CHAPTER 10

Exploring the Nutraceutical Properties of *Alpinia nigra*

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Abstract: *Alpinia nigra* (Gaertn.) B.L. Burtt, is a perennial herb of the family Zingiberaceae which is widely utilized by indigenous communities across Northeast India, Bangladesh and Myanmar for its ethnobotanical, nutritional and medicinal values. Present study documents the traditional food, therapeutic practices, and ecological significance. Its tender shoots, rhizomes and fruits serve as wild edibles, condiments and traditional remedies for gastrointestinal, respiratory, and inflammatory conditions, while trade in local markets provides supplementary income to rural households, particularly women and small-scale collectors. The species thrives in moist, shaded habitats such as forest margins, wetlands and homestead gardens, contributing to biodiversity, soil stabilization, pollinator support and other ecosystem services. Despite extensive documentation, research gaps remain in quantitative population studies, pharmacological validation, ecological function assessment and sustainable commercialization. Addressing these gaps is essential for the conservation, sustainable utilization, and potential development of *A. nigra* as a nutraceutical and therapeutic resource.

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INTRODUCTION

Alpinia nigra (Gaertn.) B.L. Burtt, a perennial herbaceous member of the family Zingiberaceae (Figure 1), represents one of the most important aromatic and medicinal species distributed across the humid tropics of South and Southeast Asia, with particular abundance in Northeast India, Bangladesh and Myanmar (Mangaly and Sahu 1992; Chakrabarty 2022). The species exhibits a strong ecological association with moist, shaded, and nutrient-rich environments, occurring frequently along forest margins, wetlands, riverbanks, and fallow lands where soils remain fertile and well-drained. Its growth is favoured by high rainfall coupled with relatively warm and humid climatic conditions typical of the Indo-Burma biodiversity hotspot, a region recognized for its floristic richness and ethnobotanical diversity (Devi *et al.,* 2025a; Devi *et al.,* 2025b). The rhizomatous nature of the plant allows it to form dense clumps, thereby contributing to soil stabilization and the maintenance of microhabitats in wetland and riparian ecosystems. It holds significant value as a wild edible resource, with its tender shoots, rhizomes and fruits widely consumed as vegetables and condiments (Devi *et al.,* 2017), while also playing a central role in the preparation of ethnomedicinal formulations among various indigenous communities (Dedrilkumar and Binu 2016; Moyon *et al.,* 2021; Devi *et al.,* 2022). Beyond its nutritional importance, the species is a reservoir of diverse secondary metabolites. Phytochemical investigations have consistently reported the presence of flavonoids, phenolics, terpenoids, alkaloids, polysaccharides and essential oils, all of which contribute to its extensive pharmacological potential (Ahmed *et al.,* 2015; Daimary *et al.,* 2024). The essential oil extracted from its leaves is particularly enriched with compounds such as 1,8-cineole, camphor, and β-pinene, which are responsible for its antimicrobial efficacy and characteristic aroma (Islam *et al.,* 2014). In addition, the fruits of A. nigra have attracted attention in the field of nanobiotechnology, being successfully employed in the green synthesis of silver nanoparticles that demonstrate strong antimicrobial and photocatalytic activities (Baruaha *et al.,* 2019).

Ethnomedicinal practices attribute multiple therapeutic roles to this species, with applications in the treatment of gastrointestinal disorders, inflammatory conditions, respiratory ailments and helminthic infections.



Figure 1: *Alpinia nigra* in its natural habitat, Loktak Lake, Manipur, India

These traditional claims are supported by pharmacological evaluations, which have confirmed its analgesic, anti-inflammatory, antibacterial, antioxidant, cytotoxic and anthelmintic properties (Roy *et al.,* 2012; Das *et al.,* 2014; Ahmed *et al.,* 2015; Daimary *et al.,* 2024). The plant also contributes directly to rural economies, as its edible parts are collected and marketed by local communities, thereby serving as a supplementary source of livelihood (Devi *et al.,* 2022). Despite its ecological adaptability and socio-economic importance, wild populations of *A. nigra* face mounting pressures

from overharvesting, habitat loss and unsustainable land-use practices, emphasizing the urgent need for its conservation, domestication, and sustainable utilization (Sanjoy *et al.,* 2022). Considering its importance in different aspects, an attempt has been made to review the ethnobotany, pharmacological constituents and habitat and ecological significance.

METHODOLOGY

The present study involved a structured approach to collecting, analyzing, and synthesizing existing knowledge on *Alpinia nigra*. Following the framework outlined by Kumar (2025), a comprehensive literature search was conducted across scientific journals, books, reports and online databases to gather relevant information on its taxonomy, phytochemistry, ethnobotanical uses, pharmacological properties and ecological significance. The selected sources were critically evaluated for accuracy, relevance and reliability and the extracted data were systematically organized to identify patterns, research gaps and areas requiring further investigation. Emphasis was placed on integration and synthesis rather than simple description, allowing the review to provide a coherent summary of current knowledge, showing key findings and suggest directions for future research. By combining thorough data collection with analytical interpretation this review aims to offer a consolidated resource for researchers, policymakers and practitioners interested in the ethnobotanical, pharmacological and ecological aspects of the species.

RESULTS AND DISCUSSION

Ethnobotany

Alpinia nigra locally known as “Pullei” in Manipur is an important species extensively utilized by indigenous communities across Northeast India, Bangladesh, and Myanmar for its diverse ethnobotanical values. Traditionally, the tender shoots, rhizomes, and fruits of the plant are consumed as vegetables, condiments or flavoring agents, and are regarded as a staple wild edible resource by several indigenous groups, including the indigenous communities of Manipur (Dedrilkumar and Binu 2016; Moyon *et al.,* 2021; Devi *et al.,* 2021). Its availability in wetlands, forest margins and homestead gardens makes it an easily accessible component of rural diets and livelihoods, where the harvested plant parts are frequently sold in local markets, providing supplementary income to local households (Devi *et al.,* 2022). Beyond its nutritional role, it holds strong ethnomedicinal significance. The rhizomes and fruits are traditionally employed in the treatment of gastrointestinal disorders, respiratory ailments and parasitic infections, while preparations from different parts of the

plant are used for managing inflammation, pain, and skin conditions (Devi *et al.,* 2020; Roy *et al.,* 2012).

It holds significant livelihood value for rural and indigenous communities in Northeast India and adjoining regions, where its edible parts are regularly traded in local markets. The tender shoots, young rhizomes are commonly harvested from wild populations and sold as vegetables, condiments or for ethnomedicinal purposes, providing a vital source of supplementary income, especially for women vendors and small-scale collectors (Dedrilkumar and Binu 2016; Moyon *et al.,* 2021; Devi *et al.,* 2022). In local or weekly markets, the plant is in demand for its distinct flavor and medicinal utility, making it a culturally significant traded species. Its commercialization, though largely informal, contributes to household economies and sustains traditional food systems, while also drawing attention the deep connection between biodiversity and local livelihoods. However, unregulated harvesting from natural habitats, coupled with habitat degradation, poses risks to its sustainable availability (Sanjoy *et al.,* 2022).



Figure 2: *A. nigra* sold in local market at Imphal, Manipur, India

Phytochemical constituents

The phytochemical profile of *Alpinia nigra* demonstrates a wide range of bioactive compounds across its various plant parts. The rhizomes and leaves are particularly rich in flavonoids, which exhibit antioxidant, anti-inflammatory and cardiovascular protective properties (Daimary *et al.,* 2024; Ahmed *et al.,* 2015). Both rhizome and fruit extracts contain phenolics and polyphenols, contributing to antioxidant, cytotoxic and hepatoprotective activities. The leaves are a significant source of terpenoids, including monoterpenes and sesquiterpenes, as well as specific compounds such as 1,8-cineole and β-pinene, which provide antimicrobial, anti-inflammatory and respiratory benefits (Islam *et al.,* 2014; Ghosh and Rangan 2013). Furthermore, alkaloids present in leaves and rhizome extracts exhibit antibacterial, antifungal and analgesic activities (Ahmed *et al.,* 2015; Roy *et al.,* 2012), while polysaccharides from rhizomes contribute immunomodulatory and anti-inflammatory effects (Daimary *et al.,* 2024). Notably, fruit extracts have been investigated for silver nanoparticle-mediated compounds, which demonstrate antimicrobial, photocatalytic and wound-healing potential (Baruaha *et al.,* 2019). Collectively, Table 1 represents the diverse bioactive potential of *A. nigra*, that reveals its ethnomedicinal and pharmacological significance.

Table 1: Phytochemical constituents of *A. nigra* and related bioactivity

Plant part(s)	Phytochemical constituents	Associated bioactivity	Source(s)
Rhizome, leaves	Flavonoids	Antioxidant, anti-inflammatory, cardiovascular protection	Daimary *et al.,* 2024; Ahmed *et al.,* 2015
Rhizome, fruit extracts	Phenolics and Polyphenols	Antioxidant, cytotoxic, hepatoprotective activity	Daimary *et al.,* 2024; Ahmed *et al.,* 2015
Leaves	Terpenoids like monoterpenes and sesquiterpenes	Antimicrobial activity	Islam *et al.,* 2014; Ghosh and Rangan, 2013
Leaves	1,8-Cineole	Antimicrobial, respiratory problems	Islam *et al.,* 2014
Leaves	β-Pinene	Antimicrobial, anti-inflammatory activity	Islam *et al.,* 2014

Leaves, rhizome extracts	Alkaloids	Antibacterial, antifungal, analgesic activity	Ahmed *et al.,* 2015; Roy *et al.,* 2012
Rhizome	Polysaccharides	Immunomodulatory, anti-inflammatory activity	Daimary *et al.,* 2024
Fruit extracts	Silver nanoparticle (AgNP) mediated compounds	Antimicrobial, photocatalytic, wound-healing potential	Baruaha *et al.,* 2019

Habitat and Ecological significance

A. nigra thrives abundantly in moist, shaded and semi-evergreen habitats across the Eastern Himalayas, Northeast India, Bangladesh and adjoining regions of Southeast Asia. It is commonly found along forest margins, wetlands, riverbanks and village homesteads, where the rich alluvial and loamy soils, coupled with high humidity, support its luxuriant growth (Roy *et al.,* 2012). Ecologically, the species plays an important role in maintaining biodiversity and providing microhabitats for insects and soil organisms, while its underground rhizomes aid in soil stabilization and erosion control in fragile hill slopes and wetland areas. The flowers and fruits also contribute to local food chains, serving as attractants for pollinators and seed dispersers. Its wide adaptability to disturbed and cultivated landscapes helps to contribute to ecosystem services such as nutrient cycling, slope protection, and sustaining traditional agro-ecosystems (Mangaly and Sabu 1992).

Research gaps

Despite the considerable ethnobotanical, ecological and nutritional information available on *A. nigra*, several research gaps remain that limit a comprehensive understanding and sustainable utilization of the species.

Firstly, while its traditional uses and market trade are well-documented, there is a lack of quantitative studies on population dynamics, harvesting pressure and sustainable yield, which are critical for developing conservation and management strategies.

Secondly, the ecological role of *A. nigra* in supporting biodiversity, soil stabilization and ecosystem services has been qualitatively described, but systematic ecological and functional studies quantifying its contribution to nutrient cycling, pollinator support and wetland resilience are limited.

Thirdly, although ethnomedicinal applications are widely reported, there are few in-depth pharmacological constituents and clinical studies that validate these traditional uses.

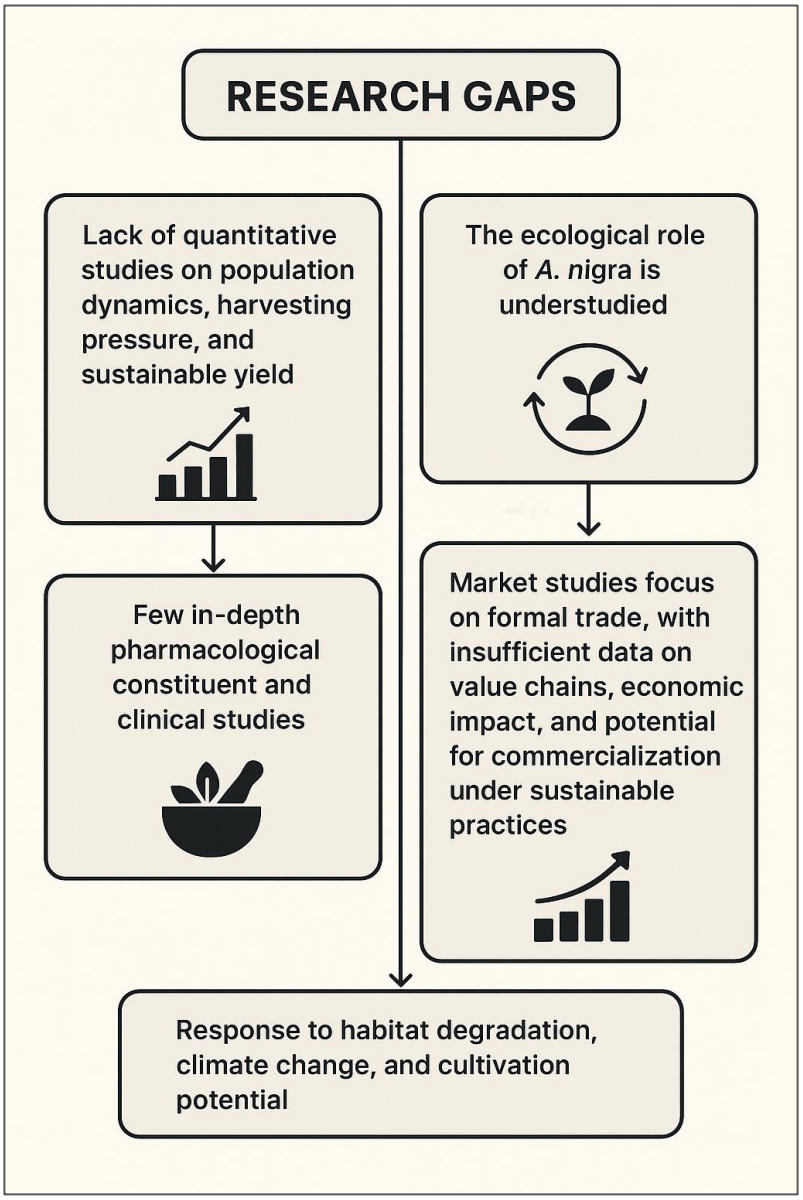


Figure 3: Research gaps w.r.t. *Alpinia nigra*

Fourth, market studies mostly focus on informal trade, and there is insufficient data on value chains, economic impact and potential for commercialization under sustainable practices, especially considering the role of women and small-scale collectors.

Finally, despite its adaptability to diverse habitats, there is a knowledge gap regarding its response to habitat degradation, climate change and cultivation potential, which is necessary to ensure long-term availability (Figure 3).

CONCLUSION

A. nigra is an important species extensively utilized by indigenous communities across Northeast India, Bangladesh and Myanmar. Its tender shoots, rhizomes, and fruits serve as staple wild edibles, condiments and ethnomedicinal resources, while its trade in local markets supports rural livelihoods, particularly for women and small-scale collectors. Ecologically, the species contributes to biodiversity maintenance, soil stabilization, pollinator support, and other ecosystem services, thriving in moist, shaded and semi-evergreen habitats. Despite the extensive documentation of its ethnobotanical and ecological significance, several research gaps persist, including the need for quantitative studies on population dynamics, sustainable harvesting, pharmacological validation of traditional uses and systematic evaluation of its ecological functions and market potential.

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