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Exploring the Versatility of *Kydia calycina* Roxb.: A Comprehensive Review on Utility, Botany, Conservation, and Cultivation Aspects

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ABSTRACT: *Kydia calycina*, commonly known as baranga, holds significant importance in traditional medicine and ethnobotanical practices worldwide. Originating from southeast Asia, southern China, and the Indian subcontinent, this plant boasts remarkable ecological adaptability and thriving in diverse habitats. This comprehensive analysis delves into various facets of *Kydia calycina*, shedding light on its taxonomy, distribution, and habitat preferences. Its distinctive appearance and phenological cycle are explored, aiding in understanding seasonal variations crucial for cultivation and conservation efforts. Notably, *Kydia calycina* exhibits promising pharmacological properties, containing bioactive compounds with antibacterial, anti-inflammatory, and antioxidant properties. Ongoing research, supported by the Compensatory Afforestation Fund Management and Planning Authority (CAMPA), MoEF&CC at ICFRE-TFRI, Jabalpur focuses on seed processing, viability, and nursery techniques. These endeavors aim to enhance propagation methods and contribute to the conservation of not only *Kydia calycina* but also other tree species in Central India. The review underscores the need for continued investigation into the clinical applications of *Kydia calycina*, emphasizing the standardization of propagation techniques. Collaborative efforts are advocated to leverage its global health benefits while ensuring conservation measures are upheld. Through these ongoing studies, there's a poised contribution towards understanding and propagating medicinal plants like *Kydia calycina* for future generations. Such endeavors not only enrich our knowledge but also hold promise in addressing healthcare needs while safeguarding biodiversity. As research progresses, *Kydia calycina*'s potential in various domains, from medicine to industry, is poised to be further unlocked, benefitting both human health and environmental sustainability.

Keywords: Traditional medicine, Ethanobotanical practices, Morphology, Conservation, Seed technology, Propagation.

INTRODUCTION

India's reputation as a global hub for diverse traditional medicinal systems is well-established, with practices like Ayurveda, Homeopathy, Siddha, and Unani deeply rooted in ancient texts such as the Vedas (Subhose *et al*., 2005; Pandey *et al*., 2013). These traditional systems seamlessly coexist alongside Allopathy, forming a comprehensive healthcare ecosystem that plays a pivotal role in disease prevention, treatment, and overall health maintenance (Vaidya & Devasagayam 2007; Rudra *et al*., 2017). Herbal medicine, a fundamental aspect of historical medical practices, continues to hold relevance in contemporary traditional medicine, attesting to its enduring significance (Rudra *et al*., 2017). The Malvaceae family, encompassing plants with a global distribution, occupies a prominent place in folk medicine, addressing various health concerns such as skin diseases, diabetes, and infertility, while also serving as antiseptic and carminative agents. Compounds like flavonoids, phenolic acids, and carbohydrates contribute to the medicinal properties of plants within the Malvaceae family (Vadivel *et al*., 2016). Among this diverse botanical array, *Kydia calycina* emerges as a notable traditional medicinal plant, recognized by various regional names like pulao, sukhlai, pula, bhoti, and baranga, and belonging to the Malvaceae family (Bhattacharjee & Das 1969; Jendek & Polakova 2014). Indigenous to various regions of Asia, including India, Sri Lanka, and Southeast Asia, *Kydia calycina* significantly shapes the regional landscape (Plants of the World online). Renowned for its rapid growth and medium-sized stature, it holds economic importance due to extensive exploitation for timber and fiber applications (Swaminathan & Kochhar 2019). *Kydia calycina* has firmly established itself as a crucial component of traditional medicine in these regions. Despite being relatively underexplored, there is a growing recognition of its potential as a source of natural products for drug development. Its botanical, ecological, and medicinal dimensions emphasize the necessity for further research, conservation efforts, and potential integration into horticultural practices to

safeguard its ecological value and contributions to traditional medicine. Considering this Ministry of Environment, Forest and Climate Change. Government of India launched a project on seed technology through CAMPA funding for development of conservation and propagation of several important medicinal plants such as *Pterspermum acerifolium* (Vijay *et al*., 2023b), *Buchnaniya lanzan* (Vijay *et al*., 2022), *Kydia calysina* and others. Continued exploration and conservation efforts are essential to fully harness the potential of *Kydia calycina* for both ecological preservation and medicinal advancements.

MATERIAL AND METHODS

A thorough and comprehensive literature review was undertaken, which involved an extensive exploration of diverse resources. Prominent databases such as PubMed, Google Scholar, Web of Science, and Springer Nature were extensively searched to gather relevant information. To ensure inclusivity, various combinations of keywords were utilized during the search process. Additionally, valuable insights were gleaned from sources beyond traditional databases, including relevant websites and pertinent thesis works. The primary aim of adopting this methodological approach was to gather a comprehensive understanding of the Utility, Botany, Conservation, and Cultivation Aspects of the targeted wild tree species. By casting a wide net across multiple sources, this approach aimed to capture a holistic view of the subject matter, incorporating insights from both academic literature and practical applications.

RESULTS AND DISCUSSION

The results of the extensive literature review revealed a rich compilation of information on the Utility, Botany, Conservation, and Cultivation Aspects of the identified wild tree species.

A. Plant Utility

Kydia calycina, with its rich ethnomedicinal history, offers a plethora of traditional applications across various cultures. Here is a detailed breakdown of its diverse uses based on existing literature survey:

Medicinal Uses: *Kydia calycina*, with its rich ethnomedicinal history, offers a multitude of traditional applications across various cultures, supported by its antioxidant potential. Gupta *et al.* (2010) highlighted the longstanding ethno-botanical use of plants for disease treatment and health maintenance, underscoring *Kydia calycina*'s historical significance in traditional medicine. The plant's roots, often prepared as a paste with butter, linseed oil, or hen's egg, have been traditionally applied to fractures or ingested orally as small tablets. Moreover, *Kydia calycina* serves as a febrifuge, effectively combating fever, and exhibits promising potential in treating skin diseases. Its leaves demonstrate analgesic and anti-inflammatory properties, while its flowers, rich in potassium and iron, display inhibitory effects on bacteria. The extensive use of *Kydia calycina* extends beyond its roots and flowers. The leaves are chewed to address saliva deficiencies and utilized in poultices for various ailments. Additionally, the pounded leaves are applied topically to relieve body pains, swellings, jaundice, skin diseases, ulcers, arthritis, diabetes, and lumbago (Pullaiah, 2006; Bhukya *et al*., 2009; Dashahre *et al*., 2014; Jadhao & Bhadage 2013). Duke (2009) noted the plant's role as an anodyne for pain relief and as a sialogogue. Further adding to its medicinal value, *Kydia calycina* seeds contain a diverse array of fatty acids, including lauric, myristic, palmitic, stearic, arachidic, behenic, oleic, linoleic, and cyclopropenoid fatty acids (Daulatabad *et al*., 1999). The stem bark, utilized externally, is employed to address issues such as sprains, blood clotting, and swelling. Similarly, the root is employed for therapeutic purposes, reflecting the comprehensive utilization of various parts of the plant in traditional medicine (Jadhao & Bhadage 2013). In summary, *Kydia calycina*'s ethnomedicinal significance is well-documented, with its antioxidant properties supporting its traditional uses in treating various disorders. The plant's roots, leaves, flowers, seeds, stem bark, and roots are all harnessed for their therapeutic potential, highlighting the diverse medicinal applications of this botanical species. Further research into its bioactive compounds and pharmacological mechanisms could unlock additional insights into its therapeutic efficacy and potential modern applications.

Nutritional Value: *Kydia calycina* boasts not only medicinal properties but also nutritional value, making it a versatile plant with various applications in traditional diets. Its nutritional composition is particularly noteworthy, with its protein content exceeding 20%, making it a significant source of dietary protein. Additionally, the flowers of *Kydia calycina* are rich in essential minerals such as potassium and iron, which are vital for overall health and well-being. Moreover, studies have shown that extracts from *Kydia calycina* exhibit inhibitory effects on Streptococcus mutans, a bacterium commonly associated with dental caries and oral health issues. This suggests that the plant may have potential oral health benefits, further adding to its nutritional value and medicinal significance. Furthermore, research by Daulatabad (1989) analyzed the seed oil composition of *Kydia calycina*, revealing a diverse array of fatty acids. The seed oil contains lauric acid (3.7%), myristic acid (6.0%), palmitic acid (4.9%), stearic acid (11.4%), arachidic acid (2.8%), behenic acid (2.5%), oleic acid (60.6%), linoleic acid (5.3%), and cyclopropenoid fatty acid (2.9%) by weight. These fatty acids play crucial roles in human nutrition and health, contributing to various physiological functions and metabolic processes. Overall, the nutritional value of *Kydia calycina*, characterized by its high protein content, mineral richness, and diverse fatty acid composition, underscores its importance as a food source in traditional diets. Incorporating this plant into dietary practices not only provides essential nutrients but also potentially offers health benefits, making it a valuable asset in promoting nutrition and well-being. Further research into its nutritional profile and bioactive components could uncover additional insights into its dietary and therapeutic potential.

Industrial Applications: *Kydia calycina* serves as a valuable resource for various industrial applications, particularly in the textile industry. The fibers derived from *Kydia calycina* are prized for their strength, durability, and versatility, making them ideal for use in textile manufacturing. These fibers are known for their resilience and resistance to wear and tear, making them suitable for producing a wide range of textiles, including fabrics, ropes, and other woven materials. In addition to its fibers, *Kydia calycina* also provides timber that is highly valued for its strength and durability. The timber from *Kydia calycina* is known for its excellent quality and is often used in construction, furniture making, and other woodworking applications. Its economical nature makes it a preferred choice for various industrial purposes, contributing to its widespread use in the production of coarse ropes and other materials requiring robust and sturdy construction. Overall, *Kydia calycina* plays a significant role in the industrial sector, providing essential raw materials for the textile industry and other manufacturing processes. Its fibers and timber are prized for their quality and reliability, making them indispensable resources in various industrial applications. As demand for sustainable and eco-friendly materials continues to rise, the utilization of *Kydia calycina* in industrial processes may further expand, highlighting its importance as a valuable natural resource.

Other Uses: *Kydia calycina*, with its versatile properties, serves various purposes beyond its medicinal and nutritional value, making it a valuable resource in multiple sectors. Firstly, the dense and sweet honey produced from *Kydia calycina* flowers is highly sought after for its flavor and quality (Chattopadhyay, 2011; Anonymous[1], 2013). The plant's flowers attract pollinators, resulting in the production of honey that is prized by beekeepers and consumers alike. Moreover, the leaves of *Kydia calycina* serve as a source of nutrition for wildlife, providing essential nutrients for various animals (Chhetri, 2010). Additionally, these leaves can be used as firewood, offering a renewable and sustainable energy source for cooking and heating. Furthermore, *Kydia calycina*, commonly known as Baranga, provides durable cordage and mucilage that is used for sugar clarification (Fatma & Jahan, 2016). This versatile plant is occasionally utilized in construction projects and is valued for its role in nurturing forest plantations. In addition to its practical uses, *Kydia calycina* is often planted as an ornamental tree in parks and gardens due to its attractive appearance and distinctive features. Its fibers, harvested from the wild, are highly valued for their quality and strength, making them suitable for various applications, including rope and cordage production (Negi, 1992; Fatma & Jahan 2016). Furthermore, *Kydia calycina* plays a crucial role in lac production, serving as a minor host plant in lac cultivation areas such as Assam (Chattopadhyay, 2011). Additionally, the plant's timber is used as firewood, providing a renewable source of energy for households and communities (Chattopadhyay, 2011; Anonymous[1], 2013). Moreover, *Kydia calycina* trees provide fodder during periods of nutritional stress, particularly in the dry season when the nutritional value of grasses and forbs is low (Chhetri, 2010). This makes them invaluable resources for cattle breeders, who often supplement their animals' diets with nutritious tree fodders to maintain milk productivity. In terms of industrial applications, *Kydia calycina* stems yield strong, high-quality fibers that are used for making ropes and cordage, especially in forestry operations (Negi, 1992). These fibers can be extracted through water retting processes, with optimization of scouring conditions to enhance their physical properties, including tenacity, elongation, and fineness (Fatma & Jahan 2016). In summary, *Kydia calycina*'s diverse uses highlight its significance as a valuable plant with numerous practical applications in agriculture, forestry, apiculture, and other sectors. Its versatility and resilience make it a valuable asset in various contexts, contributing to both economic and ecological sustainability.

In summary, *Kydia calycina* emerges as a versatile plant with extensive applications in traditional medicine, nutrition, and industrial sectors. Its multifaceted properties warrant further exploration and research in the realm of herbal medicine. The comprehensive exploration on utility of this plant provides crucial insights, addressing knowledge gaps and paving the way for future investigations into its medicinal potential.

B. Pharmacological Properties

The phytochemical analysis of *Kydia calycina* has unveiled a diverse array of bioactive compounds, including flavonoids, tannins, terpenoids, and phenolic compounds (Bhukya *et al*., 2009). Noteworthy among these are quercetin, kaempferol, and ellagic acid, which have garnered attention for their potential health benefits and pharmacological activities. These compounds exhibit significant antioxidant, anti-inflammatory, and antimicrobial properties, which contribute to the therapeutic effects associated with *Kydia calycina*. Extracts derived from the plant have been found to possess anti-inflammatory, anti-diabetic, antimicrobial, and antioxidative effects, with potential applications in wound healing and pain relief (Bhukya *et al*., 2009). The mucilaginous properties of *Kydia calycina*, coupled with its anti-inflammatory and febrifuge characteristics, have been recognized in traditional medicine. The leaves and roots of the plant are traditionally used as anti-rheumatic agents, with leaf paste applied to alleviate body pains and poultices made from leaves to treat skin diseases. Chewing the leaves stimulates saliva production, while the stem is employed for clarifying sugars. Extracts derived from *Kydia calycina* have been used in the treatment of liver disorders and skin problems, with dried bark powder mixed with honey reported to reduce blood glucose concentration. Traditional mixtures containing various plant parts of *Kydia calycina* have been utilized for their anti-diabetic effects (Bhukya *et al*., 2009). In vitro studies have demonstrated the cytotoxicity of *Kydia calycina* extracts against human carcinoma and neuroblastoma cells, with a dose-dependent inhibitory

effect observed against tumor cells. Additionally, significant antibacterial activity has been reported against various strains, along with anti-cariogenic and free radical scavenging activities. The chloroform extract of *Kydia calycina* has exhibited anti-cariogenic action against Streptococcus mutans, while demonstrating free radical scavenging activity against DPPH and superoxide radicals. Furthermore, studies have investigated the antifungal activity of *Kydia calycina* against pathogenic fungi, as well as its anthelmintic activity using earthworms (Bhukya *et al*., 2009). Ongoing global research endeavors continue to explore the potential of *Kydia calycina* as a source of plant-based remedies for various conditions. Traditional uses of the plant have been validated by scientific studies confirming its antioxidant, antifungal, anti-leukemic, anti-inflammatory, and analgesic properties. Importantly, no acute or chronic toxicity has been reported, highlighting its safety profile. However, there remains a need for further research to delve into traditional uses and conduct potential clinical studies on *Kydia calycina*. Additionally, a Sesquiterpenoid Naphthol has been isolated from *Kydia calycina*, adding to its pharmacological diversity (Joshi *et al*., 1982). For a more comprehensive understanding of the pharmacological properties of *Kydia calycina*, readers are encouraged to explore the extensive examination conducted by Goyal and Jeyabalan in 2020.

C. Taxonomy

Kydia is named by William Roxburgh to honor Col Robert Kyd (1746-1793), first director of Botanical Garden at Calcutta and calycina in means calyx for its persistent calyx. On the basis of morphological characteristics of plant, *Kydia calycina* is classified into a plants hierarchy as follows (Chinchole & Mehta, 1967)

Kingdom: Plantae
Phylum: Tracheophyta
Subphylum: Angiosperms
Series: Thalamiflorae
Class: Dicotyledon
Subclass: Polypetalae
Order: Malvales
Family: Malvaceae
Genus: Kydia
Species: calycina

Synonymes (Plants of the World Online, 2017).**:**

Hibiscus roxburghianus (Wight) Mabb.
Kydia fraterna Roxb.
Kydia roxburghiana Wight
Kydia paterna Roxb.
Kydia pulverulenta Buch.-Ham.

Common name: *Kydia calycina* tree is introduced as diverse range of names like Bharanga, Bhoti, Illya, Potari, Pulia, Pula, Pattha (Hindi), Kukuha or Pichhola (Assam), Pola (Bengal), Bende (Kannada), Khabi (Manipuri), Vattakannu (Tamil), Kapasia (Urdu), Potari (Telugu), Bankopasia (Oriya), Ranbhendi (Marathi), Vellukku (Malayalam) and Chi Guo Ma (China). Synonyms of the *Kydia calycina* tree are Kydia fraterna and *Kydia roxburghiana*.

D. Distribution

*Kydia calycina*boasts a widespread distribution, spanning multiple countries across tropical Asia, including India, Myanmar, Nepal, Pakistan, Bhutan, and China. In India, the plant's presence is documented in various regions, with significant occurrences noted in Maharashtra, particularly in Kolhapur, and extensive distribution in Karnataka, covering areas such as Belgaum, Chikmagalur, Coorg, Hassan, Mysore, North Kanara, Shimoga, and South Kanara (Bhukya *et al*., 2009; 2014). Kerala showcases specific concentrations in Kannur, Malappuram, Palakkad, and Wynad, while Tamil Nadu exhibits distribution in Coimbatore, Dharmapuri, Nilgiri, Tiruvannamalai, and Vellore. The plant's range extends from the tropical Himalayas, stretching from the Indus eastwards to Myanmar. In peninsular India, it is observed from northern Maharashtra and Madhya Pradesh southwards, encompassing Rajasthan (Dashahre *et al*., 2014; Dular, 2014). Despite its global distribution, there is evidence of a decline in the abundance of *Kydia calycina* over time in the region (Joshi *et al*., 1982). This decline raises concerns about the conservation status of the species and underscores the importance of further research and conservation efforts to safeguard its populations and habitat.

Fig. 1. Distribution map of *Kydia calycina* Roxb (*Source:* accessed via GBIF.org on 2023-12-05.)

E. Conservation Status

The evaluation conducted by Yu *et al*. (2019) affirms that *Kydia calycina*, as a tree species, maintains a broad distribution and boasts a sizable population. Consequently, it currently faces no major threats, and there are no identified significant future threats looming

over its existence. Hence, based on these findings, this species has been categorized as Least Concern according to conservation status assessments. However, despite its overall Least Concern status, alarming trends are observed on a regional scale, particularly concerning the rapid decline in the population of *Kydia calycina*. Studies conducted by Bhukya *et al*. (2009); Dashahre *et al*. (2014); Dular (2014); Joshi *et al*. (1982) provide compelling evidence of the local disappearance of this species. These regional declines underscore the urgent need for conservation efforts to mitigate further population loss and preserve the ecological integrity of *Kydia calycina*'s habitats.

F. Habitat

Kydia calycina demonstrates remarkable adaptability to various habitats, with a notable preference for arid regions. Its habitat range is characterized by a predominant presence in deciduous forests across India, particularly in the sub-Himalayan tract. The species is frequently encountered in both the Western Ghats and Eastern Ghats, where it thrives in diverse forest types, including dry deciduous forests and mixed deciduous forests. Within these habitats, *Kydia calycina* exhibits resilience across a wide range of elevations, with its distribution extending up to 1100 meters above sea level. This adaptability to different elevation levels underscores the plant's versatility and ability to thrive in diverse environmental conditions.

G. Botanic description

Kydia calycina, characterized by its moderate to fast growth rate, assumes the form of a moderate to large deciduous tree, typically attaining heights ranging from 10 to 20 meters with a breast height diameter averaging around 25.5 cm (Jadhav & Bandage 2013).

Stem: The stem of *Kydia calycina* is aerial, erect, and may exhibit either herbaceous or woody characteristics. It is covered by small scales and features a greyish-brown bark measuring approximately 5-6 mm in thickness, which tends to flake irregularly in small scales. Branchlets of the tree are terete, indicating a stellate pubescent nature (Jadhav & Bandage 2013).

Leaf: The leaves of *Kydia calycina* are notable for their suborbicular to broadly ovate shape, ranging from 6 to 14 cm in length and 6 to 16 cm in width. They feature acute or obtuse apices, sometimes rounded to subcordate bases, and irregularly denticulate margins. The upper surface of the leaves bears scattered hairs, giving it a distinctive appearance, while the underside is densely tomentose, imparting a velvety texture. The petiole, slender and stellate-tomentose, measures between 2.5 to 10 cm in length. The leaf anatomy exhibits epidermis on both sides, distinct parenchyma with hypodermis and mesophyll tissue, and unicellular hairy trichomes. On the other hand, the stem anatomy displays secondary growth and prominent medullary rays with xylem (Jadhav & Bandage 2013).

Flower:*Kydia calycina* produces polygamo-dioecious, white flowers organized in axillary and terminal panicles. The flowers feature a glandular staminal column, with male flowers containing 15 to 30 stamens adorned with sessile reniform anthers. Female flowers exhibit a globose superior ovary with a woolly texture and large stigmas. The flowers are typically 1 to 1.8 cm across, with white or pink petals 4-5 that are adnate to the staminal column (Naik, 2012; Naskar, 1993; Ahmed, 2010).

Fruit and seed: The fruit of *Kydia calycina* is a subglobose pea-sized capsule, measuring 3 to 6 mm across, stellate-tomentose, and enclosed within the persistent calyx. It is bolstered by spreading, pale green, enlarged bracts (epicalyx). The texture of the fruit is notably dense and mealy, with a tinge of rustiness that deepens as it undergoes desiccation. Fruits are typically found in clusters, with greyish-brown, reniform seeds enclosed in a capsule. The seeds are 3-valved, tomentose, and globose in shape, with a singular seed within each locule. They measure between 2 to 3 mm across, and their weight varies from 32,000 to 158,000 seeds per kilogram. The seed emptiness is assessed as moderate, contributing to the overall characteristics of *Kydia calycina*'s reproductive structure (Sen Gupta, 1937).

Phenological Cycle: The phenological cycle of *Kydia calycina*, as reported by Sen Gupta (1937), unfolds with leaf thinning initiating around December, progressing to bare trees by February. Subsequently, leaf renewal occurs in April, marking the regeneration of foliage during the onset of spring. Flower blossoming commences from late August through October, with the tree adorned by polygamo-dioecious white flowers. Fruits achieve ripeness by November to December, persisting on the tree for several months, with mature fruits available in India from December to April. This cycle underscores the plant's adaptation to seasonal changes and its pivotal role in the ecosystem (Sen Gupta, 1937).

Fig. 2. Plant, Flower, Fruit and Seeds of *Kydia calycina* Roxb.

H. Propagation

Propagation of *Kydia calycina* predominantly involves the utilization of seeds, constituting a multi-step process designed to ensure successful germination. The initial phase entails the careful collection of capsules from the branches of mature trees, employing techniques to minimize damage during harvesting. These harvested capsules are promptly transported to processing centers, where they undergo further treatment. Upon arrival, the capsules are delicately sun-dried within cloth bags, facilitating the drying process while protecting the

seeds from potential environmental hazards (Sen Gupta, 1937). Once adequately dried, the capsules are subjected to manual seed extraction, a meticulous process involving rubbing to dislodge the seeds from their enclosures, followed by thorough cleaning via winnowing to remove any debris or impurities. This meticulous cleaning process ensures the purity and quality of the extracted seeds, enhancing their viability for subsequent germination (Sen Gupta, 1937; Carlowitz, 1991). With an average of approximately 90,000 to 100,000 seeds per kilogram, *Kydia calycina* seeds are characterized by their relatively high abundance, providing ample potential for propagation. The germination process is classified as epigeal, with the seeds exhibiting varying germination percentages ranging from 12% to 30% over a period spanning 28 to 71 days, influenced by factors such as seed quality and environmental conditions (Sen Gupta, 1937; Carlowitz, 1991). To optimize germination rates, a recommended practice involves soaking the seeds in a water and cow dung mixture for a specified duration, leveraging the beneficial properties of the mixture to promote seed vitality and germination success. The optimal sowing season typically extends from December to March, aligning with favorable environmental conditions conducive to germination and seedling establishment (Sasidharan, 2013; Chhetri, 2010). Despite the potential for successful germination, moderate fungal infection poses a challenge during the propagation process, with *Fusarium moniliforme*, *F. semitectum*, and Phoma sp. identified as significant fungal pathogens affecting seed viability. Vigilant monitoring and appropriate management strategies are essential to mitigate the impact of fungal infestations and safeguard seed quality (Mohanan and Sharma 1991). Recognized as orthodox seeds, *Kydia calycina* seeds exhibit remarkable longevity, maintaining viability for 2-3 years and, in certain instances, up to 10 years. This inherent longevity underscores the resilience and adaptability of the species, enabling sustained propagation efforts over extended periods (unpublished lab results). Given the high incidence of seed infertility, seedlings are densely sown in nursery beds or germination trays to maximize the likelihood of successful germination. Regular watering and diligent care are essential throughout the germination process, ensuring optimal conditions for seedling development and growth. Subsequently, seedlings are transplanted into polythene bags filled with a suitable potting mixture, facilitating their transition to mature plants capable of thriving in their natural habitat.

CONCLUSIONS

In conclusion, *Kydia calycina* stands as a botanical treasure nestled within the intricate fabric of India's traditional medicinal practices and ecological richness. Its widespread distribution across the Indian subcontinent, coupled with its economic significance and prominent role in indigenous healing traditions, underscores its multifaceted importance. The plant's pharmacological attributes, nutritional richness, and diverse industrial applications highlight its versatility and potential for various sectors. However, the concerning decline in its regional abundance serves as a clarion call for concerted conservation endeavors to protect this invaluable species from further depletion. As *Kydia calycina* garners increasing attention within scientific circles and emerges as a subject of botanical exploration, its journey symbolizes the delicate interplay between ancient wisdom and contemporary scientific inquiry in the realms of herbal medicine and environmental preservation. With its wealth of bioactive compounds and therapeutic potential, *Kydia calycina* holds promise as a valuable resource for the development of novel pharmaceuticals and herbal remedies with enhanced efficacy and safety profiles. Moving forward, it is imperative to prioritize continued research efforts, conservation initiatives, and sustainable utilization practices to ensure the enduring legacy of *Kydia calycina* in both traditional and modern contexts. By fostering collaboration between traditional knowledge holders, scientists, policymakers, and conservationists, we can unlock the full potential of *Kydia calycina* while safeguarding its existence for future generations. As we navigate the intricate nexus of tradition, innovation, and ecological stewardship, *Kydia calycina* stands as a poignant reminder of the intricate connections between nature, culture, and human well-being.

FUTURE SCOPE

In contemplating the future trajectory of *Kydia calycina*, a multifaceted strategy unfolds, encompassing various domains such as scientific research, conservation endeavors, sustainable utilization practices, education, and awareness initiatives. Advanced methodologies such as Nano priming utilizing carbon nanotubes, as proposed by Vijay *et al*. (2023a), warrant exploration to address concerns regarding poor seed viability. Scientifically, there is a pressing need for intensified botanical and pharmacological investigations to unravel the full spectrum of bioactive compounds harbored by *Kydia calycina*, potentially yielding novel natural products of significance to the pharmaceutical industry. Clinical studies should be undertaken to validate the traditional medicinal uses attributed to the plant.

On the conservation front, concerted efforts should be directed towards habitat preservation, afforestation initiatives, and ongoing monitoring protocols, with the establishment of seed banks representing a crucial ex-situ measure to counteract regional population decline. Sustainable utilization practices can be promoted through the integration of *Kydia calycina* into horticultural and agroforestry systems, offering economic opportunities while simultaneously meeting the demands of traditional medicine.

Education and awareness initiatives play a pivotal role in fostering a deeper understanding of *Kydia calycina*'s botanical richness and traditional significance, thereby instilling a sense of responsibility for its conservation among stakeholders. Workshops, educational programs, and outreach campaigns serve as effective tools in this regard.

A synergistic approach that harmonizes scientific inquiry, conservation actions, and sustainable utilization is advocated to comprehensively develop and preserve *Kydia calycina*. By leveraging its botanical wealth and cultural heritage, *Kydia calycina* can serve as a beacon for the advancement of medicine, environmental conservation, and community well-being.

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Conflict of Interest. None.

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