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Pharmaceutical properties of Orchids

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Abstract
Orchids are one of the largest families of flowering plants which are best-known plant groups in the global horticultural and cut flower trades, including as ornamental plants, medicinal products and food. The medicinal orchids belong mainly to the genera namely *Calanthe*, *Coelogyne*, *Cymbidium*, *Cypipedium*, *Dendrobium*, *Ephemerantha*, *Eria*, *Galeola*, *Gastrodia*, *Gymnadenia*, *Habenaria*, *Ludisia*, *Luisia*, *Nevilia*, *Satirium* and *Thunia*. In the Ayurvedic system of medicine, there is one rejuvenating herbal formulation 'Astavarga' thatis derived from orchid species i.e. jivak (*Microstylis wallichii*), kakoli (*Habenaria acuminata*), riddhi (*H. intermedia*) and vriddhi (*H. edgeworthii*) are orchids.Orchid are packed with phytochemicals such as stilbenoids, anthraquinones, pyrenes, coumarins, flavonoids,anthocyanins and anthocyanidins, chroman derivatives, lignans, simple benzenoid compounds, terpenoids, steroids, alkamines, amino acids, mono- and dipeptides, Alkaloids and higher fatty acids which play vital role for immunity development and curing other critical ailments of individuals.

Keywords: Medicinal orchids, Ayurvedic medicines, phytochemicals, immunity

Introduction
Orchidaceae is the second largest family of flowering plants (~7% of the total flowering plants), although some species of the family risk extinction (Pal, Babu and Dayamma, 2022) [20]. ICAR-National Research Center for Orchids, Sikkim, established in 1996 provides research support to orchid growers in India, preserves orchid germplasm and develops sustainable use of orchid biodiversity. Globally, the largest orchid genera are *Bulbophyllum*, *Epidendrum*, *Dendrobium* and *Pleurothallis* (2000, 1500, 1400 and 1000 species, respectively). Orchids have a wide distribution range in India with ~1350 species belonging to 186 genera occurring in eight orchid habitats. The Northeastern states hold ~876 species in 151 genera contributing 70% of the country's orchid wealth. However, many of these species (~400) are endemic and rare with high ornamental value (Pal *et al*., 2022) [20, 21].
The medicinal value of orchids is recorded in ancient Sanskrit scriptures (~250-300 BC) as remedy for many ailments. Many orchid genera are used in conventional health care system; however, *Eulophia campestrtris*, *Orchis latifolia*, and *Vanda roxburghii* have medicinal properties of interest to the scientific community. Other orchid species (*Habenaria acuminata*, *H. susannae*, *Orchislatifolia*, *Pholidataarticulata* and *Satyrium* species) are consumed as nutritious food in Nagaland. Leaves and new shoots of *Cymbidium* are also used as food by many tribes in Nagaland (Pal *et al*., 2022) [20, 21].
The traditional medicinal system in India uses about 150 orchid species. In tribal or folk medicine, *Geodorum densiflorum* is used to treat ephemeral fever, *Soccolabium papillosum* (*Acampe praemorsa*) for bone fracture and body ache and *Bulbophyllum leopardinum* against sunstroke and diabetes. Fifteen of the 396 orchid species in Nagaland (Northeastern Himalaya state) are used by local practitioners to treat various diseases (rheumatism, cholera, nervous disorder and tuberculosis) as well as antimicrobial agent and antidotes to snake and insect bites (Pal *et al*., 2022) [20, 21]. Terrestrial orchids of the Himalayas (1200-4000 m altitude) are part of the Astavarga group called 'Jeevaka' (strengthens vitality and immunity). These orchids known for their immunomodulating properties are: *Microstylis muscifera* Ridl. (*Malaxis muscifera*), *Habenaria edgeworthii* Hook f. ex Colt (*Platanthera edgeworthii*, and *Habenaria intermedia* (*H. arietina*) (Pal *et al*., 2022) [20, 21].
Till date, 29,199 species have been accepted (Govaerts *et al*., 2017) [4]. One of the best-known plant groups in the global horticultural and cut flower trades, orchids are also grown and traded for various purposes, including as ornamental plants, medicinal products and food. The medicinal orchids belong mainly to the genera: *Calanthe*, *Coelogyne*, *Cymbidium*,

Cypipedium, *Dendrobium*, *Ephemerantha*, *Eria*, *Galeola*, *Gastrodia*, *Gymnadenia*, *Habenaria*, *Ludisia*, *Luisia*, *Nevilia* and *Thunia* (Szlachetko, 2001) [29]. Orchids are commercially used in Chinese and South Asian traditional medicine systems (Leon and Lin, 2017) [18]. The most prominently used orchids in traditional Chinese medicines are various *Dendrobium* spp. used to make the drug shi-hu [particularly *D. catenatum* Lindl. (including *D. officinale* Kimura & Migo), *D. loddigesii* Rolfe, *D. moniliforme* (L.) Sw. and *D. nobile* Lindl.)] (Leon and Lin, 2017; Teoh, 2016) [18, 30]. Besides, *Gastrodia elata* Blume tubers, *Bletilla striata* (Thunb.) Rchb.f.) rhizomes,*Anoectochilus* spp. Rhizomes and stems, *Cremastra appendiculata* (D.Don) Makino, *Pleione bulbocodioides* (Franch.) Rolfe and *P. yunnanensis* (Rolfe) Rolfe corms are all used (Leon and Lin, 2017; Teoh, 2016) [18, 30]. They are also popularly used in some African traditional medicine (e.g. *Vanilla madagascariensis* Rolfe in Madagascar (Randriamiharisoa *et al*., 2015) [26], North American folk medicine (e.g. *Cypripedium acaule* Aiton and *C. parviflorum* Salisb. [6] and the Unani medicine system [e.g. *Dactylorhiza hatagirea* (D.Don) *Soó Vanda tessellata* (Roxb.) Hook.ex G.Don, *Cymbidium bicolor* Lindl. and*Ipsea speciosa* Lindl. (Jayaweera and Fosberg, 1980; Thakur and Dixit, 2007; Khajuria *et al*., 2017) [13, 31, 15].

Uses of Orchids in Ayurvedic Medicine

In Ayurvedic medicine, one rejuvenating herbal formulation 'Astavarga' is derived from a group of 8 herbs and some of these herbs i.e. Jivak (*Microstylis wallichii*), Rishbhaka (*Habenaria acuminata*), riddhi (*H. intermedia*) and vriddhi (*H. edgeworthii*) are orchids (Handa, 1986; Singh and Duggal, 2009) [6, 27]. *Flickingeria macraei* is used in 'Ayurveda' by the name 'Jeevanti' as an astringent agent, aphrodisiac and in the treatment of asthma and bronchitis (Kirtiker and Basu, 1975) [17]. Other commonly used orchid drugs in the Ayurvedic system are salem (*Orchis latifolia* and *Eulophia latifolia*), jewanti (*Dendrobium alpestre*), shwethuli and rasna (*Acampe papillosa* and *Vanda tessellata*). In 'Sushrutasamhita' the underground tuberof *Orchis latifolia* is used in the drug'munjatak' that relieves cough. *Vanda roxburghii l*eaves have been prescribed in the ancient Sanskrit literature for external application to rheumatism, ear infections, fractures and diseases of nervous system. Nepal's Ayurvedic trade has 94 orchid species (Acharya and Rokaya, 2010; Subedi *et al*., 2013) [1, 28], including *Crepidium acuminatum* (D.Don) Szlach., *Habenaria intermedia* D.Don., *Herminium edgeworthii* (Hook.f. ex Collett) X.H.Jin., Schuit., Raskoti & Lu Q.Huang and *Malaxis muscifera* (Lindl.) Kuntze (Hossain, 2009; Dhyani *et al*., 2010; Khajuria *et al*., 2017) [9, 10, 15]. *Eulophia* spp. are also widely used medicinally in different parts of India [*E. dabia* (D.Don) Hochr., *E. spectabilis* Suresh in D.H.Nicolson, C.R.Suresh & K.S.Manilal (E. nuda Lindl.) (Jalal *et al*., 2014) [12] and *D. hatagirea* is used to treat various ailments (Pant and Rinchen, 2012) [23].

In some Malaya regions women boil the leaves of *Nervilia aragoana* and drink the liquid immediately after childbirth as a precaution against possible post natal sickness. *Corymborchis longiflora*, *Tropidia curculigoides* and *Acriopsis javanica* are reported as febrifuges in treating malaria.

Orchids Chemistry

Orchid phytochemicals can be classified as Stilbenoids (stilbene, bibenzyls, phenanthrenes, 9,10-dihydrophenanthrenes, phenanthraquinones, 9,10-dihydrophenanthraquinones, phenanthropyrans and pyrones, 9,10-dihydrophenanthropyrans and pyrones, fluorenones), anthraquinones, pyrenes, coumarins, flavonoids, anthocyanins and anthocyanidins, chroman derivatives, lignans, simple benzenoid compounds, terpenoids (monoterpenes, sesquiterpenes, diterpenes, triterpenes), steroids, alkamines, amino acids, mono- and dipeptides, alkaloids and higher fatty acids. Dendrobium species are known to produce various secondary metabolites such as phenanthrenes, bibenzyls, fluorenones and sesquiterpenes, and alkaloids are responsible for their wide ranging medicinal properties. Besides, a numerous phenanthrenes compounds isolated from Dendrobium species are dihydrophenanthrene, ephemeranthoquionone, shihunidine, shihunine, dendrophenol, moscatilin, moscatin, denfigenin, defuscin, amoenumin, crepaditin, rotundatin, cumulatin, and gigantol. Some other orchid genera like *Eulophia*, *Cypripedium*, *Gastrodia*, *Bletilla*, *Bulbophyllum*, *Anoectochilus*, *Arundina*, *Eria*, *Malaxis*, *Habenaria*, *Vanda*, and *Vanilla* are enriched with different important phytochemicals (Hossan, 2011) [10] (Table 1).

Table 1: Some chemical constituents from orchids

Sl. No	Chemical name	Plant source	Sl. No	Chemical name	Plant source
1.	Aeridin,	*Aerides crispum*	36.	Cypripedin Cryptostylin	*Cypripedium calceolus*, *Cypripedium macranthum*
2.	Agrostophyllin	*Agrostophyllum brevipes*	37.	Defuscin, Dendroflorin, Dengidsin, Kaempferol, Naringenin, Taraxerol	*Dendrobium auranticum var. denneanum*
3.	Annoquinone	*Cypripedium macranthum*	38.	Dendrobine, Denbinobin, Dendrobinobine, Dendroside A, D, E, F, G, Dendronobiloside A, Nobilin D and ENobilone	*Dendrobum nobile*
4.	Arundinin, Isoarundinin-I, II, Arundin	*Arundina graminifolia*	39.	Dendrocandin A, B, C, D, E, F, G, H, I	*Dendrobium candidum*
5.	Batatasin III	*Epidendrum rigidum*	40.	Dendrocrepine	*Dendrobium crepidatum*
6.	Blestrianol A, B, C, Bletilol-A, B, Blestrin A, B, C, D	*Bletilla striata*	41..	Dendrochrysanene, Erianin	*Dendrobium chrysotoxum*
7.	Bulbophythrin A, B, 3,7-Dihydroxy-2-4-6-	*Bulbophyllum odoratissimum*	42.	Dendromoniliside A,B,C, Moniliformin	*Dendrobium monoliforme*

	trimethoxyphenanthrene,				
8.	Callosmin, Imbricatin, Orchinol	*Agrostophyllum callosum*	43..	Dendroprimine, Hygrine	*Dendrobium primulinum*
9.	Calanthoside, Isatin, Indican, Glucoindican	*Calanthe discolor and C. liukiuensis*	44.	Denthyrsin, Denthyrsinone, Denthyrsinine, Denthyrsinol, Hircinol	*Dendrobium thyrsiflorum*
10.	Chysin A Chysin B	*Chysis bractescens*	45.	9,10-Dihydro-2,5-Dihydroxy-3, 4-dimethoxy-phenanthrene, Erianthridin, Fimbrinol A	*Maxillaria densa*
11.	Chrysotobibenzyl Chrysotoxin	*Dendrobium aurantiacum*	46.	2,3-Dimethoxy-9,10-dihydrophenanthrene-4,7-diol	*Epidendrum rigidum*
12.	Cirrhopetalanthin	*Cremastra appendiculata*	47.	Ephemeranthrone, Lonchophylloid A, B, 3-Methylgigantol	*Ephemerantha lonchophylla*
13.	Coelonin, 3,7-Dihydroxy-2,4,8-trimethoxyphenanthrene	*Coelogyne elata*, *Pholidota yunnanensis*	48.	Flaccidin, Flaccidinin, Oxoflaccidin, Isooxoflaccidin	*Coelogyne flaccida*
14.	Coeloginanthrin Coeloginanthridin CombretastatinC-1, Coelogin	*Coelogyne cristata*	49.	Gigantol	*Cymbidium giganteum Epidendrum rigidum*., *Scaphyglottis livida*, *Dendrobium aurantiacum var. denneanum*
15.	Confusarin Coumarin	*Dendrobium aurantiacum*	50.	Gymconopin A, B, D	*Gymnadenia conopsea*
16.	Crepidine, Crepidamine	*Dendrobium crepidatum*	51.	Gymnopusin	*Bulbophyllum gymopus*
17.	Cumulatin Densiflorol A	*Bulbophyllum kwangtungense*	52.	Homoeridictyol, Scoparone, Dendroflorin	*Dendrobium densifiorum*
18.	Isoamoenylin Amoenylin	*Dendrobium amoenum*	53.	Quercetin	*Dendrobium tosaense*
19.	Kuramerine	*Liparis kurameri*	54.	Shihunine, Shihunidine	*Dendrobium loddigesii*
20.	Lusianthridin	*Nidema boothii Lindl*.	55.	Sinensol A, B, C, D, E, F, Spirasineol B, Spiranthol-C, Spiranthoquinone	*Spiranthes sinensis var. amoena*
21.	Malaxin	*Malaxis congesta*	56.	Tristin	*Bulbophyllum triste*, *Dendrobium aurantiacum var. denneanum*
22.	Moscatin, Moscatilin	*Dendrobium moschatum*, *Dendrobium aurantiacum var. denneanum*, *Dendrobium loddiesii*	57.	Thunalbene	*Thunia alba*
23.	N-methylpiperidine	*Vandopsis longicaulis*	58.	Aloifol-I, Cymbinodin-A, B	*Cymbidium aloifolium*
24.	Nudol, Eulophiol	*Eulophia nuda*	59.	Erianin, Erianthridin	*Eria carinata*
25.	Ochrone-A, B Ochrolic acid, Ochrolon	*Coelogyne ochracea*	60.	Pendulin	*Cymbidium pendulum*
26.	Phalaenopsine	*Phalaenopsis mannii*, *Phalaenopsis equestris*, *Phalaenopsis ambilis*	61.	Agrostonin, Agrostonidin,Callosin, Callosumin	*Agrostophyllum callosum*
27.	Pholidotol A, B	*Pholidota chinensis*	62.	Flavanthridin	*Eria flava*
28.	Pieradine	*Dendrobium pierardii*,*Dendrobium aphyllum*	63.	Shancilin, Shanciol C, D, E, Sanjidin A, B	*Pleione bulbocodioides*
29.	Plicatol B	*Dendrobium plicatile*	64.	Flavidin	*Coelogyne flavida*, *Flavidinin*
30.	Parviflorin	*Vanda parviflora*	65.	Benzaldehyde	*Zygopetalum mackayi*
31.	Tessalatin	*Vanda tessellata*	66.	Vanillyl methyl ether Piperidinic acid	*Vanilla planifolia*
32.	Dengibsin, Dengibsinin	*Dendrobium gibsonii*	67.	Cycloartenol	*Catteya sp*
33.	Loroglossin	*Orchis maculata 0. incamata, 0. latifolia*	68.	Parishin, Parishin B,C, Gastrol	*Gastrodia elata*
34.	Kinsenoside	*Anoectochilus formosanus*	69.	Heptacosane, Octacosano	*Vanda roxburghii*
35.	Habenariol	*Habenaria repens*	70.	Kaempferol-7β-D-glucopyranoside, Isorhamnetin-3-O β-D-glucopyranoside, Quercetin	*Anoectochilus roxburghii*

Pharmacological Properties of Orchids

Antimicrobial: *Vanilla planifolia*, *Galeola foliata*, *Cypripedium macranthos var*. *rebunense*, *Spiranthes mauritianum*, *Bletilla striata*

Anti-inflammatory: *Anoectochilus formosanus*, *Gastrodia elata*, *Dendrobium moniliforme*, *Pholidota chinensis*, *Vanda roxburghii*

Anti-oxidant: *Anoectochilus formosanus*, *Anoectochilus roxburghii*, *Dendrobium moniliforme*, *D. nobile*, *Gastrodia elata*.

Antidiabetic: *Anoectochilus formosanus*, *Dendrobium candidum*

Antihepatotoxic: *Anoectochilus formosanus*, *Goodyera* species

Neuroprotective*:* *Coeloglossum viride*, *Gastrodia elata*

Anti-viral: Cymbidium hybrid, *Epipactis helleborine*,*Listera ovata*, *Gastrodia elata*

Antipyretic: *Dendrobium moniliforme*

Anticancer/Anti-tumor*:* *Anoectochilusformosanus*, *Bletillastriata*, *Bulbophyllum kwangtungense*, *Dendrobium chrysanthum*, *Dendrobium fimbriatum*, *Dendrobium nobile*, *Ephemerantha ionchophylla*, *Gastrodia elata*, *Spiranthes australis*, *Bulbophyllum odoratissimum*

Orchids with Immunomodulatory Action

Bletilla striata: Tuber is used to treat tuberculosis and haemorrhage. In China and Japan, it is used in wound healing, ulcers, inflammation, haemostatic and as immunomodulator (He *et al*., 2017) [8].

Corallorhiza maculata: Dried stems are used to restore blood in pneumonia patients in America and Europe (Hossain, 2011) [10].

Corymborchis longiflora: In Malayasia, it is used as febrifuge in treating malaria (Hossain, 2011) [10].

Dactylorhiza hatagirea: Tuber is used in burning sensation during urination, general debility, cough and cold, while decoction of tuber mixed with sugar is used as a drink in tuberculosis and effective against impotency (Panda and Mandal, 2013) [22].

Dendrobium aurantiacum: In China, herb is used as antipyretic, immunomodulatory, anti-ageing and in eye disorders.

Dendrobium candidum: Herb is used to strengthen stomach capacity, promote body fluid; used in the treatment of cataract, throat inflammation and immune boosters (Wang *et al*., 2014) [32].

Dendrobium chrysanthum: Powdered dry leaves are used to treat eye related problems, skin diseases, as immunomodulator and antipyretic (Gutiérrez, 2010) [5].

Dendrobium denudans: In Tibet, Amchi people use the stem for cough, cold, nasal block and tonsillitis. The Nepali folk healers use it as tonic to increase the strength of old people and children (Panda and Mandal, 2013) [22].

Dendrobium nobile: Sesquiterepenes glycosides with alloaromadendrane, emmetin and picrotoxane types aglycones are isolated from stems of *Den*. *nobile*. These compounds show immunomodulatory activity (Ye *et al*., 2002) [33].

Eulophia ochreata: Tubers are used to combat general fatigue, boost immunity, treat constipation, fever, skin diseases, wounds, tumours, boils, sunburns, cuts, injury and abdominal pain.

Habenaria edgeworthii: Leaves and tubers are used in blood and skin diseases, coughs, cold, asthma, leprosy, gout, general debility and as brain tonic and rejuvenator (Jalal *et al*., 2008) [11].

Malaxis muscifera: Powdered bulbs are used in treating male fertility while decoction is used in fever (Panda and Mandal, 2013) [22].

Satyrium nepalense: In Sikkim, tubers are used for reducing cold, cough and fever and mixed with yak ghee, used as aphrodisiac. Plant is used to proper child development and growth (Panda and Mandal, 2013) [22].

Health Benefits

Some compounds isolated from orchids demonstrate their potential physiological benefits. For example, alkaloids, primarily dendrobine from *Dendrobium nobile* stem ethanol (95%) extract improve cognitive deficits, attenuate neuroinflammation and beta amyloid (Aβ) accumulation in Alzeimer's disease (AD) mice model (Li *et al*., 2022) [19]. The alkaloids are potential therapeutic agent to prevent and treat AD since they inhibit LPS-induced NOD-like receptor family 3 ((NLRP3) inflammasome activation, release pro-inflammatory cytokines (IL-1β and IL-8) in the hippocampus and protects neuronal injury and working memory impairment. The alkaloids induce neuroprotection by ameliorating NLRP3-mediated pyroptosis (Li *et al*., 2022) [19].

Paudel *et al*., 2022 [24] listed 36 anticancer compounds isolated from *Dendrobium* species. These compounds are from bibenzyl, phenanthtrene and fluorenone groups. The anticancer mechanism is mediated via inhibition of cancer cell proliferation, apoptosis, induction, metastasis suppression and angiogenesis.

The compound 4,5,4'-trihydroxy-3,3'-dimethoxybibenzyl from *D. ellipsophyllum* is highly cytotoxic on lung cancer cells (H23, H460 and H292) and upregulates tumor repressor protein p53 significantly increasing early and late apoptosis. Erianin isolated from *D. chrysotoxum* induces apoptosis in T47D cells by attenuating Bcl-2 expression and activating caspase signaling as well as suppressing CDKs causing cell cycle arrest. It inhibits HeLa cell growth, induces apoptosis and cell cycle arrest at the G2/M phase and increases Bax and caspase-3 expressions. Gigantol inhibits lung cancer (H292 and H460) cell migration, downregulates Cav-1 and activates Akt and Cdc-42, thereby suppressing filopodia formation. It increases EMT markers including N-cadherin, vimentin and slug causing significant suppression of protein kinase B, extracellular signal-regulated kinase, and Cav-1 survival

pathways. Moscatilin (100 mg/kg) significantly suppresses breast cancer metastasis to the lungs and reduces the number of metastatic lung nodules and lung weight without toxic effects. It also impedes angiogenesis by suppressing the activation of VEGY receptor 2 (Flk-1/KDR) and c-Raf-MEK1/2-ERK1/2 signals. Denbinobin isolated from *D. nobile* and *D. moniliforme* induces human glioblastoma (GBM) cell apoptosis through IκB kinase inactivation, followed by Akt and fork head in rhabdomyosarcoma dephosphorylation and caspase-3-activation signaling cascade. It also induces apoptosis in lung and colorectal cancer via Akt inactivation, Bad activation, mitochondrial dysfunction, apoptosis-inducing factor releasing and DNA damage. It increases tubulin polymerization levels and deregulates Bcr-Ab1 signaling to inhibit human leukemia (K562) cell proliferation (Paudel *et al*., 2022) [24]. Bibenzyl, 4,5,4'-trihydroxy-3-3'-dimethoxybenzyl (TDB), extracted from *Dendrobium ellipsophyllum* inhibits human lung cancer cells by suppressing the AKT/GSK-3β signaling pathway. It also modulates adipocyte differentiation that regulates obesity by limiting G0/G1 phase progression, deactivating the AKT/GSK-3β signaling pathway and attenuating adipogenic regulators. TDB is proposed as a potential therapeutic agent against obesity (Khine *et al*., 2022) [16].

Value Added and Health benefits

Value addition in floriculture increases the economic value and consumer appeal of any floral commodity. In floriculture, value addition is made through genetic changes, processing, or diversification. Orchid is a highly diversified flower crop. Indigenous species of *Aerides*, *Bulbophyllum*, *Calanthe*, *Coelogyne*, *Cymbidium*, *Paphiopedilum*, *Rhyncostylis*, *Renanthera* and *Vanda* are used as breeding materials, dry flowers, potted plants, and herbal medicines for value addition. They are adapted to diversified climate grown both epiphytically and terrestrially. Orchids are grown organically with locally available resources. Many orchids can be grown on rocks and logs for placing in the landscape. A beautiful colour scheme can be developed with Cymbidium and Dendrobium orchids. Orchid hybrids of *Cymbidium*, *Dendrobium*, *Vanda*, *Phalaenopsis*, *Oncidium*, *Cattleya*, *Paphiopedilum*, *Mokara*, *Aranda*, *Renantanda* etc. with different colour and forms are used as cut flowers, floral display and as exhibits.

Tribal people of North-eastern hill region use wild orchids for various folk medicine as orchids are rich in alkaloids, flavonoids, glycosides, carbohydrates, and other phytochemicals. Fragrant orchids like *Aerides multiflorum*, *Aerides odoratum*, *Cattleya maxima*, *Coelogyne cristata*, *Coelogyne ochracea*, *Dendrobium chrysotoxum*, *Lycaste*, *Oncidium spaceolatum*, *Rhyncostylis retusa* and *Zygopetalum intermedium* are delightful in outdoor living areas. Leaves, tubers and pseudobulbs of different species are used for edible purposes. Vanilla- a major spice crop and source of vanillin comes from *Vanilla planifolia*. *Anoectochilus* leaves are used as vegetables in Indonesia and Malayasia. Of *Cymbidium maladimum* and *Dendrobium speciosum* pseudobulbs and *Microtis uniflora* and *Caladenia carnea* tubers are edible. Miniature cymbidiums can be used as value added packed items. Bright flowers of orchid genera like *Dendrobium*, *Cymbidium*, *Paphiopedilum Cattleya*, *Pholidota* etc. can be used for drying. Among orchids, *Cymbidium*, *Dendrobium*and *Phalaenopsis* are excellent for wedding counter-pieces.

Cosmeceutical Applications

Orchids are also used in the cosmetic industry because of their prominent properties to prevent and/or treat skin dryness, skin wrinkles and skin ageing (Kanlayavattanakul & Lourith, 2020). These adverse skin effects are due to oxidants, radicals, inflammatory mediators, enzymes responsible for dryness and skin hyper-pigmentation. Orchids used for astringency or tonic effects are associated with their anti-inflammatory activities that help prevent and/or treat skin dryness and oxidative stress induced cellular inflammatory lesions. Moreover, orchid's antioxidant activities attenuate oxidative stress in dermal cells surplus and overproduction of skin melanin pigments. Some orchid species are already commercialized in cosmetic industry. Some Dendrobium species have stronger inhibitory activities against mushroom tyrosinase than kojic acid (IC_{50} 57-112 vs 152 µg/mL) because of their phenolics and flavonoids contents. The anthocyanin rich ethanol (70%) extract of *Dendrobium Sonia* strongly inhibits collagenase, elastase, and tyrosinase that prevent collagen and elastin degradation occurring in skin dullness. The extract also suppresses cellular melanogenesis; these effects were attributed to the presence of ten phenolics (primarily sinapic and ferulic acids) and three anthocyanin (pelargonidin, cyanidin and keracyanin) constituents. Compounds isolated from Dendrobium denneannum stem exert potent anti-inflammatory effects. These compounds ([phenantheroide] 2,5-dihydro-4-methoxy-phenanthrene, 2-O-β-D-glucopyranoside [cucurbetacin] and 5-methoxy-2,4,7,9S-tetra-hydroxy-9-10-dihydrophenanthrene) suppress iNOS by p38, JNK, MAPK and 1κBα inhibition through the MPKs and NF-κB pathways (Kanlayavattanakul & Lourith, 2020).

Methanol leaf and stem extracts from *Malaxis acuminata* strongly inhibit skin ageing related enzymes (collagenase, elastase, tyrosinase and xanthine oxidase) and protect against UV-B and UV-A radiations *in vitro* with high sun protection factor. The extracts also possess anti-inflammatory activities (5-lipoxygenase and hyalurinidase) with considerable radical scavenging antioxidant activity (Bose *et al*., 2017) [2].

Provital, the Spanish company in Barcelona has developed cultured *Calanthe discolor* (terrestrial orchid native to Japan) stem cell line from a greenhouse plant (Provital, 2018) [25]. Adipocytes derived stem cells (ASCs) have beneficial effects on aging skin cells, primarily on dermal fibroblasts by increasing their antioxidant defense and extracellular matrix protein production and inhibition of metalloproteinase production. Moreover, cell proliferation and migration increases thereby aiding wound healing. Thus, ASCs influence wound healing, skin regeneration and photoaging. *Calanthe discolor* stem cell extract was incubated *in vitro* with human ASCs; orchistem induces the production of growth factors in the ASCs by increasing TGFβ1 production (50%). Orchistem also attenuates the inflammation processes, supports skin regeneration, and invigorates fibroblasts proliferation and migration. Orchistem as an active ingredient suitable for anti-aging products intended to improve skin firmness, reduce sagging, and redefine face contours according to Provital (2018) [25].

Current and Future Perspectives

India is one of the orchid-rich (~1350 species in about 185 genera) countries in the world giving rise to rich biodiversity in several growing/geographical environments. Most species

are ornamental (~200), while 55 species are considered medicinally important. However, orchids have the least production area and the minimum contribution in the turnover of floriculture products estimated at Rs. 500 crore businesses for 73,619 ha of floriculture crops with 34,349 tons of loose flowers and 49,366 cut flowers (Hegde, 2020) [7]. The Government of India has initiated developmental programs to ensure native germplasm conservation and promote sustainable development of the orchid industry through research and development programmes. India produces and registers only about 200 orchid hybrids; however, tissue-culture true-to-type hybrid clones biotechnology approach has been the foremost contributor that can be commercially exploited. Commercial potential of orchids in India has its strength in: rich orchid diversity/germplasm, diverse agroclimatic for orchid growing, technical capacity in growing, propagation, biotechnology and greenhouse technology, cheap labor and high-end increasing consumer market. Weakness of the industry is due to inadequate quantity and quality of planting materials, lack of market-driven approach in plant and flower production, low local hybrid production, inconsistent R&D backup with technical innovations, low production of planting material, inadequate quantity and quality of cut flowers to meet market demands, inadequate training and extension programmes and lack of community involvements (Hegde, 2020) [7].

Pharmacological studies on orchids indicate the immense potential of these plants in treatment of conditions such as neurodegenerative disorders, anticonvulsive, anticancer, antidiabetic, viral diseases, and others. However, gaps in studies carried out are apparent which need to be bridged to exploit full medicinal potential of orchids. Orchids have recently been proved to be a rich storehouse of chemical constituents with promising anti-tumor, anti-cancer and anti-inflammatory activities as revealed in modern biology-based studies. Investigations in progress can identify new biomolecules that confirm usefulness of traditional remedies to develop new therapeutics. Orchid's species have recently been targeted for many investigations related to their chemical, biological, pharmacological, and medical properties. Traditional use of orchids preparation of Yin tonic in the Chinese, Tibetan and Ayurvedic medicine needs to be revised in the light of modern science of health and diseases. It is true that many people of developing countries from rural now prefer traditional medicines over synthetic ones because of mineral side effect, low production cost, easy availability, and wide effectiveness. Meanwhile, consumers in developed countries are becoming disillusioned with modern health systems and are seeking alternatives. Since herbal medicines serve the health needs of about 80% of the world's population, and orchids contain many bioactive phytochemicals can be used as a promising source of medicine.

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