode of action, and structure-activity relationships of stilbenoids from *Nidema boothii.* J. Nat. Prod. 67: 160-167.
86. Matsuda H, Morikawa T, Xie H, Yoshikawa M (2004). Antiallergic phenanthrenes and stilbenes from the tubers of *Gymnadenia conopsea*. Planta Medica 70: 847-855
87. Shim JS, Kim JH, Lee J, Kim SN, Kwon HJ (2004). Anti-angiogenic activity of a homoisoflavanone from *Cremastra appendiculata*. Planta Med. 70: 171-173.
88. Hernández-Romero Y, Acevedo L, Sánchez ML, Shier WT, Abbas HK, Mata R (2005). Phytotoxic activity of bibenzyl derivatives from the orchid *Epidendrum rigidum.* J. Agric. Food Chem. 53: 6276-6280.
89. Huang NK, Chern Y, Fang JM, Lin CI, Chen WP, Lin YL (2007). Neuroprotective principles from *Gastrodia elata*. J. Nat. Prod. 70: 571-574
90. Tezuka Y, Li J, Hirano H, Ueda M, Nagashima K, Kikuchi T (1990). Studies on the constituents of Orchidaceous plants IX. Constituents of Spiranthes sinensis (PERS.) AMES var. Amoena (*M. Bieberson*) HARA. Structures of spiranthesol, spiranthoquinone, spiranthol C and spirasineol B, new isopentenyldihydrophenantrenes. Chem. Pharm.Bull. 38: 629-635.
91. Bhaskar MU, Rao JM, Prakasa NS, Rao M (1991). Ochrone A, a novel 9, 10-dihydro-1,4-phenanthraquinone from *Coelogyne ochracea*. J. Nat. Prod. 54: 386-389
92. Majumder PL, Banerjee S, Maiti DC (1995). Stilbenoids from the orchids *Agrostophyllum callosum* and *Coelogyne flaccida*. Phytochemistry 39:649-653
93. Estrada S, Rojas A, Mathison Y, Israel A, Mata R(1999). Nitric oxide/cGMP mediates the spasmolytic action of 3,4'-dihydroxy-5,5'-dimethoxybibenzyl from *Scaphyglottis livida*. Planta Medica 65: 109-114
94. Estrada S, López-Guerrero JJ, Villalobos-Molina R, Mata R (2004). Spasmolytic stilbenoids from *Maxillaria densa.* Fitoterapia 75: 690-695
95. Majumder PL, Sen S, Majumder S (2001). Phenanthrene derivatives from the orchid *Coelogyne cristata*. Phytochemistry 58: 581-586
96. Lin YL, Chen WP, Macabalang AD (2005). Dihydrophenanthrenes from *Bletilla formosana.* Chem. Pharm. Bull. 53: 1111-1113
97. Morita H, Koyama K, Sugimoto Y, Kobayashi J (2005). Antimitotic activity and reversal of breast cancer resistance protein-mediated drug resistance by stilbenoids from *Bletilla striata.* Bioorg. Med. Chem. Lett. 15: 1051-1054