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Importance of Bioactive Secondary Metabolites in Orchids: A Review

Kajal Choudhary[1], Shelja[1], Anukriti[1], Shailja[1], Jitender Kumar[1*]

[1]*Department of Plant Sciences, School of Life Sciences, Central University of Himachal Pradesh, Shahpur, Kangra, 176206, India*

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KEYWORDS

Orchids; Bioactive compounds; Pharmacological activity; Anti-oxidant; Anticancer

ABSTRACT:

Introduction: Orchids are beautiful flowering plants rich in chemical constituents. The flowers of orchids persist for a very long period and fetch high prices in the market. Since the prehistoric era, medicinal plants have been a vital part of human life. Orchids have become a part of traditional herbal remedies and have undergone extensive research due to their pharmacological significance. The alkaloids, phenolics, phenanthrenes, terpenoids and their derivatives are different biologically active substances found in leaves, stems or bulbs of orchids that exhibit pharmacological activities like anti-inflammatory, anticancer, antioxidant, anti-microbial etc.

Objectives: The current review focuses on the bioactive compounds and their significant role in orchids.

Conclusions: The extract and metabolites of plants, especially from leaves and flowers have beneficial pharmacological properties. The various disorders such as arthritis, syphilis, cholera, jaundice, piles, tuberculosis, wounds, and stomach problems have been cured by using medication made from orchids. Habitat destruction, overharvesting, and various other human activities have led to a decline in the number of species and different conservation measures are needed to protect them.

1. Introduction

Orchids are one of the largest and complex groups of angiosperms containing approximately 850 genera and 25,000 species [1]. Theophrastus used the term "orchid" which means "testicles" due to the plant's anatomy resembling testicles. Generally, orchids are terrestrial or epiphytic and some of them can be grown as saprophytes and lithophytes [2]. There are monopodial and sympodial patterns for the growth of orchids. Orchids possess simple leaves with parallel veins, while certain species in the subfamily Vanilloideae have reticulate venation [3]. All continents, excluding Antarctica are home to orchids with tropical and subtropical areas having the highest densities. The species are abundantly found in the mountains of Madagascar, Indo-China, Australia, the northern Andes of South America, New Guinea Malaysia, Sumatra and the Islands of Asia. The diversity of orchids is richest in India. About 2500 species and 167 genera are reported in Central (Sikkim and Darjeeling Hills) and Eastern Himalaya. The maximum numbers of species are documented from Arunachal Pradesh. The Indian Himalayan Region (IHR) includes about 64.14% of orchid species documented from India.

Orchids are widely known for having lovely flowers [4]. Since ancient times, they have been used as nutraceuticals and their therapeutic potential is recognized. Chinese were the first people to cultivate and study orchids as therapeutic herbs. Different orchids such as *Dendrobium nobile*, *Gastrodia elata* and *Bletilla striata* are used in traditional Chinese medicines. Traditional Ayurvedic formulations such as chyawanprash are prepared from orchids. Ashtavarga is an Ayurvedic remedy that contains four orchids namely *Malaxis acuminata, Habenaria edgeworthii, Habenaria intermedia and Malaxis muscifera* [5]. *Calanthe, Coelogyne, Cypipedium, Dendrobium, Eria, Ephemerantha, Galeola, Gastodia, Gymnadenia, Habenaria, Ludisia, Luisia* and *Thunia* are the genera that contain medicinal orchids [6]. The physiological, biological and pharmacologically significant secondary metabolites are known to be produced by orchids. These are alkaloids, phenolic acids, stilbenes, flavonoids, dihydrostilbenoids, anthocyanins, phenanthrenes and terpenes [7]. Many metabolites are employed to treat a wide range of illnesses including cancer and other

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cellular problems [8]. Orchids have been utilized as a remedy for chest pain, arthritis, piles, tuberculosis, cholera, acidity, boils, tumors, syphilis, wounds, stomach problems, eczema, inflammation, menstruation, spermatorrhea, muscular discomfort and other infections [9]. The extract of orchids has shown antioxidant, antimicrobial, inflammatory and tyrosinase inhibitory activity [10]. The therapeutic value of a medicinal plant is determined by its phytoconstituents [11]. The medicinal value of *Dendrobium nobile* has significantly raised due to the existence of numerous active compounds in its stems and leaves such as dendrophenol, dendrobine, nobiline, gigantol, denbinobine and moscatilin [12]. The population and diversity of orchid are mostly dependent on the habitat's size, elevation range, the quantity of light available, soil moisture, height and area of the canopy [13]. Some orchid species are rare, naturally endangered and endemic to particular regions [14]. The IUCN Red List's global criteria revealed that 56.5% of the 948 orchids are threatened worldwide [15].

2. Bioactive Compounds in Orchids

The different bioactive substances are identified including alkaloids, phenanthrenes, flavonoids, bibenzyl derivatives and terpenoids having pharmacological value [16]. The amount of secondary metabolites varies in species of orchid but phenols are the richest bioactive compound [17].

Phenolics

Phenols play a significant function as defense-related compounds and their antioxidant activity provides protective measures against free radical damage. These phenolic compounds transfer the electron to free radicals and make them stable by preventing cell damage [18]. Denbinobin (1, 4-phenanthrenequinone) in *Flickingeria xantholeuca*, later found in *Dendrobium nobile* and *D. candidum* blocks human immuno virus-1 replication via the nuclear factor-kappaB dependent mechanism [19]. According to *in vitro* research, denbinobine promotes apoptosis in different tumor cell lines such as leukemia, colorectal, malignancies and lungs [20]. Denbinobin has an antifibrotic impact on the liver and prevents liver cirrhosis [21]. Protocatechualdehyde, commonly known as 3, 4-dihydroxybenzaldehyde (3, 4-DHB) in *Spiranthes sinensis* exhibits anticancer, anti-inflammatory, neuroprotective and antioxidant properties [22]. Vanillin is obtained by an economically significant orchid called as *Vanilla planifolia* which results in the inhibition of acetylcholinesterase [23]. The different phenolic compounds such as catechin, chlorogenic acid, cinnamic acid, kaempferol, epicatechin, p-coumaric acid, quercetin, protocatechuic acid, gallic acid, caffeic acid, syringic acid, vanillin, o-coumaric acid, ferulic acid, sinapic acid, p-hydroxybenzoic acid, benzoic acid, rutin, rosmarinic acid and luteolin were analyzed by HPLC (High-Performance Liquid Chromatography) in ethyl acetate extract of *Dactylorhiza romana* [24]. The protocatechuic acid, p-coumaric acid indicates antiproliferative, antimicrobial, antityrosinase and anti-inflammatory action [25]. Luteolin exhibits anti-inflammatory, antitumor, antioxidant and pro-oxidant enzyme-inhibiting properties [26]. Studies have shown that *Habenaria repens* has anti-oxidant action due to habenariol and this species is used as an aphrodisiac in China [27]. The HPLC of *Bulbophyllum odoratissimum* extract (leaf, pseudobulb and root) contains caffeic acid, catechin, rutin, naringin, quercetin, salicylic acid, syringic acid, ferulic acid and sinapic acid in higher concentration [28]. Besides this, phenolic acids also have several pharmacological impacts like anti-inflammatory, antidepressant, anticancer, antiulcer and cytotoxic properties [29].

Flavonoids

The most common flavonoid in *Dendrobium catenatum* is quercetin and it has anti-inflammatory characteristics [30]. The chemical analysis of the flower *Cymbidium finlaysonianum, Grammatophyllum specious*, *Pogonia japonica* revealed the presence of cyanidin-3-glycoside and cyanidin-3-rutinoside [31]. In China, *Bulbophyllum odoratissimum* is utilized for curing breathing problems and wounds. It contains the flavonoid chrysin which has anti-inflammatory properties and inhibits the nuclear factor for interleukin 6 (NF-IL6) DNA-binding activities which reduces lipopolysaccharide-induced cyclooxygenase-2 enzyme production [32]. Pinobanksin is the flavonoid found in *Bulbophyllum odoratissimum* and has antioxidant activity towards LDL (low-density lipoprotein) [33]. The phenylpropanoids are substances from the coumarin class that have anticoagulant and antiplatelet properties. *Spiranthes australis* a plant used in China, Trinidad and Tobago for the therapy of inflammatory diseases, cancer, urinary issues and

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diabetes was found to contain an anti-cancer dihydroflavanoid [34].

Terpenoids and Steroids

The GC/HRMS analysis of *Phalaenopsis bellina* reveals monoterpenes like linallol, myrcene, geraniol and ocimene [35]. Linalool is a main compound found in the petals of *Cymbidium* hybrid "Sunny Bell" [36]. Plant steroids have medicinal and pharmaceutical functions like anti-cancer, antihepatotoxicity, antimicrobial, parasiticidal, cytostatic and cardiotonic activity [37]. The ethanol extract of *Pholidota cantonensis* was used to extract the two diterpenoid glycosides known as phocantoside A and phocantoside B which exhibit anticancer properties [19]. Lonchophylloids A and B are the two pimarane diterpenoids obtained from the stem of *Ephemerantha lonchophylla* [38]. The main monoterpenes found in *Vanda* Mimi Palmer flower are cymene, linalool oxide, linalool and nerolidol (sesquiterpene) [39]. *Cymbidium* contains α-copaene, eucalyptol, β-caryophyllene, α -pinene and trans-β-ocimene [40]. There is a use of numerous terpenoids as flavours, and aromas in food and cosmetics. They serve as phytoalexins in a plant's defense and plants release volatile terpenes to attract insects for pollination [41].

Alkaloids

Dendrobine, dendrobine-N-oxide, nobilonine, dendroxine, 6-hydroxy-nobilonine, 13-hydroxy-14-oxodendrobine, mubironine, and dendramine are the primary alkaloids found in the dried stems of *Dendrobium* [42]. The alkaloid homocrepidine A and homocrepidine B were found in *D. crepidatum* [43]. The methanolic extract of *Dendrobium phalaenopsis* and *Dendrobium lineale* leaves shows the antiviral activity against SARS-CoV-2 [44]. The studies have proved that the alkaloids of *Dendrobium* contribute to liver protection [45]. Besides this alkaloids have antihypertensive, antiarrhythmic, antimalarial and antitumor activity. The flowers of *Epipactis helleborine* have oxycodone and morphinan/indole compounds [46].

Phytoalexins

The 9,10-dihydrophenanthrenes are the major phytoalexins present in orchids. The first phytoalexin orchinol was discovered in *Orchis militaris* [47]. Orchinol and loroglossol prevent *Phytophthora infestans* spore germination. The phytoalexins like loroglossol and hircinol found in the tuber of *Himantoglossum robertianum* have antioxidant, immunostimulatory and anti-cancer actions [48]. Phytoalexins have antifungal, anti-oxidant, anti-tumor and antibacterial properties. It is indeed noted that the native medicine in Nepal primarily employs orchids for small diseases such as wounds (*Coelogyne, Rhynchostylis* and *Vanda*), pimples (*Dendrobium*) and boils (*Coelogyne, Dendrobium* and *Vanda*) [49]. Maslinic acid is a naturally occurring phytoalexin having different biological effects like anticancer, antidiabetic, anti-parasitic, cardioprotective, neuroprotective and growth-stimulating properties [50].

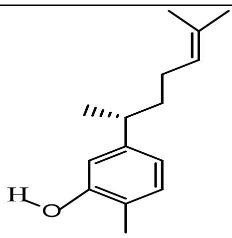
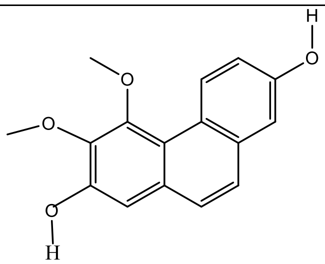
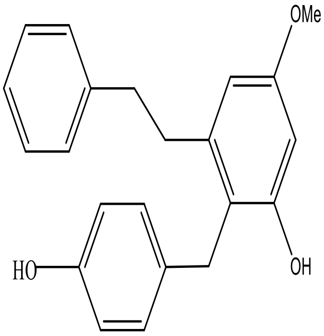
Phenanthrenes

The several phenanthrenes exhibiting amazing biological functions are identified and a large portion of phenanthrene compounds are present in Orchidaceae mainly in *Bulbophyllum, Bletilla, Coelogyna, Cymbidium, Epidendrum, Eria, Maxillaria, Dendrobium* [51]. Since 2000, 66 phenanthrene derivatives, comprising 23 dihydrophenanthrenes, 26 polycyclic aromatic hydrocarbons, seven dimeric and ten phenanthrenes have been identified in *Dendrobium* [52]. The seven phenanthrenes, comprising three dihydrophenanthrenes, three multisubstituted phenanthrenes and one phenanthrene derivative were identified from *Dendrobium loddigesii* [53]. The fifty-four phenanthrene derivatives were produced by *Cremastra* including one triphenanthrene, fifteen modified phenanthrenes, six phenanthrene derivatives, seven dihydrophenanthrenes and six dimeric phenanthrenes [54].

Lusianthridin, a dihydroxymethoxy phenanthrene and the phenanthroquinone denbinobin have cytotoxic properties in *Dendrobium nobile* [55]. The compounds moniliformediquinone, annoquinone and denbinobin exhibiting anti-inflammatory effects were isolated from *Dendrobium moniliforme* [56]. Blespirol, a distinct monophenanthrene was obtained from *Bletilla striata* and dendrochrysanene monophenanthrene was isolated from *Dendrobium chrysanthum* [57]. Diphenanthrenes are generally found in *Agrostophyllum callosum, Bletilla striata, Bulbophyllum reptens, Cremastra appendiculata, Dendrobium plicatile, Eria flava, Gymadenia conopsea, Pleione bulbodioides, Eulophia nuda* and *Pholidota yunnanensis* [58]. The two new dihydrophenanthrenes, sinensols G and H were discovered in *Spiranthes sinensis* which shows anti-hepatoma activity [34]. A single triphenanthrene was identified from *Cremastra appendiculata*'s tubers [54].

It is found that the compound nudol in *Dendrobium nobile* inhibits osteosarcoma cell growth, G2/M cell cycle arrest, induced cancer cell death and oxidative stress cell migration. Nudol is an effective drug for the development of chemotherapies for osteosarcoma [30]. The three novel biphenanthrene derivatives known as aerimultins A-C, natural phenylpropanoid ester dihydrosinapyl dihydroferulate were discovered in *Aerides multiflora* and they were evaluated for their alpha-glucosidase inhibitory activity. The most powerful activity was shown by aerimultin C [59]. The two 9,10-dihydrophenanthrenes named phocantol and phocantone showing cytotoxic action in mouse were extracted from the ethanol extract of *Pholidota cantonensis* [19]. The dimeric phenanthrenes reptanthrin and isoreptanthrin were extracted from *Bulbophyllum reptans*. It has been found that the two novel phenanthrene derivatives 2, 3, 7-trihydroxy-5H-phenanthro [4, 5-bcd] pyran and 2, 3-dihydroxy-7-methoxy-5H-phenanthro [4, 5-bcd] pyran are antitumor compounds extracted from the stems of *Pholidota chinensis* [60]. The denbinobin phenanthrene in *Dendrobium nobile* triggers apoptosis. In K562 cells, denbinobin exhibits an antitumor effect by boosting tubulin polymerization levels and downregulating BcrAbl signaling [61]. Monbarbatains A, B, C and D are derivatives of the compounds biphenanthrene and triphenanthrene that have mild cytotoxic activity against several human tumour cell lines [62]. The 3, 7-dihydroxy-2,4-dimethoxyphenanthrene in *Scaphyglottis livida* is employed to alleviate stomachache [63]. The structures of some important phytochemicals present in orchids are listed in table 1.

Table 1: List of some important bioactive compounds present in orchids

Botanical Name	Name of the Compound	Structure	Class of the Compound	References
Aerides odoratum Lour	Xanthorrhizol		Phenol	[64]
Appendicula reflexa Blume	Nudol		Phenanthrenes	[65]
Arundina graminiflora (D.Don) Hochr	Arundinan		Stilbenoid	[66]

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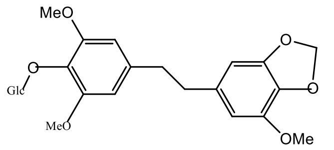
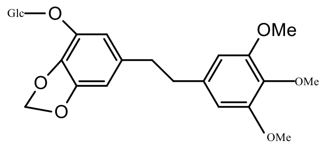
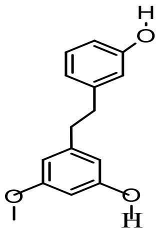
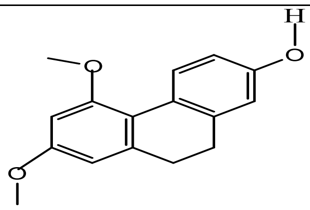
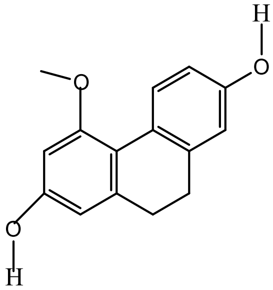
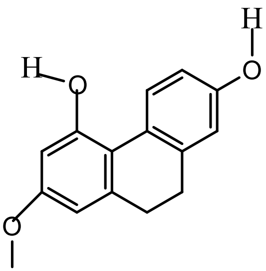
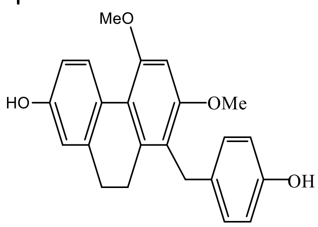
Arundina graminiflora (D.Don) Hochr	Graminibiben-zyls A, Graminibiben-zyls B, Batatasin III		Bibenzyls	[67]
Arundina graminiflora (D.Don) Hochr	Orchinol, Coelonin, Lusianthridin, Arundinaol, Blestriarene A		Phenanthrenes	[68]

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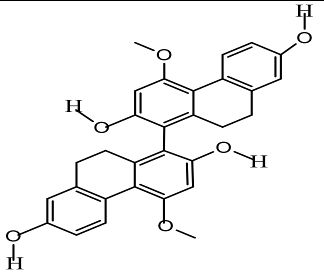
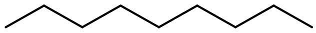
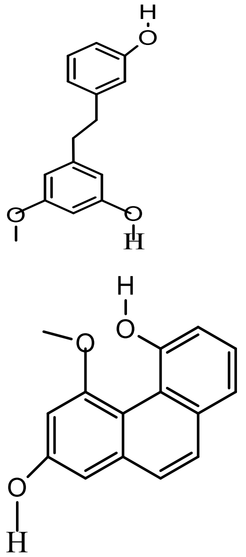
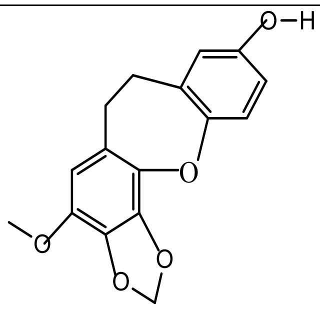
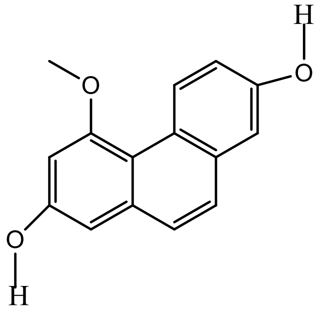
				
Bulbophyllum kaitense W.G. Walpers	Nonane		Acyclic alkane	[69]
Bulbophyllum odorastissimum (Sm.) Lindl.	Batatasin 111, Mosacatin		Phenol	[69]
Bulbophyllum odorastissimum (Sm.) Lindl.	Bulbophythrin A and bulbophythrin B		Biphenanthrene	[69]
Cremastra appendiculata (D. Don) Makino	Flavanthrinin		Dihydrophenanthrene	[70]

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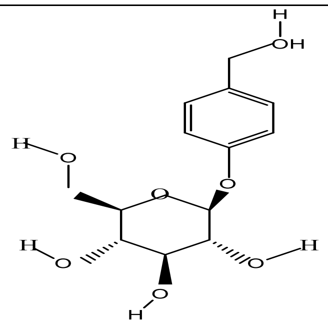
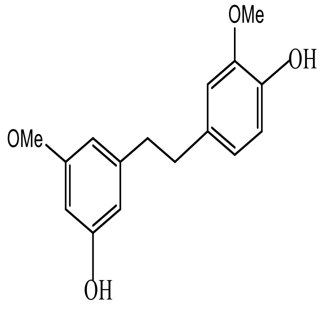
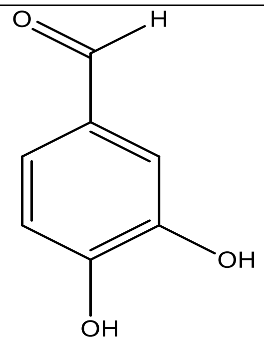
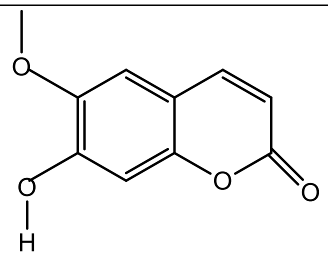
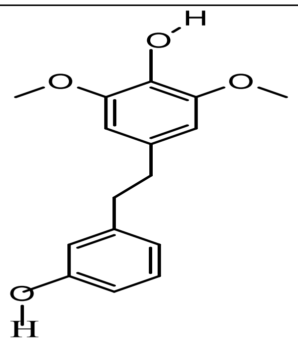
Cremastra appendiculata (D. Don) Makino	Gastrodin		Glucoside	[71]
Cymbidium goeringii W.G. Walpers	Gigantol		Phenolic	[72]
Dactylorhiza romana (Sebast.) Soo	Protocatechuic acid		Phenolic	[24]
Dendrobium densiflorum Lindl	Scopoletin		Alkaloid	[73]
Dendrobium moniliforme (L.) Sw.	Aloifol 1		Bibenzyl	[72]

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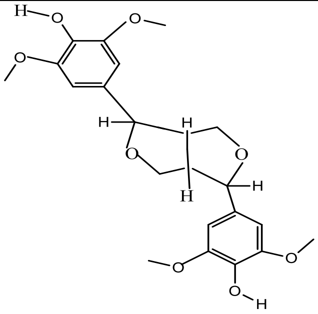
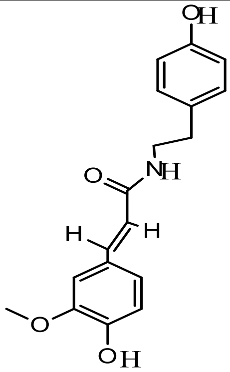
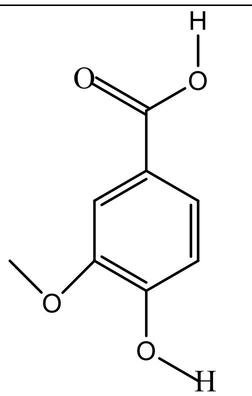
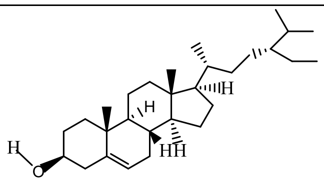
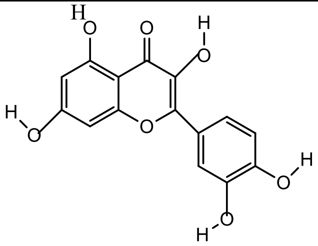
Dendrobium moniliforme (L.) Sw.	Syringaresinol		Furofuran lignin	[72]
Dendrobium moniliforme (L.) Sw	Moupinamide		Alkaloid	[72]
Dendrobium moniliforme (L.) Sw.	Vanillic acid		Benzoic Acid	[72]
Dendrobium thyrsiflorum B.S. Williams	Sitosterol		Steroid	[73]
Dendrobium tosaense Makino	Quercetin		Polyphenol flavonoids	[74]

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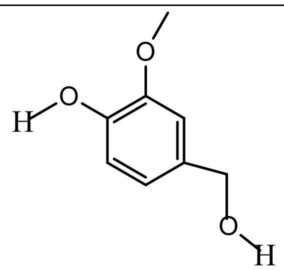
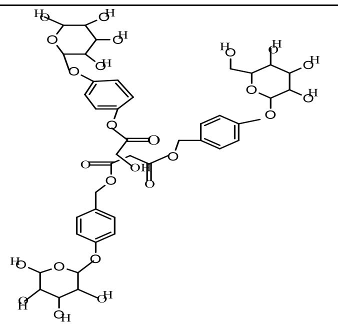
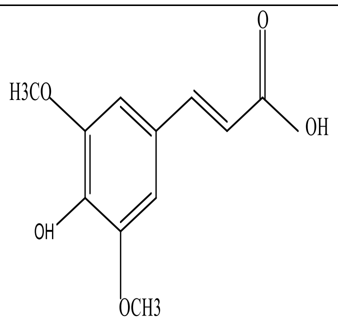
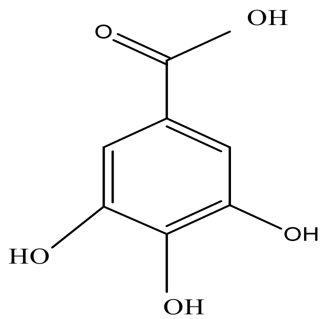
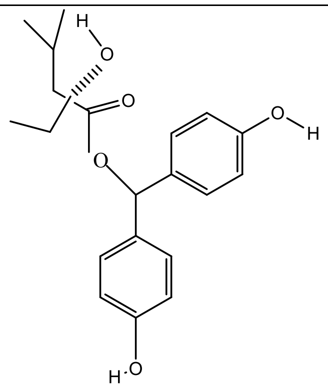
Gastrodia elata Blume	Vanillyl alcohol		Phenolic	[4]
Gastrodia elata Blume	Parishin		Phenolic Glucoside	[4]
Habenaria intermedia D. Don	Sinapic acid, Gallic acid	 	Phenolic acid	[75]
Habeneria repens Nutt.	Habenariol		Phenolic	[27]

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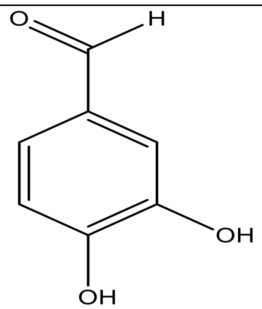
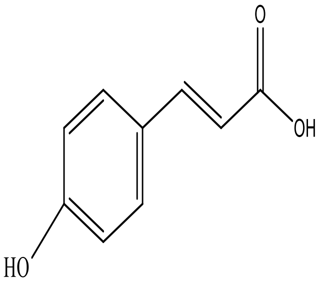
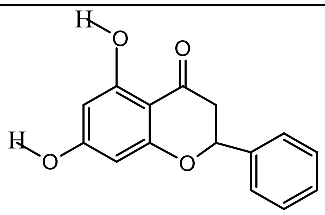
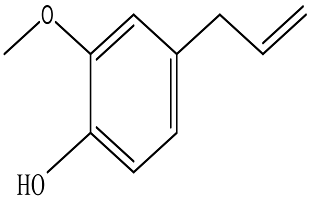
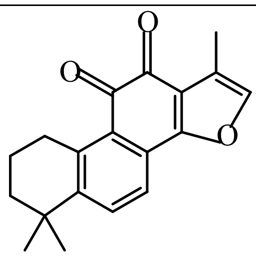
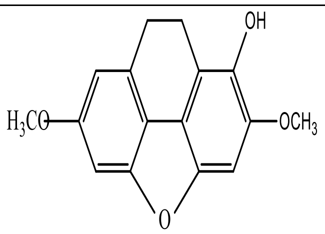
Malaxis acuminata D. Don	Protocatechuic acid, p-Coumaric acid	 	Phenolic acids	[76]
Oncidium sotoanum R. Jimenez & Hagsater	Chrysin, Eugenol	 	Flavonoid	[77]
Pholidota cantonensis Rolfe	Tanshinsone		Phenanthrenes-quinone	[19]
Pholidota cantonensis Rolfe	Phocantol, Phocantone		Dihydrophenanthrenes	[19]

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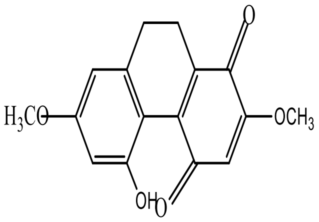
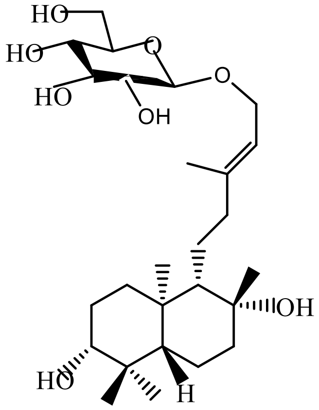
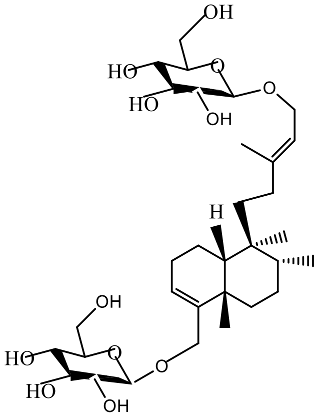
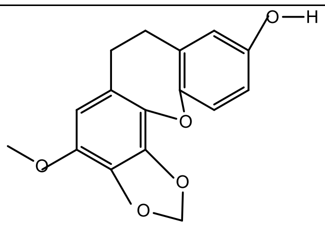
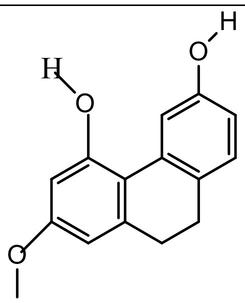
				
Pholidota cantonensis Rolfe	Phocantoside A, Phocantoside B	 	Diterpenoid	[19]
Pholidota chinensis Lindl.	Bulbophylol B		Benzoxepin derivative	[78]
Pholidota chinensis Lindl	Cannabihydrophenanthrene		Dihydrophenanthrene	[79]

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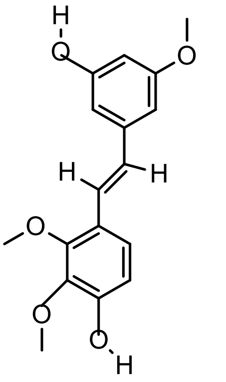
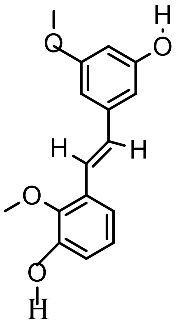
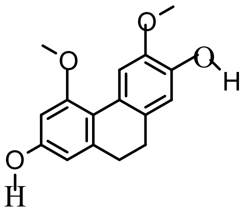
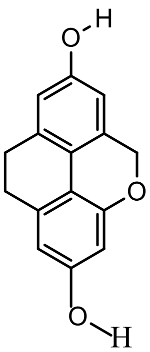
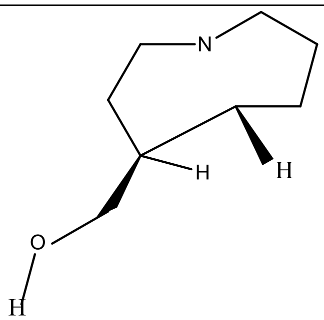
Pholidota yunnanensis Rolfe	Phoyunbene-B, Phoyunbene-C	 	Stilbene	[80]
Vanda coerulea Griff. Ex Lindl	Methoxycoelonin,Flavidin	 	Stilbenoid	[81]
Vanda hindsii Lindl.	Laburnine acetate		Alkaloid	[73]

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3. Conclusion

In recent years, researchers have invested a lot of effort and time in identifying novel bioactive compounds and their biological activity. The development of novel drugs has always been focused on natural compounds and their derivatives. Orchids are a rich source of bioactive substances with therapeutic value. Bioactive substances can influence metabolic activities and exhibit useful properties like an antioxidant effect, the inhibition of receptor functions, induction or inhibition of enzymes, and the induction and inhibition of gene expression. Phytochemicals play vital functions in the diagnosis and treatment of inflammatory and oxidative disorders. The potential benefits of investigating these huge chemical compounds are very important in the field of medicine. However, a different number of phytochemicals have been discovered in orchids but nature still has many more. The natural products produced by the plants and the synthesis of their derivatives from known compounds lead to the manufacturing of pharmaceuticals.

References

1. Jolman D., Batalla M. I., Hungerford A., Norwood P., Tait N., Wallace L.E., 2022. The challenges of growing orchids from seeds for conservation: An assessment of asymbiotic techniques. Applications in Plant Sciences. 10(5), 1-18.
2. Misra S., Orchids of Odisha: A handbook, Bishen Singh Mahendra Pal Singh, 2014.
3. Zhang S., Yang Y., Jiawei L., Qin J., Zhang W., Huang W., Hong H., 2018. Physiological diversity of orchids. Plant diversity. 40(4) 196-208.
4. Zhang F.P., Huang J.L., Zhang S.B., 2016. Trait evolution in the slipper orchid *Paphiopedilum* (Orchidaceae) in China. Plant signaling & behavior. 11(3), 1-8.
5. Panda A.K., Mandal D., 2013. The folklore medicinal orchids of Sikkim. Ancient science of life. 33(2), 92.
6. Szlachetko D.L., 2003. Gynostemia Orchidalium III: Orchidaceae-Vandoideae (Polystachyeae, Cymbidieae, Cataseteae, Thecosteleae, Vandeae). Acta Botanica Fennica. 176, 1-305.
7. Gantait S., Das A., Mitra M., Chen J.T., 2021. Secondary metabolites in orchids: Biosynthesis, medicinal uses, and biotechnology. South African Journal of Botany. 139, 338-351.
8. Ramasamy T.S., Yu J.S., Selden C., Hodgson H., Cui W., 2013. Application of three-dimensional culture conditions to human embryonic stem cell-derived definitive endoderm cells enhances hepatocyte differentiation and functionality. Tissue Engineering Part A. 19(3-4), 360-367.
9. Dalar A., Guo Y., Esim N., Bengu A.S., Konczak I., 2015. Health attributes of an endemic orchid from Eastern Anatolia, *Dactylorhiza chuhensis* Renz & Taub.–*In vitro* investigations. Journal of Herbal Medicine. 5(2), 77-85.
10. Rahman M., Surag A.T., Begum R., Tusher M.H., Huda M.K., 2022. Phytochemical, Antioxidant, Anti-Inflammatory, and Thrombolytic Properties of *Cleisomeria lanatum* (Lindl.) Lindl. ex G. Don. Scientifica. 1-7.
11. Shaikh J.R, Patil M.K., 2020. Qualitative tests for preliminary phytochemical screening: An overview. International Journal of Chemical Studies. 8(2), 603-608.
12. Minh T.N., Khang D.T., Tuyen P.T., Minh L.T., Anh L.H., Quan N.V., Xuan T.D., 2016. Phenolic compounds and antioxidant activity of *Phalaenopsis* orchid hybrids. Antioxidants. 5(3), 1-31.
13. McCormick, Mellisa K., Jacquemyn H., 2014. What constrains the distribution of orchid populations. New Phytologist. 202(2), 392-400.
14. Antolin Barberena F.F.V., Baumgratz J.F.A., De Barros F., 2018. Ecological data for an orchid diversity hotspot show that the subtribe Laeliinae may be endangered in the Brazilian Atlantic Forest. Nordic Journal of Botany. 36(7), 1-37.
15. Efimov P.G., 2020. Orchids of Russia: annotated checklist and geographic

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www.jchr.org

JCHR (2024) 14(1), 2009-2025 | ISSN:2251-6727

distribution. Nature Conservation Research. 5(1), 1-18.

16. Kumar S., Mishra S., Mishra A.K., 2021. Diversity of orchid species of Odisha state, India. With note on the medicinal and economic uses. 5, 1-26.
17. Natta S., Mondol M.S.A., Pal K., Mandal S., Sahana N., Pal R., Kalaivanan N.S., 2022. Chemical composition, antioxidant activity and bioactive constituents of six native endangered medicinal orchid species from north-eastern Himalayan region of India. South African Journal of Botany. 150, 248-259.
18. Dai J., Mumper R.J., 2010. Plant phenolics: extraction, analysis and their antioxidant and anticancer properties. Molecules. 15(10), 7313-7352.
19. Li B., Ali Z., Chan M., Li J., Wang M., Abe N., Li S.X., 2017. Chemical constituents of *Pholidota cantonensis*. Phytochemistry. 137, 132-138.
20. Song J.I., Kang Y.J., Yong H.Y., Kim Y.C., Moon A., 2012. Denbinobin, a phenanthrene from *Dendrobium nobile*, inhibits invasion and induces apoptosis in SNU-484 human gastric cancer cells. Oncology reports. 27(3), 813-818.
21. Yang H., Lee P.J., Jeong E.J., Kim H.P., Kim Y.C., 2012. Selective apoptosis in hepatic stellate cells mediates the antifibrotic effect of phenanthrenes from *Dendrobium nobile*. Phytotherapy Research. 26(7), 974-980.
22. Liu L., Yin Q.M., Yan X., Hu C., Wang W., Wang R.K., Zhang X.W., 2019. Bioactivity-guided isolation of cytotoxic phenanthrenes from *Spiranthes sinensis*. Journal of agricultural and food chemistry. 67(26), 7274-7280.
23. Kundu A., Mitra A., 2013. Flavoring extracts of *Hemidesmus indicus* roots and *Vanilla planifolia* pods exhibit, acetylcholinesterase inhibitory activities. Plant foods for human nutrition. 68, 247-253.
24. Kotiloğlu D., Acet T., Özcan K., 2020. Phytochemical profile and biological activity of a therapeutic orchid from Anatolia: *Dactylorhiza romana* subsp. Georgica. Journal of Food Measurement and Characterization. 14(6), 3310-3318.
25. Bose B., Choudhury H., Tandon P., Kumaria S., 2017. Studies on secondary metabolite profiling, anti-inflammatory potential, *in vitro* photoprotective and skin-aging related enzyme inhibitory activities of *Malaxis acuminata*, a threatened orchid of nutraceutical importance. Journal of Photochemistry and Photobiology B: Biology. 173, 686-695.
26. Ali F., Jyoti S., Naz F. , Ashafaq M., Shahid M., Siddique Y.H., 2019. Therapeutic potential of luteolin in transgenic Drosophila model of Alzheimer's disease. Neuroscience letters. 692, 90-99.
27. Asseleih L.M.C., García R.A.M., Cruz J.Y.S.R., 2015. Ethnobotany, pharmacology and chemistry of medicinal orchids from Veracruz. Journal of Agricultural Science and Technology A. 5, 745-754.
28. Prasad G., Seal T., Mao A.A., Vijayan D., Lokho A., 2021. Assessment of clonal fidelity and phytomedicinal potential in micropropagated plants of *Bulbophyllum odoratissimum*-An endangered medicinal orchid of Indo Burma megabiodiversity hotspot. South African Journal of Botany. 141, 487-497.
29. Ghasemzadeh A., Jaafar H.Z., Rahmat A., 2010. Antioxidant activities, total phenolics and flavonoids content in two varieties of Malaysia young ginger (*Zingiber officinale* Roscoe). Molecules. 15(6) 4324-4333.
30. Zhang X., Zhang S., Gao B., Qian Z., Liu J., Wu S., Si J., 2019. Identification and quantitative analysis of phenolic glycosides with antioxidant activity in methanolic extract of *Dendrobium catenatum* flowers and selection of quality control herb-markers. Food Research International. 123, 732-745.
31. Poobathy R., Zakaria R., Murugaiyah V., Subramaniam S., 2018. Autofluorescence study and selected cyanidin quantification in the Jewel orchids *Anoectochilus* sp. and *Ludisia discolor*. Plos one. 13(4), 1-19.
32. Woo K.J., Jeong Y.J., Inoue H., Park J.W., Kwon T.K., 2005. Chrysin suppresses lipopolysaccharide-induced cyclooxygenase-2 expression through the inhibition of nuclear

factor for IL-6 (NF-IL6) DNA-binding activity. FEBS letters. 579(3), 705-711.

33. Sharifi-Rad J., Quispe C., Bouyahya A., Menyiy N.El., Omari N.El., Shahinozzaman M., Calina D., 2022. Ethnobotany, phytochemistry, biological activities, and health-promoting effects of the genus *Bulbophyllum*. Evidence-based Complementary and Alternative Medicine. 1-15.
34. Kuo Y.J., Pei J.K., Chao W.W., 2022. Pharmacological and Chemical Potential of *Spiranthes sinensis* (Orchidaceae): A Narrative Review. Plants. 11(13), 1692.
35. Chuang Y.C., Hung Y.C., Tsai W.C., Chen W.H., Chen H.H., 2018. PbbHLH4 regulates floral monoterpene biosynthesis in *Phalaenopsis* orchids. Journal of experimental botany. 69(18), 4363-4377.
36. Baek Y.S., Ramya M., An H.R., Park P.M., Lee S.Y., Baek N.I., Park P.H., 2019. Volatiles Profile of the floral organs of a new hybrid *Cymbidium*,'Sunny Bell'using headspace solid-phase microextraction gas chromatography-mass spectrometry analysis. Plants. 8(8), 251.
37. Patel S.S., Savjani J.K., 2015. Systematic review of plant steroids as potential antiinflammatory agents: Current status and future perspectives. The journal of phytopharmacology. 4(2), 121-125.
38. Reveglia P., Cimmino A., Masi M., Nocera P., Berova N., Ellestad G., Evidente A., 2018. Pimarane diterpenes: Natural source, stereochemical configuration, and biological activity. Chirality. 30(10), 1115-1134.
39. Kumari P., Panwar S., Soni N., Soni A., 2017. Biosynthesis, composition and sources of floral scent in ornamental crops: a review. Chem Sci Rev Lett. 6(23), 1502-1509.
40. Gaytán V.G., Mendoza M.D.L.N.R., Hernández M.S., Trejo-Téllez L.I., Santos M.E.P., Ponce G.V., 2013. Volatile components in the flower, pedicellate ovary and aqueous residue of *Cymbidium* sp.(ORCHIDACEAE). Journal of Analytical Sciences, Methods and Instrumentation. 3(4), 1-7.
41. Zheng B., Li X., Wang Y., 2023. New Insights into the Mechanism of Spatiotemporal Scent Accumulation in Orchid Flowers. Plants. 12(2), 304.
42. Fu X., Chen S., Xian S., Wu Q., Shi J., Zhou S., 2023. *Dendrobium* and its active ingredients: Emerging role in liver protection. Biomedicine & Pharmacotherapy. 157, 1-13.
43. Wang YH., 2021. Traditional uses and pharmacologically active constituents of *Dendrobium* plants for dermatological disorders: a review. Natural Products and Bioprospecting. 11, 465-487.
44. Rafli M., Rohmiati T., Kinasih A., El Hakim A., Semiarti E., 2022. Potential of *Dendrobium* spp. Secondary Metabolites as Medicinal Source for SARS-CoV-2. 7th International Conference on Biological Science, Atlantis Press. 424-430.
45. Huang S., Wu Q., Liu H., Ling H., He Y., Wang C., Lu Y., 2019. Alkaloids of *Dendrobium nobile* lindl. Altered hepatic lipid homeostasis via regulation of bile acids. Journal of Ethnopharmacology. 241, 1-9.
46. Jakubska A., Przado D., Steininger M., Aniol-Kwiatkowska J., Kadej M., 2005. Why do pollinators become" sluggish"? nectar chemical constituents from *Epipactis helleborine*(L.) Crantz(orchidaceae). Applied Ecology and Environmental Research. 3(2), 29-38.
47. Kaur S., 2022. Phytoalexins in Orchids. Orchids Phytochemistry, Biology and Horticulture. 215-222.
48. Badalamenti N., Russi S., Bruno M., Maresca V., Vaglica A., Ilardi V., Basile A., 2021. Dihydrophenanthrenes from a Sicilian accession of *Himantoglossum robertianum* (Loisel.) P. Delforge showed antioxidant, antimicrobial, and antiproliferative activities. Plants. 10(12), 2776.
49. Manandhar N.P, Plants and people of Nepal, Timber press, 2002.
50. Lozano-Mena G., Sánchez-González M., Juan M.E., Planas J.M., 2014. Maslinic acid, a natural phytoalexin-type triterpene from

olives—a promising nutraceutical. Molecules. 19(8), 11538-11559.
51. Kovács A., Vasas A., Hohmann J., 2008. Natural phenanthrenes and their biological activity. Phytochemistry. 69(5), 1084-1110.
52. Honda C., Yamaki M., 2000. Phenanthrenes from *Dendrobium plicatile*. Phytochemistry. 53(8), 987-990.
53. Hwang J.S., Lee S.A., Hong S., Han X., Lee C., Kang S., Hwang B.Y., 2010. Phenanthrenes from *Dendrobium nobile* and their inhibition of the LPS-induced production of nitric oxide in macrophage RAW 264.7 cells. Bioorganic & medicinal chemistry letters. 20(12), 3785-3787.
54. 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*, Journal of natural products 69(6), 907-913.
55. Bhummaphan N., Petpiroon N., Prakhongcheep O., Sritularak B., Chanvorachote P., 2019. Lusianthridin targeting of lung cancer stem cells via Src-STAT3 suppression. Phytomedicine. 62, 1-18.
56. Pollastro F., Minassi A., Fresu L.G., 2018. *Cannab*is phenolics and their bioactivities. Current medicinal chemistry. 25(10), 1160-1185.
57. Teoh E.S. Orchids as Aphrodisiac, Medicine or Food, Modern Treasure Hunters, Springer, Cham, 2019.
58. Guo X., Wang J., Wang N., Kitanaka S., Liu H.W., Yao X.S., 2006. New stilbenoids from *Pholidota yunnanensis* and their inhibitory effects on nitric oxide production. Chemical and pharmaceutical bulletin. 54(1) 21-25.
59. Thant M., Sritularak B., Chatsumpun N., Mekboonsonglarp W., Punpreuk Y., Likhitwitayawuid K., 2021. Three Novel Biphenanthrene Derivatives and a New Phenylpropanoid Ester from *Aerides multiflora* and Their α-Glucosidase Inhibitory Activity. Plants. 10(2) 385.
60. Wang D., Lin F.X., Tang M.M., Zhou X.M., Yi J.L., Wang T.T., 2021. Two new phenanthrene derivatives from *Pholidota chinensis*. Phytochemistry Letters. 43, 123-125.
61. Zhao R., Zheng S., Li Y., Zhang X., Rao D., Chun Z., Hu Y., 2023. As a novel anticancer candidate, ether extract of *Dendrobium nobile* overstimulates cellular protein biosynthesis to induce cell stress and autophagy. Journal of Applied Biomedicine. 21(1), 1-13.
62. Sut S., Maggi F., Dall'Acqua S., 2017. Bioactive secondary metabolites from orchids (Orchidaceae). Chemistry & biodiversity. 14(11), 1-14.
63. Mata R., Figueroa M., Navarrete A., Rivero-Cruz I., 2019. Chemistry and biology of selected Mexican medicinal plants. Progress in the Chemistry of Organic Natural Products. 108, 1-142.
64. Paraste V.K., Sarsaiya S., Mishra U.C., Sourabh P., 2023. A comprehensive review on global research trends on *Aerides* genus with reference to *Aerides odorata* species. Journal of Applied Biology and Biotechnology. 11(2), 55-62.
65. Apel C., Dumontet V., Lozach O., Meijer L., Guéritte F., Litaudon M., 2012. Phenanthrene derivatives from *Appendicula reflexa* as new CDK1/cyclin B inhibitors. Phytochemistry Letters. 5(4), 814-818.
66. Zhang X., Chen W., Du Y., Su P., Qiu Y., Ning J., Liu M., 2021. Phytochemistry and pharmacological activities of *Arundina graminifolia* (D. Don) Hochr. And other common Orchidaceae medicinal plant. Journal of Ethnopharmacology. 276, 1-25.
67. Gao Y., Jin Y., Yang S., Wu J., Gao X., Hu Q., Ma Y., 2014. A new diphenylethylene from *Arundina graminifolia* and its cytotoxicity. Asian Journal of Chemistry. 26(13), 3903.
68. Liu Q., Wang H., Lin F., Dai R., Lin Yu., Lv F., 2017. Study on the structures and anti-hepatic fibrosis activity of stilbenoids from *Arundina graminifolia* (D. Don) Hoch. IOP Conference Series: Materials Science and Engineering. 274(1), 1-7.
69. Sharifi-Rad J., Quispe C., Bouyahya A., El Menyiy N., Omari El, 2022. Ethnobotany, phytochemistry, biological activities, and

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(1), 2009-2025 | ISSN:2251-6727

health-promoting effects of the genus *Bulbophyllum*. Evidence-Based Complementary and Alternative Medicine. 1-15.

70. Liu X., Li X.P., Yuan Q.Y., 2015. A new biphenanthrene glucoside from *Cremastra appendiculata*. Chemistry of natural compounds. 51, 1035-1037.
71. Wang Y., Guan S. H., Meng S. Y., Zhang Y., Cheng C.R., Shi Y.Y., Guo D., 2013. A: Phenanthrenes, 9, 10-dihydrophenanthrenes, bibenzyls with their derivatives, and malate or tartrate benzyl ester glucosides from tubers of *Cremastra appendiculata*. Phytochemistry. 94, 268-276.
72. Zhao N., Yang G., Zhang Y., Chen L., Chen Y., 2016. A new 9, 10-dihydrophenanthrene from *Dendrobium moniliforme*. Natural product research. 30(2), 174-179.
73. Semiarti E., Purwantoro A., Puspita Sari I., 2020. Biotechnology approaches on characterization, mass propagation, and breeding of Indonesian orchids *Dendrobium lineale* (Rolfe.) and *Vanda tricolor* (Lindl.) with its phytochemistry. Orchids Phytochemistry, Biology and Horticulture: Fundamentals and Applications. 1-14.
74. Wu C.T., Huang K.S., Yang C.H., Chen, J.W. Liao, C.L. Kuo, H.S. Tsay, Inhibitory effects of cultured *Dendrobium tosaense* on atopic dermatitis murine model. International Journal of Pharmaceutics 463(2), 193-200.
75. Virk J., Gupta V., Maithani M., Rawal R.K., Kumar S., Singh S., Bansal P., 2020. Isolation of Sinapic Acid from *Habenaria intermedia* D. Don: A New Chemical Marker for the Identification of Adulteration and Substitution. Current Traditional Medicine. 6(4), 380-387.
76. Bose B., Choudhury H., Tandon P., Kumaria S., 2017. Studies on secondary metabolite profiling, anti-inflammatory potential, *in vitro* photoprotective and skin-aging related enzyme inhibitory activities of *Malaxis acuminata*, a threatened orchid of nutraceutical importance. Journal of Photochemistry and Photobiology B: Biology. 173, 686-695.
77. Sherif I., Al-Mutabagani L.A., Sabry D., 2020. Antineoplastic activity of chrysin against human hepatocellular carcinoma: New insight on GPC3/SULF2 axis and lncRNA-AF085935 expression. International Journal of Molecular Sciences. 21(20), 7642.
78. Teoh E.S. Secondary metabolites of plants. In Medicinal orchids of Asia, 2016.pp. 59-73.
79. Wang J., Wang L., Kitanaka S., 2007. Stilbene and dihydrophenanthrene derivatives from *Pholidota chinensis* and their nitric oxide inhibitory and radical-scavenging activities. Journal of Natural Medicines. 61, 381-386.
80. Moon I., Kim J., Jun J.G., 2015. Syntheses of Phoyunbenes A-D and Thunalbene for their Anti-Inflammatory Evaluation. Bulletin of the Korean Chemical Society. 36(12), 2907-2914.
81. Nag S., Kumaria S., 2018. *In vitro* propagation of medicinally threatened orchid *Vanda coerulea*: An improved method for the production of phytochemicals, antioxidants and phenylalanine ammonia lyase activity. Journal of Pharmacognosy and Phytochemistry. 7(4), 2973-2982.