**BIODIVERSITAS**
Volume 26, Number 5, May 2025
Pages: 2416-2428

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d260539

# Ethnobotany of Piperaceae in Nakhon Nayok Province, Central Thailand

**PIYAPORN SAENSOUK[1], THAWATPHONG BOONMA[2,3], TAMMANOON JITPROMMA[2], TRAN VAN CHEN[4], SURAPON SAENSOUK[2,♥]**

[1]Diversity of Family Zingiberaceae and Vascular Plant for Its Applications, Department of Biology, Faculty of Science, Mahasarakham University. 41 Kham Riang, Kantharawichai, Maha Sarakham 44150, Thailand
[2]Diversity of Family Zingiberaceae and Vascular Plant for Its Applications, Walai Rukhavej Botanical Research Institute, Mahasarakham University. 41 Kham Riang, Kantharawichai, Maha Sarakham 44150, Thailand. Tel./fax.: +66-880-293958, ♥email: surapon.s@msu.ac.th
[3]Brio Botanical Research Garden. 53 M.5 Phikul-ok, Ban Na, Nakhon Nayok 26110, Thailand
[4]Faculty of Traditional Medicine, University of Medicine and Pharmacy at Ho Chi Minh City. No. 217, Hong Bang Street, Ward 11, District 5, Ho Chi Minh City 700000, Vietnam

Manuscript received: 4 March 2025. Revision accepted: 13 May 2025.

**Abstract.** *Saensouk P, Boonma T, Jitpromma T, Chen TV, Saensouk S. 2025. Ethnobotany of Piperaceae in Nakhon Nayok Province, Central Thailand. Biodiversitas 26: 2416-2428.* This study investigates the ethnobotanical significance of Piperaceae in Nakhon Nayok Province, Central Thailand, documenting the species diversity, traditional uses, and cultural importance of this plant family. A total of 31 Piperaceae taxa were recorded, comprising two genera: *Peperomia* (22 taxa) and *Piper* (nine species). Among these, only eight species are native, while 23 taxa are introduced, highlighting the predominance of non-native species in the area. *Piper nigrum* exhibited the highest Cultural Index (1.11), followed by *Piper sarmentosum* (0.84), *Piper betle* (0.66), *Peperomia pellucida* (0.59), and *Piper retrofractum* (0.5), with other taxa scoring below 0.5. The most common use category was ornamental plants (Cultural Index: 9.49), followed by vegetables and spices (1.89), herbal medicine (0.94), and cultural practices and rituals (0.51). The whole plant was the most frequently used part, especially for ornamental purposes, while the leaves were the most frequently used for therapeutic purposes. In therapeutic applications, Piperaceae plants are primarily used to treat gastrointestinal issues, followed by respiratory ailments, cutaneous conditions, and musculoskeletal and joint diseases. They also address disorders related to nutrition, blood, the cardiovascular system, and conditions affecting the ear, nose, oropharynx, oral cavity, and the endocrine system, respectively. These findings emphasize the diverse applications of Piperaceae species in local traditions, particularly their ornamental, culinary, and medicinal uses. The study provides valuable insights into the ethnobotanical knowledge of this plant family, emphasizing the importance of conservation efforts in preserving both native species and traditional botanical knowledge amid changing environmental and socio-economic conditions.

**Keywords:** Diversity, ethnobotany, Nakhon Nayok, *Piper*, Piperaceae

## INTRODUCTION

The family Piperaceae, known as the pepper family, is a significant group of flowering plants primarily distributed across tropical and subtropical regions worldwide (POWO 2025). Comprising about five genera and over 3,800 species, with *Peperomia* and *Piper* being the most prominent (Callejas-Posada 2020; POWO 2025), this family is renowned for its medicinal, culinary, and cultural uses (Islam et al. 2020). Many species are valued for their aromatic properties, secondary metabolites, antioxidant activities, antibacterial, antifungal properties, and pharmacological activities, forming an integral part of traditional medicine systems, particularly in Indian Ayurvedic practices (Islamudin et al. 2019; Martínez-Bautista et al. 2019; Salehi et al. 2019; Yadav et al. 2020; Nayaka et al. 2021; Carsono et al. 2022; Saensouk et al. 2025).

Thailand, a country located entirely within the Indo-Burma biodiversity hotspot (CEPF 2025) is home to several Piperaceae species, comprising three genera and 69 species, including *Peperomia*, *Piper*, and *Zippelia* (Suwanphakdee et al. 2024). These species have been long used for medicinal, culinary, and ethnobotanical purposes, and their traditional knowledge has been passed down through generations (Sudmoon 2012; Suwanphakdee et al. 2020, 2022, 2024). However, rapid urbanization and deforestation threaten both the preservation of this knowledge and the sustainable use of plant resources (Saensouk et al. 2021; Saisor et al. 2021; Pearson et al. 2023). Therefore, documenting ethnobotanical knowledge is vital for the conservation and future utilization of these plants (Boonma et al. 2024).

Nakhon Nayok Province is a key region for studying the ethnobotany of Piperaceae due to its varied ecosystems and growing significance in the ornamental plant market. Nakhon Nayok, located near Khao Yai National Park, a UNESCO World Heritage Site, features diverse habitats ranging from protected forests to agricultural and urban landscapes, making it an ideal setting for studying plant diversity and ethnobotanical uses (Boonma et al. 2023). The province is a major hub for floriculture and horticulture in Thailand, supplying the entire country with a wide range of ornamental plants and foliage. This makes Nakhon Nayok an ideal location for examining the

ornamental potential of Piperaceae species alongside their traditional uses.

Despite the recognized importance of Piperaceae species in Nakhon Nayok, a significant gap exists in ethnobotanical documentation at the provincial level. While individual species are well-known for their use in local medicine and cuisine, detailed ethnobotanical studies remain limited. As Nakhon Nayok evolves as a center for ornamental plant production (Boonma et al. 2023), it is crucial to explore how traditional knowledge about Piperaceae species adapts in the face of urbanization, land-use changes, and the expansion of the ornamental plant industry.

Piperaceae species are well-documented in Southeast Asia for their medicinal and cultural significance, especially in treating ailments such as digestive and respiratory issues (Pei et al. 2020; Suwanphakdee et al. 2020, 2022, 2024; Kamsu and Ndebia 2024). Species like *Piper betle* also have cultural importance, particularly in rituals such as betel chewing. However, comprehensive studies on the full spectrum of Piperaceae uses, particularly at the provincial level in Thailand, remain scarce (Saensouk et al. 2025). In Nakhon Nayok, the ethnobotanical use of these plants has likely evolved due to shifts in local culture and the growing demand for ornamental plants (Boonma et al. 2023). This study aims to fill this gap by documenting the ethnobotanical relevance of Piperaceae species in Nakhon Nayok Province and assessing their potential for sustainable use in both traditional contexts and the ornamental plant market.

The study's primary objectives are to identify the species of Piperaceae in Nakhon Nayok, document their traditional applications, and explore their cultural significance within the local community. Additionally, the research will assess the contributions of these species to food security, health practices, and local economies. By examining their role in the ornamental plant market, the study will provide insights into the commercial value of these species and their potential for sustainable agricultural practices. By documenting the ethnobotanical knowledge of Nakhon Nayok's communities, this study will contribute to the conservation of both plant species and indigenous knowledge. The findings will support future studies on the pharmacological potential of Piperaceae plants and promote the sustainable use of plant resources in the province. Integrating traditional knowledge with modern scientific research will enhance our understanding of the potential of these plants, support biodiversity conservation, and ensure the preservation of valuable plant resources for future generations.

## MATERIALS AND METHODS

### Study area

Piperaceae plant materials were gathered in 2024 from various locations across Nakhon Nayok Province, Central Thailand (13°57′41″N to 14°30′46″N, 100°54′50″E to 101°30′19″E). (Figure 1), with surveys conducted once or twice per month. Efforts focused on exploring accessible forested areas, as well as residential zones, local markets, plant shops, and other sites within the province. No specimens were collected within the national park; instead, only photographic documentation and field observations were recorded. Collected living specimens were cultivated at the Brio Botanical Research Garden in Nakhon Nayok Province, while spirit specimens, preserved in 70% ethyl alcohol, were deposited at the Vascular Plant Herbarium, Mahasarakham University (VMSU), Thailand.

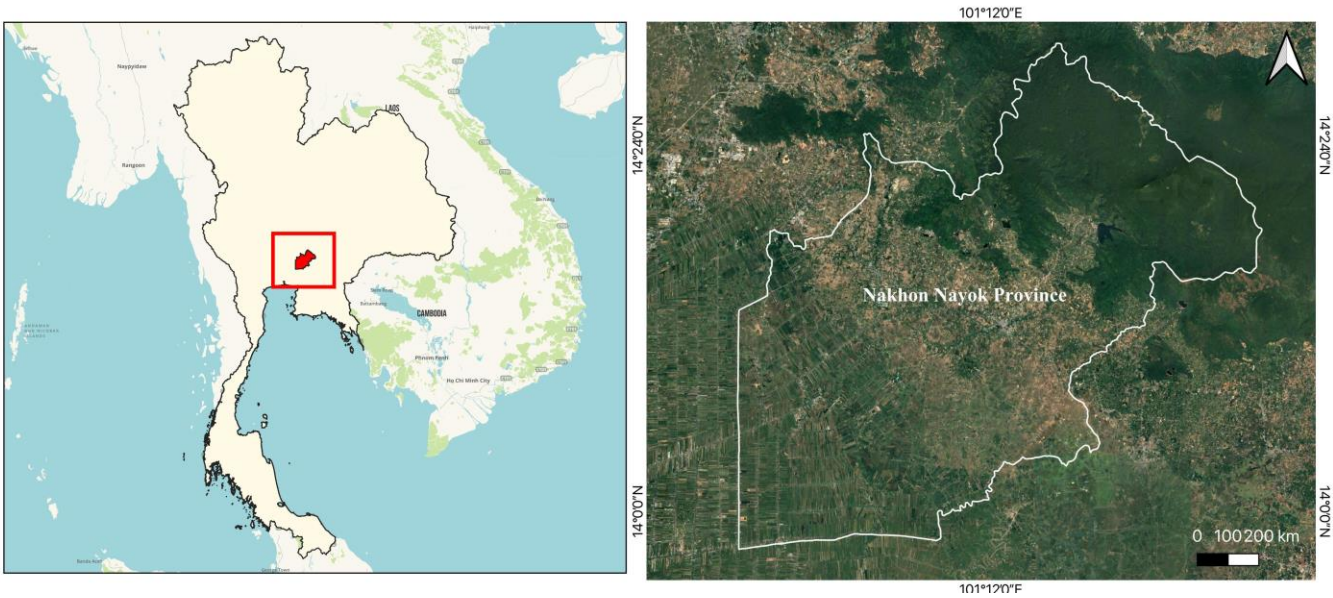


**Figure 1.** Map showing the location of Nakhon Nayok Province, Central Thailand

**Data collection**

Specimens were collected for morphological analysis, and their identification was based on a comparative examination against established taxonomic descriptions (e.g., Radh and Nampy 2018; Mathieu 2020; Queiroz and Guimarães 2020; Suwanphakdee et al. 2020, 2022, 2024; Trujillo et al. 2022; Jaramillo et al. 2023; Silva et al. 2024; Su et al. 2024). Observations were made using a stereoscopic microscope (Stemi 2000-C, ZEISS, Oberkochen, Germany), with measurements recorded using a vernier caliper. To validate species identification, specimens were cross-referenced with herbarium collections (e.g., BK, BKF, KKU, QBG) and verified using digital resources such as the Kew Science website (POWO 2025) and The Global Plants Database (https://www.jstor.org). A comprehensive review of taxonomic literature and major research databases, including Scopus, Web of Science, and Google Scholar, was conducted to corroborate species identification with recent studies (Suwanphakdee et al. 2020, 2022, 2024).

Ethnobotanical data were collected through interviews with 80 randomly selected villagers in Nakhon Nayok Province in 2024, ensuring gender balance among participants. Participants were informed about the study's objectives and gave their consent prior to the interviews, which focused solely on plant-related knowledge, such as the uses of plant parts and their applications. Personal information was not solicited, and formal ethics approval was not required. All specimens examined during the study were permanently deposited in the Vascular Plant Herbarium, Mahasarakham University (VMSU).

Medicinal uses of the plants were classified into 17 therapeutic groups according to the Thailand National List of Essential Medicines (NLEM 2022), including systems such as gastrointestinal, cardiovascular, respiratory, and central nervous systems, as well as musculoskeletal, joint diseases, and others. Additionally, plant samples were collected for species identification by comparing their morphological characteristics with protologue descriptions, previous studies in Thailand (e.g., Suwanphakdee et al. 2020, 2022), and the Flora of Thailand Volume 16, Part 3 (Suwanphakdee et al. 2024). Online databases, including Kew's Herbarium (POWO 2025), the Queen Sirikit Botanic Garden Herbarium (QBG), and the Muséum national d'Histoire Naturelle (https://science.mnhn.fr), were consulted to cross-check and confirm the species identity.

**Data analysis**

*Cultural Importance Index (CI)*

The Cultural Importance Index (CI) is used to demonstrate the role of plants in people's daily lives. It is based on questionnaire and interview data about species utilized in different activities (Tardío and Pardo-De-Santayana 2008). The CI value is calculated using the formula:

$$CI = \sum_{u=u_1}^{u_{NC}} \sum_{i=i_1}^{i_{NC}} \frac{UR_{ui}}{N}$$

Where, NC represents the total number of use categories, UR refers to the total number of use reports, and N denotes the total number of informants.

*Fidelity Level (FL)*

Fidelity Level (FL) refers to the degree of agreement or consistency among informants regarding the use of a species for a particular therapeutic purpose. It is calculated as the ratio of the number of informants who independently suggested the same therapeutic use of a species to the total number of informants who provided information about that species (Friedman et al. 1986; Numpulsuksant et al. 2021). A higher fidelity level indicates a stronger consensus or reliability of the therapeutic use suggested by the informants. Mathematically, Fidelity Level (FL) can be expressed using the formula:

$$\%FL = \frac{\mathrm{Ip} \times 100}{\mathrm{Iu}}$$

Where, Np is the number of informants citing the same therapeutic uses, and Nt is the total number of informants mentioning the species.

*Informant Consensus Factor (ICF)*

Informant Consensus Factor (ICF) to assess the level of agreement among informants regarding the medicinal use of plant taxa for specific ailment categories (Heinrich et al. 1998). The Informant Consensus Factor (ICF) was calculated following the formula:

$$ICF = \frac{\mathrm{Nur} - \mathrm{Nt}}{\mathrm{Nur} - 1}$$

Where, Nur represents the total number of use reports for a particular ailment category, and Nt denotes the number of plant taxa documented for that category. The value of ICF ranges from 0 to 1, with higher values indicating strong consensus among informants, meaning that relatively few species are widely recognized for treating a specific ailment. In contrast, lower values suggest greater variability in plant selection among informants.

The use reports were categorized based on distinct ailment groups, and data were compiled through structured interviews and field observations. Each reported plant use was recorded and classified according to standardized ethnobotanical categories. The ICF values were then computed for each ailment category to identify the degree of knowledge homogeneity among the participants.

*Economic Value (EV)*

Economic Value (EV): the economic value of the plants was assessed by calculating the total annual revenue based on both price and quantity sold. Price ranges, from a minimum to a maximum value, were considered along with the annual quantity sold, which also had a range of values. The total revenue was then determined by multiplying the respective price and quantity ranges, providing a range of possible economic values for the plants sold annually. This approach enables the estimation of the economic contribution of the plants, taking into account variations in both price and sales volume. The total revenue can be calculated using the following formula (Saensouk et al. 2024; Jitpromma et al. 2025):

Total Revenue ranges = (Pmin × Qmin) to (Pmax × Qmax)

Where, Pmin (Minimum Price) is the lower price point of the range, Pmax (Maximum Price) is the upper price point of the range, Qmin: Minimum Quantity Sold per Year, and Qmax: Maximum Quantity Sold per Year. The currency unit used in this study is the Thai baht (THB).

## RESULTS AND DISCUSSION

### Diversity of Piperaceae species in Nakhon Nayok Province

A total of 31 Piperaceae taxa have been recorded in Nakhon Nayok Province, encompassing two genera: *Peperomia* and *Piper* (Table 1). The genus *Peperomia* comprises 22 taxa, while *Piper* consists of 9 species, reflecting the botanical richness of this plant family in the area. Only 8 species are native, while 23 taxa are introduced, indicating a greater presence of non-native species in the area.

### Traditional utilization of Piperaceae in Nakhon Nayok Province

The utilization of Piperaceae in Nakhon Nayok Province varies across different categories, including cultural practices and rituals, herbal medicines, ornamental plants, and vegetables and spices (Table 1).

*Cultural importance of Piperaceae in Nakhon Nayok Province*

The Cultural Importance Index (CI) values of Piperaceae plants in this study (Table 2) demonstrate varying levels of cultural significance. *Piper nigrum* ranks highest with a CI value of 0.99, followed by *Piper sarmentosum* (0.84), *P. betle* (0.75), and *Peperomia pellucida* (0.63), indicating their strong cultural and economic relevance in the area.

While other species have CI values lower than 0.50, the lowest CI value is *Piper kurzii* (0.05). When CI was determined based on usage categories, ornamental plants were the most common use category (Cultural Index: 9.4875), followed by vegetables and spices (CI: 1.8875), herbal medicine (CI: 1.2625), and cultural practices and rituals (CI: 0.5125) (Table 2).

**Table 1.** The diversity of Piperaceae at Nakhon Nayok Province, Thailand, including their vernacular names, distribution, phenology, utilization, used parts, Cultural Importance Index (CI), and collector number

| Scientific name | Vernacular name | Distribution | Utilization | Used parts | Collector no. |
|---|---|---|---|---|---|
| *Peperomia albovittata* 'Piccolo Banda' | Pepper Haang Nok Yoong | ITD | OP | WP | Boonma P001 |
| *Peperomia argyraea* | Peperomia Lai Taeng Mo | ITD | OP | WP | Boonma P002 |
| *Peperomia asperula* | Pepper Gu Larb Hin Keaw | ITD | OP | WP | Boonma P003 |
| *Peperomia caperata* | Peperomia Nah Yon Keaw | ITD | OP | WP | Boonma P004 |
| *Peperomia caperata* 'Burgundy Ripple' | Peperomia Nah Yon Daeng | ITD | OP | WP | Boonma P005 |
| *Peperomia caperata* 'Frost' | Peperomia Bai Ngern | ITD | OP | WP | Boonma P006 |
| *Peperomia caperata* 'Pink Lady' | Peperomia Pink Lady | ITD | OP | WP | Boonma P007 |
| *Peperomia graveolens* | Pepper Ku Larb Hin Daeng | ITD | OP | WP | Boonma P008 |
| *Peperomia incana* | Pepper Incana | ITD | OP | WP | Boonma P009 |
| *Peperomia metallica* | Peperomia Metallic | ITD | OP | WP | Boonma P010 |
| *Peperomia obtusifolia* | Pepper Yok | ITD | OP | WP | Boonma P011 |
| *Peperomia obtusifolia* | Pepper Daang | ITD | OP | WP | Boonma P012 |
| *Peperomia pellucida* | Ga Sang | ITD | HM, OP, VS | LP, ST, WP | Boonma P013 |
| *Peperomia polybotrya* | Peperomia Raindrop | ITD | OP | WP | Boonma P014 |
| *Peperomia prostrata* | Sai Paan Tao | ITD | OP | WP | Boonma P015 |
| *Peperomia quadrangularis* | Peperomia | ITD | OP | WP | Boonma P016 |
| *Peperomia rugosa* | Mini Pepper | ITD | OP | WP | Boonma P017 |
| *Peperomia serpens* | Pepper Lueay | ITD | OP | WP | Boonma P018 |
| *Peperomia serpens* ‘variegata’ | Pepper Lueay Daang, Pepper Hua Jai Ngern | ITD | OP | WP | Boonma P019 |
| *Peperomia tetragona* | Mongkut Phet | ITD | OP | WP | Boonma P020 |
| *Peperomia tetraphylla* | Peperomia Hope | NTV | OP | WP | Boonma P021 |
| *Peperomia turboensis* | Pepper Taeng Mo Daeng | ITD | OP | WP | Boonma P022 |
| *Piper betle* | Ploo | NTV | CR, HM | LV | Boonma P023 |
| *Piper kurzii* | Prik Thai Paa | NTV | HM | LV, ST | Boonma P024 |
| *Piper nigrum* | Prik Thai | ITD | HM, VS | FT, RT | Boonma P025 |
| *Piper ornatum* | Ploo Long Ya Chomphoo | ITD | OP | WP | Boonma P026 |
| *Piper porphyrophyllum* | Ploo Long Ya Kam Ma Yi | NTV | OP | WP | Boonma P027 |
| *Piper retrofractum* | Dee Plee | NTV | HM, VS | FT | Boonma P028 |
| *Piper ribesioides* | Ta Khan, Sa Khan | NTV | HM | VN | Boonma P029 |
| *Piper sarmentosum* | Cha Ploo | NTV | HM, VS | LV, RT | Boonma P030 |
| *Piper sylvaticum* | Ploo Long Ya, Ploo Ngern | NTV | OP | WP | Boonma P031 |

Notes: Distribution: ITD: Introduced; NTV: Native. Utilization: CR: Cultural practices and rituals; HM: Herbal medicines; OP: Ornamental plants; VS: Vegetable and spices. Used parts: FT: Fruits; LV: Leaves, RT: Roots; ST: Stems; VN: Vine; WP: Whole plant

**Table 2.** Cultural importance (CI) of Piperaceae in Nakhon Nayok, Thailand

| Scientific name | Cultural practices and rituals | Herbal medicine | Ornamental plants | Vegetable and spices | Total number of used reports | CI of each species |
|---|---|---|---|---|---|---|
| *Peperomia albovittata* 'Piccolo Banda' | - | - | 36 | - | 36 | 0.45 |
| *Peperomia argyraea* | - | - | 34 | - | 34 | 0.43 |
| *Peperomia asperula* | - | - | 30 | - | 30 | 0.38 |
| *Peperomia caperata* | - | - | 29 | - | 29 | 0.36 |
| *Peperomia caperata* 'Burgundy Ripple' | - | - | 25 | - | 25 | 0.31 |
| *Peperomia caperata* 'Frost' | - | - | 27 | - | 27 | 0.34 |
| *Peperomia caperata* 'Pink Lady' | - | - | 26 | - | 26 | 0.33 |
| *Peperomia graveolens* | - | - | 28 | - | 28 | 0.35 |
| *Peperomia incana* | - | - | 31 | - | 31 | 0.39 |
| *Peperomia metallica* | - | - | 29 | - | 29 | 0.36 |
| *Peperomia obtusifolia* | - | - | 27 | - | 27 | 0.34 |
| *Peperomia obtusifolia* 'Variegata' | - | - | 29 | - | 29 | 0.36 |
| *Peperomia pellucida* | - | 15 | 19 | 16 | 50 | 0.63 |
| *Peperomia polybotrya* | - | - | 32 | - | 32 | 0.40 |
| *Peperomia prostrata* | - | - | 30 | - | 30 | 0.38 |
| *Peperomia quadrangularis* | - | - | 28 | - | 28 | 0.35 |
| *Peperomia rugosa* | - | - | 37 | - | 37 | 0.46 |
| *Peperomia serpens* | - | - | 32 | - | 32 | 0.40 |
| *Peperomia serpens* ‘variegata’ | - | - | 39 | - | 39 | 0.49 |
| *Peperomia tetragona* | - | - | 33 | - | 33 | 0.41 |
| *Peperomia tetraphylla* | - | - | 35 | - | 35 | 0.44 |
| *Peperomia turboensis* | - | - | 34 | - | 34 | 0.43 |
| *Piper betle* | 41 | 19 | - | - | 60 | 0.75 |
| *Piper kurzii* | - | 4 | - | - | 4 | 0.05 |
| *Piper nigrum* | - | 11 | - | 68 | 79 | 0.99 |
| *Piper ornatum* | - | - | 29 | - | 29 | 0.36 |
| *Piper porphyrophyllum* | - | - | 30 | - | 30 | 0.38 |
| *Piper retrofractum* | - | 5 | - | 24 | 29 | 0.36 |
| *Piper ribesioides* | - | 23 | - | - | 23 | 0.29 |
| *Piper sarmentosum* | - | 24 | - | 43 | 67 | 0.84 |
| *Piper sylvaticum* | - | - | 30 | - | 30 | 0.38 |
| Total number of used reports | 41 | 101 | 759 | 151 | 1052 | |
| CI of each category of used | 0.5125 | 1.2625 | 9.4875 | 1.8875 | | |

Notes: Total number of informants: 80

*Piperaceae are used in cultural practices and rituals*

In Nakhon Nayok Province, the use of betel leaves (*P. betle*) for betel chewing (Figure 2) is still observed among the elderly, particularly as a way to welcome guests and visitors. Offering a receptacle for betel to guests is considered a warm gesture of hospitality and a means of fostering strong community ties. The receptacle for betel consists of betel leaves, areca nut (*Areca catechu*), and slaked lime, commonly known as red lime, which is prepared by mixing slaked lime with turmeric (*Curcuma longa*) to enhance its color and flavor for betel chewing. Although the practice of betel chewing has significantly declined among younger and middle-aged generations, it remains common among the elderly. They often use it when hosting friends of a similar age, preserving social connections, and expressing goodwill within the community. Additionally, households with elderly individuals who frequently chew betel often grow their own betel vines (*P. betle*) and areca palms (*A. catechu*) to ensure convenient access for personal use, thereby helping to sustain and promote the cultural significance of these plants. Some households with an abundance of betel vines and areca palms not only share them with neighbors but also sell them in local markets. This practice helps strengthen community relationships while contributing to the local economy's sustainability.

Additionally, betel leaves were used in offerings for sacred beings. The areca nut was sliced, mixed with slaked lime, and wrapped in betel leaves. These were then rolled into cones and tied with cotton thread (*Gossypium herbaceum*). Sometimes, synthetic thread was used instead of cotton thread when cotton thread was unavailable to secure the rolled betel leaves. The rolled betel leaves are arranged in sets, with five being the most common. These sets also include five pieces of rolled betel leaves and dried tobacco leaves (*Nicotiana tabacum*), sometimes accompanied by small pieces of the bark of the heartwood tree (*Senegalia catechu*). On special occasions, such as large ceremonial rituals, 108 pieces may be used. These betel chewing sets are used in rituals to honor sacred spirits, such as the spirit of the house, guardian spirits, and the souls of ancestors. The use of betel in this way is a gesture of respect and a plea for blessings from the sacred beings for prosperity and well-being of life and family.

*Piperaceae are used as vegetables and spices*

This study identified four species of pepper plants used for food and spices, including one species from the genus *Peperomia* and three species from the genus *Piper* (Figure 3). The entire *P. pellucida* plant is edible, both raw and cooked. It is commonly consumed with chili paste, mixed into salads, added to clear soups, or stir-fried with soybean paste. *Piper nigrum*, with its pungent aroma, is a spice that imparts a hot flavor. Dried pepper is commonly used in cooking, while fresh pepper adds heat when incorporated into dishes such as Pad Kheemao (Thai Drunken Spicy Stir-Fry) and Pad Cha (Spicy Stir-Fried Clams with Herbs). *Piper retrofractum*, young fruits can be consumed fresh as vegetables, while ripe fruits are often used in chili paste or as a spice to enhance aroma and mask the smell of meat. *Piper sarmentosum* leaves are used in various dishes, such as Thai Curry with River Snail and Betel Leaf, Fermented Pork and Crispy Rice Salad, and Crab and Betel Leaf Curry. They also serve as a vegetable accompaniment to chili paste. Most notably, they are a key ingredient in Miang Kham (Figure 3), a traditional Thai snack that combines sweet, salty, sour, and spicy flavors in a single bite. The dish consists of betel leaves (*P. sarmentosum*) wrapped around a mixture of toasted coconut, roasted peanuts, diced ginger rhizome, diced lime (with the peel), diced shallots, dried shrimps, and chilies. A signature Miang Kham sauce, made from coconut sugar, fish sauce, shrimp paste, water, finely pounded galangal or ginger, and ground-roasted peanuts, is drizzled over the filling before eating.


**Figure 2.** Piperaceae plant used in cultural practices and rituals: A. Betel chewing sets; B. Components of betel chewing set; C. *Piper betle*. Photograph by: A. Thawatphong Boonma; B. Suriya Phimpha; C. by Tammanoon Jitpromma

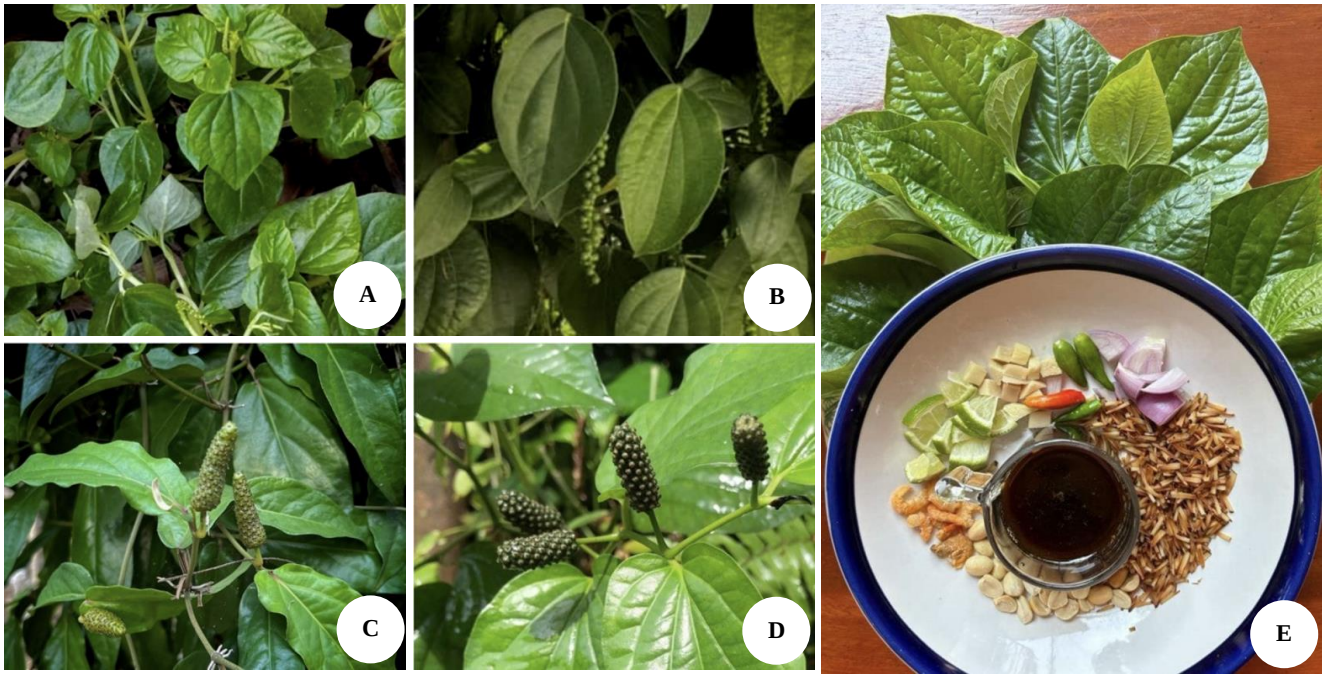


**Figure 3.** Piperaceae plants used as vegetables and spices: A. *Peperomia pellucida*; B. *Piper nigrum*; C *Piper retrofractum*; D. *Piper sarmentosum*; E. Ingredients of Miang Kham on the plate, eaten with *P. sarmentosum* leaves. Photograph by: A. Yuphin Daengnu-ngam; B, C, and D. Thawatphong Boonma; E. Wannaporn Daengnu-ngam

To enjoy Miang Kham, a wild betel leaf is used as a wrapper, with small portions of each ingredient placed inside before it is folded into a bite-sized parcel. This allows all the flavors to blend harmoniously in every mouthful. The snack is not only a flavorful treat but also a nutritious one, providing fiber, vitamins, and antioxidants from its herbal and vegetable components. Traditionally enjoyed as a family snack or served at special gatherings, Miang Kham embodies the Thai culinary philosophy of balancing flavors with natural, healthful ingredients.

*Piperaceae are used as ornamentals*

A total of 25 Piperaceae taxa (Table 1, Figure 4) were found to be used as ornamental plants in Nakhon Nayok Province. Most of these taxa are introduced species that have adapted well to the local climate and are commonly sold in small pots. These plants are particularly suitable for decorating tropical gardens, where they thrive in warm, humid conditions.


**Figure 4.** Piperaceae plants used as ornamentals: A. *Peperomia albovittata* 'Piccolo Banda'; B. *Peperomia argyraea*; C. *Peperomia asperula*; D. *Peperomia caperata*; E. *Peperomia caperata* 'Burgundy Ripple'; F. *Peperomia caperata* 'Frost'; G. *Peperomia caperata* 'Pink Lady'; H. *Peperomia graveolens*; I. *Peperomia incana*; J. *Peperomia metallica*; K. *Peperomia obtusifolia*; L. *Peperomia obtusifolia* 'Variegata'; M. *Peperomia polybotrya*; N. *Peperomia prostrata*; O. *Peperomia quadrangularis*; P. *Peperomia rugosa*; Q. *P. serpens*; R. *Peperomia serpens* 'variegata'; S. *Peperomia tetragona*; T. *Peperomia tetraphylla*. Photographs by Thawatphong Boonma

The diversity of these taxa contributes to the aesthetic appeal of gardens, adding texture, color, and visual interest to the landscape. Many of these plant taxa generate income for local farmers who propagate and sell them, especially at the Klong 15 Plant Market, located in Ongkharak District. The market offers a diverse range of ornamental and flowering plants in numerous species and cultivars.

*Piperaceae is used as an herbal medicine*

Seven species of the Piperaceae family were identified for ornamental purposes, including *P. pellucida*, *P. betle*, *P. kurzii*, *P. nigrum*, *P. retrofractum*, *P. ribesioides*, and *P. sarmentosum* (Table 3). These species are emphasized for their applications in treating gastrointestinal, cutaneous, respiratory, cardiovascular, endocrine, and musculoskeletal conditions.

*Peperomia pellucida*: The leaves were the most frequently utilized part, with three distinct preparation methods. Fresh leaves were consumed to treat scurvy and bleeding gums (46.67%). Squeezed leaf juice was used as an edible remedy for stomachaches (13.33%). Crushed leaves were applied externally to abscesses and wounds (33.33%), while the whole plant was soaked in water to relieve itchy rashes (6.67%).

*Piper betle*: The leaves were extensively used with multiple preparation methods. Boiling or pounding the leaves, followed by filtration, resulting in a drink used to alleviate stomachaches, improve digestion, reduce swelling, and promote stomach nourishment (36.84%). Pounded leaves mixed with liquor were applied externally to alleviate hives (26.32%). Chewing the leaves was a remedy for bad breath (21.05%). Heated leaves were applied to the skin for relief of musculoskeletal pain, swelling, and bruises (15.79%).

*Piper kurzii*: Both the leaves and stems were used equally (50% each), boiled, and filtered to prepare a drink with carminative properties.

*Piper nigrum*: Fruits and roots were utilized for gastrointestinal benefits. Powdered or granulated fruit was consumed to relieve flatulence, bloating, colic, and excessive gas (45.45%). Boiled and filtered roots were used as a drink to alleviate stomach discomfort and dizziness and improve digestion (54.55%).

*Piper retrofractum*: The fruits were used in two preparations: boiling and filtering to prepare a drink for relieving flatulence, bloating, and stomachaches (40%), and grinding dry ripe fruit with lime juice and salt to gargle or sip for alleviating coughing and expelling phlegm (60%).

*Piper ribesioides*: The vine was exclusively used (100%), boiled, and filtered to prepare a drink for expelling intestinal gas and relieving colic, flatulence, and bloating.

*Piper sarmentosum*: Both leaves and roots were utilized across multiple therapeutic categories. The leaves were commonly boiled and filtered for various medicinal applications, including gastrointestinal carminative and appetite-stimulating effects (18.75%), cardiovascular blood circulation enhancement (12.50%), respiratory expectorant (18.75%), and endocrine adjunct in diabetes treatment (12.50%). The roots were also boiled and filtered to expel respiratory phlegm (18.75%) and gastrointestinal gas (6.25%), and to support endocrine elemental balance (12.50%). These findings highlight the significant medicinal potential of these species, demonstrating their extensive use in traditional medicine for treating various ailments.

The distribution of cases across various body systems is as follows: the gastrointestinal system accounts for 46.67%, the cutaneous system for 14.67%, and the respiratory system for 12.00%. The nutrition and blood category contributes 9.33%, while the ear, nose, oropharynx, and oral cavity, as well as the endocrine system, each represent 5.33%. The musculoskeletal and joint diseases category constitutes 4.00%, and the cardiovascular system comprises 2.67% (Figure 5). The percentages in Figure 5 were derived from the sum of Np values for each category based on the data in Table 3. For example, musculoskeletal and joint diseases have an Np value of 3 out of a total Np of 75, which corresponds to 4.00%. Similarly, the respiratory system category has a sum Np of 3+3+3=9 out of a total Np of 75, which corresponds to 12%.

Various parts of Piperaceae species are utilized for therapeutic purposes, with leaves being the most frequently used (60%), followed by roots (16%), fruits (13.33%), stems and vines (9.33%), and whole plants (1.33%) (Figure 6). The most common preparation method is boiling the liquid in water and then filtering it for consumption. The percentages of plant parts used were also calculated based on the number of informants citing the same plant part for therapeutic uses (Np), as presented in Table 3. These values are not based on the number of rows, but on the summed Np values. For example, Fruits have an Np of 5+2+3=10 out of a total Np of 75, which corresponds to 13.33%.

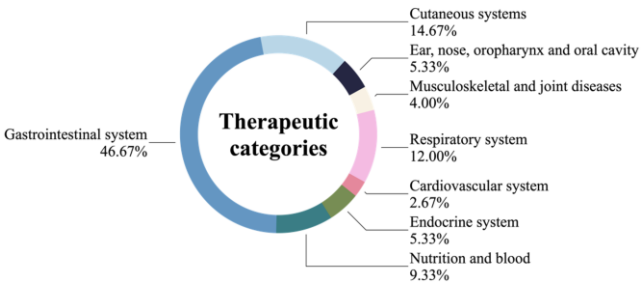


**Figure 5.** Piperaceae species are utilized in various therapeutic categories

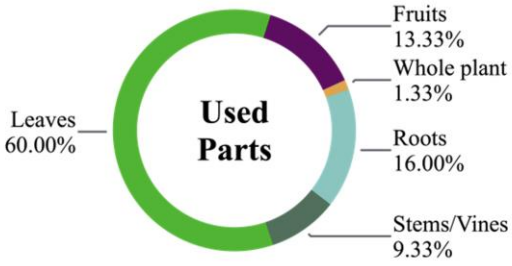


**Figure 6.** Percentage of used parts of Piperaceae species are utilized for therapeutic purposes

**Table 3.** Piperaceae plants in Nakhon Nayok Province, Central Thailand, are used as herbal medicines along with their %FL, used parts, preparation, method of uses, and therapeutic uses and health benefits

| Scientific name | Np | Nt | %FL | Used parts | Preparation | Method of use | Therapeutic categories | Therapeutic Uses and Health Benefits |
|---|---|---|---|---|---|---|---|---|
| *Peperomia pellucida* | 7 | 15 | 46.67 | Leaves | Eat fresh | Eat | Nutrition and blood | Treat scurvy and bleeding gums |
| | 2 | 15 | 13.33 | Leaves | Squeeze juice from leaves | Eat | Gastrointestinal system | Alleviate stomachaches |
| | 5 | 15 | 33.33 | Leaves | Crushed leaves | Use externally | Cutaneous systems | Directly applied to abscesses and wounds, or applied to purulent abscesses |
| | 1 | 15 | 6.67 | Whole plant | Soaked in water | Use externally | Cutaneous systems | Relieve itchy rashes |
| *Piper betle* | 7 | 19 | 36.84 | Leaves | Boil in water and filter to retain only the liquid, or pounded finely, and the juice is squeezed out and mixed with hot water | Drink | Gastrointestinal system | Alleviate stomachaches, aid in digestion, reduce swelling, and nourish the stomach |
| | 5 | 19 | 26.32 | Leaves | Pounded and mixed with liquor | Use externally | Cutaneous systems | Alleviate hives |
| | 4 | 19 | 21.05 | Leaves | Chewing and spitting out the leaves | Chewing | Ear, nose, oropharynx, and oral cavity | Remedy for bad breath |
| | 3 | 19 | 15.79 | Leaves | Heated over a fire | Applied to skin | Musculoskeletal and joint diseases | Applied to painful, swollen, or bruised areas for relief |
| *Piper kurzii* | 2 | 4 | 50.00 | Leaves | Boil in water and filter to retain only the liquid | Drink | Gastrointestinal system | Used as carminative agents |
| | 2 | 4 | 50.00 | Stems | Boil in water and filter to retain only the liquid | Drink | Gastrointestinal system | Used as carminative agents |
| *Piper nigrum* | 5 | 11 | 45.45 | Fruits | Powdered, granulated tableted, or dissolved in drinking water | Drink or eat | Gastrointestinal system | Alleviate symptoms of flatulence, bloating, colic, and excessive gas |
| | 6 | 11 | 54.55 | Roots | Boil in water and filter to retain only the liquid | Drink | Gastrointestinal system | Facilitate the expulsion of intestinal gas, alleviate stomach discomfort and dizziness, and promote digestive function |
| *Piper retrofractum* | 2 | 5 | 40.00 | Fruits | Boil in water and filter to retain only the liquid | Drink | Gastrointestinal system | Infusion to relieve flatulence, bloating, stomachache, and nausea caused by elemental imbalances |
| | 3 | 5 | 60.00 | Fruits | Grind dry ripe fruit with lime juice and a pinch of salt | Gargle or sip | Respiratory system | Alleviate coughing and expel phlegm |
| *Piper ribesioides* | 5 | 5 | 100.0( | Vine | Boil in water and filter to retain only the liquid | Drink | Gastrointestinal system | Expel intestinal gas and relieve colic, flatulence, and bloating |
| *Piper sarmentosum* | 3 | 16 | 18.75 | Leaves | Boil in water and filter to retain only the liquid | Drink | Gastrointestinal system | Consumed as a carminative, appetite stimulant, |
| | 2 | 16 | 12.50 | Leaves | Boil in water and filter to retain only the liquid | Drink | Cardiovascular system | Blood circulation enhancement |
| | 3 | 16 | 18.75 | Leaves | Boil in water and filter to retain only the liquid | Drink | Respiratory system | Expectorant |
| | 2 | 16 | 12.50 | Leaves | Boil in water and filter to retain only the liquid | Drink | Endocrine system | Adjunct treatment for diabetes |
| | 3 | 16 | 18.75 | Roots | Boil in water and filter to retain only the liquid | Drink | Respiratory system | Consumed to expel phlegm |
| | 1 | 16 | 6.25 | Roots | Boil in water and filter to retain only the liquid | Drink | Gastrointestinal system | Facilitate the expulsion of intestinal gas |
| | 2 | 16 | 12.50 | Roots | Boil in water and filter to retain only the liquid | Drink | Endocrine system | Support elemental balance |

Precautions in using plants as herbal medicine: In some cases, the scientific name of the plant used for medicinal purposes is incorrectly identified. For example, Dee Plee (*P. retrofractum*) is used as a medicinal plant. Still, some shops or products may use an illustration of Dee Plee (*P. retrofractum*) while mislabeling it as *Piper longum*. These two species can be distinguished by morphological characteristics, such as the oblong or elliptic-shaped leaves of *P. retrofractum*. At the same time, *P. longum* has heart-shaped leaves with a cordate base. When utilizing plants, especially for medicinal purposes, it is important to ensure the correct species is used, along with the appropriate plant part, method, and intended therapeutic purpose, to avoid potential side effects in treatment.

**Informant Consensus Factor (ICF)**

The informant consensus factor (ICF) was calculated for Piperaceae plants used as herbal medicines in Nakhon Nayok Province (Table 3). The ICF was calculated for various medicinal categories to assess the level of agreement among informants regarding the use of plant taxa for treating specific ailments. The ICF values ranged from 0.82 to 1.00, indicating varying degrees of consensus among participants (Table 4).

The highest ICF value (1.00) was observed in multiple categories, including nutrition and blood, ear, nose, oropharynx, oral cavity, musculoskeletal and joint diseases, cardiovascular system, and endocrine system. An ICF value of 1.00 suggests strong agreement among informants, where a single plant species was predominantly used to treat the specific ailment. This high level of consensus may indicate the cultural importance and well-established traditional knowledge associated with these medicinal applications.

The cutaneous system (ICF: 0.90) and respiratory system (ICF: 0.88) also showed relatively high consensus, suggesting that a small number of plant taxa are commonly recognized for treating skin-related conditions and respiratory ailments. Such consistency in plant use may reflect the efficacy of these species in traditional medicine, warranting further pharmacological investigation.

The gastrointestinal system exhibited the lowest consensus (ICF: 0.82), indicating greater variability in plant selection for digestive disorders. This lower value suggests that multiple plant taxa are used for gastrointestinal treatments, potentially due to the diverse range of symptoms and conditions within this category. The variation in plant usage may also reflect regional or individual differences in traditional knowledge and preferences.

The high ICF values across most categories indicate a strong shared understanding of medicinal plant use within the studied community. The findings highlight the importance of further ethnopharmacological research to validate the therapeutic potential of widely recognized plant species.

**Economic Value (EV) of Piperaceae in Nakhon Nayok Province**

The sales data for various plant species reveals substantial variations in both pricing and revenue generation (Table 5). Among the *Peperomia* species, prices for whole plants range from 25 THB to 1,500 THB per pot, with annual revenue varying significantly from 1,250 THB to 450,000 THB. High-value species such as *Peperomia rugosa* and *P. turboensis* contribute significantly to total revenues, reaching up to 450,000 THB and 178,000 THB, respectively. The *Piper* species, including *P. betle* and *P. nigrum*, exhibit similar variability, with revenue from fruits and leaves adding another layer to overall income, ranging from 1,500 THB to 250,000 THB annually. This data highlights the diverse economic potential across different species, with prices reflecting both demand and rarity.

**Discussion**

The Piperaceae family exhibits remarkable diversity in Nakhon Nayok Province, with 31 taxa identified across two genera: *Peperomia* and *Piper*. Notably, *Peperomia* dominates with 22 taxa, while *Piper* comprises 9 species. This distinction highlights the area's botanical richness, with an overwhelming presence of non-native species, 23 taxa, compared to only 8 native ones, as recorded in Thailand by Suwanphakdee et al. (2024) and on the POWO website (Suwanphakdee 2024; POWO 2025). The high proportion of introduced species reflects both the adaptability of these plants to local conditions and the human influence on the area's flora, particularly through cultivation and ornamental use.

The cultural and medicinal significance of Piperaceae in Nakhon Nayok is considerable. The cultural importance index (CI) values illustrate the varying degrees of cultural relevance, with *P. nigrum* leading the group, followed by *P. betle* and *P. sarmentosum*, indicating the strong cultural and economic value of these species. The CI analysis reveals that ornamental plants are the most used category, followed by vegetables and spices, highlighting their widespread application in daily life and cultural practices. The highest CI values indicate that species such as *P. nigrum* and *P. betle* have a deeply rooted cultural significance, with *P. nigrum* being used not only in culinary practices but also in rituals. The declining use of betel chewing among younger generations may reflect shifting social norms and lifestyles, although the tradition persists among the elderly, thereby preserving cultural continuity. Moreover, the practice of growing these plants for both personal and commercial purposes suggest a continuing cultural attachment to these species, ensuring their ongoing relevance in the community (Saensouk et al. 2025).

The findings also underscore the versatility of Piperaceae in traditional medicine, where species such as *P. pellucida* and *P. betle* are used to treat a wide range of ailments, including gastrointestinal and respiratory issues, as well as skin conditions. The broad medicinal applications of these plants suggest an intricate understanding of their therapeutic properties, which have been passed down through generations. The use of specific

plant parts, such as leaves, fruits, and stems, for various ailments further emphasizes the nuanced knowledge embedded in local practices (Saisor et al. 2021; Boonma et al. 2023). However, misidentification of species used for medicinal purposes, such as the confusion between *P. retrofractum* and *P. longum*, underscores the importance of accurate botanical knowledge for both effective treatment and safety.

Notably, *P. pellucida* has been reported to contain active Angiotensin-Converting Enzyme (ACE) inhibitors (Islamudin et al. 2019), supporting its traditional use as an antihypertensive remedy. This highlights the pharmacological potential of Piperaceae species and underscores the relevance of traditional knowledge in guiding scientific investigations. Although this study does not focus on the isolation of these compounds, such findings underscore the importance of medicinal plant research and the need for further exploration of bioactive compounds within the Piperaceae family. The integration of traditional knowledge with pharmacological studies remains crucial for identifying novel therapeutic agents. Given the diverse medicinal uses of Piperaceae, future research should continue to examine the bioactive properties of its species, contributing to both conservation efforts and drug discovery.

**Table 4.** The informant consensus factor of Piperaceae plants in each therapeutic category

| Therapeutic categories | Nur | Nt | ICF |
|---|---|---|---|
| Cardiovascular system | 2 | 1 | 1.00 |
| Ear, nose, oropharynx and oral cavity | 4 | 1 | 1.00 |
| Endocrine system | 4 | 1 | 1.00 |
| Musculoskeletal and joint diseases | 3 | 1 | 1.00 |
| Nutrition and blood | 7 | 1 | 1.00 |
| Cutaneous systems | 11 | 2 | 0.90 |
| Respiratory system | 9 | 2 | 0.88 |
| Gastrointestinal system | 35 | 7 | 0.82 |

**Table 5.** Economic Value (EV) assessment of Piperaceae in Nakhon Nayok Province, Thailand

| Scientific name | Products type | Prices (THB) | | Quantity sold (per year) | Total revenue per year (THB) |
|---|---|---|---|---|---|
| | | Min | Max | | |
| *Peperomia albovittata* 'Piccolo Banda' | Whole plant | 190/pot | 250/pot | 50-500 | 9,500-125,000 |
| *Peperomia argyraea* | Whole plant | 60/pot | 200/pot | 50-500 | 3,000-100,000 |
| *Peperomia asperula* | Whole plant | 35/pot | 100/pot | 50-500 | 1,750-50,000 |
| *Peperomia caperata* | Whole plant | 40/pot | 60/pot | 50-500 | 2,000-30,000 |
| *Peperomia caperata* 'Burgundy Ripple' | Whole plant | 60/pot | 150/pot | 50-500 | 3,000-75,000 |
| *Peperomia caperata* 'Frost' | Whole plant | 40/pot | 80/pot | 50-500 | 2,000-40,000 |
| *Peperomia caperata* 'Pink Lady' | Whole plant | 90/pot | 120/pot | 50-500 | 4,500-60,000 |
| *Peperomia graveolens* | Whole plant | 50/pot | 100/pot | 50-500 | 2,500-50,000 |
| *Peperomia incana* | Whole plant | 250/pot | 350/pot | 50-500 | 12,500-175,000 |
| *Peperomia metallica* | Whole plant | 50/pot | 160/pot | 50-500 | 2,500-80,000 |
| *Peperomia obtusifolia* | Whole plant | 25/pot | 60/pot | 50-500 | 1,250-30,000 |
| *Peperomia obtusifolia* 'variegata' | Whole plant | 50/pot | 150/pot | 50-500 | 2,500-75,000 |
| *Peperomia pellucida* | Whole plant | 50/kg | 60/kg | 30-50 | 1,500-3,000 |
| *Peperomia polybotrya* | Whole plant | 60/pot | 450/pot | 50-500 | 3,000-225,000 |
| *Peperomia prostrata* | Whole plant | 100/pot | 180/pot | 50-500 | 5,000-90,000 |
| *Peperomia quadrangularis* | Whole plant | 100/pot | 150/pot | 50-500 | 5,000-75,000 |
| *Peperomia rugosa* | Whole plant | 450/pot | 1,500/pot | 50-300 | 22,500-450,000 |
| *Peperomia serpens* | Whole plant | 80/pot | 200/pot | 50-500 | 4,000-100,000 |
| *Peperomia serpens* ‘variegata’ | Whole plant | 120/pot | 250/pot | 50-500 | 6,000-125,000 |
| *Peperomia tetragona* | Whole plant | 100/pot | 150/pot | 50-500 | 5,000-75,000 |
| *Peperomia tetraphylla* | Whole plant | 250/pot | 500/pot | 50-500 | 12,500-250,000 |
| *Peperomia turboensis* | Whole plant | 380/pot | 890/pot | 50-200 | 19,000-178,000 |
| *Piper betle* | Whole plant | 100/pot | 200/pot | 50-300 | 5,000-60,000 |
| | Leaves | 200/kg | 250/kg | 800-1,000 | 160,000-250,000 |
| *Piper retrofractum* | Whole plant | 50/pot | 150/pot | 50-300 | 2,500-45,000 |
| | Fruit | 200/kg | 250/kg | 20-60 | 4,000 -15,000 |
| *Piper nigrum* | Whole plant | 50/pot | 100/pot | 100-500 | 5,000 -50,000 |
| | Fruit | 200/kg | 250/kg | 300-600 | 60,000-150,000 |
| *Piper ornatum* | Whole plant | 80/pot | 200/pot | 50-500 | 4,000-100,000 |
| *Piper porphyrophyllum* | Whole plant | 80/pot | 250/pot | 50-500 | 4,000-125,000 |
| *Piper ribesioides* | Whole plant | 80/pot | 200/pot | 50-500 | 4,000-100,000 |
| *Piper sarmentosum* | Whole plant | 30/pot | 50/pot | 50-300 | 1,500-15,000 |
| | Leaves | 25/kg | 120/kg | 800-1,200 | 20,000-144,000 |
| *Piper sylvaticum* | Whole plant | 80/pot | 200/pot | 50-500 | 4,000-100,000 |

Note: Pot size 4 inches. 1 USD: 33.298 THB

The cultural role of *P. betle* in Nakhon Nayok Province underscores its profound significance in both social and ritual contexts. Among the elderly, betel chewing remains a key tradition, reinforcing hospitality and social cohesion. The decline of this practice among younger generations suggests shifting cultural dynamics, yet its continued presence in specific groups ensures its persistence. The cultivation of *betel vines* and areca palms reflects a conscious effort to sustain these traditions, linking personal use with community exchange and local markets. In ritual contexts, the structured use of betel in offerings to sacred beings and ancestors emphasizes its spiritual value. The careful preparation of betel sets, including *A. catechu*, slaked lime, and *C. longa*, demonstrates a commitment to traditional customs. The adaptation of synthetic thread as a substitute for cotton thread illustrates how cultural practices evolve while maintaining their core meanings.

Beyond its cultural significance, *P. betle* has been recognized for its medicinal properties. Nayaka et al. (2021) reported that *P. betle* is a popular medicinal plant in Asia, valued for its antibacterial and antifungal properties. Its extracts and essential oils have demonstrated inhibitory effects on various Gram-negative and Gram-positive bacteria, including drug-resistant strains. The plant's affordability and abundance make it a promising candidate for further research and industrial applications, particularly in the food and pharmaceutical industries. The combination of *P. betle* extracts with antibiotics has shown the potential to enhance antibacterial efficacy, which may contribute to the development of novel therapeutic solutions. The interplay between social customs, ritual practices, and medicinal applications ensures that *P. betle* remains a culturally and scientifically significant plant despite generational changes. Its continued use underscores the resilience of ethnobotanical traditions and highlights the need for further exploration of its pharmacological potential.

Furthermore, the Informant Consensus Factor (ICF) analysis provides insight into the level of consensus among local informants regarding the medicinal use of Piperaceae species. High ICF values in categories such as the gastrointestinal, musculoskeletal, and cardiovascular systems suggest a well-established traditional knowledge base where specific plant species are consistently recognized for treating particular ailments. The lower ICF value for gastrointestinal disorders may reflect the greater diversity of symptoms and conditions in this category, resulting in a broader range of plant taxa being utilized.

The economic value of Piperaceae species demonstrates their vital role in strengthening local horticultural systems and supporting household economies in Nakhon Nayok Province. By cultivating and marketing both ornamental and medicinal species, community members engage in diverse livelihood strategies that are closely tied to traditional ecological knowledge and sustainable resource use. This integration of local biodiversity into income-generating activities promotes not only economic resilience but also cultural continuity. Moreover, the high market demand for certain Piperaceae species encourages their conservation and domestication, contributing to the diversification of horticultural products. Such value-based cultivation fosters a deeper appreciation of native flora, reinforcing efforts to preserve species that may otherwise be overlooked or underutilized. The economic valuation of these plants, therefore, extends beyond monetary metrics, it underscores their broader contribution to sustainable development, community well-being, and biodiversity conservation. Importantly, these findings highlight the potential for scaling up local plant-based enterprises and incorporating ethnobotanical knowledge into formal horticultural and economic planning. By documenting and analyzing the economic value of Piperaceae, this study provides a foundation for future initiatives aimed at promoting community-led conservation, rural entrepreneurship, and the sustainable use of native plant resources.

In conclusion, the study reveals the complex and multifaceted role of Piperaceae in Nakhon Nayok Province, underscoring the interplay between biodiversity, cultural practices, and traditional medicine. The diversity of species, coupled with their varying levels of cultural and medicinal importance, highlights the adaptability of the Piperaceae family to local environments and human needs. These findings not only contribute to the understanding of local plant diversity but also emphasize the need for further research into the pharmacological properties of these species to validate and expand their traditional uses.

## ACKNOWLEDGEMENTS

This research project was financially supported by Mahasarakham University, Thailand. We would also like to extend our appreciation to the villagers from every community and all plant shops in Nakhon Nayok Province, Thailand, as well as to our families, for their cooperation and valuable information provided. We thank the Walai Rukhavej Botanical Research Institute, Mahasarakham University, Thailand, for providing us with a laboratory. We are also grateful to all the curators of the herbaria we visited for their assistance and support.

## REFERENCES

Boonma T, Saensouk S, Saensouk P. 2023. Diversity and traditional utilization of the Zingiberaceae plants in Nakhon Nayok Province, Central Thailand. Biodiversitas 24 (8): 904. DOI: 10.3390/d15080904.

Boonma T, Saensouk S, Saensouk P. 2024. Biogeography, conservation status, and traditional uses of Zingiberaceae in Saraburi Province, Thailand, with *Kaempferia chaveerachiae* sp. nov. Horticulturae 10 (9): 934. DOI: 10.3390/horticulturae10090934.

Callejas-Posada R. 2020. Piperaceae. In: Davidse G, Ulloa C, Hernández MHM, Knapp S (eds). Flora Mesoamericana 2. Missouri Botanical Garden Press, Saint Louis.

Carsono N, Tumilaar SG, Kurnia D, Latipudin D, Satari MH. 2022. A review of bioactive compounds and antioxidant activity properties of *Piper* species. Molecules 27 (19): 6774. DOI: 10.3390/molecules27196774.

Critical Ecosystem Partnership Fund (CEPF). 2025. Indo-Burma. Critical Ecosystem Partnership Fund, USA. https://www.cepf.net/our-work/biodiversity-hotspots/indo-burma.

Friedman J, Yaniv Z, Dafni A, Palewitch D. 1986. A preliminary classification of the healing potential of medicinal plants, based on a rational analysis of an ethnopharmacological field survey among Bedouins in the Negev desert, Israel. J Ethnophamacol 16: 275-287. DOI: 10.1016/0378-8741(86)900944-2.

Heinrich M, Ankli A, Frei B, Weimann C, Sticher O. 1998. Medicinal plants in Mexico: Healers' consensus and cultural importance. Soc Sci Med 47 (11): 1859-1871. DOI: 10.1016/s0277-9536(98)00181-6.

Islam MT, Hasan J, Snigdha HMSH, Ali ES, Sharifi-Rad J, Martorell M, Mubarak MS. 2020. Chemical profile, traditional uses, and biological activities of *Piper chaba* Hunter: A review. J Ethnopharmacol 257: 112853. DOI: 10.1016/j.jep.2020.112853.

Islamudin A, Neneng SSA, Berna E, Hanita O, Kamarza M, Arry Y, Osamu N, Abdul M. 2019. A new angiotensin-converting enzyme inhibitor from *Peperomia pellucida* (L.) Kunth. Asian Pac J Trop Biomed 9 (6): 257-262. DOI: 10.4103/2221-1691.260398.

Jaramillo MA, Rodríguez-Duque D, Escobar-Alba M. 2023. A new species of Piper (Piperaceae) with peltate leaves from Serranía de las Quinchas, Colombia. PhytoKeys 227: 9-24. DOI: 10.3897/phytokeys.227.101405.

Jitpromma T, Saensouk S, Saensouk P, Boonma T. 2025. Diversity, Traditional uses, economic values, and conservation status of Zingiberaceae in Kalasin Province, Northeastern Thailand. Horticulturae 11 (3): 247. DOI: 10.3390/horticulturae11030247.

Kamsu GT, Ndebia EJ. 2024. A comprehensive review of the ethnobotanical uses, pharmacological, and toxicological profiles of *Piper capense* L.f. (Piperaceae). Biodiversitas 25 (3): 598-614. DOI: 10.3390/ddc3030034.

Martínez-Bautista BG, Bernal-Ramírez LA, Bravo-Avilez D, Samain M-S, Ramírez AJM, Rendón-Aguilar B. 2019. Traditional uses of the family Piperaceae in Oaxaca, Mexico. Trop Conserv Sci 12: 1-22. DOI: 10.1177/1940082919879315.

Mathieu G. 2020. Endemic *Peperomia* (Piperaceae) novelties from eastern Madagascar. Candollea 75: 75-82. DOI: 10.15553/c2020v751a7.

National List of Essential Medicines (NLEM). https://ndi.fda.moph.go.th/uploads/file_news/202410091466330775.xls.

Nayaka NMDMW, Sasadara MMV, Sanjaya DA, Yuda PESK, Dewi NLKAA, Cahyaningsih E, Hartati R. 2021. *Piper betle* (L): Recent review of antibacterial and antifungal properties, safety profiles, and commercial applications. Molecules 26 (8): 2321. DOI: 10.3390/molecules26082321.

Numpulsuksant W, Saensouk S, Saensouk P. 2021. Diversity and ethnobotanical study of medicinal plants in Ban Hua Kua, Kae Dam District, Thailand. Biodiversitas 22 (10): 4349-4357. DOI: 10.13057/biodiv/d221027.

Pearson J, Jackson G, McNamara KE. 2023. Climate-driven losses to knowledge systems and cultural heritage: A literature review exploring the impacts on Indigenous and local cultures. Anthropocene Rev 10 (2): 343-366. DOI: 10.1177/20530196211005482.

Pei S, Alan H, Wang Y. 2020. Vital roles for ethnobotany in conservation and sustainable development. Biodiversitas 23 (6): 399-400. DOI: 10.1016/j.pld.2020.12.001.

Plant of the World Online (POWO). 2025. Plant of the World. Royal Botanic Gardens, Kew. http://www.plantsoftheworldonline.org/.

Queiroz G, Guimarães EF. 2020. *Peperomia* (Piperaceae) no leste metropolitano do Rio de Janeiro, Brasil. Rodriguesia 71: e02512018. DOI: 10.1590/2175-78602020711420xx.

Radh SS, Nampy S. 2018. *Peperomia ekakesara*: A new species of Piperaceae from Mathikettan shola National Park, Kerala, India. Phytotaxa 364 (3): 283-288. DOI: 10.11646/Phytotaxa.364.3.8.

Saensouk P, Boonma T, Saensouk S. 2021. *Curcuma siamensis* (Zingiberaceae, Zingibereae), a new species of *Curcuma subgen*. Ecomata from Southeastern Thailand. Biodiversitas 22 (12): 5239-5246. DOI: 10.13057/biodiv/d221201.

Saensouk P, Saensouk S, Hein KZ, Appamaraka S, Maknoi C, Sonthongphithak P, Koompoot K, Sonthongphithak P, Boonma T, Jitpromma T. 2025. Diversity, ethnobotany, and horticultural potential of local vegetables in Chai Chumphol Temple Community Market, Maha Sarakham Province, Thailand. Biodiversitas 26 (3): 243. DOI: 10.3390/horticulturae11030243.

Saensouk P, Saensouk S, Maknoi C, Setyawan AD, Boonma T. 2024. A horticultural gem unveiled: *Curcuma peninsularis* sp. nov. (Zingiberaceae), a new species from Peninsular Thailand, previously misidentified as *Curcuma aurantiaca* Zijp. Horticulturae 10 (9): 950. DOI: 10.3390/horticulturae10090950.

Saisor N, Prathepha P, Saensouk S. 2021. Ethnobotanical study and utilization of plants in Khok Nhong Phok Forest, Kosum Phisai District, Northeastern Thailand. Biodiversitas 22 (10): 4336-4348. DOI: 10.13057/biodiv/d221026.

Salehi B, Zakaria ZA, Gyawali R, Ibrahim SA, Rajkovic J, Shinwari ZK, Khan T, Sharifi-Rad J, Ozleyen A, Turkdonmez E, Valussi M, Tumer TB, Monzote FL, Martorell M, Setzer WN. 2019. *Piper* species: A comprehensive review on their phytochemistry, biological activities, and applications. Molecules 24 (7): 1364. DOI: 10.3390/molecules24071364.

Silva L, Queiroz GD, Silva DD, Silva ND, Guimarães E. 2024. Three new species of *Peperomia* Ruiz & Pav. (Piperaceae) from the Brazilian Atlantic Forest. Authorea 1: 1-10. DOI: 10.22541/au.170664240.05329223/v1.

Su F, Qin X-W, Fan R, Yan L, Ji X-Z, Hao CY. 2024. *Piper motuoense*, a new species of Piperaceae from Xizang, China. PhytoKyes 238: 85-94. DOI: 10.3897/phytokeys.238.115494.

Sudmoon R, Tanee T, Wongpanich V, Nat B, Chaveerach A. 2012. Ethnobotany and species-specific molecular markers of some medicinal Sakhan (*Piper*, Piperaceae). J Med Plant Res 6: 1168-1175.

Suwanphakdee C, Hodkinson TR, Chantaranothai C. 2022. New species and a revision of the genus *Peperomia* (Piperaceae) in Thailand. Thai For Bull Bot 50 (2): 104-119. DOI: 10.20531/tfb.2022.50.2.11.

Suwanphakdee C, Simpson DA, Hodkinson TR, Chantaranothai C. 2020. A synopsis of Thai Piper (Piperaceae). Thai For Bull Bot 48 (2): 145-183. DOI: 10.20531/tfb.2020.48.2.08.

Suwanphakdee C, Simpson DA, Hopkinson TR. 2024. Piperaceae. In: Chayamarit K, Balslev H, Newman MF, Barfod AS, Esser H-J, Simpson DA, Parnell JAN (eds). Flora of Thailand Vol. 16, Part 3. The Forest Herbarium, Department of National Parks, Wildlife and Plant Conservation, Bangkok, Thailand.

Tardío J, Pardo-De-Santayana M. 2008. Cultural importance indices: A comparative analysis based on the useful wild plants of Southern Cantabria (Northern Spain). Econ Bot 62: 24-39. DOI: 10.1007/s12231-007-9004-5.

Trujillo W, Trujillo ET, Ortiz-Morea FA, Toro DA, Jaramillo MA. 2022. New *Piper* species from the eastern slopes of the Andes in northern South America. PhytoKeys 206: 25-48. DOI: 10.3897/phytokeys.206.75971.

Yadav V, Krishnan A, Vohora D. 2020. A systematic review on *Piper longum* L.: Bridging traditional knowledge and pharmacological evidence for future translational research. J Ethnopharmacol 247: 112255. DOI: 10.1016/j.jep.2019.112255.