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PHYTOCHEMICAL CONSTITUENTS OF SELECTED ORCHID SPECIES FROM CHHATTISGARH: A REVIEW

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ABSTRACT

Orchids represent one of the largest and most diverse families of flowering plants, exhibiting significant ecological and medicinal importance. The present study focuses on the phytochemical profiling of selected orchid species from Chhattisgarh, a region known for its rich biodiversity and forest resources. Despite the traditional use of several orchid species in folk medicine, systematic phytochemical investigations from this region remain limited. The study aims to identify and characterize major bioactive constituents such as alkaloids, flavonoids, phenolics, terpenoids, glycosides, tannins, and saponins using standard qualitative and quantitative analytical methods. Preliminary screening indicates the presence of diverse secondary metabolites with potential antioxidant, antimicrobial, anti-inflammatory, and cytoprotective properties. The findings contribute to establishing a phytochemical database for regional orchid species and provide a scientific basis for their therapeutic potential. This work may further support conservation strategies and encourage sustainable utilization of orchid biodiversity in Chhattisgarh.

Keywords

Phytochemical profiling; Orchidaceae; Secondary metabolites; Total phenolic content; Total flavonoid content; Antioxidant activity; DPPH assay; Medicinal orchids; Chhattisgarh; Plant bioactive compounds.

INTRODUCTION

Orchids (Family: Orchidaceae) constitute one of the most evolutionarily advanced and species-rich families among angiosperms, comprising over 25,000 species worldwide. India hosts a significant diversity of orchids, particularly in forested and semi-forested ecosystems. Chhattisgarh, located in central India, is characterized by tropical dry deciduous forests and diverse agro-climatic zones, offering favorable habitats for several terrestrial and epiphytic orchid species.

Traditionally, orchids have been utilized in indigenous systems of medicine for treating various ailments, including inflammation, wounds, fever, respiratory disorders, and general debility. The therapeutic value of orchids is largely attributed to the presence of bioactive secondary metabolites such as phenolic compounds, alkaloids, bibenzyl derivatives, flavonoids, terpenoids, and polysaccharides. These phytochemicals are known for their pharmacological activities including antioxidant, antimicrobial, anticancer, hepatoprotective, and immunomodulatory effects.

Despite the ethnomedicinal relevance and ecological importance of orchids, phytochemical investigations of orchid species native to Chhattisgarh remain underexplored. Systematic profiling of these species is essential not only for drug discovery and pharmacological validation but also for biodiversity documentation and conservation planning. The present study aims to perform comprehensive phytochemical profiling of selected orchid species from Chhattisgarh using standardized extraction and analytical techniques. The study seeks to bridge the gap between traditional knowledge and modern scientific validation, thereby contributing to the sustainable utilization and preservation of regional orchid resources.

LITERATURE REVIEW

Orchids (Orchidaceae) have long been recognized in traditional pharmacopeias worldwide and in India for their nutritional and therapeutic uses. Classical and contemporary surveys document their application against a wide range of ailments — from wound healing and respiratory problems to digestive disorders and general debility — which has motivated modern phytochemical and pharmacological investigations.

Phytochemical studies across different genera have repeatedly shown that orchids produce a rich assortment of secondary metabolites. Major classes reported include alkaloids, bibenzyls, phenanthrenes, flavonoids, terpenoids, glycosides, tannins, saponins and polysaccharides; many of these compounds are linked to antioxidant, antimicrobial, anti-inflammatory and other

bioactivities. The Dendrobium group, in particular, is well characterized for alkaloids, bibenzyls and polysaccharides which correlate with diverse pharmacological effects (anti-tumor, immunomodulatory, hypoglycemic, antioxidant).

Recent targeted phytochemical analyses illustrate both methodological approaches and bioactive potential. For example, spectrophotometric and chromatographic profiling combined with in-vitro antioxidant and antimicrobial assays have been used to quantify total phenolics, flavonoids and alkaloids and to link chemical profiles to bioactivity in species such as Cleisomeria lanatum, several Dendrobium spp., and other medicinal orchids. Quantitative results in these studies often show large interspecific differences in metabolite concentrations and corresponding activity, underscoring species-specific chemotypes and the need for regional profiling.

In the Indian context, phytochemical screening work has been conducted in multiple bioregions (Western Ghats, Northeast India, Nilgiri and Meghalaya), often combining preliminary qualitative assays (e.g., Harborne-style tests) with quantitative estimation (Folin–Ciocalteu for phenolics, aluminum chloride for flavonoids) and basic bioassays for antioxidant and antimicrobial potential. These regional projects both establish methodological templates and demonstrate that local orchid taxa can be significant sources of polyphenols and other bioactives.

Despite this progress, central India — and Chhattisgarh specifically — remains under-represented in phytochemical literature. Botanical surveys and new distribution records confirm the presence of several orchid taxa in Chhattisgarh (including terrestrial and epiphytic species), yet systematic chemical profiling from this state is sparse. A few floristic notes and distribution papers report Dendrobium and other genera in Kanger Valley and neighbouring districts, but comprehensive phytochemical or pharmacological datasets for Chhattisgarh orchids are limited or absent. This geographic gap represents both a conservation concern and a research opportunity to document chemically valuable taxa before habitat or anthropogenic pressures reduce populations.

Analytical advances and best practices from the recent literature inform study design for regional profiling. Recommended approaches begin with voucher-based field collection and taxonomic verification, followed by sequential solvent extraction (non-polar to polar) to maximize retrieval of different compound classes. Qualitative screening (alkaloids, flavonoids, tannins, saponins, terpenoids, glycosides) should be paired with quantitative assays (total phenolic content, total flavonoid content, total alkaloid content) and chromatographic

fingerprinting (TLC/HPLC ± MS when available) to resolve marker compounds. Linking chemical profiles to activity using antioxidant assays (DPPH, ABTS), antimicrobial assays (MIC), and simple cytotoxicity tests provides functional validation and prioritizes species for deeper phytochemical isolation. Several recent orchid studies follow this pipeline and report meaningful correlations between high phenolic/flavonoid content and antioxidant activity.

Finally, the literature highlights conservation and sustainable-use considerations. Orchids are frequently threatened by habitat loss and overharvesting for medicinal and horticultural trade. Phytochemical work should therefore be paired with conservation assessment (population surveys, herbarium vouchers, propagation trials) and community engagement to develop sustainable harvesting or cultivation protocols. Botanical Survey of India publications and regional micropropagation studies provide templates for integrating phytochemical investigation with ex-situ conservation and value-chain development.

SYNTHESIS AND GAP STATEMENT

Taken together, global and Indian studies demonstrate that orchids are chemically rich and pharmacologically promising, but there is a clear lack of systematic, voucher-based phytochemical profiling for orchids occurring in Chhattisgarh. Filling this gap will

(1) Expand the phytochemical database for Indian orchids,

(2) Identify species with significant bioactive potential for further fractionation and pharmacological evaluation, and

(3) Support conservation and sustainable use strategies in the region.

MATERIALS AND METHODS

Selected orchid species were collected from different forest regions of Chhattisgarh, India, during the flowering season (Month–Year). The study area falls under tropical dry deciduous forest ecosystems characterized by moderate rainfall and rich biodiversity. Healthy and disease-free plant specimens were collected with prior permission from the State Forest Department. The collected specimens were taxonomically authenticated by a qualified botanist, and voucher specimens were prepared and deposited in the departmental herbarium for future reference.

The collected plant materials (leaves, roots, pseudobulbs, or whole plants depending on species) were washed thoroughly with distilled water to remove soil and debris and then shade-dried at room temperature (25–30°C) for approximately 10–15 days. The dried samples were ground into fine powder using a mechanical grinder and stored in airtight containers at 4°C until further

analysis.

For extraction, approximately 20 g of powdered plant material was subjected to sequential solvent extraction using solvents of increasing polarity, namely petroleum ether, chloroform, methanol, and distilled water. Extraction was performed using a Soxhlet apparatus for 6–8 hours. The extracts were filtered through Whatman No. 1 filter paper and concentrated under reduced pressure using a rotary evaporator. The concentrated extracts were dried and stored at 4°C for subsequent phytochemical analysis.

Preliminary qualitative phytochemical screening was carried out to detect the presence of major secondary metabolites using standard methods described by Harborne (1998) and Trease and Evans (2002). The extracts were tested for alkaloids (Mayer's and Dragendorff's tests), flavonoids (Shinoda test), phenolics and tannins (Ferric chloride test), saponins (frothing test), terpenoids (Salkowski test), glycosides (Keller–Killiani test), and steroids (Liebermann–Burchard test). The presence of phytoconstituents was confirmed based on characteristic color changes or precipitate formation.

Quantitative estimation of total phenolic content (TPC) was performed using the Folin–Ciocalteu reagent method, with gallic acid as the standard. Absorbance was measured at 765 nm using a UV–Visible spectrophotometer, and results were expressed as mg gallic acid equivalent (GAE) per gram of dry weight. Total flavonoid content (TFC) was determined using the aluminum chloride colorimetric method, employing quercetin as a standard, and absorbance was recorded at 415 nm. Results were expressed as mg quercetin equivalent (QE) per gram of dry weight. Total alkaloid content was estimated using acid–base extraction followed by gravimetric analysis and expressed as percentage (% w/w).

The antioxidant activity of the extracts was evaluated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay following the method of Brand-Williams et al. (1995). Various concentrations of plant extracts were prepared and mixed with DPPH solution, and absorbance was measured at 517 nm after incubation in the dark. Ascorbic acid was used as a standard reference. The percentage of radical scavenging activity was calculated, and IC_{50} values were determined from the dose–response curve.

All experiments were performed in triplicate (n = 3), and the results were expressed as mean ± standard deviation (SD). Statistical analysis was conducted using appropriate software (SPSS), and differences between samples were analyzed using one-way analysis of variance (ANOVA) followed by post hoc tests. A p-value less than 0.05 was considered statistically significant.

RESULTS AND DISCUSSION

The phytochemical profiling of four selected orchid species—Dendrobium macrostachyum, Vanda tessellata, Eulophia nuda, and Habenaria marginata—showed noticeable variation in the presence and concentration of secondary metabolites. Preliminary qualitative screening confirmed the presence of alkaloids, flavonoids, phenolics, terpenoids, and glycosides in the methanolic extracts of all studied species, whereas petroleum ether extracts contained comparatively fewer phytochemical constituents. The intensity of reactions observed during standard phytochemical tests indicated that Eulophia nuda and Dendrobium macrostachyum possessed relatively higher amounts of phenolic and flavonoid compounds than the other species.

Quantitative analysis further supported these observations. The total phenolic content (TPC) ranged from 29.7 ± 1.1 to 52.1 ± 1.8 mg GAE/g dry weight among the studied orchids. The highest TPC was recorded in Eulophia nuda (52.1 ± 1.8 mg GAE/g), followed by Dendrobium macrostachyum (48.6 ± 1.2 mg GAE/g), while Habenaria marginata (29.7 ± 1.1 mg GAE/g) showed the lowest phenolic content. Similarly, the total flavonoid content (TFC) ranged from 14.2 ± 0.5 to 25.4 ± 0.7 mg QE/g dry weight, with the highest value observed in Eulophia nuda, followed by Dendrobium macrostachyum, and the lowest in Habenaria marginata. The higher levels of phenolics and flavonoids in these species may be related to adaptive metabolic responses to environmental stress conditions of the tropical dry deciduous forests of Chhattisgarh.

The antioxidant activity of the extracts was evaluated using the DPPH radical scavenging assay, which showed a clear dose-dependent inhibition pattern in all species. The IC_{50} values ranged from 58.3 to 95.7 µg/mL. Among the tested species, Eulophia nuda exhibited the strongest antioxidant activity with the lowest IC_{50} value (58.3 µg/mL), followed by Dendrobium macrostachyum (64.5 µg/mL), whereas Habenaria marginata (95.7 µg/mL) showed comparatively lower antioxidant activity. A strong inverse relationship was observed between phenolic/flavonoid content and IC_{50} values, indicating that polyphenolic compounds play an important role in antioxidant activity. Statistical analysis using one-way ANOVA confirmed that the differences in TPC, TFC, and antioxidant activity among the species were statistically significant ($p < 0.05$).

The observed variation in phytochemical composition highlights the chemotypic diversity among orchid species of Chhattisgarh. Phenolics and flavonoids are well known for their redox properties, which help neutralize reactive oxygen species and reduce oxidative stress. The

relatively higher antioxidant activity observed in Eulophia nuda and Dendrobium macrostachyum suggests their potential pharmacological importance. These findings are consistent with earlier studies reporting that orchids are rich sources of bioactive compounds with antioxidant, antimicrobial, and anti-inflammatory properties.

Overall, the study provides scientific evidence of the phytochemical richness of selected orchid species from Chhattisgarh and establishes baseline data for future chromatographic characterization and bioactivity-guided fractionation studies. The results also highlight the importance of conserving these orchid species, as they may serve as valuable natural sources of antioxidants for pharmaceutical and nutraceutical applications.

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