

## REVIEW ARTICLE



# A review on the phytochemical properties of five selected genera of orchids

Lalrosangpuii\*<sup>1</sup> and Lalrokimi<sup>2</sup>

<sup>1</sup>Department of Life Sciences, Pachhunga University College, Aizawl 796001, India

<sup>2</sup>Department of Biotechnology, Mizoram University, Aizawl 796004, India

Orchidaceae family includes some of the most important ornamental plants with medicinal purposes. It is one of the largest groups among the Angiosperms. Even though there are several studies on the medicinal purposes of orchidaceae, lesser is known about the phytochemical compound present in the different parts of the plant. Therefore, in this present review paper five genus from Orchidaceae family has been selected to highlight the important phytochemical compounds present in the orchid plant. The commonly found phytochemicals are alkaloid, flavanoid, phenol, terpenoid, steroid and saponin.

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\*For correspondence:

[lalrosangpuii@gmail.com](mailto:lalrosangpuii@gmail.com)

Contact us:

[sciencevision@outlook.com](mailto:sciencevision@outlook.com)

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## Introduction

Orchids comprises the largest and the most diverse group among the flowering plants.<sup>1</sup> Orchids are generally cultivated for ornamental purposes, but it also happens to have enormous economic importance. The origin of orchids on the earth could be traced back to 120 million years. But the earliest written record was seen on 4<sup>th</sup> millennium B.C. only. In China, orchids have been used as a source of herbal remedies as early as 2800 B.C.<sup>2,3</sup> Whereas in India, some orchids have been used for their curative and aphrodisiac properties since the Vedic period (2000–600 B.C.)<sup>4</sup> Orchid has been mentioned as 'Vanda' in the Indian Vedic scriptures.

There are various types of orchids and is represented by terrestrial, epiphytic and saprophytic species. The occurrence of orchid is worldwide and exhibited different diversity in shape, color, and size of the flowers. They have an aesthetical and

medicinal importance, and are also considered as an ecological indicator.<sup>5</sup> In Europe and Asia orchids are known for its medicinal purposes since ancient times,<sup>6</sup> but lesser was known about its therapeutic use in the New World.<sup>7</sup>

Orchids are popularly known for their aesthetic value but less for their medicinal values. There has been a tremendous research reports recently as medicinal plants, however, orchids are not completely explored for its medicinal applications and pharmacological studies.<sup>8</sup> Among the orchids, the genera *Dendrobium*, *Coelogyne*, *Cymbidium*, *Cypripedium*, *Eria*, *Anoectochilus*, *Calanthe*, *Bulbophyllum*, *Dactylorhiza*, *Habenaria*, *Nevilia*, *Pholidota*, *Galeola*, and *Gastrodia* are mainly considered to have medicinal value. It has been reported that extracts and metabolites from these different plants parts like flowers, stem and leaves

has beneficial pharmacological activities such as diuretic, anti-rheumatic, anti-inflammatory, anti-carcinogenic, hypoglycemic activities, anti-microbial, anti-convulsive, relaxation, neuroprotective and anti-virus activities.<sup>8</sup> A number of chemical compounds such as alkaloids, bibenzyle derivatives, flavonoids, phenanthrenes and terpenoids have been isolated from orchids worldwide. The most common alkaloids extracted include chysine, drobine, dendronine, grandifolin and crepidine.<sup>8</sup> Chemical components of orchid isolated from Europe and Asia has shown significant antimicrobial activity against human pathogens.<sup>6</sup>

There has been a significant scientific report on orchids as medicinal plants with an abundant number of papers published on this specific topic. However lesser number of review papers regarding the phytochemical properties on orchids has been published. For this reason we decided to focus more on the presence of different phytochemical compound by selecting five genus.

## Features of Orchidaceae

The plants under the Orchidaceae family comprises of extensively evolved and widely distributed monocotyledons with a large number of terrestrial, saprophytic and epiphytic species. It comprises of nearly 30,000 species in which falls under about 750 genera.<sup>9</sup> Orchids are of very high aesthetic beauty and therefore account for multi million dollars in cut flower industries in many parts of the world.<sup>10,11</sup> The original home of orchids is believed to be South-East Asian Tropic (Indo-Malaya Regions), where there is high concentration of genera, species and individuals.

## Phytochemicals in Orchids

Phytochemicals are non-nutritive chemical constituents of plants which occur naturally in it, i.e., the chemicals which are derived from plants are called Phytochemicals.<sup>12</sup> The major chemical constituents reported from orchid species are alkaloids, terpenoids, flavonoids, tannins, bibenzyl derivatives, phenanthrenes and stilbenoids. Presence of these phytochemicals provides antimicrobial, antitumor, anti-inflammatory, antiviral activities, etc.

Alkaloids are known to have antipyretic activity,<sup>13</sup> and also have the ability to inhibit the Na<sup>+</sup>-K<sup>+</sup> ATPase activities in kidneys of rats.<sup>14</sup> Flavanoids have been found to have antioxidative properties,<sup>15</sup> Anti platelet aggregation activity,<sup>16</sup> antitumor,<sup>17</sup> and antifungal activities.<sup>18</sup> Terpenoids are involved in sensitization of cells that express multi drug resistance phenotype to the toxicity of anticancer drug doxorubicin<sup>19</sup> and immunomodulatory activity.<sup>20,21</sup> Bibenzyl derivatives have anticancer activities,<sup>22,23,24</sup> anti-aggregation activity,<sup>25</sup> anti-

oxidative and antibacterial activity,<sup>26,27</sup> antiangiogenic activity,<sup>28</sup> spasmolytic activity,<sup>29</sup> anti-tumor activity.<sup>30</sup> Phenanthrenes have also been found to exhibit anti-tumor, anti-fungal, anti-oxidative, anti-aggregation, spasmolytic activity, cytotoxic<sup>31</sup> and anti-inflammatory activities.

## Genus *Liparis*

*Liparis* is a genus that comprises of about 250 members.<sup>32</sup> Among the orchidaceae family, the genus *Liparis* is one of the first to be investigated for the presence of alkaloids. Boorsma (1902) was the first person to report the presence of alkaloids in *L. parviflora*. *Liparis* is not commonly used for medicinal purposes except in China despite the presence of alkaloids in many species.<sup>33</sup>

## *Liparis regnieri*

*Liparis regnieri* is an herbaceous plant from orchidaceae family. It is one of the members of the genus *Liparis*. Its common name is Regnier's *Liparis*. The whole plant is used for extract preparation. The phytochemical studies on *Liparis regnieri* includes phenanthrene glycosides namely nudoglycosides A and B.<sup>34</sup> These phenanthrenes are a great compound for antimicrobial activity. In the same plant Ren *et al.*, 2017 has reported biphenanthrene named liparisbiphenanthrene A and ten new nervogenic acid derivatives namely liparisbenzoate B, liparisbenzoate C, liparisbenzoate D, liparisbenzoate E, liparisbenzoate F, liparisbenzoate G, liparisbenzoate H, liparisenoate A, liparisenoate B, liparisacrylate A, and liparisacrylate B.

## *Liparis nervosa*

A small terrestrial herb no taller than 12 cm, stem is fleshy, erect, sheathed by two plicate, ovate to ovate-elliptical, pointed leaves. It is mainly used for detoxicating and hemostatic functions.<sup>35</sup> Pyrrolizidine-alkaloids which has an antitumor activity has been isolated from *Liparis nervosa*<sup>36</sup>. Huang *et al.*, 2013<sup>37</sup> has also reported five new nervogenic acid derivatives such as 3,5-bis(3-methyl-2-butenyl)-4-O-[[ $\beta$ -D-glucopyranosyl-(1 $\rightarrow$ 4)- $\beta$ -D-glucopyranosyl] ben-zoic acid, 3,5-bis(3-methyl-2-butenyl)-4-O-[[ $\beta$ -D-glucopyranosyl-(1 $\rightarrow$ 2)- $\alpha$ -L-arabinopyranosyl] benzoic acid, 3,5-bis(3-methyl-2-butenyl)-4-O-[[ $\beta$ -D-glucopyranosyl-(1 $\rightarrow$ 2)- $\beta$ -D-glucopyranosyl] benzamide, 3,5-bis(3-methyl-2-butenyl)-4-O-[[ $\beta$ -D-glucopyranosyl-(1 $\rightarrow$ 2)- $\alpha$ -L-arabinopyranosyl] ben-zamide and 3,5-bis(3-methyl-2-butenyl)-4-O-[[ $\beta$ -D-glucopyranosyl-(1 $\rightarrow$ 4)- $\beta$ -D-glucopyranosyl] benzamide. In 2016, the ethanolic extract of the whole plant of *Liparis nervosa* was found to have nervosine VII, nervosine VIII and nervosine IX. These are pyrrolizidine alkaloids and the structures were

extensively elucidated with spectroscopic examination.<sup>38</sup> Three new biphenanthrenes was again isolated from the ethanolic extract of *Liparis nervosa* by bioactivity-guided fractionation. The three new biphenanthrenes includes liparis-phenanthrenes A, liparisphen-anthrenes B and liparisphenanthrenes C. These biphenanthrenes are found to have potent cytotoxic activity against stomach (HGC-27) and colon (HT-29) cancer cell lines.<sup>39</sup> On a study conducted by Song *et al.*, 2013, the butanol extract was found to have new nervogenic acid glycoside where the structure elucidated by extensive spectroscopic measurements was 3, 5-bis (3-methylbut-2-enyl)-4-O-[ $\beta$ -D-xylopyranosyl-(1 $\rightarrow$ 2)- $\beta$ -D-glucopyranosyl]-benzoic acid. It was also found to promote ADP-induced platelet aggregation. From the butanol extract itself Adenosine was isolated for the first time in this plant.

### *Liparis japonica*

*Liparis japonica* is a perennial hermaphrodite plant. It has the effects of promoting blood circulation and stopping bleeding,<sup>40</sup> reducing swelling and relieving pain (Institute of Jilin Traditional Chinese Medicine, 1982), and its whole plant is used in folk remedies for tonsillitis and bruises.<sup>41</sup> From *Liparis japonica* one new lignan glycoside (7R,8S)-9'-acetyl-dihydro-dehydrodiconiferyl alcohol 9-O- $\beta$ -D-xylopyranoside was isolated along with six known lignanoids and four known flavonoids were isolated from the Ethyl alcohol extract of *Liparis japonica*. After elucidating the structures it was proved that the known lignanoids are illiciumlignan D, illiciumlignan F, tetracentronside B, (7R', 8S')-dihydro-dehydrodiconiferyl alcohol 9'-O- $\beta$ -D-xylopyranoside, (-)-dehydrodiconiferyl alcohol, (-)-dihydrodehydrodiconiferyl alcohol, quercetin, quercetin-3-O- $\alpha$ -D-arabinopyranoside, kaempferol-3-O- $\alpha$ -D-arabinopyranoside and dihydroapigenin.<sup>42</sup>

### Genus *Vanda*

The genus *Vanda* is famous for ornamental purposes due to its beautiful flower that it produced. *Vanda* belonging to Orchidaceae family consists of about 73 species. It is widely distributed in Southeast Asia and is most popular especially in India<sup>43</sup>. The name *Vanda* comes from Sanskrit language<sup>44</sup> and the different species of *Vanda* genus are commonly used in the treatment of rheumatic pain, ear infection and nervous system disorders which was mentioned in one of the ancient Sanskrit literature named 'Sushrutasamhita', where it was given under the name of "*Rasna*" in Ayurvedic formulations.<sup>7,45</sup> *Vanda* species are being used in the folk medicine in various part of the Asia, mainly in India, Nepal, China and Bangladesh.<sup>46-48</sup>

### *Vanda coerulea*

*Vanda coerulea* is a monopodial orchid, an epiphytic plant commonly found in the northeastern region of India (Meghalaya, Mizoram, Assam and Manipur) and northern parts of Thailand and Burma. *Vanda coerulea* is primarily used for ornamental as well as horticultural purposes. Apart from its ornamental values, it is also an important ethno botanical plant and used to prepare several traditional medicines, which is due to the presence of several biochemical compounds such as flavidin, coelonin, imbricatin, gigantol, methoxycoelonin, phytosterol<sup>49</sup>. The common name for *Vanda coerulea* is "Blue Vanda of Asia" and "Autumn lady's tresses". Due to habitat destruction, overexploitation, extensive collection, deforestation there is a huge decline of this species from its natural habitat and it has been enlisted as threatened species and included in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).<sup>50</sup> The presence of different phytochemical compound such as alkaloid, carbohydrates, glycoside, phenol,  $\alpha$ -amino acid, saponin, tannin, flavonoid, steroid, terpenoid, reducing sugar and starch was reported from studying the whole plant extract of *Vanda coerulea*.<sup>51</sup> From examining the ethanolic extracts of *Vanda coerulea*, several phytochemical constituents namely methoxycoelonin, imbricatin and gigantol was identified. These constituents were also found to have anti-aging properties.<sup>52</sup> Flavidin and imbricatin were extracted and identified from stems of *Vanda coerulea*. Additionally, two phenanthrene derivatives, coelonin and methoxycoelonin were also reported from the stems of *Vanda coerulea*.<sup>49</sup>

### *Vanda tessellate*

*Vanda tessellate* is an epiphytic perennial plant, and a horticultural and medicinally important orchid. The common name of *Vanda tessellate* is grey orchid. It is commonly found in India and Indo-China. In the study conducted using different solvents extraction of the leaves and flowers, phytochemicals such as alkaloids, anthocyanins, anthraquinones, cardiac glycosides, coumarins, flavonoids, flavones, glycosides, tannins, terpenoids, saponins, phenols and phalobatannin were reported to be present on both the leaves and flowers of *Vanda tessellate*.<sup>53</sup> Petroleum ether extract of leaves of *Vanda tessellate* showed potent 1, 1-diphenyl-2-picrylhydrazyl (DPPH) and nitric oxide (NO) radicals scavenging activities.<sup>54</sup> In another study conducted by Gupta (2016), a new compound named 3-ethoxy-10,17-dimethyltetradecahydro-1H-cyclopenta[a]phenanthren-17(2H)-one, was isolated from *Vanda tessellate* which showed potent antibacterial activity against *B. subtilis*, *E. coli* and *Proteus mirabilis*. Another phenanthropyran derivative such as,

tessallatin from the whole plant of *Vanda tessellate* was identified.<sup>55</sup> Additionally, from the whole plant of *Vanda tessellate* a phenanthropyron derivative which was named as oxo-tessallatin was extracted and identified.<sup>56</sup>

### *Vanda teres*

Simmler *et al.*, 2011<sup>57</sup> has isolated and identified three new derivatives of glucopyranosyloxybenzyleucomate, i.e., vandateroside I-III along with eucomic acid from *Vanda teres* stem for their anti-aging effects in immortalized keratinocyte cellline of human origin (HaCaT). Similarly, Vandaterosides which are eucomate derivatives were isolated from different solvent fraction prepared from *Vanda teres* extract.<sup>58</sup> In another study conducted using three solvents namely Petroleum ether, ethanol and methanol of plant extraction, it was found that in petroleum ether extract alkaloid, saponin and tannin were present, and in ethanolic extract alkaloid, steroid, saponin and tannin were found to be present whereas in the methanolic extract alkaloid, reducing sugars, flavonoid, steroid, saponin and tannin were present.<sup>59</sup>

### Genus *Bulbophyllum*

The genus *Bulbophyllum* is one of the largest genera of the Orchidaceae family consisting of about 1000 species. *Bulbophyllum* are mostly found in Asia, America and Africa. There are 100 species in India.<sup>60</sup> The generic name *Bulbophyllum* is derived from the Greek words *bulbo* (bulb) and *phyllon* (leaf). The plant maybe perennial, epiphytic or lithophytic herbs, rhizome may or not may not be present. Pseudobulbs is present on the rhizome and could be distant or clustered.

### *Bulbophyllum neilgherrense*

*Bulbophyllum neilgherrense* is an epiphytic monocot of Orchidaceae family. It is abundantly contained in the Western Ghats region.<sup>61</sup> It is endemic to South India mainly in the forest of Kerala, Karnataka and Tamil Nadu. The distinct characteristic of the plant is the presence of green, angled pseudobulb, which is a solid bulbous enlargement of the stem to preserve water and nutrients. Pseudobulbs in this orchid are 4 cm long and 2 cm across, smooth, green and four angled. Different phytochemical compounds such as alkaloids, tannins, phenols, flavonoids, steroids, saponin glycosides and reducing sugar were found in pseudobulb extract, additionally, a flavonoid known as Chrysin which was detected in the methanolic extract of the pseudobulb was found to have anti hyperlipidemic and anti-inflammatory activity<sup>62</sup>. The same author has also found the

presence of alkaloids, tannins and phenols in the methanolic extract of the leaf, stem and root of *B. neilgherrense*. Simultaneously the water extract of leaf has also showed reducing sugars and saponin glycoside.<sup>62</sup>

### *Bulbophyllum odoratissimum*

*Bulbophyllum odoratissimum* is an epiphyte belonging to Orchidaceae family. It is commonly found in Asian countries such as China, India, Nepal, Burma, Bhutan, Thailand, Laos and Vietnam, it is widely used as folk medicine to treat tuberculosis, chronic inflammation and fracture.<sup>63,64</sup> Lin *et al.*,<sup>74</sup> have discovered three new Dihydrostilbenes from the whole plant of *B. odoratissimum* which was having a significant cytotoxicity toward human cancer cell lines. A new compound known as Bulbophyllinoside was discovered in the whole plant investigation of *B. odoratissimum*.<sup>39</sup> A new phenanthraquinone named bulbophyllanthrone was isolated from *B. odoratissimum* along with known flavonoids chrysin and pinobanksin.<sup>65</sup> From the investigation of the whole plant of *B. odoratissimum* the following compounds were isolated moscatin, coelonin, densiflorol B, gigantol, batatasin III, tristin and two simple aromatic compounds namely vanillic acid and syringaldehyde.<sup>36</sup>

### *Bulbophyllum vaginatum*

*Bulbophyllum vaginatum* is commonly known as The Vagina. It is commonly found in Malaysia, Thailand, Java and Borneo. *Bulbophyllum vaginatum* collected from Singapore was found to have biphenanthrene and phenanthrene [4, 3-b] furan derivative. These compounds were found from the whole plant study of *Bulbophyllum vaginatum*.<sup>66</sup> Two new phenanthrenes (4,9-dimethoxyphen-anthrene-2,5-diol and 4,6-dimethoxyphen-anthrene-2,3,7-triol) and two new 9,10-dihydrophenanthrenes (4-methoxy-9,10-dihydrophenanthrene-2,3,7-triol and 4,6-dimethoxy-9,10-dihydrophenanthrene-2,3,7-triol).<sup>67</sup> Later continuing the studies two new phenanthrenes (4-methoxyphenanthrene-2,3,7-triol and 4-methoxyphenanthrene-2,3,6,7-tetrol) and two new 9,10- dihydrophenanthrenes (5-methoxy-9,10-dihydrophenanthrene-2,3,7-triol and 4-methoxy-9,10-dihydrophenanthrene-2,3,6,7-tetrol) were isolated from the dichloromethane extract of *Bulbophyllum vaginatum*.<sup>67</sup>

### Genus *Acampe*

*Acampe* is a genus of monopodial, epiphytic vandaceous species of orchids, distributed from tropical Asia from India, China, Malaysia, Philippines as well as Africa and Madagascar. They have thick, leathery, distichous leaves. They are large in size but



have rather small flowers, and this is the reason they are rarely cultivated. Eight different species are recognized under this genus.

### *Acampe praemorsa* (Roxb)

*Acampe praemorsa* is an epiphytic wild orchid. It is a robust plant with stout stem, covered by sheathing bases of leaves, with persisting old inflorescence axis and long stout aerial roots among the leaves. The flowers are dense, not wide openings, yellowish in colour and have a mild sweet smell. The phytochemical study of *Acampe praemorsa* (Roxb) showed the presence of alkaloid, flavanoid, phenol, terpenoid and steroid constituents. The aqueous extract showed the presence of saponin, phenol, terpenoid, tannin and glycoside. The ethanolic extract further revealed saponin, phenol, terpenoid, tannin and steroid. However, silver nitrate extract revealed the presence of terpenoid, tannin and steroid constituents.<sup>68</sup> Cyanogenic glycosides and flavonoids have also been reported from the phytochemical studies of *Acampe praemorsa*.<sup>69</sup> Praemorsin, a newly recorded phenanthropyran was isolated from the whole plant of *A.praemorsa*.<sup>70</sup> Two compounds, namely flavidin and flavidin in have also been isolated from this orchid. The petroleum ether extract of *Acampe praemorsa* leaf showed significant activity against *E. coli* and the methanolic extract showed good zone of inhibition against the bacterium, *Klebsiella pneumonia*.<sup>71</sup> The ethyl acetate extract showed good antibacterial activities against *Lactobacillus acidophilus*, *Klebsiella pneumonia*, *Escherichia coli* and *Enterococcus faecalis*.<sup>71</sup> Antifungal activity against *Candida albicans* is also exhibited by the methanolic and ethyl acetate extracts of *Acampe praemorsa*. In vitro cytotoxic potential of ethyl acetate extract of *Acampe praemorsa* is also found to be very significant against the HeLa and MCF-7 cell lines.<sup>71</sup>

### *Acampe papillosa* (Lindl.) Lindl

*Acampe papillosa* is an epiphytic orchid native to the Himalayas. This plant produces small, strongly fragrant, long lasting flowers which are present near the axils of the leaf. Akter *et al.*<sup>73</sup> screened the plant for phytochemicals and found that the leaf extract of the plant contained a sufficient amount of alkaloids. Secondary metabolites like glycosides, flavonoids, tannins, terpenoids, steroids, quinine and coumarin were also found to be sufficiently present and is therefore considered as a very potent medicinal orchid. Both the water and acetone extracts of *Acampe papillosa* showed good antibacterial property when tested against the non-resistant (MTCC), Ampicillin resistant and Kanamycin resistant strains of *E. coli*.<sup>72</sup>

### *Acampe ochracea* (Lindl.) Hochr

*Acampe ochracea* is an epiphytic orchid native to India, Bangladesh, Sri Lanka, Cambodia, Laos, Myanmar, Thailand, Malaysia and Vietnam. The water and acetone extracts of *A. ochraceae* showed good antibacterial activity against non-resistant strain, ampicillin resistant strain and kanamycin resistant strains of *E. coli* with the water extract showing maximum zone of inhibition against kanamycin resistant strain cultured in kanamycin suspended LB agar.<sup>72</sup>

### Genus *Aerides*

This genus is native to the tropics of Asia, India, Nepal, Southern China, Southeast Asia, Philippines and New Guinea. They are monopodial epiphytic plants with waxy flowers which are usually white with purple or pink edges.

### *Aerides odoratum* Lour.

Phytochemical screening of the leaf extracts of *A. odoratum* was found to contain secondary metabolites like glycosides, flavonoids, tannins, terpenoids, steroids, quinine, coumarin. Lower presence of saponins and anthroquinone was observed. Phlobatannin test indicated its absence in *Aerides odoratum*. The qualitative test for alkaloids from the leaf extract of *A. Odoratum* showed high presence of alkaloids in Dragendorff's reagent, Hager's reagent, Wagner's reagent and in Tannic acid reagent<sup>73</sup>. The water and acetone extracts of *Aerides odoratum* showed good antibacterial efficacy against three strains of *E. coli* i.e., the ampicillin resistant variety, the kanamycin resistant variety and the non-resistant varieties.<sup>75</sup> Jhansi & Khasim<sup>71</sup> studied the antibacterial and antifungal activities of *A. odoratum* in terms of zone of inhibition of their growth. The ethyl acetate extract in comparison with the methanolic extract was found to be more active against *Lactobacillus acidophilus* with an inhibition zone of 17 mm. It also showed good efficacy against *Bacillus megaterium*, *Escherichiacoli*, *Enterococcus faecalis* and *Proteus vulgaris*. *A. odorata* also showed good antifungal activity with an inhibition zone of 14 mm against *Candida albicans*. Methanolic extract of *Aerides odorata* showed a very significant *In vitro* cytotoxicity against MCF-7 cell lines and was found to suppress more cell proliferation in comparison with the HeLa cell line.<sup>71</sup>

### *Aerides crispum*

Aeridin, a new natural compound which is a phenanthropyran derivative was isolated from *Aerides crispum*. Its structure was expounded as 2,7-dihydroxy-1,3-dimethoxy-9,10-dihydroxyphenan-

thropyran.<sup>55</sup>

## Conclusion

The present study deals with the study of five genus from Orchidaceae family and concludes that besides having several beneficiary health effects and pharmaceutical activities, Orchidaceae family has several active phytochemical compounds which are present in different parts of the plant. These compounds indicate their potential use in pharmaceutical development. Although, India is blessed with the presence of a several different species of orchid, some of them are at the verge of extinction. So, this review helps us to gain the importance of conserving the orchid from extinction by mentioning some of the important phytochemical compounds present in various genus of Orchidaceae family. Hopefully in the future we will be able to utilise these phytochemical compounds for the discovery of medicinal drugs.

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