Universitat de les Illes Balears

FINAL DEGREE PROJECT

USES OF THE ORCHIDACEAE FAMILY: FROM TRADITION TO BIOTECHNOLOGY

Kimberley Nikky Josie Tartare

Degree in Biology

Faculty of Sciences

Academic Year 2022-23

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Tutor's Name: Dr. Juan Rita Larrucea

Abstract

Orchids have been a source of fascination for Humans since ancient times, captivating them with their extravagant and graceful morphology, but also for their hypogeal organs, which have inspired myths, rituals, and traditions across the world. Orchidaceae is one of the largest family of flowering plants, sheltered from tropical forests to alpine mountains, worldwide. Those plants are commonly used as ornamental and have also found uses in popular traditional Medicine to treat infections, cough, allergies, wounds, and even as an aphrodisiac tonic. However, the properties that orchid possess, conceded by their secondary metabolites and other bioactive substances, bring them far beyond this point. Orchids find applications in numerous aspects of our day-to-day, from our plates to our beauty routines. However, those magnificent plants are threatened of extinction by unregulated collection, overexploitation, and habitat loss, among other factors. To reduce the threats that orchids are facing, the integration of traditional knowledge of these plants with biotechnology advancements as plant tissue culture and micropropagation could present a suitable alternative to reduce pressure on natural populations and promoting sustainable utilization. Therefore, the aim of this project was to carry out a literature review and compile available information from the past to present uses of orchids in different fields. It serves as a valuable reference for further investigation and emphasizes the strategies essentially required for the conservation and sustainable uses of the Orchidaceae family.

Las orquídeas han sido fuente de fascinación para los humanos desde la antigüedad, cautivándoles por su extravagante y elegante morfología, pero también por sus órganos hipogeos, que han inspirado mitos, rituales y tradiciones en todo el mundo. Las orquidáceas son una de las mayores familias de plantas con flores, albergadas desde los bosques tropicales hasta las montañas alpinas de todo el mundo. Estas plantas se utilizan habitualmente como ornamentales y también han encontrado usos en la medicina tradicional popular para tratar infecciones, tos, alergias, heridas e incluso como tónico afrodisíaco. Sin embargo, las propiedades que poseen las orquídeas, concedidas por sus metabolitos secundarios y otras sustancias bioactivas, las llevan mucho más allá. Las orquídeas encuentran aplicaciones en numerosos aspectos de nuestro día a día, desde nuestros platos hasta nuestras rutinas de belleza. Sin embargo, estas magníficas

plantas están amenazadas de extinción por la recolección no regulada, la sobreexplotación y la pérdida de hábitat, entre otros factores. Para reducir las amenazas a las que se enfrentan las orquídeas, la integración del conocimiento tradicional de estas plantas con avances biotecnológicos como el cultivo de tejidos vegetales y la micropropagación podría presentar una alternativa adecuada para reducir la presión sobre las poblaciones naturales y promover una utilización sostenible. Por lo tanto, el objetivo de este trabajo era realizar una revisión bibliográfica y recopilar la información disponible sobre los usos pasados y presentes de las orquídeas en diferentes campos. Sirve de valiosa referencia para futuras investigaciones y hace hincapié en las estrategias esencialmente necesarias para la conservación y los usos sostenibles de la familia Orchidaceae.

Les orquídies han estat font de fascinació per als humans des de l'antiguitat, captivant per la seva extravagant i elegant morfologia, però també pels seus òrgans hipogeus, que han inspirat mites, rituals i tradicions a tot el món. Les orquidàcies són una de les majors famílies de plantes amb flors, presents en els boscos tropicals fins a les muntanyes alpines de tot el món. Aquestes plantes s'utilitzen habitualment com a ornament i també s'han trobat usos en la medicina tradicional popular per a tractar infeccions, tos, al·lèrgies, ferides i fins i tot com a tònic afrodisíac. No obstant, les propietats que posseeixen les orquídies, concedides pels seus metabòlits secundaris i altres substàncies bioactivas, les porten molt més allà. Les orquídies troben aplicacions en nombrosos aspectes del nostre dia a dia, des dels nostres plats fins a les nostres rutines de bellesa. Tot i això, aquestes magnífiques plantes estan amenaçades, en perill d'extinció, degut a la recol·lecció no regulada, la sobreexplotació i la pèrdua d'hàbitat, entre d'altres factors. Per a reduir les amenaces a les quals s'enfronten les orquídies, la integració del coneixement tradicional d'aquestes plantes amb avanços biotecnològics (com el cultiu de teixits vegetals i la micropropagació) podria presentar una alternativa adequada per a disminuir la pressió sobre les poblacions naturals i promoure una utilització sostenible. Per tant, l'objectiu d'aquest treball és realitzar una revisió bibliogràfica i recopilar la informació disponible sobre els usos passats i presents de les orquídies en els diferents camps. Serveix de valuosa referència per a futures recerques i posa l'accent en les estratègies essencials necessàries per a la conservació i els usos sostenibles de la família Orchidaceae.

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I. Introduction

In his letter to Hooker on the 16^{th} of June 1860, Charles Darwin wrote: "Have pity on me & let me write once again on Orchids for I am in a transport of admiration at most simple contrivance, & which I should so like you to admire." (*Darwin Correspondence Project*, n.d.). Orchids, gracious plants of captivating beauty, have long enchanted admirers around the world. Beyond their ornamental value, orchid present a large selection of hidden treasures with diverse applications in broad spectrum of fields. From ancient traditions to biotechnology improvements, including culinary delights and a potential cosmetical Fountain of Eternal Youth, orchids have always found applications throughout history. This work reviews the fascinating and multifaceted uses of orchids, shedding lights on their most important applications, uncovering the untold stories of these extraordinary flowers. It is an approach of orchid uses that will allow a greater concretion in the future for those who want to investigate deeper the subject.

General consideration

According to Canals et al. (2016), the Orchidaceae represents nearly 10% of the flowering plants, being one of the largest and most evolved family of angiosperms. Group et al. (2016) classifies with APG IV the Family Orchidaceae in the Order Asparagales of Monocots (Lilidae). Depending on the source consulted, most authors refer this family contains between 18,000 to 35,000 species distributed in up to 850 genera (Eggli, 2020; Hossain, 2011; Jain et al., 2021; S. Zhang et al., 2018). Specimens of this ubiquitous family are found worldwide, nevertheless, an inequitable distribution can be observed, clearly shifted toward the tropical and subtropical zones, where an exceptional diversity of species is found (Hossain, 2011). Among these areas, continents and regions display substantial distribution variability (Cribb et al., 2003). Based on their work concerning a global perspective of orchid conservation, Cribb et al. (2003) reported:

> The northern Andes of South America, the mountains of the narrow neck of Mesoamerica, Madagascar, Indochina and SW China, Sumatra, Borneo, New Guinea, and temperate SW Australia are all particularly rich in orchids. The Andes of Colombia and Ecuador are the richest places on earth in terms of orchid diversity, with perhaps a quarter of all known species found there. At first glance, these regions have little in common, but diversity of habitat, geology, climate and degree of isolation are the most apparent constant factors. (p. 2)

Fekete et al. (2023) also claimed in their work that the distribution of orchids is influenced by different factors, such as latitude and altitude, following a latitudinal diversity gradient which implies a negative correlation between species richness and latitude. As commented previously, climate is an important factor conditioning orchids growth, and the climatic conditions differ upon elevation and latitude of the area (Tsiftsis et al., 2019). More precisely, the northern Andes show an utmost orchid diversity between 1.000- and 2.000-meters elevation, this range might be justified by the high microsite differentiation in this region (Hágsater et al., 1996). According to Sêssi et al. (2017), tropical rainforests and mountains with stable climate are the perfect shelter for propitious orchid habitats. However, species of the Orchidaceae family can be found in many types of habitats. In the Mediterranean region, the most common habitats for orchids are evergreen sclerophyllous bush and scrub (Hágsater et al., 1996). Specimens of this family can also be found in the mountains of the Alpine zones, up to 3.000 meters elevation, as for Arctic regions (Hágsater et al., 1996). The northern highlands of Mexico host orchid species in their grasslands. To sum up, many species of this family can also find a home in wetlands (Hágsater et al., 1996). Within all these types of habitats, orchids can grow on different substrates: on multiple soil types, on rocks, and even on other plants and structures, adopting an epiphytic lifestyle, and even underground as the species of the Australian genus *Rhizanthella* (Hágsater et al., 1996; Thorogood et al., 2019).

Main morphological characteristics

The Orchidaceae is a family of perennial, terrestrial or epiphytic herbs. Most of the roots of the terrestrial species are tuberous, while the epiphytic species present aerial roots with a multi-layered velamen. Depending on the species, the stems can present different aspect, being practically non-existent when they form corms or rhizomes in terrestrial species, or appearing clearly visible when inflated into pseudobulbs in epiphytic species, in this case often rooting at nodes. When present, the leaves are entire, alternate, and disposed helicoidally. While some species can present distichous, occasionally opposite, or whorled leaves, most of the species have fleshy leaves, occasionally scale-like. In other species where the leaves disappeared, the photosynthesis proceeds in the green roots. Inflorescences can be seen in lateral racemes or panicles, or as solitary flowers. The bracts can be herbaceous or membranous. The flowers are mostly hermaphrodites and zygomorphic, epigynous and the floral parts suffered a 180º turn. The perianth is composed of three sepals and three petaloid tepals, the basal tepal called labellum is differentiable by size and colour and is larger in most of the species. The androecium is composed of three stamens with longitudinal or dehiscence anthers. The third stamen, the only functional, is ended in a bilobular anther, where the pollen stored into pollinia is waiting for the pollinators to be transported to another flower. The pollen is seen as tetrads in most species or can form massulae or monads in some groups. The gynoecium, syncarpous, presents a special configuration of a three lobed stigma, one of the lobes is modified into a large rostellum forming a barrier between the anther and the fertile lobed of stigma to prevent self-pollination. The style, single and terminal, is fused to two of the three stamens to form a gynostegium or column. The ovary is inferior and composed of three carpels, with many ovules, and the placentation can be parietal or axile. The fruits produced are capsules or sometimes berries, dehiscing longitudinally to release millions of seeds in some species, without endosperm, and the minute embryo is undeveloped (Canals et al., 2016; Eggli, 2020; Guerra et al., 1988; Simpson, 2019).

Floral ecology

The ecology of orchid pollination is enthralling and constantly changing. As mentioned Hágsater et al. (1996): "few would doubt the pre-eminence of the Orchidaceae in beauty and in the complexity of its flowers and pollination mechanisms". Many studies of orchid pollination have been conducted since Darwin's works (Neiland & Wilcock, 1998). Numerous species developed a very specialized pollination system, where each orchid species is pollinated by a single species of pollinator. Consequently, a specific system has been described: the deceptive pollination mechanism. The most common is sexual deception, it is an extreme method of pollination which involves the mimic of female insects in terms of their olfactory, visual, and tactile cues to engage the pollinator for pseudocopulation (Jersáková et al., 2006). As an example, the flower of the species of *Ophrys* mimics the female of the pollinating insect and attracts the males by secreting a species-specific pheromone. When the male insects land on the flower and attempt to mate, they carry on pollination by pseudo-copulating (Khasim et al., 2020). However, multiple types of deceptive pollination mechanisms have been designed by most members of the Orchidaceae family, included generalized food deception, Batesian floral mimicry, and brood-site imitation, among others (Kamaladhasan et al., 2020). Jersáková et al. (2006) described the generalized food deception as the exhibition of mimicked advertising signals of common rewarding flowers, particularly scent, shape, colors, nectar guides, pseudo-pollen and false anthers; and the brood-site imitation for when the flowers imitate visually the female pollinator oviposition sites and secrete false odor to attract the male pollinators. Finally, the Batesian floral mimicry have been described by Schlüter & Schiestl (2008) as a mechanism in which certain rewarding features of the flower are mimicked to specifically attract pollinators.

Some important species

In the horticulture industry, the most popular gender of orchid is undoubtedly *Phalaenopsis* spp. (Figure 1), commercialized worldwide for the beauty of its unique-shaped flowers (L. M. Huang et al., 2021). *Phalaenopsis amabilis* and *P. aphrodite* are bred to produce the famous large-and-white-flower hybrids (Hsu et al., 2018). Victim of international success in floriculture trade, orchids reached the second place of most notorious cut flowers and potted crop (Hossain, 2011). Another planetary-famous orchid species is *Vanilla planifolia*, as the name suggests, from which the vanilla flavor is extracted for further applications in culinary, perfumery and pharmaceutical industries (Gallage & Møller, 2015).

Figure 1: *Phalaenopsis* sp. in Kemenuh Butterfly Park, Sukawati, Bali, Indonesia. Picture from the author. All Rights Reserved.

Authors from all around the world have been publishing research papers, articles, books, reviews, and reports about orchids studies and eventually mention their potential uses over the centuries. Nevertheless, the existing information usually focuses on a particular region, species or specific type of use made from orchids (Hossain, 2011).

Objectives of this project

The purpose of this present work is to present the uses of the Orchidaceae family consolidated from an extensive literature review, in view to spread the knowledge of the potential uses of this family, from traditional beliefs to advances in biotechnology. The limitation of this work would not permit an exhaustive listing of all uses of orchids, thus a summary was organized by fields of applications. Lastly, an annexed table was elaborated to compile the species according to their uses, geographical location and the references consulted.

II. Traditional and Cultural uses of Orchids

History and origins

According to Hossain MM (2011), orchid plants appeared on Earth about 120 million years ago, although written evidence are only dating from the 4th century BCE. Doubtlessly, the Chinese civilization took the lead on orchid description and cultivation for medicinal and further uses, as refers the Chinese legend of Shên-nung describing a species of *Dendrobium* and *Bletilla striata* in his "Materia Medica", dating from the 28th century BCE (Bulpitt, 2005). Hossain MM (2011) also reported that in this part of the world, orchids were names by the Chinese word "*lan*", which mean elegant woman, strong, and beautiful. Moreover, Sinha & Sinha (2001) mentioned that Indian civilizations have been using orchids for curative and aphrodisiac purposes since the Vedic period, between 2000 BCE and 600 BCE. When it comes to Central America, the Ancient Maya and Aztec civilizations, whose historical periods are estimated from the 1st century BCE to the 16th century CE, have utilized many orchid species for both medical and culinary application, among others (Estrada Belli, 2010; Ossenbach, 2005). Japan also holds an enthralling legend regarding history of orchid uses. The story says that the Emperor Shi-Kotei (250–233 BCE), after several years of a childless marriage, was advised by his physician to dispose an orchid, supposedly *Cymbidium ensifolium*, in the accommodations of the Emperess Yohki-Hi. Afterwards, the plant bloomed into thirteen perfumed flowers, the Emperess breathed the flower scent and gave birth to thirteen sons (Hossain, 2011).

The most ancient reference of orchid in Europe comes from Greek mythology, with the antique origin of the name orchids (Craves, 2012). Indeed, the myth of Orchis, son of a nymph and a satyr known for his exceptional beauty and charm, tells that after becoming intoxicated, Orchis tried to rape a Meanad during a festival of Dionysus -the god of wine and fertility. As punishment for his actions, the gods turned Orchis into a plant with testicle-like hypogean structures, which we now know as the *Orchis* genera (Kumbaric et al., 2013). In fact, the Greek word *órkhis* means testicles. For that matter, Theophrastus, the Greek father of botany, named the European terrestrial species of orchids after that word in his work 'Enquiry into Plants' (4th century BCE) for the resemblance of the paired underground bulbs with testes (Kumbaric et al., 2013). A century later, Dioscorides used in his work "De Materia Medica" (65 BCE) the same word Orchis to define these plants (Bulpitt, 2005; Pant, 2013). Thereby, he applied the "Theory of Signature", by which plants were used to cure certain organs in accordance with their resemblance with human anatomy, since he connected the use of orchids with fertility (Bulpitt, 2005; Kumbaric et al., 2013). As Craves (2012) described in her listing, not only the nomenclature of the genus *Orchis* takes its roots from Classical Mythology. For instance, *Dendrobium aphrodite* honours the goddess of desire and beauty; *Epidendrum medusae* and *Bulbophyllum medusae* borrowed their name from Medusa, a long-hair beautiful woman that slept with Poseidon, arose the jealousy of Athena which have turned Medusa's hair into a nest of snakes and a hideous face so that any man that looked at her was turned into a stone statue; the etymology of the genera *Promenaea* takes its origin from Promenia, one of the three priestess guarding the Oracle of Dodona, surrounded by oaks -tree of the powerful god Zeus, comprehended the wind whispering through the oak leaves as a message from Zeus. Slightly, the exploration of these origins confers upon orchidology a sense of mystical aspect (Craves, 2012).

Orchids in ancient art

Photoiconography studies, which analyse how plants are represented in art, archaeology and on historical monuments with the purpose of providing important information on the naturalistic and symbolic significance of plants across diverse historical periods, have recently revealed depictions of orchid species in ancient Roman archaeological monuments (Kumbaric et al., 2013). In particular, the Ara Pacis, the altar to Peace edified in Rome by Augustus in 9 BCE to celebrate Roman victories and the commencement of a new prosperous era, holds orchid representations on the external fence (Caneva, 2011). More specifically, the gynostemium of orchid flowers was sculpted on the monument as a symbol of fertility and new life (Firgure 2), with the cultural belief to bring fruits and seeds (Kumbaric et al., 2013).

Figure 2. On top: *Cephalanthera* sp. on the frieze of Ara Pacis (upper left); compared to the flower in the wild (upper right). Bottom: *Spiranthes spiralis* on the frieze of Ara pacis (bottom left); compared to the plant in the wild (bottom right). From Kumbaric et al (2013).

Based on the bibliography consulted, 22 traditional and cultural uses of 163 orchid species have been catalogued in the Annex 1, specifying the geographical zone where they were exploited, and the part of the plant used for its preparation. It is to note that these numbers are not exhaustive, since they are based on the literature consulted, the real values are much higher and would need a deeper investigation. Within those 22 listed uses, it can be affirmed undeniably that the orchids have been most used for Salep preparation and for numerous medicinal applications, mostly to treat dysentery, cough, fever, skin affections, wounds, inflammations and to relieve pain, which will be further explained. Other common uses given to orchids throughout the world as aphrodisiac or tonic potions, for psychedelic purposes, in alimentation, for ritual ceremonies or for ornamental uses (Bazzicalupo et al., 2023; Bulpitt, 2005; Craves, 2012; Hossain, 2011; Ossenbach, 2005, 2009).

Rituals and Folklore

Orchid species have been used in rites in folklore traditions all around the world. According to Bazzicalupo et al. (2023), various species of orchids involved with aphrodisiac practices have been used in Italy for rituals, to reunite or separate couples, such as *Dactylorhiza maculata*, *Gymnadenia conopsea*, *G. rhellicani* and *Orchis purpurea*, inter alia. Moreover, *Orchis masculata* have been in Italian rituals as well to protect the children from snakes and other animals. In a small Spanish village, Villarino de los Aires, the young boys used to offer flowers of *Ophrys scolopax* to show the girls they liked them (Bazzicalupo et al., 2023). In South Africa, the Zulus tribes were using *Ansellia humilis* for various purposes. One such usage was to inflict harm upon unmarried maidens, preventing them from conceiving and bearing children. Additionally, it was employed as a remedy for dispelling bad dreams and alleviating instances of madness (Hossain, 2011). The Zulus have also been using the stems of another species of this genus, *Ansellia gigantea*, for its aphrodisiac properties in a love potion (Craves, 2012). Besides, during the early days of the slave trade in South Africa, *Eupholia aha*, commonly referred to as 'Wild cocow', was brought to the region, possibly for its perceived healing properties or for utilization in voodoo-like rituals (Hossain, 2011).

Ossenbach (2009) explains how in Central America, the Aztecs would have used *Encyclia pastoris* for its mucilaginous substances to prepare an adhesive paste of which the preparation was consisting of slicing the pseudobulbs, letting them dry in the sun, store them for a while and then soaked the mucilage to give it different uses. Surprisingly, the Mayas have been using the stems of *Myrmecophila tibicinis* as musical instruments, as trumpets and flutes (Ossenbach, 2005).

Traditional Chinese Medicine

Shi-Hu, derived from various species of *Dendrobium* is a widely used Chinese medicine. It is included in the Chinese pharmacopoeia and is known for its therapeutic properties for kidney, lung, and stomach diseases, as for its effects on fever, dry mouth, swelling, and diabetes. It has been demonstrated by experimental studies that Shi-Hu promotes stomach acid secretion and has additional benefits including longevity enhancement, thirst alleviation, and calming effects. This preparation is also used to treat various afflictions including rheumatism, impotence, leucorrhea, cataracts, and menstrual pain (Bulpitt et al., 2007; Hossain, 2011). Further studies have recently revealed potential immune-boosting, anti-aging, and anti-cancer properties, as well as glycemia regulation and enhancement of insulin sensitivity in diabetic models and patients (Hossain, 2011; Yan et al., 2014). As it is to expect for the diversity of orchids in this region of the world, a large portion of South American countries used orchids for various medicinal purposes, as compiled in the Table 1 (Teoh, 2019).

Orchids have also had their role in cuisine. In Australia, several orchid bulbs, such as *Gastrodia sesamoides*, various *Dendrobium Caladenia* species, were utilized as emergency bush food (Hossain, 2011). In some instances, the seed capsules of *Selenipedium chica*, known for being the tallest plants in the orchid family, were used as a substitute for vanilla, a flavor extracted from an orchid species which will be further explained (Hossain, 2011).

Surprisingly, according to the Conet-e database (https://conecte.es/), which is the most comprehensive ethnobotanical database in Spain in general, and particularly in the Balearic Islands, no traditional uses of orchids have been recorded in this country, beyond their ornamental use. However, Amengual (2022) registers in his recent review of medicinal plants of the Balearic Islands, 16 species of orchids for their medicinal uses, most notably for the preparation of Salep, but also for their use in relieving gout pain, as a treatment for digestive issues, and even as an aphrodisiac. However, this author does not mention that these uses have been carried out on the Balearic Islands. Besides, other studies on the medicinal plants of the Balearic Islands do not mention any orchid species, so it does not seem that any orchid is integrated in the culture and tradition of the archipelago (Palau, 1993; Romo, 2000).

To conclude, orchids have been traditionally employed by civilizations on a global scale since ancient and mythological times until the present day. The most common used given to the species of this family are as medicinal plants, for alimentation, for ornamental purposes, in traditional rituals, in art and as tonic or aphrodisiac potions. The Theory of Signature correlates, since antiquity, orchid plants to fertility and beauty.

III. Orchids in Cuisine

Despite their captivating beauty and glamorous fragrance, orchids have found their place in the alimentary industry, with their unique flavors and aromatic profiles. Even though orchid earned a multitude of application in gastronomy, two remarkable preparations draw attention for their multifaceted properties: Vanilla and Salep. These delicate orchid products, much appreciated for their delightful taste and cultural significance since ancient times, have left a permanent mark on the culinary world. This part shed light on the history and high potential of human life improvement of these two preparations based on orchids.

Vanilla

Orchids have led an important influence on gastronomical industry. Vanilla turned into a worldwide famous flavour exploited extensively in the food, beverage, perfumery, and pharmaceutical industries. It is derived from the cured pods of distinct species of vanilla orchids: *Vanilla planifolia*, *Vanilla pompona* and *Vanilla tahitensi*, notwithstanding the first one fulfils the highest quality of components. A legend from the Mexican Totonac tribe gives vanilla a romantic origin story. It is said that two young members of the tribe, Tzacopontziza and Zkatan-oxga, were tragically killed by the gods due to their forbidden love. In the place where they were sacrificed, a solitary tree (zkatan-oxga) grew, and soon after, a vine (tzacopontziza) interleaved around it, symbolizing the eternal union of the lovers. The Mayans were the first to use the flavouring properties of *Vanilla planifolia* (Figure 3), as a spice for their hot chocolate beverages. Further, the Aztec civilization recognized the practical use of this orchid, even used as payment for tributes until 1482. They considered vanilla as one of three reputed aphrodisiac spices added to their chocolate, believed to possess potent erotic qualities (Ossenbach, 2005).

The Spanish Conquistador Hernán Cortés brought vanilla to Europe in 1520; however, it took approximately 300 years for commercial production of vanilla to begin. Efforts to grow vanilla in other countries failed because the flowers relied on specific pollinators, bees from the genera *Eulaema*, which would not survive elsewhere than Mexico. It wasn't until 1838 when Charles Morren from Belgium discovered the manual pollination method for vanilla flowers. Following this breakthrough, the French, Dutch, and British began cultivating vanilla in their colonies. In 1858, Gobley isolated vanillin, the crystalline component of vanilla, and Carles established its structure in 1870, paving the way for industrial production of vanilla substitutes (Hossain, 2011; Ossenbach, 2005). Despite competition from other tropical regions and the widespread production of synthetic vanillin, Mexican vanilla has maintained its unparalleled quality. The demand for Mexican vanilla remains high, attesting to its exceptional reputation in the industry. After saffron, vanilla ranks as the second most onerous flavouring spice (Hossain, 2011; Ossenbach, 2005).

Figure 3: *Vanila planifolia* in the gardens of Satria Agrowisata, Bali, Indonesia. Picture from the author. All Rights Reserved.

Natural vanilla extract is a sophisticated combination of molecules, consisting of over 200 different components that collectively contribute to its unique taste and fragrance. The primary ingredient is vanillin (4-hydroxy-3-methoxybenzaldehyde), which accounts for 1%–2% w/w concentration in cured vanilla pods (A. K. Sinha et al., 2008). The process of fermenting vanilla pods to obtain the extract results in a pure and delicate spicy flavour, which is challenging to replicate using technological methods. Nonetheless, the market price of natural vanillin obtained from vanilla pods became extremely high and subject to fluctuations due to the unpredictable availability of vanilla pods. Crop yields are closely linked to weather conditions, disease prevalence, as well as local and international political and economic factors. Indeed, vanillin extracted from vanilla pods carries a market price that ranges from approximately US$1200/kg to over US$4000/kg (Gallage & Møller, 2015). Therefore, vanillin is now mostly produced synthetically with lignin or other substrates as guaiacol, being a least costly option for an average of US$15/kg (Arya et al., 2021; Hossain, 2011).

However, vanilla is commonly used in the elaboration of flavoured ice cream and other dairy products, in pastry, beverages, but not only in the alimentary industry, yet vanilla extracts are also used in perfumery and cosmetics (Hossain, 2011). Because of the popular affectation of vanilla in these fields, less attention has been given to the bioactive characteristics of vanillin. Although, considering its lack of toxicity in rats confirmed by serious studies, vanillin should be considered as a promising bioactive compound with potential pharmacological applications (Arya et al., 2021). Actually, vanillin is conformable to European Pharmacopoeia, US Pharmacopoeia NF and Food chemical codex (Hossain, 2011). Arya et al. (2021) lists all the potential pharmacological applicability of the bioactivities of vanillin, reported in the Figure 4. Vanillin can be applied as well as blood purifier, diuretic, vermifuge, aphrodisiac, antispasmodic, stimulant and childbirth accelerator (Hossain, 2011).

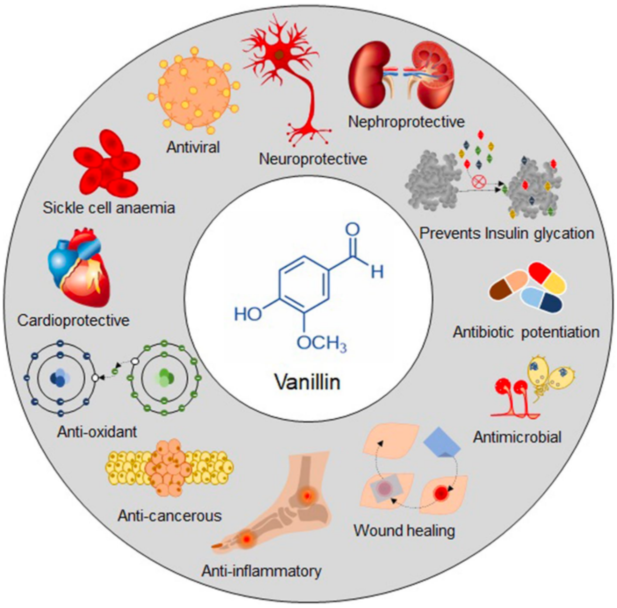

Figure 4: Pharmacollogical applicability of vanillin and its chemical structure. From Arya et. al (2021).

Salep

The most famous traditional preparation that includes orchids is Salep, derived from the tubers of terrestrial species. It is named after a Turkish word that refers to both the hot drink and the orchid bulbs used to produce it. This flour is made by grinding dried tubers of orchid species such as *Orchis mascula*, *Orchis militaris*, and related varieties, which contain a nutritious starch-like polysaccharide called glucomannan (Hossain, 2011). In Turkey, as the leading producer of high-quality salep, approximately 120 taxa from various genera, including *Ophrys*, *Orchis*, *Himantoglossum*, *Serapias*, *Anacamptis*, *Compreria*, *Barlia*, *Dactylorhiza*, *Aceras*, and *Neotinea*, are used to prepare the blend (Caliskan et al., 2018). According to (Font i Quer, 1985), the Salep has to be prepared with the new tubers, as follows: the tubers are cleaned in hot water, then air-dried, and once dry the tubers turn hard but get softer by macerating in water.

The popularity of this mixture, due to its nutritive and demulcent properties, extends beyond Turkey, with historical usage in the East, where its primarily production takes place, with significant collection in Asia Minor and to some extent in Germany, France, and other parts of Europe. In the UK, salep was sold in London during Oliver Cromwell's time, even before coffee was introduced, and was served as a hot drink in the streets (Panda & Mandal, 2013). Its popularity spread to England and Germany, becoming an alternative beverage in coffee houses. In England, it was known as "saloop" and gained significant popularity in the 17th and 18th centuries. Ancient Romans also used ground orchid bulbs to make drinks, considering them potent aphrodisiacs (Hossain, 2011).

The constituents of salep vary depending on the season of collection and orchid species. Mucilage is the most important component, accounting for 48% of the preparation. It also contains sugar (1%), starch (3%), nitrogenous substances (5%), and a trace of volatile oil when fresh (Hossain, 2011). It serves as a valuable dietary option for convalescents and children, often boiled with milk or water. Additional flavours such as sassafras chips, cloves, cinnamon, and ginger were sometimes added to enhance the taste (Hossain, 2011). In Turkey and in Greece, the substance is used as an ingredient for sweets and to prepare a derivate ice cream (Bazzicalupo et al., 2023).This mixture is not only destined for alimentary use, Salep finds medical application as well to alleviate gastrointestinal irritation and dysentery, or for the treatment of cough and fever. The beverage is also employed as a tonic, to increase appetite and enhance sexual potency. Finally, the German Pharmacopoeia recognizes salep mucilage as an official preparation (Bazzicalupo et al., 2023; Hossain, 2011).

Finally, consuming orchids in cuisine leads to several potential health benefits. Numerous bioactive compounds are present in these plants, which may contribute to human health and well-being. Extensive scientific research surrounding the nutritional and medicinal properties of orchids might be needed, shedding light on their potential contributions to a healthy and balanced diet. Notwithstanding, the integration of orchids in cuisine still represents a captivating fusion of artistry, culture, and gastronomy.

IV. Orchids in Cosmetics

The use of orchids in cosmetics has acquired significant attention in the last decades, outstanding their unique benefits for the skincare and beauty products, besides their delicate fragrances. Orchid extracts and oils are reputed for their moisturizing, soothing and anti-aging properties. This section surveys the multiple applications of orchids in cosmetic formulations, highlighting their potential as natural ingredients for skin health, conceded by the chemical properties of second metabolites and by-products.

Orchids, a key to the Fountain of Eternal Youth

Several orchid components are used in the cosmeceutical industry, recognized as potent anti-aging and skin moisturizing products (André et al., 2011; Simmler et al., 2011). Wrinkles, the most common sign of aging skin, are induced by reactive oxygen species (ROS) which promote the degradation of collagen and inhibit its synthesis (Hadi et al., 2015). ROS are generated by extended UV exposure, then enhances the expression of cyclo-oxygenase 2 (COX-2), which increases the synthesis of prostaglandin E2 in keratinocytes, a process observed more frequently in aged skins (Seo et al., 2003; Simmler et al., 2010). Thus, to counteract these effects, antioxidants like polyphenols are the perfect allies. Surprisingly, orchids of the genus *Vanda* contain active compounds with antioxidant activity, such as imbricatin, methoxycoelonin, gigantol and anthocyanin (Hadi et al., 2015; Hu et al., 2020). Different studies driven on the active compounds present in *Vanda* species lead on the conclusion that the extract of *V. coerulea* (Figure 5) and *V. teres* has the potential to be used as an active agent in anti-aging formulations, thanks to the anti-inflammatory and antioxidant properties of the several polyphenols they dispose (Hadi et al., 2015).

Moreover, the high content of intracellular mucilage of most orchid species makes their extracts recommended for dry or sensitive skin (Hadi et al., 2015). Indeed, mucilage is a type of polysaccharide that possesses abundant hydroxyl groups with a high capacity of water binding (Malviya et al., 2011). Those bonds help maintaining the hydrated state of the skin and prevent from water evaporation. This characteristic justifies the suitability of mucilage-rich orchid extracts for being a hydrating agent, valuable in the cosmeceutical industry (Hadi et al., 2015). Additionally, a recent study of Axiotis et al. (2022) demonstrated the suitability of *Cymbidium* sp. by-products as potential candidates for anti-ageing and rejuvenator components of dermo-cosmetic formulations.

Figure 5: Exemplar of *Vanda coerulea* in Kemenuh Butterfly Park, Sukawati, Bali, Indonesia. Picture from the author. All rights reserved.

On the other hand, the antioxidant and anti-inflammatory properties of orchids from the anthocyanin pigments can also be used as soothing and skin tone enhancer (Hu et al., 2020). A clinical trial demonstrated that a cosmetic formulation with orchid extract shows the same efficacity as a formula based on vitamin C for the whitening treatment of melasma and solar lentigines, cutaneous hyperpigmentation issues (Hu et al., 2020; Tadokoro et al., 2010).

Additionally, flowers of *Anacamptis morio* are macerated in cold pressed sunflower oil at low temperature to extract the lipid soluble components of this species, for the purpose to produce orchid oil. This oil, highly nourishing and soothing, is used for its beneficial applications on the skin, such as improvement of skin elasticity and promotion of cell regeneration, particularly helpful for aging skin and for the treatment of psoriasis and eczema conditions. Orchid oil extracts can also be applicated on hair for moisturizing and regenerating purposes (*Divine Archetypes*, n.d.).

Vanilla applications in cosmetics

As commented previously, the fragrance and antioxidant properties of vanillin concede a prominent place to *Vanilla* species in the world trade, turning them into the orchids of greatest economic interest worldwide (Arya et al., 2021; Rodríguez-Deméneghi et al., 2023). Vanillin properties play a key role in haircare and skin renewal and repair, thus the use of vanilla extracts as cosmeceutical ingredients are promising. Precisely, the natural plant-based hair care brand Leonor Greyl Paris® exploits the moisturizing, regenerating and anti-aging properties of *Vanilla planifolia* extracts in their "Masque à l'orchidée" hydrating hair mask (*Leonor Greyl Paris*, n.d.).

To conclude, the use of orchids in cosmetics offers promising skincare and haircare benefits. The nourishing and rejuvenating properties make orchid extracts and oils valuable ingredients in anti-aging, moisturizing and protective formulations. These characteristics, added to their pleasant scent, make orchids a coveted element to the cosmeceutical industry. Notwithstanding, further clinical trials are required to validate all potential applications of vanillin on human health and welfare (Arya et al., 2021).

V. Orchids in Medicine

Orchids have been traditionally used for various health conditions, and their extracts have shown promising effects in areas such as anti-inflammatory, anticancer, and antioxidant activities. Understanding the medicinal potential of orchids can contribute to the development of new pharmaceutical interventions. This section aims to demonstrate the medical applications of orchids, highlighting their potential therapeutic properties conceded by specific bioactive secondary metabolites.

Orchidaceae is a family with a long history in herbal medicine since ancient times and have applications all over the world (Kong et al., 2003). As commented in the traditional and cultural uses section, these plants have been most used traditionally for medical purposes, including stomach disorders, chest pain, arthritis, acidity, allergies, tumours, inflammations, menstrual disorder, muscular pain, dysentery, bone fractures, rheumatism, asthma, malaria, earache, wounds, and sores (Hossain, 2011). Besides, many preparations based on orchids are used as aphrodisiac, tonic, sex stimulator, contraceptive, sedative, and remedies in animal bites (Hossain, 2011). Nonetheless, these medical applications must be investigated to be validated.

Identification of bioactive compounds

Numerous authors have studied the species implicated in traditional medical uses and have identified the bioactive compounds of the plants capable of the biological activity associated with the therapeutic applications (Barragán-Zarate et al., 2022; Bulpitt et al., 2007;

Gantait et al., 2021; Mukherjee & Jagtap, 2020; Natta et al., 2022). Under special circumstances like stress, plants produce secondary metabolites with unique chemical properties and biological activities(Thakur et al., 2019). Several classes of secondary metabolites produced by medicinal orchids, including alkaloids, phenolics, terpenoids, flavonoids and tannins, among others, exhibit an important role in the pharmaceutical area (Gantait et al., 2021).

The presence of total phenol and flavonoid contents in orchids demonstrates their medicinal properties and their role in antioxidant activity. The antioxidant effects of secondary metabolites, particularly phenolics, are attributed to their redox properties, enabling them to function as singlet oxygen quenchers, reducing agents, and hydrogen donors (Natta et al., 2022). Moreover, tannins are known for their various medicinal effects, including anti-parasitic, antiviral, antibacterial, anti-inflammatory, anti-ulcer, and neuroprotective properties (Natta et al., 2022). These compounds have also demonstrated potent antioxidant potential for medicinal purposes, as supported by studies conducted on rodents (Bhattacharyya et al., 2014; Natta et al., 2022; Souza et al., 2007).

Properties of Medicinal orchids

On the other hand, some orchids, particularly the species of the genera *Dendrobium*, are rich in alkaloids (Zhang et al., 2003).More specifically, saponins, a specific class of steroidal alkaloids, are found in significant quantities in certain orchid species (Natta et al., 2022). The presence of saponins has led to the utilization of orchid extracts in wound healing and bleeding management thanks to their ability to precipitate and coagulate red blood cells and bind cholesterol (Hossain, 2011). Additionally, *Dendrobium* species and other medicinal orchids also present highly potent bioactive flavonoids (Natta et al., 2022). These substances demonstrate therapeutic potential as enzyme inhibitors and possess anti-inflammatory and antibacterial properties (Oyedemi et al., 2012). The high levels of flavonoids, such as quercetin and catechins, found in species like *D. nobile*, *D. moschatum*, *D. densiflorum*, and *Coelogyne nitida* (Figure 6), likely contribute to their notable antioxidant activity observed in laboratory tests (Natta et al., 2022). Various phenolic compounds have been identified and associated with multiple biological properties, including antioxidant, anticancer, antibacterial, radical-scavenging, anti-inflammatory, antiviral, and antimicrobial activities (Natta et al., 2022).

Figure 6: Flower of *Coelogyne nitida*. From https://www.flickr.com/photos/snotch/46966531965/in/photostream/

Examples of demonstrated specific therapeutic properties of medicinal orchids include the antibacterial effects of isoamoenylin isolated from *Dendrobium amoenum* roots, the anti-inflammatory properties of certain phenolic compounds found in the rhizomes of *Gastrodia elata*, the anti-allergic properties of the methanol extract from *Gymnadenia conopsea* tubers, the sedative and anti-convulsant properties of goodyerin isolated from *Goodyera schlechtendaliana*, and the neuroprotective effects of dactylorhin B isolated from *Coeloglossum viride* for the treatment of Alzheimer's disease (Du et al., 2002; Gantait et al., 2021; Khan & Omoloso, 2004; Lee et al., 2006; Ye et al., 2002; Zhou et al., 2006). Moreover, the antiviral response of mannose-specific lectins isolated from *Cymbidium*, *Listera ovate*, and *Epipactis helleborine*, which present an inhibitory response to influenza A virus, justifies the traditional use of these species against the flu symptoms (Gantait et al., 2021).

Furthermore, there are specific medicinal orchids, such as *Anoectochilus formosanus, Bulbophyllum kwangtungense, Cremastra appendiculata,* and certain *Dendrobium* or *Ephemerantha* species, that exhibit anti-cancer or antitumour activity through mechanisms such as apoptosis, tumour necrosis, and inhibition of tubulin polymerization (Gantait et al., 2021; Y. C. Huang et al., 2005; Tseng et al., 2006).

Barragán-Zarate et al. (2022) have demonstrated the anti-inflammatory properties of *Prosthechea karwinskii*, an endemic orchid of Mexico used traditionally for the treatment of chronic degenerative diseases and other health conditions related to the inflammatory processes, including diabetes, cough, wounds and burns, miscarriage and childbirth features (Christiansen et al., 2006; Gabriela Cruz-Garcia et al., 2014; Hadley et al., 2018; Kamimura et al., 2010; Wang et al., 2019). The study showed that the presence of compounds like chlorogenic acid, rutin, quinic acid, embelin and guanosine contribute, alone or synergistically, by decreasing the production of several proinflammatory cytokines, among other pharmacological properties related to diabetes treatment and anti-inflammatory effects (Kalyan Kumar et al., 2011; Kim et al., 2015; Ong et al., 2013; Quincozes-Santos et al., 2014).

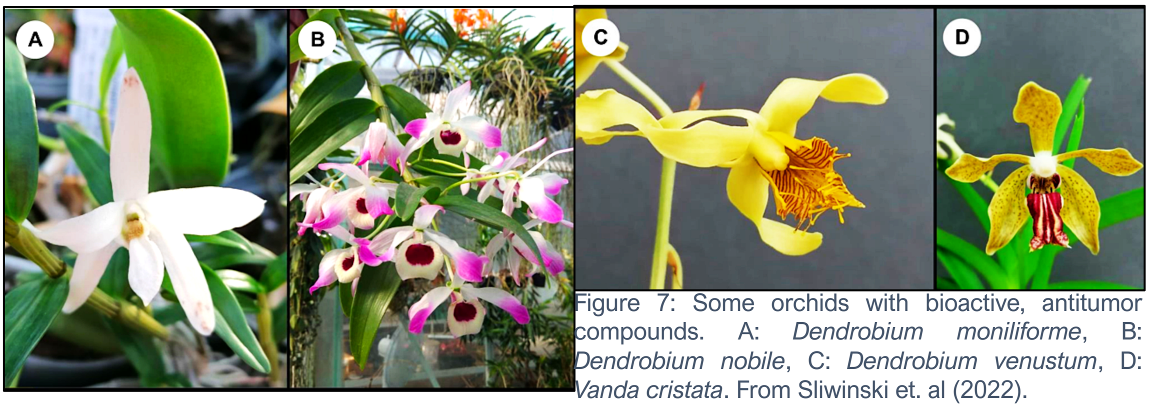

Figure 7: Some orchids with bioactive, antitumor compounds. A: *Dendrobium moniliforme*, B: *Dendrobium nobile*, C: *Dendrobium venustum*, D: *Vanda cristata*. From Sliwinski et. al (2022).

Orchids in contemporary Chinese Medicine

Figure 8: Chinese Shihu Tea preparation. From https://dragonteahouse.biz/organic-wild-shihu-fengdou-herbal-dendrobii-dendrobium-stem-natural-chinese-herb0/

In China, the orchid-based traditional Chinese herbal medicine "Shihu" that have been mentioned earlier, is currently available for sale (Bulpitt, 2005). It is utilized as a tea (Figure 8) for indigestion, rehydration, as an antipyretic, to boost white blood cell count, and alleviate fatigue. This product is usually prepared with the extracts of several *Dendrobium* species, including *Dendreobium loddigesii*, and *Gastrodi elata* (Bulpitt, 2005). Interestingly, this preparation is recommended in Chinese medicine to treat stomach and lung cancer, meanwhile those medical properties have been demonstrated in moscatilin, a compound derived from *Dendreobium loddigesii* (Ho & Chen, 2003). Moreover, *Gastrodia elata* is used to address allergies, headaches, and fatigue. It is a component in many herbal formulas aimed at treating hypertension, convulsions, migraines, wind-related ailments, and cramps (An et al., 2003).

In conclusion, orchids have demonstrated significant potential for medicinal applications. Their diverse bioactive compounds, such as flavonoids, phenols, and alkaloids, among others, contribute to their therapeutic properties. The traditional uses of orchids align with scientific research, supporting their value in treating various health concerns. Further clinical research and exploration of orchid-based pharmaceuticals hold promise for future pharmaceutical development.

VI. Orchids in Biotechnology

In the field of biotechnology, orchids have become fascinating subjects with significant applications. By exploiting biotechnological tools such as in vitro tissue culture, cryopreservation, and mircopropagation, we can not only protect orchid diversity, but also explore their potential for pharmaceutical, alimentary, and horticultural applications. Facing the constant threat of extinction empowered by habitat loss, global climate change, illegal trade, and the high demand of certain species, orchid conservation is now essential. This section highlights the essential connection between orchid preservation and biotechnology, relating the need for innovative approaches to protect these prominent plants for future generations.

In vitro tissue culture

As demonstrated in the previous sections, the Orchidaceae family offers a rich source of biologically active compounds with promising potential in the pharmaceutical industry and human welfare. At the same time, the special conditions needed for natural synthesis of second metabolites and the preservation status of various species confronts the high demand for those precious extracts. Thankfully, biotechnological methods offer a solution by enabling constant access to valuable biomass through in vitro cultivation, while enhancing synthesis and accumulation of desired secondary metabolites (Śliwiński et al., 2022). In vitro propagation protocols have been successfully developed for various medically important orchid species, for instance, Pujari et al. (2021) have demonstrated simple, fast, and cost-effective tissue culture protocols for *Dendrobium ovatum*.

Thin layer culture micropropagation

A different biotechnological culture method that can be applied to orchids is the protoplast or thin cell layer culture (Śliwiński et al., 2022). This micropropagation protocol for *Hadrolaelia grandis* has been successfully developed by Vudala et al. (2019), providing a potential route for large-scale in vitro plant breeding. Eventually,Śliwiński et al. (2022) suggest the consideration of special bioreactors for the culture of several tissues and cells as sources of significant compounds, yet these instruments ensure the sterile preservation of plant material in vitro, which allows the optimization of the whole breeding process, with significant technological and economic perspective.

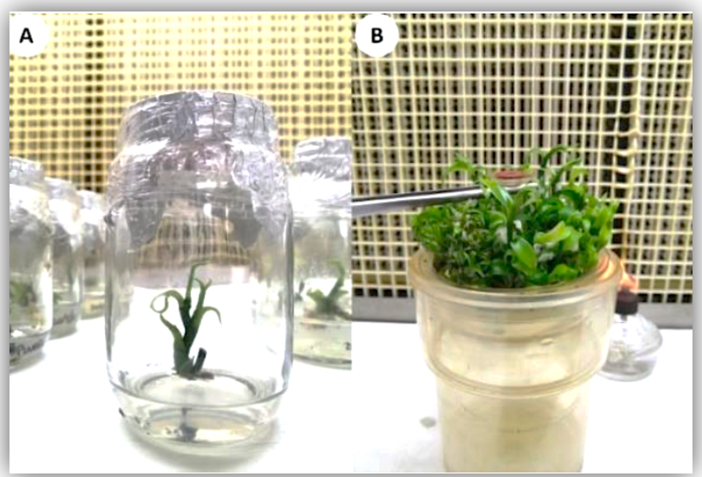

Figure 9: Propagation of *Vanilla planifolia* in vitro. A: Cultivated in semi-solid medium; B: Cultivated in Bioreactor RITA®. From Rodríguez-Deméneghi et al.(2023).

Regarding the alimentary industry, the globally important example of vanillin production mentioned previously in the corresponding section finds a path though biotechnological bioengineering. Indeed, genetically engineered plants cultures have been considered by Chee et al. (2017) as a prospective alternative to produce this molecule with the intention to enhance its commercial and medical potential in the future. Additionally, according to Gallage & Møller (2015), it is also relevant to consider microorganism characterized by fast growth rates and compatibility with molecular genetics as a suitable platform for the biotechnological synthesis of vanillin.

Cryopreservation

Biotechnology departments of numerous universities and laboratories worldwide are implicated in the conservation and propagation of orchid species. The high ornamental and therapeutical values of orchids make them a prized asset for commercial application in the floriculture and pharmaceutical industries. Currently, orchids have become a lucrative industry worth millions of dollars several countries around the world (Chugh et al., 2009a). Thus, in vitro techniques have been developed to insure the conservation of orchid species, such as cryopreservation. This method provides double advantages, depending on the type of explant used. First, the utilization of seeds for cryopreservation allows the conservation of the entire genetic information present within the populations. Second, when somatic tissues such as apical meristems, axillary buds, or protocorm-like bodies (PLBs) are used for cryopreservation, it enables the preservation of specific genotypes, thereby preserving valuable commercial stocks (Das et al., 2021).

Finally, the possibility of enhancing orchid production through diverse physical and chemical factors, along with future genetic modifications, undoubtedly holds the promise of developing efficient and comprehensive solutions allowing the use of orchids as producers of essential compounds for multiple life-enhancing applications (Śliwiński et al., 2022).

VII. Discussion and Conclusion

As reviewed in this work, the members of Orchidaceae family are victim of a planetary success in multiple fields due to their versatile characteristics. Many species are famous worldwide in the ornamental market for their exotic beauty and long shelf life, traditionally used in rituals and tonic preparations for their aphrodisiac qualities, medically considered for their healing capacities, involved in the alimentary industry for their flavouring properties, and even considered in biotechnology. Meanwhile, the orchid population has faced a significant decline in their natural habitats, not only due to the unregulated commercial collection and extensive use, but also because of the deforestation, habitat loss and fragmentation caused by climate change and anthropogenic activities (Das et al., 2021; Nongdam et al., 2023; Phillips et al., 2020). This frightening decline convicted the entire Orchidaceae family to be labelled in the Appendix-II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and more than 600 species are listed as threatened in the Red List of the International Union for the Conservation of Nature (Cribb et al., 2003; Fay, 2018; Nongdam et al., 2023). Therefore, some governments have taken initiatives to preserve orchid biodiversity, for instance, the Indian authorities have created Biosphere Reserves, National Parks, and Sanctuaries in the appropriated regions, in addition to the prohibition of wild-collected orchid exportation (Chugh et al., 2009). Moreover, the exportation of Salep produced from tubers of wild orchids is prohibited by the Turkish Ministry of Agriculture and Rural Affairs, as well as the recollection of wild orchid specimens in Greece (Tamer et al., 2006). Despite the efforts apported, *in situ* conservation actions are not being effective enough to prevent the extinction of species, as a result of the many factors that impact negatively on orchid biodiversity preservation, and because the natural method of propagation of orchids has many drawbacks like slow growth, low germination rate and susceptibility to pesticides (Chugh et al., 2009; Gantait et al., 2021).

Consequently, an efficient conservation strategy is compulsory to ensure the survival of the precious species and to satisfy the high demand of orchids in various industries, with a significant economic potential (Chugh et al., 2009). To overcome these challenges, biotechnological propagation and conservation strategies have been used successfully to rapidly produce orchid plants on a commercial scale, such as micropropagation and cryopreservation (Chugh et al., 2009; Das et al., 2021; Nongdam et al., 2023).

Furthermore, biotechnological advancements are decisive for the secondary metabolite extraction of medicinal orchids, as well as the production of biosynthetic vanillin as a consequence of the growing demand for natural flavours and health products (Gallage & Møller, 2015; Gantait et al., 2021). According to Nongdam et al. (2023), a number of orchids have been successfully micropropagated on semi-solid media. Additionally, the field of bioengineering microorganisms for flavour production is rapidly expanding, driven by innovative biotechnologies. Various biotechnological approaches for synthesizing vanillin rely on the bioconversion of specific natural substances like lignin, ferulic acid, eugenol, and isoeugenol, utilizing microorganisms such as yeasts, fungi, and bacteria as hosts for production (Gallage & Møller, 2015).

However, even though various investigations on biotechnological approaches have been explored, these methods are not yet developed enough for industrial application (Gallage & Møller, 2015). Further studies are needed to conciliate the potential of secondary metabolite exploitation of orchids with the conservation of the species, and to reveal the potential of these extraordinary members of the plant kingdom.

VIII. Methodology

This bibliographical asset is based on the literature consulted on the data bases including PubMed, NCBI, Web of Science (WOS), DialNet, Google Scholar, Science Direct, Elsevier, Scopus, Springer, among others, which access was granted by the University of the Balearic Islands. The keywords or topic terms used alone or in combination with advanced search and Booleans tools include: "orchid", "Orchidaceae", "traditional uses", "medicinal uses", "uses of orchids", "vanilla", "vanillin", "orchids in cosmetics", "orchids in biotechnology", "orchid conservation", "micropropagation" among others. The nomenclature of the species cited is based on the bibliography consulted, according to each author.

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X. Annex

Annex 1. Compilation of 163 species of orchids, their uses given, the geographical regions where they are used, the part of the plant used[a], and the type of use given, according to the references consulted. [a] S: hypogean portion used for Salep; T: tuber; RZ: rhizome; R: roots; L: leaves; AP: aerial parts; FS: flowering stem; F; flowers; W: whole plant; UN: unspecified.

Species	Use	Geographical zone	Plant part used for preparation	References	Medicinal plant	Aphrodisiac plant	Alimentary uses	Psychedelic plant	Ritual uses	Pigment/adhesive	Tonic preparation	Ornamental plant
Aa paleacea	Contraceptive. Against lonelyness and depression.	Peru.	L	(Teoh, 2019)	x							
Acampe papillosa	Medicinal plant.	India.	UN	(Hossain, 2011)	x							
Acriopsis javanica	Treat malaria.	Malaya.	UN	(Hossain, 2011)	x							
Anacamptis coriophora	Salep. Treat wounds, abscess, inflammation, digestive diseases. To improve circulatory system and mental wellness. Food.	Turkey. Serbia. Bulgaria. Greece.	S; T	(Bazzicalupo et al., 2023)	x		x					
Anacamptis laxiflora	Medicinal food. Treat dysentry. Treatment of bronchitis. Salep	Turkey. Serbia. Southern Europe.	S; T	(Bazzicalupo et al., 2023)	x		x					
Anacamptis morio	Treat flu, digestive diseases, wounds, cough. Salep. Increase sex potency. Tonic. Food. Ornamental. Medicinal plant. Rituals.	Albania. South Kosovo. Turkey. Bosnia-Herzegovina. Italy. Bulgaria. Serbia. Greece. Hungary. Central Europe.	S; T; FS; UN	(Bazzicalupo et al., 2023)	x	x	x		x		x	x
Anacamptis palustris	Treat respiratory diseases. Salep. Ornamental.	Bulgaria. Turkey.	S; FS	(Bazzicalupo et al., 2023)	x		x					x
Anacamptis papilionacea	Salep. Ornamental. Rituals.	Turkey. Bulgaria. Greece. Italy.	S; FS	(Bazzicalupo et al., 2023)			x		x			x
Anacamptis pyramidalis	Treat cough, flu. Vasodilatator. Tonic. Aphrodisiac. Psychedelic. Salep. Medicinal food. Ornamental.	Bosnia-Herzegovina. Turkey. Serbia. Greece. Italy.	S; T; FS; W	(Bazzicalupo et al., 2023)	x	x	x	x	x		x	x
Ansellia africana	Contraceptive.	Africa.	L; T	(Hossain, 2011)	x							
Ansellia gigantea	Aphrodisiac.	South Africa.	FS	(Craves, 2012; Hossain, 2011)		x						
Ansellia humilis	Rituals. Treat madness.	South Africa.	UN	(Hossain, 2011)					x			
Arethusa bulbosa	Relieve toothache.	America.	R	(Hossain, 2011)	x							
Arpophyllum spicatum	Treat dysentry.	Central America.	UN	(Hossain, 2011; Ossenbach, 2009)	x							
Artorima erubescens	Ornamental.	Central America.	UN	(Ossenbach, 2009)								x
Bletia campanulata	Adhesive. Treat dysentry. Ornamental.	Central America.	UN	(Ossenbach, 2009)	x							x
Bletia catenulata	Treat dysentry.	Central America.	UN	(Hossain, 2011)								x
Bletia coccinea	Adhesive. Ornamental.	Central America.	UN	(Ossenbach, 2009)								
Bletia purpurea	Medicinal tea. Tonic. Antidote for fish-poisoning. Treat digestive diseases, skin affections.	America.	T	(Hossain, 2011)	x							
Bromheadia finlaysoniana	Relieve pain.	North America.	R	(Hossain, 2011)	x							
Bulbophyllum vaginatum	Relieve earhache.	America.	F	(Hossain, 2011)	x							
Caladenia spp.	Food.	Australia.	UN	(Hossain, 2011)			x					
Catasetum fimbriatum	Contraceptive.	Paraguay. Brazil.	T	(Teoh, 2019)	x							
Catasetum integerrimum	Adhesive. Pigments.	Central America.	UN	(Ossenbach, 2009)						x		
Catasetum maculatum	Treat wounds, tumors.	Central America.	UN	(Ossenbach, 2009)	x							
Catasetum sp.	Treat abscesses.	Brazil.	UN	(Teoh, 2019)	x							
Cattleya crispa	Treat digestive diseases.	Brazil.	UN	(Teoh, 2019)	x							
Cleistes rosea	Treat mouth sores.	Brazil	L	(Teoh, 2019)	x							
Corallorhiza maculata	Treat pneumonia.	America.	FS	(Hossain, 2011)	x							
Corymborchis longiflora	Treat malaria.	Malaya.	UN	(Hossain, 2011)	x							
Cranichis speciosa	Adhesive. Treat dysentry. Pigments.	Central America.	UN	(Hossain, 2011; Ossenbach, 2009)						x		
Cranichis tubularis	Adhesive. Pigments.	Central America.	UN	(Ossenbach, 2009)						x		
Cymbidium canaliculatum	Treat dysentry. Food.	Australia.	UN	(Bulpitt, 2005)			x					
Cymbidium canaliculatum	Treat dysentry, relieve pain, control ringworm.	Australia.	UN	(Hossain, 2011)	x							
Cymbidium madidam	Treat dysentry. Oral contraceptive.	Australia.	T	(Hossain, 2011)	x							
Cymbidium madidum	Treat dysentry. Orla contraceptive.	Australia.	UN	(Bulpitt, 2005)	x							
Cypripedium calceolus	Sedative. Reduce pain. Headhache.	Europe. European Russia.	R; RZ	(Bazzicalupo et al., 2023)	x							
Cypripedium spp.	Sedative. Reduce pain, headhache, fever. Help for childbirth. Tonic.	North America.	UN	(Hossain, 2011)	x							
Cyrtopodium andersonii	Treat flu and wounds.	Brazil.	T	(Teoh, 2019)	x							
Cyrtopodium punctatum	Promote cicatrization. Control high blood pressure.	Brazil. Argentina.	T	(Teoh, 2019)	x							

Species	Use	Geographical zone	Plant part used for preparation	References	Medicinal plant	Aphrodisiac plant	Alimentary uses	Psychedelic plant	Ritual uses	Pigment/adhesive	Tonic preparation	Ornamental plant
Cyrtopodium sp.	Treat abscesses.	Brazil.	UN	(Teoh, 2019)	x							
Cyrtorchis arcuata	Treat diabetes, skin infections. Promote friendships.	Malawi.	UN	(Hossain, 2011)	x							
Dactylorhiza baumanniana	Salep. Treat cough. Aphrodisiac. Tonic.	Bulgaria.	S	(Bazzicalupo et al., 2023)	x	x	x				x	
Dactylorhiza cordigera	Treat cough, inflammation, skin affections, wounds. Aphrodisiac. Tonic.	Turkey. Bulgaria. Greece. Italy.	T; L	(Bazzicalupo et al., 2023)	x	x					x	
Dactylorhiza iberica	Salep.	Turkey	S; T	(Bazzicalupo et al., 2023)			x					
Dactylorhiza incarnata	Food. Salep. Tonic. Aphrodisiac.	Italy. Bulgaria.	S; T	(Bazzicalupo et al., 2023)		x	x				x	
Dactylorhiza insularis	Ornamental.	Italy.	FS	(Bazzicalupo et al., 2023)								x
Dactylorhiza kalopissii	Salep. Tonic. Aphrodisiac.	Bulgaria.	S	(Bazzicalupo et al., 2023)		x	x				x	
Dactylorhiza maculata	Salep. Aphrodisicac. Psychedelic. Food. Rituals.	Italy. UK. Greece.	S; T; FS	(Bazzicalupo et al., 2023)		x	x	x	x			
Dactylorhiza majalis	Medicinal plant. Salep. Reduce pain. Treat dysentry.	Turkey.	S; T	(Bazzicalupo et al., 2023)	x		x					
Dactylorhiza osmanica	Salep. Medicinal food. Treat cough, inflammation, ulcers, skin affections. Aphrodisiac. Tonic.	Turkey.	S; T	(Bazzicalupo et al., 2023)	x	x	x					
Dactylorhiza romana	Salep. Food. Treat cough. Aphrodisiac. Tonic.	Turkey. Bulgaria.	S	(Bazzicalupo et al., 2023)	x	x	x				x	
Dactylorhiza saccifera	Salep. Medicinal plant.	Turkey. Greece.	S; T	(Bazzicalupo et al., 2023)	x		x					
Dactylorhiza sambucina	Treat cough, respiratory diseases. Food. Salep.	Turkey. Greece. Italy. Macedonia.	S; T; L; F	(Bazzicalupo et al., 2023)	x		x					
Dactylorhiza umbrosa	Tonic. Treat wounds, abscess, inflammation. Salep.	Turkey.	S; T	(Bazzicalupo et al., 2023)	x		x				x	
Dactylorhiza urvilleana	Treat skin affections, wounds, abscess, inflammation. Tonic.	Turkey.	T; L	(Bazzicalupo et al., 2023)	x						x	
Dendrobium alpestre	Medicinal plant.	India.	UN	(Hossain, 2011)	x							
Dendrobium discolor	Treat dysentry, relieve pain, control ringworm.	Australia.	UN	(Hossain, 2011)	x							
Dendrobium speciosum	Food.	Australia.	UN	(Hossain, 2011)			x					
Dendrobium spp.	Tonic. Trat inflammation. Relieve pain. Medicinal plant.	China.	UN	(Hossain, 2011)	x						x	
Dendrobium teratifolium	Treat dysentry, relieve pain, control ringworm.	Australia.	UN	(Bulpitt, 2005; Hossain, 2011)	x							
Dichaea morrisii	Treat conjunctivitis.	Brazil	AP	(Teoh, 2019)	x							
Diuris maculata	Food.	Australia.	T	(Hossain, 2011)			x					
Elleanthus sp.	Psychedelic tea.	Brazil	L	(Teoh, 2019)				x				
Encyclia citrina	Treat wounds.	Central America.	UN	(Hossain, 2011)	x							
Encyclia pastoris	Treat dysentry. Adhesive. Pigments.	Central America.	UN	(Ossenbach, 2009)	x					x		
Epidendrum bifidum	Expell intestinal parasites.	Malaya.	T	(Hossain, 2011)	x							
Epidendrum cochlidium	Treat nerve disorders.	Ecuador.	F	(Teoh, 2019)	x							
Epidendrum pastoris	Treat dysentry.	Central America.	UN	(Hossain, 2011)	x							
Epidendrum sp.	Treat mouth sores.	Brazil	T	(Teoh, 2019)	x							
Epipactis helleborine	Treat rheumatisms, insanity, wounds. Aphrodisiac.	Mediterranean Europe. Italy.	RZ; R; L; UN	(Bazzicalupo et al., 2023)	x	x						
Epistephium brevicristatum	Treat wounds.	Colombia	L	(Teoh, 2019)	x							
Eria pannea	Treat fever.	Malaya.	W	(Hossain, 2011)	x							
Eriopsis sceptrum	Treat mouth sores.	Brazil	T	(Teoh, 2019)	x							
Euchile citrina	Treat wounds.	Central America.	UN	(Ossenbach, 2009)	x							
Eulophia aha	Rituals. Relieve pain.	South Africa.	UN	(Hossain, 2011)	x				x			
Eulophia alta	Reduce inflammation.	Brazil.	T	(Teoh, 2019)	x							
Eulophia cucullata	Prevent epilepsy.	Malawi.	UN	(Hossain, 2011)	x							
Eulophia flaccida	Relieve pain.	South Africa.	UN	(Hossain, 2011)	x							
Eulophia latifolia	Medicinal plant.	India.	UN	(Hossain, 2011)	x							
Flickingeria macraei	Treat digestive and respiratory disease. Aphrodisiac.	India.	UN	(Hossain, 2011)	x	x						

Species	Use	Geographical zone	Plant part used for preparation	References	Medicinal plant	Aphrodisiac plant	Alimentary uses	Psychedelic plant	Ritual uses	Pigment/adhesive	Tonic preparation	Ornamental plant
Gammatophyllum scriptum	Treat skin affections.	Indonesia.	T	(Hossain, 2011)	x							
Gastrodia elata	Medicinal plant.	China.	UN	(Hossain, 2011)	x							
Gastrodia sesamoide	Food.	Australia.	UN	(Hossain, 2011)			x					
Goodyera pubescens	Treat mad dog bite.	North America.	T	(Hossain, 2011)	x							
Govenia liliacea	Adhesive. Pigments.	Central America.	UN	(Ossenbach, 2009)						x		
Govenia superba	Adhesive. Pigments.	Central America.	UN	(Ossenbach, 2009)						x		
Grammatophyllum scriptum	Treat wounds.	America.	T	(Hossain, 2011)	x							
Gymnadenia conopsea	Treat respiratory disease. Increase sex potency. Salep. Medicinal plant. Perfume. Ornamental. Rituals. Treat allergies.	Central Europe. Italy. Bosnia-Herzegovina. Serbia.	S; T; FS; UN	(Bazzicalupo et al., 2023)	x	x	x		x			x
Gymnadenia rhellicani	Digestive. Aphrodisiac. Food. Treat respiratory deseases, fever. Rituals.	Italy.	T; F; W	(Bazzicalupo et al., 2023)	x	x	x		x			
Habenaria conopsea	Treat dysentry.	South Africa.	FS	(Hossain, 2011)	x							
Habenaria foliosa	Emetic.	South Africa.	UN	(Hossain, 2011)	x							
Hetaesia obliqua	Relieve pain.	America.	L	(Hossain, 2011)	x							
Himantoglossum affine	Salep.	Turkey.	S	(Bazzicalupo et al., 2023)			x					
Himantoglossum hircinum	Salep. Medicinal plant. Treat dysentry.	Turkey.	S; T	(Bazzicalupo et al., 2023)	x		x					
Himantoglossum jankae	Salep.	Bulgaria.	S	(Bazzicalupo et al., 2023)			x					
Himantoglossum robertianum	Food. Tonic. Salep. Aphrodisiac. Treat cough, digestive diseases. Ornamental.	Spain. Italy. Turkey.	S; T; FS; W	(Bazzicalupo et al., 2023)	x	x	x				x	x
Laelia anceps	Ornamental.	Central America.	UN	(Ossenbach, 2009)								x
Laelia autumnalis	Treat cough. Adhesive. Ornamental.	Central America.	UN	(Hossain, 2011; Ossenbach, 2009)	x					x		x
Laelia speciosa	Ornamental.	Central America.	UN	(Ossenbach, 2009)								x
Lissochilus dilectus	Treat skin affections.	Malaya.	FS	(Hossain, 2011)	x							
Lissochilus spp.	Aphrodisiac.	Malaya.	UN	(Hossain, 2011)		x						
Lockhartia pittieri	Medicinal plant.	Central America.	UN	(Ossenbach, 2009)	x							
Lycaste gigantea	Treat kidney infection.	Ecuador.	F	(Teoh, 2019)	x							
Masdevallia sp.	Reduce balader inflammation. Diuretic.	Colombia.	W	(Teoh, 2019)	x							
Myrmecophila tibicinis	Help for childbirth. Musical instruments.	Central America.	UN	(Ossenbach, 2009)	x							
Neotinea tridentata	Food. Salep. Tonic. Aphrodisiac.	Serbia. Turkey. Bulgaria. Italy.	S; T	(Bazzicalupo et al., 2023)		x	x				x	
Neotinea ustulata	Food. Tonic. Salep.	Italy. Serbia. Bulgaria.	S; T	(Bazzicalupo et al., 2023)			x				x	
Neottia ovata	Tincture to improve skin tone. Treat digestive diseases, wounds. Salep.	UK. Spain.	S; RZ; UN	(Bazzicalupo et al., 2023)	x		x			x		
Nervilia aragoana	Prevent sickness after childbirth.	Malaya.	L	(Hossain, 2011)	x							
Oncidium cebolleta	Medicinal plant. Psychedelic.	Central America.	UN	(Ossenbach, 2009)	x			x				
Oncidium spp.	Ornamental.	Central America.	UN	(Ossenbach, 2009)								x
Ophrys apifera	Food. Treat inflammations, dysentry, digestive diseases. Diuretic. Salep. Medicinal plant. Ornamental.	Italy. Turkey.	S; T; FS	(Bazzicalupo et al., 2023)	x		x					x
Ophrys argolica	Ornamental.	Turkey.	FS	(Bazzicalupo et al., 2023)								x
Ophrys fusca	Salep.	Turkey.	S	(Bazzicalupo et al., 2023)			x					
Ophrys holosericea	Medicinal plant. Treat dysentry. Salep.	Turkey.	S; T	(Bazzicalupo et al., 2023)	x		x					
Ophrys lutea	Food.	Turkey.	T	(Bazzicalupo et al., 2023)			x					
Ophrys reinholdii	Salep. Psychedelic. Medicial tea. Ornamental.	Turkey.	S	(Bazzicalupo et al., 2023)	x		x	x				x
Ophrys scolapax	Salep. Psychedelic. Medicial tea. Rituals.	Turkey. Spain.	S	(Bazzicalupo et al., 2023)	x		x	x	x			
Ophrys speculum	Ornamental.	Italy.	W	(Bazzicalupo et al., 2023)								x
Ophrys sphegodes	Salep. Medicinal plant. Treat dysentry. Ornamental.	Turkey. Italy.	S; T; FS	(Bazzicalupo et al., 2023)	x		x					x
Ophrys tenthredinifera	Salep. Ornamental.	Turkey.	FS	(Bazzicalupo et al., 2023)			x					x
Ophrys umbilicata	Salep. Food.	Turkey.	S	(Bazzicalupo et al., 2023)			x					
Oprhys insectifera	Medicinal plant. Treat dysentry.	Europe.	T	(Bazzicalupo et al., 2023)	x							

Species	Use	Geographical zone	Plant part used for preparation	References	Medicinal plant	Aphrodisiac plant	Alimentary uses	Psychedelic plant	Ritual uses	Pigment/adhesive	Tonic preparation	Ornamental plant
Orchis anatolica	Salep. Psychedelic. Treat dysentry, cough, chest pain. Tonic.	Turkey.	S; T	(Bazzicalupo et al., 2023)	x			x			x	
Orchis anthropophora	Salep. Medicinal food. Treat respiratory diseases.	Turkey. Greece.	S; T	(Bazzicalupo et al., 2023)	x		x					
Orchis italica	Salep. Psychedelic. Ornamental.	Turkey. Greece.	S; FS	(Bazzicalupo et al., 2023)			x	x				x
Orchis latifolia	Treat cough. Medicinal plant.	India.	T	(Hossain, 2011)	x							
Orchis mascula	Food. Tonic. Treat dysentry. Salep. Aphrodisiac. Medicinal plant. Rituals.	Italy. Turkey. Greece. Central Europe.	S; T; R; L; FS; UN	(Bazzicalupo et al., 2023)	x	x	x		x		x	
Orchis militaris	Salep. Food. Medicinal food.	Italy. Greece. Serbia.	S; T	(Bazzicalupo et al., 2023)	x		x					
Orchis pallens	Salep. Aphrodisiac.	Bulgaria. Serbia.	S	(Bazzicalupo et al., 2023)		x	x					
Orchis provincialis	Salep. Aphrodisiac.	Greece. Bulgaria.	S	(Bazzicalupo et al., 2023)		x	x					
Orchis punctulata	Salep. Food. Treat cold, flu. Medicinal tea. Psychedelic.	Turkey.	S; T	(Bazzicalupo et al., 2023)	x		x	x				
Orchis purpurea	Medicinal food. Salep. Rituals.	Italy. Turkey. Serbia.	S; T	(Bazzicalupo et al., 2023)	x		x		x			
Orchis simia	Salep. Aphrodisiac. Tonic. Food. Treat cold, flu, dysentry. Medicinal tea.	Turkey. Greece. Italy. Bosnia-Herzegovina. Mediterranean Europe.	S; T	(Bazzicalupo et al., 2023)	x	x	x				x	
Orchis spitzelii	Treat cough. Tonic. Salep. Aphrodisiac. Food.	Turkey.	S; T	(Bazzicalupo et al., 2023)	x	x	x				x	
Phragmipedium ecuadorense	Treat digestive diseases.	Colombia.	W	(Teoh, 2019)	x							
Platanthera bifolia	Treat cough, cold, flu, rheumatisms. Salep. Medicinal food.	Italy. Serbia. Turkey. Bosnia-Herzegovina.	S; T; L	(Bazzicalupo et al., 2023)	x		x					
Platanthera chlorantha	Medicinal food. Treat ulcers.	Serbia. UK.	T; AP	(Bazzicalupo et al., 2023)	x		x					
Prosthechea karwinskii	Ornamental. Medicinal plant. Treat diabetes, cough, wound, burns. Prevent misscarriage, help childbirth.	Mexico.	L; T; FS; W	(Barragán-Zarate et al., 2022)	x							x
Psychilis bifida	Diuretic. Purgative to expulse worms.	Guyana. Martinique. Guadeloupe.	UN	(Teoh, 2019)	x							
Psygmorchis pusilla	Treat wounds.	Colombia. Ecuador.	W	(Teoh, 2019)	x							
Rodriguezia lanceolata	Contraceptive.	Paraguay. Brazil.	T	(Teoh, 2019)	x							
Sarcoglottis acaulis	Treat diabetes.	Trinidad and Tobago.	UN	(Teoh, 2019)								
Scaphyglottis livida	Relieve pain.	Brazil. Argentina.	UN	(Teoh, 2019)	x							
Selenipedium chica	Food.	Australia.	UN	(Hossain, 2011)			x					
Serapias lingua	Salep. Medicinal plant. Treat dysentry.	Turkey.	S; T	(Bazzicalupo et al., 2023)	x		x					
Serapias vomeracea	Salep. Medicinal plant. Treat dysentry, cold, flu. Ornamental.	Turkey. Italy.	S; T; FS	(Bazzicalupo et al., 2023)	x		x					x
Sobralia fragans	Medicinal plant.	Central America.	UN	(Ossenbach, 2009)	x							
Spiranthes diuretica	Diuretic.	Chile.	UN	(Teoh, 2019)	x							
Spiranthes spiralis	Aphrodisiac. Tonic. Ornamental.	Europe. Italy.	RZ; FS; W	(Bazzicalupo et al., 2023)		x					x	x
Stanhopea hernandezii	Ornamental. Tonic. Sunstroke.	Central America.	UN	(Hossain, 2011; Ossenbach, 2009)	x						x	x
Stanhopea tigrina	Ornamental.	Central America.	UN	(Ossenbach, 2009)								x
Sudamerlycaste gigantea	Treat kidney infection.	Peru.	F	(Teoh, 2019)	x							
Sudamerlycaste gigantea	Treat infertility.	Ecuador.	Fruits	(Teoh, 2019)	x							
Traunsteinera globosa	Food.	Italy.	T	(Bazzicalupo et al., 2023)			x					
Trichocentrum cebolleta	Treat wounds.	Venezulea.	UN	(Teoh, 2019)	x							
Tropidia curculigoides	Treat malaria.	Malaya.	UN	(Hossain, 2011)	x							
Vanda hookeriana	Treat joints pain.	North America.	L	(Hossain, 2011)	x							
Vanda roxburghii	Treat skin affections, rheumatisms, earhache, fractures, diseases of nervous system.	India.	L	(Hossain, 2011)	x							
Vanda tessellata	Medicinal plant.	India.	UN	(Hossain, 2011)	x							
Vanilla planifolia	Food (aromatic). Aphrodisiac. Diuretic. Aid digestion. Rituals.	Central America.	UN	(Ossenbach, 2009)	x	x	x		x			