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Amarkand: A comprehensive review on its ethnopharmacology, nutritional aspects, and taxonomy

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ABSTRACT

In India, the term "*Amarkand*" is commonly used for around 30 different plant species belonging to genus *Eulophia* (Orchidaceae). This single local name *Amarkand* to different taxonomical species creates uncertainty about its ethnomedical and nutritional claims. In the present article, we have reviewed available literature regarding ethnopharmacology, phytochemistry, taxonomy, nutritional, and pharmacological studies of different *Amarkand* species. The literature was searched using Google Scholar, PubMed, Scopus, and Web of Science databases. Some textbooks and reference books were also used to collect information about traditional and ethnopharmacological records. *Amarkand* species have been used as a remedy for the treatment of various diseases such as diarrhea, stomach pain, rheumatoid arthritis, cancer, asthma, bronchitis, sexual impotency, tuberculosis, and so on. Nutritionally, *Amarkand* is considered as an excellent food for children and convalescents. Recent studies confirm antioxidant, anti-inflammatory, anti-diarrheal, and so forth activities to *Amarkand* species. These species are reported to possess various phytoconstituents such as flavonoids, terpenoids, and phenanthrene derivatives. The present review will help to understand overall ethnopharmacology, nutritional aspects, and taxonomy of *Amarkand* species.

KEY WORDS: *Amarkand*, ethnobotanical uses, pharmacology, phytochemistry

INTRODUCTION

Traditional medicines with therapeutic utility have been used since antiquity and are still contributing a significant role in the primary health-care system. It is estimated that 70-80% of the world's population relies on traditional herbal medicines for their primary health care [1]. Parallel to traditional medicines, several ethnobotanical medicinal plants have also been validated for their therapeutic efficacy with the help of modern scientific tests. Some of these ethnobotanical plants are receiving merits as both food and medicine [2], and *Amarkand* is one of the best examples of this.

The word *Amarkand* is composed of two different words "*Amar*" means immortal and "*kand*" stands for tubers. The word *Amarkand* is commonly used for 30 closely related plant species from genus *Eulophia* (Orchidaceae) and for one species from the genus *Dioscorea* (*Dioscorea bulbifera*, family: Dioscoreaceae). Since ancient times, *Amarkand* is believed to be an excellent health-promoting agent. Rizhomes/tubers of *Amarkand* are routinely consumed by the tribal parts of India as food as well as a therapeutic entity for better health and longevity [2-4]. In Ayurvedic medicine, *Amarkand* is generally prescribed as expectorant, anabolic, tonic, diuretic, astringent, digestive, and soft purgative [5]. Moreover, the usefulness of these species for the treatment of ear discharge, blood clotting, joint edema, and debility has also been highlighted in some ancient texts [5]. However, this single local name, *Amarkand* to different taxonomical species creates confusion about its ethnomedical and nutritional claims. In the present article, we have reviewed

the available literature regarding ancient therapeutic claims and recent chemical and pharmacological studies about Indian *Eulophia* species so as to link their ethnobotanical applications with recent scientific advances.

DISTRIBUTION

Genus *Eulophia* is highly diverse, occurs in a wide range of habitats, and belongs to family Orchidaceae. This plant produces two shoots, reproductive and vegetative, from their underground tubers. The genus *Eulophia* has a wide distribution and comprises over 230 species, which are widespread from tropical and Southern Africa, Madagascar and from neotropics to throughout tropical and subtropical parts of Asia and Australia. Among these, one species occurs in tropical America. In India, this genus is particularly distributed in tropical Himalaya and Deccan peninsula region. There are almost 723 records under *Eulophia* in International Plant Name Index. However, 500 are synonyms and many of them are ornamental [6]. Web of Science and Scopus showed about 247 and 80 documents, respectively, under the keyword "*Eulophia*" till October 2015.

Around 28 species are recorded from all over India, out of these, 20 species have medicinal importance. The medicinal properties of these species are documented in Table 1 [7-13]. *Eulophia* species are used for several therapeutic purposes in different parts of India [14]. *Amarkand* is the most prevailing name to all *Eulophia* species in India, however, these species are also known by several vernacular names such as *Balakand*, *Manakand*, *Munjatak*, *Amrita* (Sanskrit), *Ambarkand*, *Salam* (Hindi), *Budbar* (Bengali), *Salab* (Gujrati), *Amarkand, and Salibmisri* (Marathi).

MORPHOLOGY

Species under genus *Eulophia* are terrestrial herbs, autotrophic, or rarely heteromycotrophic [Figure 1a]. Perennating organs may be pseudobulbs or tuber like. These pseudobulbs are subterranean or born above ground, corm like, tuberous or rhizomatous, usually with several nodes and slender or thick fibrous roots at the base. *Eulophia* develops a chain of underground tubers [Figure 1b]. Leaves appear at or after anthesis, which are thin but tough, narrow, and grass like or lanceolate and plicate and are one to many, basal and having

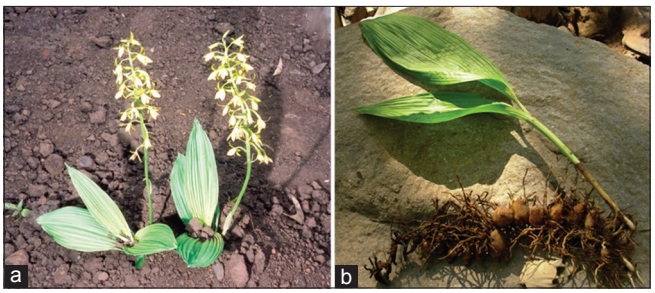

Figure 1: Representative photograph of (a) whole plant of *Eulophia* species and (b) chain of underground tubers of *Eulophia* species

Table 1: Distribution of *Eulophia* species throughout India

Species name	Synonymous	States*
Eulophia andamanensis Rchb. f.	-	Andaman and Nicobar
Eulophia bicallosa (D. Don.) Summerh.	-	Arunachal Pradesh
Eulophia dabia (D. Don.) Hochr.	*Eulophia campestris*	Arunachal Pradesh, Maharashtra
Eulophia densiflora Lindl.	-	Arunachal Pradesh, Assam
Eulophia dufossei Guillaumin.	-	Bihar
Eulophia epidendraea (J. Koenig ex. Retz.) C.E. C. Fisch.	-	Maharashtra
Eulophia explanata Lindl.	-	Gujarat, Goa
Eulophia flava (Lindl.) Hook. f.	-	Arunachal Pradesh, Himachal Pradesh
Eulophia graminae Lindl.	-	Tamil Nadu
Eulophia herbacea Lindl.	-	Maharashtra, Arunachal Pradesh
Eulophia kamarupa S. Chowdh.	-	Assam
Eulophia mackinnonii Duthie.	-	Arunachal Pradesh, Assam
Eulophia mannii (Rchb.f.) Hook. f.	-	Assam, Sikkim
Eulophia obtusa (Lindl.) Hook. f.	-	Uttar Pradesh, Himachal Pradesh
Eulophia ochreata Lindl.	-	Maharashtra
Eulophia pratensis Lindl.	*Eulophia ramentacea*	Maharashtra
Eulophia promensis Lindl.	-	West Bengal
Eulophia spectabilis (Dennst.) Suresh.	*Eulophia nuda*	Uttarakhand, Karnataka, Maharashtra
Eulophia tenella Rchb. f.	-	Arunachal Pradesh
Eulophia zollingeri (Reichb. f.) J.J. Sm.	-	Arunachal Pradesh
Eulophia pulchra (Thouars) Lindl.	-	Tamil Nadu, Kerala
Eulophia bracteosa Lindl.	-	Assam
Eulophia campanulata Duthie.	-	Himachal Pradesh, Uttarakhand
Eulophia campbellii Prain.		Assam, Sikkim
Eulophia emilianae C. J. Saldanha.	-	Karnataka
Eulophia tenella Rchb.f.		Uttarakhand
Eulophia macrobulbon (Par. et. Rchb. f.) hook. f.	-	Uttar Pradesh
Eulophia nicobarica N.P. Balkar and N.G. Nair.	-	Andaman and Nicobar
Eulophia pauciflora Guillaumin.	-	Bihar
Eulophia pulchra (Thouars) Lindl.	-	Tamil Nadu, Kerala

*States mentioned above are illustration purpose only

petiole-like leaf base, sometimes overlapping and forming a pseudostem. Some species lack green leaves and are saprophytic. The inflorescence is erect, lateral, racemose or rarely paniculate, laxly to sub-densely many flowered or occasionally reduced to a solitary flower. *Eulophia* species are mostly identified by their flowers. Two types of flowers occur within *Eulophia*. In the first type, the sepals and petals are similar in size, shape, and color while in the other, sepals are smaller than petals and often recurved. In both types, the lip extends into a spur which can be very diverse in shape [6,15].

ANATOMICAL STUDIES

Infrageneric classification of *Eulophia* R. Br. ex Lindl. was carried out based on methods of classical taxonomy, particularly the examination of generative and vegetative characters, followed by their comparison based on the data obtained from molecular studies and scanning electron microscopy [6]. Study on *Eulophia andamanensis* Rchb. f. found that 0.1% colchicine is effective to induce mutations to increase flower size [16]. *E. graminae* Lindl. was also studied for its unique storage structure of the rhizome, brief juvenile stage, *in vitro* flowering and autogamous mating system, which explains its strong colonization ability [17]. An anatomical study has been carried out on *Eulophia alta* to investigate the pollination biology, breeding system, nectar production, and floral scent composition of the plant. This study clearly showed that flowers of *E. alta* were self-compatible, partially autogamous and effectively pollinated by five bee species. The nectar sugar content was reported to be highest on the third day after flower opening. Floral fragrance analyzes revealed 42 compounds, of which monoterpenes and benzoids are predominant [18]. Studies on asymbiotic and symbiotic seed germination of the same plant revealed that the symbiotic seed culture is a more efficient way of propagation [19]. An optimized method was devised for asymbiotic *in vitro* seed germination, seedling development, and field establishment of *Eulophia nuda* [20], a similar study was carried out with *E. culleni* [21].

MYCORRHIZAL STUDY

Eulophia zollingeri (Rchb.f.) J J Sm. was tested for its mycorrhizal specificity along with mycorrhizal association pattern, which was examined using DNS-based fungal identification. Results revealed that it exclusively associates with the group of fungi belonging to *P. candolleana* group and provide evidence that mycoheterotrophic plants can achieve wide distributions, even though they have high mycorrhizal specificity, if its fungal partner is widely distributed [22]. Yan-Qiu *et al*. [23] identified the presence of endophytic fungi in the fresh roots of *Eulophia flava* Lindl. Total of 52 fungal strains of 17 genera were isolated from fresh root samples of plants growing in sugarcane fields and on the mountain. *Rhizoctonia* and *Fusarium* were the dominant endophytes in these specimens.

TAXONOMICAL AMBIGUITY

Genus *Eulophia* was formally described by John Lindley in 1823. In India, species from this genus were identified in the early 19th century. *Amarkand* is well known to Indians since *Vedic* period, as a medicinal and food species. However, until today, no authentic information is available with respect to the exact species of *Eulophia* which are termed as *Amarkand* in ancient texts. The existing botanical name was assigned to Indian *Eulophia* species in the 19th century, but these species do not match with the description of *Amarkand* in ancient texts. In addition, most of the species of *Eulophia* are morphologically closely similar. Initially, *E. nuda* Lindl. was identified as *Amarkand* [24]. It was later revealed that *Eulophia ochreata* Lindl. possesses higher medicinal and food value than *E. nuda* Lindl. [25,26]. Recently, it has been found that two newly described species of *Eulophia* have much better pharmacological activities than the earlier species. However, until today, no authentic information is available with respect to the exact species of *Eulophia* which could be considered as *Amarkand*.

TRADITIONAL AND ETHNOBOTANICAL USES

In Ayurvedic medicine, *Amarkand* is generally prescribed as expectorant, anabolic, tonic, diuretic, astringent, digestive, and soft purgative, and also recommended for the treatment of ear discharge, blood clotting, joint edema, and debility [5]. In addition, it is also considered as a general tonic to promote strength and alleviates all the three "doshas" [27]. These are also used in stomatitis, purulent cough; and in the heart problems, dyscrasia, and scrofulous diseases of the neck; bronchitis, blood diseases, and as a vermifuge [28].

Different *Eulophia* species have been extensively used in the traditional system of medicines in many countries [29,30]. In India, several ethnopharmacological uses/application have been reported for different species of *Eulophia* in different parts of the country, which are summarized in Table 2.

NUTRITIONAL STUDIES

Some of the *Eulophia* species have been studied for their nutritional properties. *E. campestris* Wall. is available as a *salep* (flour of starch) in Indian markets, as food for children and convalescents [50].

Balance between nutrients and anti-nutrients were studied in *E. ochreata* Lindl. It was found that tubers had low values of all free carbohydrates and had a low content of anti-nutrients such as phytic acid and trypsin inhibitors [51]. The proximate composition and mineral constituents indicated that these tubers are a good source of plant fibers, proteins, and carbohydrates [52].

Proximate analysis and minerals composition studies of tubers are also reported from India. Tubers of this wild edible plant are affluent of all nutrients such as starch, free sugars, oils, proteins, antioxidant phenols, and also a good source of almost all elements. Elemental profile of the same plant was checked using flame photometer and atomic absorption spectroscopy which revealed the presence of microelements such as iron and zinc in considerable amount. Jagtap *et al*. [26] studied the nutritive

Table 2: Ethnobotanical uses of *Eulophia* species

Botanical names	Part utilized	Form of drug	Uses
Eulophia campestris Wall.	Tubers	Fresh Juice	Gastro-intestinal disorders such as diarrhea, dysentery, stomach pain, laxative. Taken as an appetizer [31]
	Rhizome	Not mentioned	As a tonic. Stomach problem, as an aphrodisiac and for cough and cold [11]
	Tubers	Mucilage	Worm infestation and scrofula [12]
Eulophia dabia (D. Don.) Hochr.	Tubers	Not mentioned	Cough and cold [32]
Eulophia epidendrea (JKoen) Schltr.	Tubers	Paste	Applied externally on boils and on breast of feeding mother to control pain due to milk clotting [33]
	Tubers	Not mentioned	To treat tumor and Diarrhea [34]
	Tubers	Not mentioned	As an appetizer, anthelmintic, aphrodisiac, stomachic, alterative, worm infestation. Commonly give it to stimulate appetite and to purify blood in heart troubles [35]
Eulophia graminae Lindl.	Tubers	Extract	To treat ear problems as an ear drop [36]
Eulophia herbacea Lindl.	Tubers	Extract	To reduce liver swelling [37]
	Tubers	Roasted	To increase sperm count [37]
	Tubers	Crushed tubers fried in Mustered oil	Applied externally for rheumatism [38]
	Tubers	Not mentioned	Belly-ach [39]
	Tubers	Paste	To treat pimples [40]
	Seeds	Powder	Weakness (Fatigue) [41]
Eulophia nuda Lindl.	Tubers	Extract	Worm infestation and scrofula [12]
	Tubers	Not mentioned	To treat skin rash, acidity, piles, anorexia, anthrax, and stomach complaints [42]
	Tubers	Raw tubers	Rheumatoid arthritis [43]
	Tubers	Extract	Anticancer, antiasthmatic, and antibronchitis activity [44]
	Whole plant	Paste	Applied externally for boils and abscesses [27]
	Root	Root juice	To treat snakebite [38]
	Tubers	Extract	Anti-inflammatory activity [3]
	Tubers	Whole tuber	Abdominal pain due to non-menstruation, Spermatorrhea, Leukorrhea [45]
Eulophia ochreata Lindl	Tubers	*Salep*	Treatment of sexual impotency and male sterility [27,46]
	Tubers	Paste	Asthma and acute bronchitis [47,48]
	Tubers	Powder	To increase the stamina for physical activities [13]
	Tubers	Tonic	For restoring general health, strength, and vigor [25]
	Tubers	Decoction	Antinode in snakebite and to cure leukemia [43]
Eulophia pratensis Lindl.	Tubers	Paste	Applied externally and given internally to remove scrofulous gland in the neck [27]
Eulophia ramentaceae Lindl. Ex. Wight	Tubers	Not mentioned	Impotency related problems [49]

values of *E. ochreata* Lindl. (*Amarkand*) tubers with reference to its total protein content, fat content, reducing sugars, total carbohydrates, and Vitamin C, and reported that the tubers contain all nutritional factors in moderate quantity, except the maximum content of lipids (9 mg/g) among all the plants under the study. Authors suggested that these tubers could have potential worth in the diets of poor rural communities of India [53].

PHYTOCHEMISTRY

Medicinal plants produce thousands of patho-physiologically active principles that have been exploited over the years in the treatment of various ailments [54]. The qualitative and quantitative estimation of the phytochemical constituents of the medicinal plant is considered to be an important step in the herbal drug standardization [55]. Progress in phytochemistry has been aided enormously by the development of rapid and accurate methods of screening plants for particular bioactive chemicals.

Methanolic extracts of tubers of *E. epidendrea* (JKoen) Schltr. showed the presence of several classes of phytochemicals such as flavonoids, reducing sugars, cyanogenic glycosides terpenoids, and tannins [56]. Thin-layer chromatography (TLC) studies of the isolated fractions from leaves and tubers indicated the presence of flavonoids, sterols, and terpenoids [Table 3] [57].

Bhandari *et al.* [58] have detected the presence of phenanthrene nudol (2, 7-dihydroxy-3, 4-dimethoxyphenanthrene) in the fresh tubers of *E. nuda* Lindl. In the subsequent study, another six phenanthrene derivatives were also isolated from the same plant tubers [Table 2] [24]. Among these derivatives, the therapeutic potential was largely attributed to 9, 10-dihydro-2, 5-dimethoxyphenanthrene-1, 7-diol. Kshirsagar *et al.* [14] validated the ethnobotanical rejuvenating claim of *E. ochreata* Lindl. by studying its antioxidant activity. Two radical scavenging molecules were isolated from dichloromethane and ethyl acetate extracts of tubers of *E. ochreata* Lindl. [Table 2].

RECENT PHARMACOLOGICAL STUDIES

Pharmacology is the science of drug action on biological systems. Pharmacological characters can provide a better understanding of active principles in plants and their mode of action. Pharmacological trials are needed to investigate the unexploited potential of plants.

Table 3: List of biologically active compounds isolated from *Eulophia* species

Eulophia species	Plant part	Compound present
Eulophia epidendrea (JKoen) Schltr.	Leaves	Apigenin, luteolin, kaempferol, and quercetin
	Tuber fractions	β-sitosterol, β-sitosterolglucoside, β- amyrin and lupeol
Eulophia nuda Lindl.	Fresh tubers	2, 7-dihydroxy-3, 4-dimethoxyphenanathrene (Nudol)
		9,10-dihydro-2,5- dimethoxyphenanthrene-1,7-diol
		9,10-dihydro-4-methoxyphenanthrene-2,7- diol
		1,5-dimethoxyphenanthrene-2,7-diol
		1,5,7-trimethoxyphenanthrene-2, 6-diol
		5,7-dimethoxyphenanthrene-2,6-diol
		4,4′,8,8′-tetramethoxy-1, 1′-biphenanthrene-2,2′7,7′-tetrol
		4-Hydroxybenzaldehyde
		4-hydroxybenzyl alcohol
Eulophia ochreata Lindl.	Fresh tubers	9, 10-Dihydro-2, 5-Dimethoxyphenanthrene-1, 7-diol
		5, 7-Dimethoxyphenanthrene-2, 6-diol

Tubers of *E. campestris* Wall. are well known for its binding properties [23]. Ghule *et al*. [59] pointed out that large quantity of mucilage from tubers of this plant is used as binding agent in tablet formulation. This mucilage produces a sticky film of hydration on the surface of prepared tablets, which ultimately reduces drug release rate. Thick jelly of this mucilage is also reported to be highly nutritious [60]. Glycation inhibitory activity of *salep* (*E. campestris* Wall.) extract was assessed by trichloroacetic acid treatment. In this study, the formation of glycated products/AGEs was decreased at the highest concentration of *salep*, i.e., at 25 mg/ml [10]. Mucilage isolated from tubers of *E. herbacea* Lindl. has a potential as a suspending agent. It has a low rate of sedimentation, high viscosity, weak acidic pH and is easily re-dispersible. Thus, it can also be used as pharmaceutical adjuvant [61].

Methanol extract of tubers of *E. epidendrea* (JKoen) Schltr could significantly inhibit castor oil-induced diarrhea in rats, which was assessed by reduction in the frequency of defecation and the wetness of the fecal droppings compared to untreated control rats. The extract also significantly inhibited intestinal fluid accumulation (enteropooling). In addition, the extract appears to act on all parts of the intestine. Thus, it inhibited the propulsive movement of the intestinal contents in the charcoal meal treated model. These finding suggested that the methanol extract of the tubers of *E. epidendrea* (JKoen) Schltr may have an anti-diarrheal effect. This study validates the use of this plant as a non-specific anti-diarrheal agent in folk medicine [62].

The crude drug in the powder form prepared from tubers of *E. nuda* Lindl. has aphrodisiac potential [63]. Phenanthrene compounds, such as 1-phenanthrenecarboxylic acid, 1, 2, 3, 4, 4a, 9, 10, 10a-octahydro-1, 4a-dimethyl-, methyl ester, were isolated from *Eulophia herbacea* were found to have anticancer potential [64]. Pure compounds such as phenanthrene derivative, 9, 10-dihydro-2, 5-dimethoxyphenanthrene-1, 7-diol isolated from fresh tubers of *E. nuda* Lindl. showed good anti-proliferative activity against human breast cancer cell lines MCF-7 and MDA-MB-231 at concentration of 1000 μg/ml [42]. The same compound was isolated from tubers of *E. ochreata* Lindl. in the pure form and was analyzed for its anti-inflammatory activity using cell line and carrageenan-induced rat paw edema model. The compound inhibited the release of several pro-inflammatory mediators, particularly cytokines and could be a promising anti-inflammatory agent [65].

Similarly, anti-inflammatory and antioxidant activities were attributed to the methanolic extract of tubers of *E. ochreata* Lindl [25]. Moreover, different solvent extracts of this tuber were found to have potent antibacterial activity against *Bacillus subtilis*, *Staphylococcus Aureus*, and *Escherichia coli* [66]. Tubers are also reported to have promising antioxidant, antiglycation, and alpha-amylase inhibitory activity and may have potential in the treatment and management of the Type II diabetes [67]. Recently, we have studied seven *Amarkand* species for its phytochemical profile, polyphenolic content, and free radical scavenging activity and found that *D. bulbifera* and *E. ochreata* had the highest antioxidant potential [66,68]. Similarly, tubers of *E. ochreata* and bulbils of *D. bulbifera* have shown a high anti-fatigue potential among different *Amarkand* species [69]. Among different *Eulophia* species, *E. ochreata* has the highest score for biological activities [34].

PATENT

An Indian patent filed by Upadhyay *et al*. [70] focused on novel derivatives of phenanthrene, Eulophiol from *Eulophia* species, and its potential application in inhibition of immune stimulation involving Toll-like receptor ligands, especially TLR-4.

FUTURE PROSPECTIVES AND CONCLUSIONS

In India, traditional herbal medicines have a long history of practice and still are heavily practiced in rural and tribal populations. Around 2500 plants, out of 18,000 recorded plant species, are in medicinal use in the country [71]. Besides this, tribal communities of India have their own treasure of ethnomedicines based on their ecological and sociocultural background [72]. Most of the ethnomedicines have huge merits as potential medicines and functional foods [73]. However, single local name to different taxonomical species creates confusion about ethnomedical and nutritional efficacies. Therefore, there is need to identify exact and most bioactive ethnobotanical species, as well as validation of their ethnopharmacological and nutritional claims on the modern scientific ground.

Amarkand is a good example of having a strong background of regional ethnopharmacological and food uses. However, these species are not gaining expected regional and global attention due to the lack of scientific records about their biological and pharmacological activities. The ethnobotanical claims from the present review need to be subjected to pharmaco-chemical evaluation, which will help to discover true potential species of *Amarkand*. In addition, validation, standardization, and isolation of active ingredients from different *Amarkand* species are also important for their commercial exploitation.

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