

From traditional knowledge to multi-omics: the future of biotechnology-driven ethnobotany in Hainan Island, China

Shuya Yang^{1,2#}, Ke Deng^{1,2#}, Haikuo Fan³, Long Zhao^{1,2}, Xiaochen Hu², Weiqi Xu⁴ and Zhihua Mu^{1,2,4*}

¹ Academy of Agriculture and Forestry Sciences, Qinghai University, Xining, Qinghai 810016, China

² Qinghai University, Qinghai 810016, China

³ Coconut Research Institute, Chinese Academy of Tropical Agricultural Sciences, Wenchang, Hainan 571339, China

⁴ Hainan Seed Industry Laboratory, Sanya, Hainan 572024, China

Authors contributed equally: Shuya Yang, Ke Deng

* Correspondence: 2025990083@qhu.edu.cn (Mu Z)

Abstract

Hainan Island, with its unique tropical climate and rich biodiversity, is home to diverse ethnic minorities, including the Li, Miao, and Hui, who possess profound traditional knowledge of plant utilization in medicine and diet. However, this knowledge is increasingly threatened by modernization and environmental changes, highlighting the need to integrate traditional wisdom with modern science for conservation and sustainable use. This study explores the role of biotechnology-driven medicinal ethnobotany in Hainan, combining ethnobotanical surveys, field investigations, and advanced biotechnologies such as multi-omics (genomics, metabolomics) and tissue culture. It documents extensive plant use by ethnic groups: over 500 plant species utilized by the Li, including 282 medicinal species for treating rheumatism and gastrointestinal disorders, and 26 wild edible species in minority regions. Multi-omics analyses revealed key active compounds and genetic traits, while tissue culture techniques supported propagation of endangered species. These findings show that the use of traditional medicinal plants is linked to ecological sustainability, and integrating multi-omics with traditional knowledge enhances resource conservation and utilization. This approach bridges cultural heritage and scientific innovation, offering a framework to safeguard Hainan's ethnobotanical diversity and promote low-carbon, sustainable development.

Citation: Yang S, Deng K, Fan H, Zhao L, Hu X, et al. 2026. From traditional knowledge to multi-omics: the future of biotechnology-driven ethnobotany in Hainan Island, China. *Medicinal Plant Biology* 5: e006 <https://doi.org/10.48130/mpb-0026-0002>

Introduction to Hainan and its unique climate and vegetations

Hainan Island, the southernmost province of China (Fig. 1a), exhibits a distinctive tropical and subtropical climate that significantly influences its biodiversity and agricultural practices. Unlike other southern regions with tropical fragments (e.g., southern Yunnan and Guangxi), 42.5% of Hainan Island's land area falls within the tropical and subtropical zone. The island experiences an annual average temperature of 23–25 °C and mean annual rainfall exceeding 1,600 mm, creating favorable conditions for diverse plant species, including native and economically significant crops such as coconuts^[1]. Hainan's unique geographical and climatic conditions also shape its ecological landscape. The island hosts the most extensive and well-preserved tropical forests in China, supporting higher levels of native plant endemism and diversity than fragmented tropical areas in Yunnan and Guangxi. For instance, Hainan is home to over 6,000 vascular plant species (of which about 15% are endemic), far surpassing the tropical plant diversity of Guangxi's coastal areas and exceeding the endemic species ratio of Yunnan's Xishuangbanna^[2,3].

Culturally, Hainan's ethnic diversity further enhances its uniqueness. Unlike Yunnan's diverse ethnic groups with cross-border cultural connections or Guangxi's Zhuang-dominated ethnic landscape, Hainan is home to the Li people and Miao, Hui, and Yao communities that have developed isolated, island-specific ethnobotanical knowledge over millennia^[4]. For example, the Li people's utilization of over 500 plant species for medicine, food, and crafts—such as *Mallotus furetianus* (Zhegu tea) and *Broussonetia papyrifera*

(Li bark cloth raw material)—is distinct from the ethnobotanical practices of Yunnan's Dai or Guangxi's Zhuang, which are shaped by continental cultural exchanges^[5,6]. This unique blend of intact tropical ecosystems and isolated ethnic traditions makes Hainan a globally significant site for ethnobotanical research—offering insights into human-plant interactions.

Ecologically, Hainan's central and southern mountainous areas (e.g., Wuzhishan and Jianfengling) are identified as key hotspots for plant endemism^[2]. Hainan's unique geographical and climatic conditions also shape its ecological dynamics. The spatial distribution of plant diversity is largely driven by environmental factors such as temperature, precipitation, and soil composition. Notably, climate change is influencing agricultural suitability on the island, with studies predicting shifts in optimal cultivation zones for crops like green oranges^[3]. Additionally, the presence of non-native species, mainly introduced through human activities, poses ecological challenges, as these species compete with native flora and alter biodiversity patterns^[7].

These ecological cultural characteristics highlight Hainan's irreplaceable value: it is not only a repository of China's most intact tropical biodiversity but also a living archive of unique ethnic botanical knowledge, making it a critical focus for ethnobotanical research and conservation.

Ethnic minorities in Hainan and their utilization of local plants

Besides these unique plantations, Hainan is home to 55 officially recognized ethnic minorities, including the Li, Miao, Hui, Zhuang,

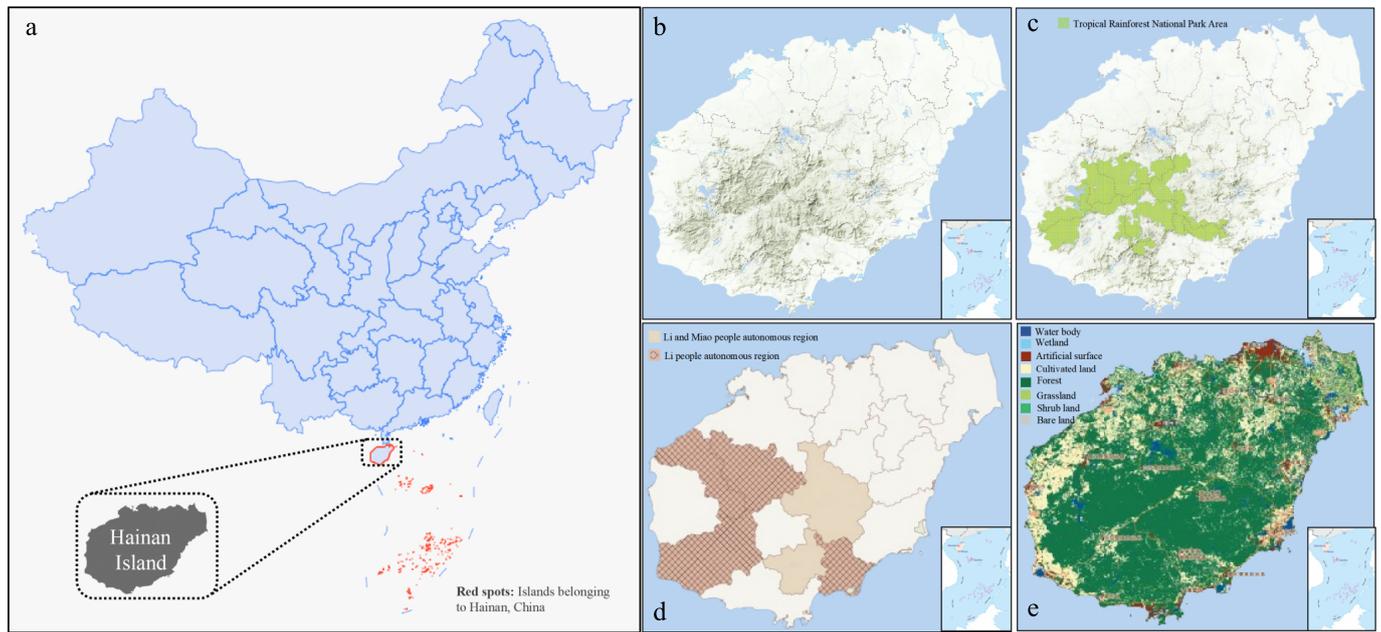


Fig. 1 Maps of Hainan Province: terrain, ethnic groups, forest coverage, ethnic population, and its location in China. (a) The location of Hainan in China. (b) Topographic map of Hainan. (c) Distribution of tropical rainforest national parks in Hainan. (d) Map of minority languages in Hainan. (e) Surface coverage map of Hainan. The map inspection number of (a) is GS (2024) 0650, and this map was supervised by the Ministry of Natural Resources of China. The inspection numbers of (c) and (d) are GS(2024)056 -survey qualification certificate No. 1100471, and these maps were supervised by Hainan Provincial Bureau of Surveying, Mapping, and Geographic Information, data acquired from the National Platform for Common Geospatial Information Services of China. All maps used in this figure are based on the official Chinese map provided by the Standard Map Service System of the Ministry of Natural Resources of China (<http://bzdt.ch.mnr.gov.cn>).

and Yao, which significantly enriches the region's cultural diversity, traditional craftsmanship, and economic activities^[8]. The Li, the island's earliest settlers with a population exceeding 1.2 million, are renowned for their UNESCO-listed Li ethnic brocade (Li Jin), traditional agriculture, and medicinal plant knowledge^[9]. The Miao, descendants of Ming Dynasty soldiers, excel in silverware processing, brocade weaving, and herbal medicine^[9]. The Hui, with roots tracing back to Persian and Arab merchants, maintain Islamic traditions in religion, cuisine, and clothing, primarily in Yanglan Town, Sanya^[10]. The Zhuang, engaged in agriculture, are culturally known for their folk songs and dances, sharing affinities with their Guangxi counterparts^[11]. The Yao, residing in the northwest, are experts in traditional embroidery and medicinal plant knowledge, contributing to local healthcare practices^[4]. Despite modernization and tourism challenges, these communities play a vital role in preserving Hainan's cultural and ecological heritage, necessitating increased conservation efforts^[12].

These ethnic minorities have developed extensive traditional knowledge regarding plant utilization, particularly in food, medicine, and material culture. The Li people have a rich ethnobotanical tradition, utilizing over 500 species of plants for medicinal, culinary, and utilitarian purposes^[6]. Among these, medicinal plants play a significant role, with 282 species identified in Li traditional medicine, used primarily for treating ailments such as rheumatism, gastrointestinal disorders, and traumatic injuries^[13]. The Miao and Hui also employ plant-based medicine, with many species shared with traditional Chinese medicine (TCM) and local folk practices^[14]. In addition to medicinal uses, plants play a crucial role in food and cultural practices. The Li people cultivate indigenous crops such as mountain rice (Shanlan upland rice) and use wild plants to create traditional rice dishes, including herbal soups and fermented foods.

The Miao ethnic group is known for using wild herbs and spices in cuisine, while the Hui integrate their Islamic dietary customs with local plant resources^[5]. Furthermore, many ethnic groups in Hainan utilize plant materials for handicrafts, such as bamboo weaving, textile dyeing, and wood carving, preserving traditional craftsmanship and cultural heritage^[15]. Despite the richness of ethnobotanical knowledge, modernization and environmental degradation pose challenges to the preservation of traditional practices. The increasing commercialization of ethnic cultural heritage, particularly in tourism, has altered the way indigenous knowledge is transmitted, with some concerns over the authenticity and sustainability of cultural preservation efforts^[12]. Efforts to document and protect traditional botanical knowledge remain crucial to maintaining the cultural and ecological diversity of Hainan.

Situated within the tropical zone, Hainan Province represents China's most biodiverse region and harbors several distinctive ethnic minority groups. The areas where ethnic minorities live in compact communities in Hainan Province highly overlap with the mountainous regions with high biodiversity in Hainan Province, as demonstrated in Fig. 1b–e. To investigate the traditional botanical knowledge and plant utilization patterns among these indigenous communities, researchers in Hainan have implemented ethnobotanical approaches, establishing a novel framework for studying the intricate relationships between local ethnic groups and their floristic environment. Ethnobotany is an interdisciplinary field that examines the complex relationships between humans and plants. The term was first introduced by John William Harshberger in 1896, originally defined as 'the study of plants used by aborigines'^[16]. Over time, its scope has expanded significantly, encompassing various dimensions of human-plant interactions.

Utilization of medical ethnobotanical plants in Hainan province

The development of global ethnobotany can be summarized as follows: In its early stages (19th to early 20th century), ethnobotany emerged from natural history and plant taxonomy, with scientists beginning to document indigenous traditional knowledge of plants and applying it to medical and agricultural research^[17]. During the modern phase (mid-20th to early 21st century), ethnobotany integrated with disciplines such as ecology, chemistry, and pharmacology, driving research on traditional medicinal plants and the development of new drugs^[18]. In the contemporary era (21st century to present), ethnobotany has increasingly focused on sustainable development, biodiversity conservation, and cultural preservation, while utilizing modern technologies such as DNA analysis and remote sensing to enhance research depth^[19]. This evolution reflects the field's growing interdisciplinary nature and its critical role in addressing global challenges related to environmental and cultural sustainability.

Based on the historical development of ethnobotanical research in Hainan, the earliest systematic studies can be traced back to the

late 1980s. The pioneering work by Pei Shengji laid the theoretical foundation for ethnobotanical research in southern China, although it primarily focused on Yunnan Province^[20]. Subsequently, scientists from Hainan conducted the first specialized ethnobotanical investigation on the Li people's medicinal plant use in Hainan Island, published in *Economic Botany*, marking a significant milestone in Hainan's regional ethnobotany^[21]. These seminal works collectively established the academic framework for understanding the traditional botanical knowledge systems of Hainan's ethnic minorities, which have been developed and preserved over centuries. It also explores how different ethnic groups perceive, utilize, conserve, and manage plant resources. It includes research on the economic, medicinal, ecological, and cultural significance of plants across diverse communities.

The people of Hainan make extensive use of the region's unique plants in various aspects of life. These plants are employed in clothing, food, shelter, transportation, and medicine, which reflects the residents' deep understanding and utilization of the natural resources. Several highly representative ethnobotanical plants were selected and presented in Fig. 2 below.

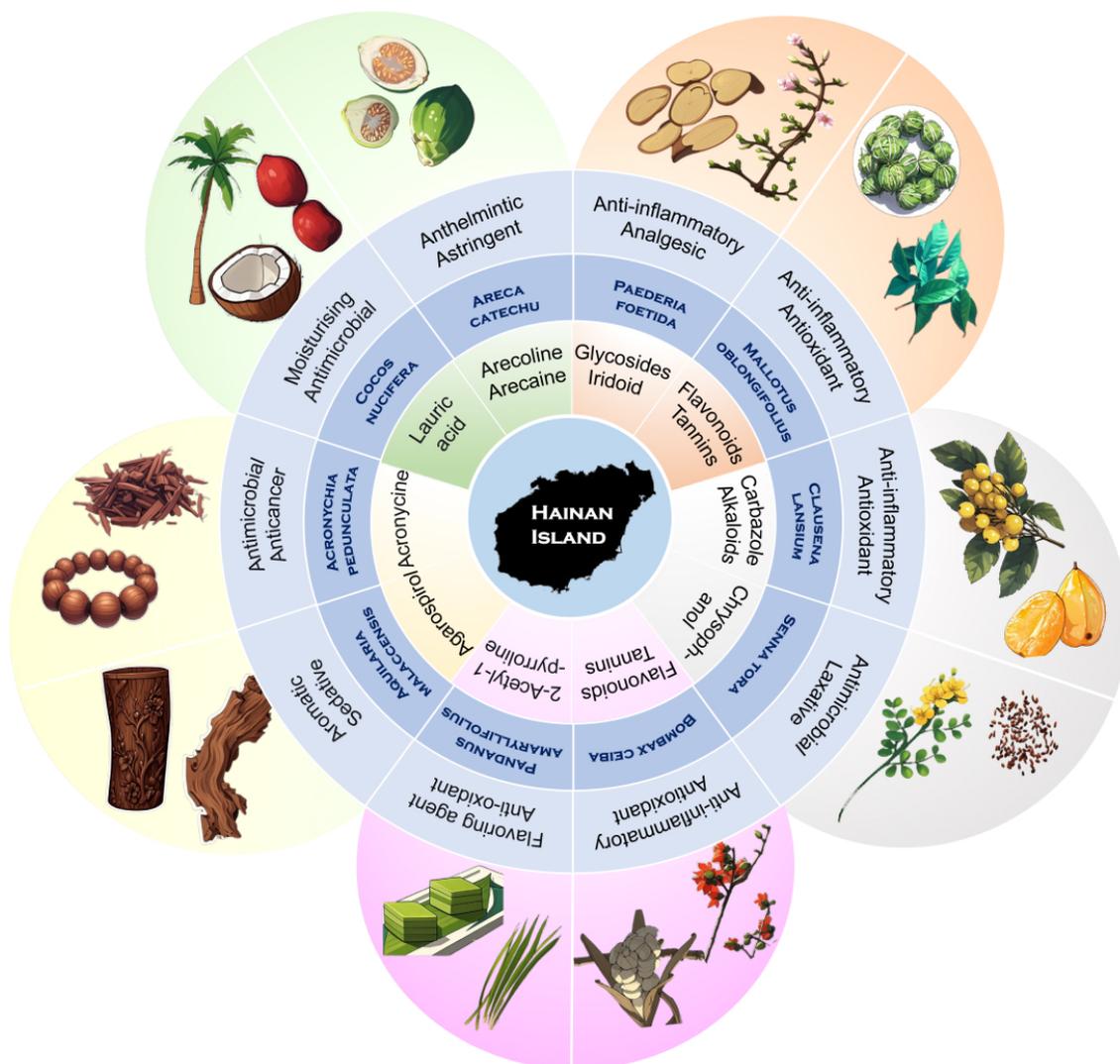


Fig. 2 Diagram of the ten representative ethnic plants in Hainan. All edible plants listed can act both as medicine and food in the traditional Hainan medicine system.

Ethnobotanical utilization of plants in Hainan: medicinal, dietary, and cultural dimensions

The application of ethnobotanical plants as medicinal plants

In Hainan Island, China, ethnic minority groups, such as the Li and Miao people, have a long tradition of using local plants for medicinal purposes. Their knowledge, passed down through generations, is deeply rooted in the island's rich biodiversity^[22]. These communities rely on wild herbs, roots, leaves, and barks to treat various ailments, from common colds to chronic conditions^[23]. Their practices often combine spiritual beliefs with natural remedies, emphasizing harmony with nature^[23]. While modern medicine is increasingly accessible, many still prefer traditional plant-based treatments due to their cultural significance and perceived effectiveness^[14]. However, this indigenous knowledge faces challenges from deforestation and cultural erosion. Efforts are being made to document and preserve these practices as part of Hainan's intangible cultural heritage. In recent years, remarkable progress has been made in the study of medicinal ethnobotany in Hainan Province, mainly focusing on the Li ethnic group and other ethnic groups. The Li people have a long-standing history of using medicinal plants. Studies show that they utilize 50 species from 36 families, and the Run dialect group of the Li people uses 282 species from 89 families and 222 genera^[13]. The most common families are Leguminosae (14%), Compositae (6%), and Euphorbiaceae (6%). The main preparation methods are decoction (84%), crushing (38%), and ointment (34%), mainly for treating bleeding, pain, gastrointestinal diseases, and trauma^[5]. This paper summarizes the ethnic minority medicinal plants recorded in various historical materials in Hainan Province, as shown in Table 1. The core differences in rheumatism-treating medicinal plant selection between the Li and Miao ethnic groups stem from their distinct ecological niches and cultural practices. The Li, residing in Hainan's central-southern mountains, favor *Leguminosae* and *Euphorbiaceae* plants, prepared as decoctions/ointments to adapt to damp-heat environments. In contrast, the Miao inhabit more isolated highlands with shamanistic traditions, emphasizing diverse herbaceous plants with spiritual elements, showing unique anti-inflammatory preferences alongside overlaps^[24]. The Li's tropical forest proximity supports endemic damp-resolving shrubs, while the Miao, influenced by Ming migrations, integrate cross-regional herbs linked to their weaving/silverware cultures to combat humid-island parasitic infections. Yet overall similarity remains high due to shared biodiversity hotspots, reflecting the common adaptation of local ethnic groups to the island's unique ecological and climatic conditions^[24].

The application of ethnobotanical plants in a health-promoting diet

In Hainan, ethnic minorities have long utilized local plants not only as medicine but also as tea, food, and flavorings, blending nutrition and health, as shown in Table 2. Wild herbs, leaves, and roots are often brewed into herbal teas, believed to aid digestion, detoxification, and general well-being. Many plants are incorporated into daily meals, either as staple ingredients or seasonal supplements, enhancing both flavor and nutritional value^[31]. Some aromatic or pungent plants serve as natural condiments, adding unique tastes to traditional dishes. In Baoting and Lingshui in

Hainan Province (both are minority-inhabited regions), a recent ethnobotanical survey documented 26 species of wild edible vascular plants, encompassing 24 genera and 16 families. The majority (84.62%) of these species were identified as annual or perennial herbs, demonstrating a strong reliance on herbaceous flora in local dietary practices^[32]. Aboveground plant parts, such as leaves, stems, and young shoots, were the most frequently utilized components, suggesting a sustainable harvesting approach that allows for plant regeneration. Among various preparation methods, stir-frying emerged as the predominant culinary technique, reflecting both traditional cooking preferences and the practical suitability of these plants for high-heat preparation^[32].

Additionally, certain plants function as both food and medicine, consumed for their therapeutic benefits while providing sustenance, as shown in Table 2. For example, herbal teas (*liáng chá*), represent an important category of functional beverages widely consumed in southern China, especially in Hainan, Guangdong, and Guangxi. Documentation revealed that 222 ethnotaxa (representing 238 botanical taxa at species, variety, and subspecies levels) were utilized in *liáng chá* preparations^[33]. These taxa span 209 genera from 86 plant families, demonstrating significant biodiversity in this traditional pharmacopeia^[33]. Coconut water, a refreshing beverage documented by various ethnic minorities in Hainan, is widely cherished by the local people^[34]. These practices reflect a deep connection to nature, where diet and health are intertwined. However, modernization and habitat loss threaten this knowledge, prompting efforts to preserve these traditions as part of Hainan's cultural heritage.

Heavy metal content and toxic secondary metabolite testing have been conducted on the food safety of 'medicinal food homologous' plants like purslane (*Portulaca oleracea*) and fake konjac (*Amorphophallus konjac*) in Table 2. For purslane, studies in China have assessed bioaccumulation of metals like Cd, Pb, and Zn in contaminated soils, showing its phytoremediation potential but highlighting risks of elevated levels in edible parts, with recommendations for safe harvesting thresholds^[35]. For fake konjac, analyses have evaluated secondary metabolites such as alkaloids and their potential toxicity, confirming anti-tumor benefits but noting reductions in harmful compounds like β -glucuronidase through processing, ensuring safety in traditional uses^[36].

Heritage and cultural significance of ethnobotanical plants in Hainan

In Hainan, ethnobotanical plants play a vital role in the religious and cultural life of indigenous communities such as the Li and Miao peoples. These plants possess not only practical functions but also profound symbolic meanings, deeply embedded in rituals and traditional medicine, reflecting a worldview rooted in the harmonious coexistence between humans and nature. Archaeologists believe that coconuts were introduced and utilized by the ancient people of Hainan over two thousand years ago. With its majestic and tall appearance, the coconut tree is regarded by the people of Hainan as the 'hero tree', embodying justice and strength^[40]. These ethnobotanical traditions form the foundation of local religious practices and everyday life, while also representing a significant area of inquiry in ethnobotany and cultural anthropology^[14]. However, this invaluable knowledge is increasingly endangered by modernization and the erosion of traditional lifestyles. Therefore, systematic documentation, research, and preservation of Hainan's ethnobotanical heritage are essential for safeguarding indigenous wisdom, revitalizing ethnic cultures, and promoting sustainable ecological development. In ancient times, due to its geographical remoteness and

Table 1. Medicinal plants recorded in historical materials in Hainan Province.

Scientific name/ Chinese name/Pinyin	Main distribution regions	Medical main chemical components	Pharmacological activity	Ref.
<i>Bidens pilosa</i> L. 三叶鬼针草 (sān yè guǐ zhēn cǎo)	Cities and counties, including Haikou, Sanya, Danzhou, Wenchang, and Qionghai, wastelands, roadsides, farmlands	Flavonoids, triterpenoids, and volatile oils	Diarrhea	[25]
<i>Polyalthia suberosa</i> (Roxb.) Thwaites 暗罗 (àn luó)	Southern and western cities and counties, including Qiongzong, Baoting, Lingshui, Wuzhishan, Ledong, sparse forests, thickets	Alkaloids, flavonoids, and terpenoids	Clearing heat and detoxifying	
<i>Zanthoxylum nitidum</i> (Roxb.) DC. 两面针 (liǎng miàn zhēn)	Mountainous areas in central and southern regions, including Qiongzong, Wuzhishan, Baoting, Lingshui, and Wanning, sparse forests, bushwood	Alkaloids, flavonoids, and coumarins	Anti-inflammatory, stopping bleeding	
<i>Polygonum chinense</i> (L.) H. Gross 火炭母 (huǒ tàn mù)	Cities and counties, including Haikou, Danzhou, Chengmai, Ding'an, and Qionghai, shady and moist areas	Flavonoids, anthraquinones, and phenolic acids	Hepatitis B	
<i>Equisetum ramosissimum</i> Desf. 节节草 (jié jié cǎo)	Cities and counties, including Haikou, Danzhou, Chengmai, Ding'an, and Qionghai, wetlands	Alkaloids, flavonoids, and triterpenoids	Hypertension	
<i>Polygonum perfoliatum</i> L. 杠板归 (gàng bǎn guī)	Southern and western cities and counties, including Sanya, Ledong, Dongfang, and Changjiang, valleys, roads	Flavonoids, anthraquinones, and phenolic acids	Relieving cough, sore throat	[26]
<i>Ludisia discolor</i> (Ker-Gawl.) A. Rich. 血叶兰 (xuè yè lán)	Central and southern mountainous areas, including Qiongzong, Wuzhishan, Baoting, and Jiangfengling(Ledong), terrestrial habitats	Flavonoids, terpenoids, phenolic acids, polysaccharides	Clearing heat and nourishing yin- deficiency (a TCM syndrome characterized by dryness, fatigue, and heat intolerance), hepatitis B	
<i>Pholidota chinensis</i> Lindl. 石仙桃 (shí xiān táo)	Central mountainous areas, including Qiongzong, Wuzhishan, Baoting, and Jiangfengling(Ledong), epiphytes on plants	Flavonoids, terpenoids, phenolic acids, and polysaccharides	Clearing heat and moistening the lung	
<i>Cleisostoma paniculatum</i> (Ker Gawl.) Garay 大序隔距兰 (dà xù gé jù lán)	Southern cities and counties, including Sanya, Lingshui, Baoting, and Ledong, epiphytes on plants	Flavonoids, terpenoids, phenolic acids, and trace alkaloids	Rheumatoid joint pain	
<i>Dendrobium williamsonii</i> Day & Rchb. f. 黑毛石斛 (hēi máo shí hú)	Central mountainous areas, including Qiongzong, Wuzhishan, Baisha, and Baoting, epiphytes on plants	Dendrobine-type alkaloids, flavonoids, triterpenoids, and polysaccharides	Joint pain	
<i>Eulophia graminea</i> Lindl. 美冠兰 (měi guān lán)	Northern and western cities and counties, including Haikou, Wenchang, Danzhou, Lingao, and Chengmai, terrestrial habitats	Alkaloids, flavonoids, terpenoids, and phenolic acids	Reproductive system disease	
<i>Flickingeria fimbriata</i> (Blume) Hawkes 流苏金石斛 (liú sū jīn shí hú)	Cities and counties, including Sanya, Baoting, and Qiongzong, epiphytes on plants	Flavonoids, terpenoids, phenolic acids, and polysaccharides	Thyroid, hepatitis	
<i>Eria corneri</i> Rchb. f. 半柱毛兰 (bàn zhù máo lán)	Jiangfengling Mountain region, Ledong, stone	Flavonoids, terpenoids, phenolic acids, and trace polysaccharides	Gout	[26]
<i>Dendrobium nobile</i> Lindl. 石斛 (shí hú)	Cities and counties, including Sanya, Lingshui, Qiongzong, Changjiang, Baisha Li, and Ding'an, plants or stone	dendrobine-type alkaloids, flavonoids, terpenoids, polysaccharides, and phenolic acids	Clearing heat and detoxifying	
<i>Acampe rigida</i> (Buch. -Ham. ex Sm.) P. F. Hunt 多花脆兰 (duō huā cuì lán)	cities and counties, including Lingshui, Sanya City, Chengmai, Ledong, Lingao, and Qiongzong, epiphytes on plants	Flavonoids, terpenoids, phenolic acids, polysaccharides	Stimulating appetite and aiding digestion	
<i>Arundina graminifolia</i> (D. Don) Hochr. 竹叶兰 (zhú yè lán)	Central and southern mountainous areas, including Sanya, Lingshui, Baoting, Dongfang, Ledong, Baisha, and Qiongzong, terrestrial habitats	Flavonoids, alkaloids, terpenoids, phenolic acids, polysaccharides	Clearing heat and detoxifying	
<i>Dendrobium densiflorum</i> Lindl. 密花石斛 (mì huā shí hú)	Central and southern mountainous areas, including Sanya, Lingshui, Baoting, Dongfang, Ledong and Qiongzong, epiphytes on plants	Dendrobine-type alkaloids, flavonoids, terpenoids, polysaccharides, phenolic acids	Snake bites and sores, bone fracture	
<i>Dendrobium lindleyi</i> Steud. 聚石斛 (jù shí hú)	Cities and counties, including Sanya, Lingshui, Baisha, Qiongzong, and Chengmai, epiphytes on plants	Dendrobine-type alkaloids, flavonoids, terpenoids, polysaccharides, phenolic acids	Icteric hepatitis, gastrointestinal disease	
<i>Phalaenopsis deliciosum</i> Rchb. f. 大尖囊兰 (dà jiān náng lán)	Cities and counties, including Ledong, Changjiang, and Sanya, epiphytes on plants	Flavonoids, terpenoids, phenolic acids	Arthritis	
<i>Habenaria rhodocheila</i> Hance 橙黄玉凤花 (chéng huáng yù fēng huā)	Cities and counties, including Ledong, Changjiang, Wuzhishan, and Baisha, terrestrial habitats	Alkaloids, flavonoids, phenolic acids, polysaccharides	Stomach ache, scald	
<i>Bulbophyllum ambrosia</i> (Hance) Schltr. 芳香石豆兰 (fāng xiāng shí dòu lán)	Wuzhi mountain region, Ledong, plants or stone	Flavonoids, terpenoids, phenolic acids, volatile oils, polysaccharides	Clearing heat and detoxifying	
<i>Dendrobium loddigesii</i> Rolfe 美花石斛 (měi huā shí hú)	Baisha, epiphytes on plants	Alkaloids, bibenzyls	Nourishing and tonifying	
<i>Liparis viridiflora</i> Lindl. 长茎羊耳蒜 (cháng jīng yáng ěr suàn)	Cities and counties, including Sanya, Lingshui, Baoting, Ledong, plants or stone	Flavonoids, phenanthrenes, triterpenoid saponins	Clearing heat and detoxifying	
<i>Pholidota cantonensis</i> Rolfe 细叶石仙桃 (xì yè shí xiān táo)	Cities and counties, including Wuzhishan, Sanya, Lingshui, Baoting, Wanning, plants or stone	Stilbenoids, phenols, diterpenoids, triterpenoids	Clearing heat and detoxifying	[26]

(to be continued)

Table 1. (continued)

Scientific name/ Chinese name/Pinyin	Main distribution regions	Medical main chemical components	Pharmacological activity	Ref.
<i>Goodyera procera</i> Rchb. f. 高斑叶兰 (gāo bān yè lán) <i>Appendicula cornuta</i> Bl. 牛齿兰 (niú chǐ lán)	Jiangfengling Mountain region, Ledong, terrestrial habitats Lingshui, and Baoting, plants or stone	Phenolic acids, coumarins, fatty acid glycerides Flavonoids, terpenoids, phenolic acids, polysaccharides	Pulmonary tuberculosis, and hepatitis Setting bones, anti-inflammatory and relieving cough Stop bleeding	
<i>Cymbidium bicolor</i> (Roxb.) Sw. 硬叶吊兰 (yìng yè diào lán)	Cities and counties, including Sanya, Lingshui, Changjiang, Baisha, epiphytes on plants	Flavonoids, terpenoids, phenolic acids, polysaccharides, alkaloids, volatile Oils	Nourishing and tonifying	
<i>Dendrobium chrysanthum</i> Lindl. 束花石斛 (shù huā shí hú)	Wuzhi Mountain, Jianfengling Mountain, and Diaoluo Mountain areas, epiphytes on plants	Dendrobine-type alkaloids, flavonoids, terpenoids, polysaccharides, phenolic acids	Curing cough	
<i>Dendrobium sinense</i> Tang & F. T. Wang 华石斛 (huá shí hú)	Cities and counties, including Baoting, Ledong, Baisha, Qiongzong, epiphytes on plants	Dendrobine-type alkaloids, flavonoids, terpenoids, polysaccharides, phenolic acids	Clearing heat and detoxifying	
<i>Liparis cespitosa</i> (Thouars) Lindl. 丛生羊耳蒜 (cóng shēng yáng ěr suàn)	Cities and counties, including Baoting, Lingshui, Qiongzong, plants or stone	Flavonoids, terpenoids, phenolic acids, polysaccharides	Scald	
<i>Cymbidium eburneum</i> Lindl. 独占春 (dú zhàn chūn)	Cities and counties, including Yazhou(Sanya), and Changjiang, terrestrial habitats	Flavonoids, phenolic acids, polysaccharides, alkaloids	Traumatic injury	
<i>Renanthera coccinea</i> Lour. 火焰兰 (huǒ yàn lán)	Cities and counties, including Sanya, Lingshui, Baoting, Ledong, Danzhou, Qiongzong, plants or stone	Flavonoids, phenolic acids, polysaccharide	Nourishing yin and cooling blood, relieving cough, and moistening the lung Reducing swelling and relieving pain	
<i>Spiranthes sinensis</i> (Pers.) Ames 盘龙参 (pán lóng shēn)	Li ethnic mountainous areas, Hainan, terrestrial habitats	Flavonoids, polysaccharides, alkaloids	Nourishing and tonifying	
<i>Cleisostoma striatum</i> (Rchb. f.) Garay 短序隔距兰 (duǎn xù gé jù lán)	Cities and counties, including Baoting, and Qiongzong, epiphytes on plants	Phenolic acids, Lignan glycosides, Nucleosides	Curing fracture	
<i>Flickingeria angustifolia</i> (Blume) Hawkes 狭叶金石斛 (xiá yè jīn shí hú)	Wuzhi Mountain region, epiphytes on plants	Phenanthrenes, bibenzyls, fluorenes, phenolic acids	Nourishing and tonifying	
<i>Robiquetia spathulata</i> (Blume) J. J. Sm. 大叶寄树兰 (dà yè jì shù lán)	Cities and counties, including Sanya, Lingshui, Baoting, Qionghai, Qiongzong, and Lingao, epiphytes on plants	Triterpenoids, steroids, alkaloids	Nourishing and tonifying	
<i>Rhynchostylis gigantea</i> (Lindl.) Ridl. 海南钻喙兰 (hǎi nán zuàn huì lán)	Cities and counties, including Lingshui, Sanya, Changjiang, Baisha, and Chengmai, epiphytes on plants	Triterpenoids, phenanthrenes	Clearing heat and draining dampness	
<i>Ania penangiana</i> (Hook. f.) Summerh. 绿花安兰 (lǜ huā ān lán)	Cities and counties, including Yazhou(Sanya), and Changjiang, terrestrial habitats	Phenanthrenes, bibenzyls	Reducing swelling	
<i>Cymbidium dayanum</i> Rchb. f. 冬凤兰 (dōng fēng lán)	Jiangfengling Mountain region, Ledong, plants or stone	Phenanthrenes, bibenzyls, flavonoids	Lung disease and hepatopathy	
<i>Schoenorchis juncifolia</i> (Lindl.) J. J. Sm. 匙唇兰 (chí chún lán)	Cities and counties, including Wanning, Lingshui, Sanya, Ding'an, and Baoting, epiphytes on plants	Phenanthrenes, bibenzyls	Curing cold	
<i>Thelasis pygmaea</i> (Griff.) Blume 矮柱兰 (ǎi zhù lán)	Distributed throughout Hainan, epiphytes on plants	Phenanthrenes, bibenzyls	Epilepsy, uterine inflammation	
<i>Tainia ruybarrettoi</i> (S.Y.Huet Barretto) Z.H.Tsi 南方带唇兰 (nán fāng dài chún lán)	Li ethnic mountainous areas, Hainan, epiphytes on plants	Phenanthrenes, bibenzyls, triterpenoids	Snake bites, intoxication, and Cardio pathology	[27]
<i>Acronychia pedunculata</i> (Linn.) Miq. 降真香 (jiàng zhēn xiāng)	Mountainous areas around Sanya, Lingshui, Baoting, forests	Alkaloids, flavonoids, coumarins, volatile oils	Clearing heat and detoxifying	[28]
<i>Wikstroemia indica</i> (L.) C. A. Mey. 了哥王 (le gē wáng)	Widely distributed in Hainan, forests, and on roads	Flavonoids, coumarins, lignans, diterpenoids	Curing cold, snake bites, hepatitis, and mumps	
<i>Clerodendrum cyrtophyllum</i> Turcz. 大青 (dà qīng)	Widely distributed in Hainan, shady and moist areas	Phenylethanoid glycosides, flavonoids, triterpenoids, iridoid glycosides	Clearing heat and detoxifying	
<i>Andrographis paniculata</i> (Burm. f.) Wall. ex Nees in Wallich 穿心莲 (chuān xīn lián)	Western and southwestern mountain areas, Hainan, shady areas	Diterpene lactones, flavonoids	Stomach ache	
<i>Aphanamixis grandifolia</i> Bl. 大叶山楝 (dà yè shān liàn)	Cities and counties, including Danzhou, Dongfang, Ledong, Sanya, and Lingshui, wet areas	Limonoids, triterpenoids	Constipation, extracting toxins and promoting tissue regeneration	
<i>Aporosa chinensis</i> (Roxb.) Müll. Arg. 银柴 (yín chái)	Cities and counties, including Wenchang, Qionghai, Wanning, Danzhou, sparse forests, bushwood	Tannins, flavonoids, triterpenoids	Rheumatoid arthritis, heating toxic and bleeding	[28]
<i>Asclepias curassavica</i> L. 马利筋 (mǎ lì jīn)	Cities and counties, including Haikou, Wenchang, Sanya, Danzhou, abundant sunlight areas	Cardenolides, pregnanes, flavonoids	Curing scald	
<i>Cayratia japonica</i> (Merr.) G. Parmar & L. M. Lu 节毛乌藟莓 (jié máo wū lěi méi)	Cities and counties, including Qiongzong, Baoting, Ledong, Dongfang, sparse forests, thickets	Flavonoids, triterpenoid saponins, polysaccharides		

(to be continued)

Table 1. (continued)

Scientific name/ Chinese name/Pinyin	Main distribution regions	Medical main chemical components	Pharmacological activity	Ref.
<i>Crotalaria hainanensis</i> L. 海南野百合 (hǎi nán yě bǎi hé)	Wuzhi Mountain and Diaoluo Mountain areas, forests, roads	Pyrrrolizidine alkaloids	Curing blister	
<i>Cyperus diffusus</i> L. 绿穗莎草 (lǜ suì shā cǎo)	Cities and counties, including Haikou, Wenchang, Qionghai, forests, roadsides, stream	Volatile oils, flavonoids, triterpenoids	Rheumatism	
<i>Markhamia stipulata</i> (Wall.) Seem. 猫尾木 (māo wěi mù)	Baoting county, villages, low-lying wastelands	Iridoids, phenylethanoid glycosides, flavonoids	Rheumatism	
<i>Justicia ventricosa</i> Wall. Ex Hook. F. 黑叶接骨草 (hēi yè jiē gǔ cǎo)	Southeastern mountainous areas, Hainan, thickets	Alkaloids, flavonoids, triterpenoids	Traumatic swelling and pain	
<i>Helicia hainanensis</i> Hayata 海南山龙眼 (hǎi nán shān lóng yǎn)	Cities and counties, including Dongfang, Baisha, Wuzhishan, Baoting, and Danzhou, shady and moist areas	Tannins, flavonoids	Stomach ache, hematochezia, constipation	
<i>Lygodium circinnatum</i> (Burm. f.) Sw. 海南海金沙 (hǎi nán hǎi jīn shā)	Yazhou (Sanya), moist areas	Flavonoids, triterpenoids	Liver diseases	
<i>Neocinnamomum lecomtei</i> H. Liu 海南新樟 (hǎi nán xīn zhāng)	Jianfengling Mountain areas (Ledong), thickets, dense forests	Volatile oils, alkaloids, flavonoids	Traumatic injury, chills, and fever	
<i>Randia hainanensis</i> Merr. 海南山黄皮 (hǎi nán shān huáng pí)	Bawangling Mountain region, Changjiang, limestone mountain	Triterpenoids, iridoids, alkaloids	Snake bites, arthroplogosis	
<i>Scleria elata</i> (L.) Fasset 高秆珍珠茅 (gāo gǎn zhēn zhū máo)	Li ethnic mountainous areas, Hainan, forests, roads	Tannins, flavonoids, phenolic acids	Rheumatism	
<i>Ophiopogon bodinieri</i> H. Lévl. 高节沿阶草 (gāo jié yán jiē cǎo)	Distributed throughout Hainan, shady and moist habitats	Steroidal saponins, homoisoflavonoids, polysaccharides	Rheumatism	
<i>Pogonatherum crinitum</i> (Thunb.) Kunth 金丝草 (jīn sī cǎo)	Distributed throughout Hainan, wet places, forests, roads	Flavonoids, triterpenoids, phenolic acids	Rheumatism	
<i>Kyllinga brevifolia</i> Kunth 水蜈蚣 (shuǐ wú gōng)	Distributed throughout Hainan, villages, and roads	Volatile oils, flavonoids, triterpenoids	Rheumatis	
<i>Gardenia stenophylla</i> Merr. 狭叶栀子 (xiá yè zhī zi)	Distributed throughout Hainan, shady and moist habitats, stream	Iridoids, triterpenoids, flavonoids	Rheumatis	
<i>Adiantum flabellulatum</i> L. 扇叶铁线蕨 (shàn yè tiě xiàn jué)	Widely distributed in Hainan, thickets	Triterpenoids, flavonoids, phenolic acids	Nail loss	[29]
<i>Adiantum caudatum</i> L. 鞭叶铁线蕨 (biān yè tiě xiàn jué)	Cities and counties, including Dongfang, Sanya, Baoting, rocks, valley	Flavonoids, triterpenoids	Nail loss	
<i>Blechnum orientale</i> L. 乌毛蕨 (wū máo jué)	Distributed throughout Hainan, shady and moist habitats	Tannins, flavonoids, triterpenoids	Carbuncles, malignant sores, and pustules	
<i>Palhinhaea cernua</i> (L.) Franco et Vasc. 铺地蜈蚣 (pū dì wú gōng)	Wuzhi Mountain region, Hainan, grasslands, sparse forests	Alkaloids, triterpenoids	Kidney stones, rheumatic joint pain, and sciatica	
<i>Helminthostachys zeylanica</i> (L.) Hook 七指蕨 (qī zhǐ jué)	Wuzhi Mountain region, Hainan, wet areas, forested areas	Flavonoids, triterpenoids, steroids	Lung - heat cough, asthma, whooping cough, and syphilis	
<i>Lygodium japonicum</i> (Thunb.) Sw. 海金沙 (hǎi jīn shā)	southern Hainan, thickets, forest edges, roads	Flavonoids, triterpenoids, phenolic acids	Hepatitis, gallstones, high-fever colds, and fractures	
<i>Cinnamomum porrectum</i> (Roxb.) Kosterm. 黄樟 (huáng zhāng)	Distributed throughout Hainan, forests, and valleys	Volatile oils, alkaloids, flavonoids	Postpartum wind, liver cirrhosis, nephritis edema, cold - induced fevers	
<i>Litsea cubeba</i> (Lour.) Pers. 山苍子 (shān cāng zi)	Distributed throughout Hainan, sunny slopes, forest edges, thickets	Volatile oils, alkaloids, flavonoids	Liver ascites, nephritis edema, and various types of stone diseases	
<i>Litsea glutinosa</i> (Lour.) C. B. Rob. 潺槁木姜 (chán gǎo mù jiāng)	Distributed throughout Hainan, forest margins, streams, sparse forests	Alkaloids, flavonoids, triterpenoids	Bruises, uterine inflammation, mumps, and mastitis	
<i>Cyclea barbata</i> (Wall) Miers. 毛叶轮环藤 (máo yè lún huán téng)	Distributed throughout Hainan, shrubs, trees	Alkaloids, triterpenoids	Colds, pharyngitis, coughs, and bruises	
<i>Stephania succifera</i> H. S. Lo et Y. Tsoong. 小叶地不容 (xiǎo yè dì bù róng)	Wuzhi mountain region, Hainan, valleys, streams, forests	Alkaloids, triterpenoids	Gastritis, duodenal ulcers, and lung-heat coughs	
<i>Piper nigrum</i> L. 胡椒 (hú jiāo)	Widely cultivated throughout Hainan, warm, humid, shaded environments	Alkaloids, volatile oils, amides	Warm the stomach, promote digestion, and relieve indigestion	
<i>Piper sarmentosum</i> Roxb. 假蒟 (jiǎ jǔ)	Distributed throughout Hainan, wet places, forests, roads	Volatile oils, amides, flavonoids	Cold pain in the stomach and abdomen, coughs, and indigestion	[29]
<i>Sarcandra hainanensis</i> (Pei.) Swamy et Bailey. 海南草珊瑚 (hǎi nán cǎo shān hú)	Distributed throughout Hainan, shady and moist areas	Flavonoids, coumarins, triterpenoids	Fractures, rheumatic arthritis, and pneumonia	
<i>Portulaca oleracea</i> L. 马齿苋 (mǎ chǐ xiàn)	Eastern and southern cities and counties, including Wenchang, Wanning, Lingshui, vegetable gardens, farmlands, roadsides	Alkaloids, flavonoids, organic acids, polysaccharides	Hematuria, mastitis, hemorrhoid bleeding, and enteritis	
<i>Polygonum chinense</i> L. 火炭母 (huǒ tàn mù)	Distributed throughout Hainan, streams, wetlands, mountain slopes	Flavonoids, tannins, anthraquinones	Swollen sores, eczema, enteritis, and snake bites	

(to be continued)

Table 1. (continued)

Scientific name/ Chinese name/Pinyin	Main distribution regions	Medical main chemical components	Pharmacological activity	Ref.
<i>Achyranthes aspera</i> L. 土牛膝 (tǔ niú xī)	Distributed throughout Hainan, mountain slopes, roadsides, villages	Triterpenoid saponins, ecdysterones, alkaloids	Malaria, kidney stones, and dog bites	
<i>Aquilaria sinensis</i> (Lour.) Cifg. 白木香 (bái mù xiāng)	Distributed throughout Hainan, mountain rainforests, semi-evergreen monsoon forests	Volatile oils, chromones, triterpenoids, aromatic compounds	Chest and abdominal pain, poliomyelitis, and rheumatism	
<i>Passiflora cochinchinensis</i> Spreng. 蛇王藤 (shé wáng téng)	Distributed throughout Hainan, mountain valleys	Flavonoids, cyanogenic glycosides, alkaloids	Snake bites and sores	
<i>Carica papaya</i> L. 番木瓜 (fān mù guā)	Li ethnic areas, Hainan, courtyards, and orchards	Alkaloids, terpenoids, flavonoids, proteases, glycosides	Indigestion, insufficient milk in women, excessive leucorrhea	
<i>Hylocereus undatus</i> (Haw.) Britt. et Rose 量天尺 (liáng tiān chǐ)	Distributed throughout Hainan, various habitats	Flavonoids, alkaloids, terpenoids, polysaccharides, sterols	Coughs, bronchitis, mumps, prolapse of the anus, and hypertension	
<i>Rhodomyrtus tomentosa</i> (Ait.) Hassk. 桃金娘 (táo jīn niáng)	Distributed throughout Hainan, mountainous regions	Flavonoids, triterpenoids, tannins, phenols	Anemia - related dizziness and weakness after illness	
<i>Syzygium jambos</i> (L.) Alston 蒲桃 (pú táo)	Distributed throughout Hainan, sparse forests	The bark contains tannins and flavonoids; the leaves contain volatile oils	Dysentery, knife - wound bleeding, and dermatitis	
<i>Melastoma candidum</i> D. Don. 野牡丹 (yě mǔ dān)	Mountainous areas and hills throughout Hainan, bushwood, sparse forests	Flavonoids, tannins, sterols	Bruises, burns, and gastric bleeding	
<i>Melastoma sanguineum</i> Sims. 毛稔 (máo rěn)	Cities and counties, including Sanya, Lingshui, Baoting, Ledong, mountainous region, sparse forests	Flavonoid glycosides, phenols, tannins	Gastrointestinal flatulence, menstrual pain, and traumatic bleeding	
<i>Cratogeomys cochinchinense</i> (Spach.) Blume 黄牛木 (huáng niú mù)	Distributed throughout Hainan, mountainous region, sparse forests	The bark contains flavonoids and triterpenoids; the leaves contain volatile oils, tannins	Cough, trachitis, dysentery, and skin allergy	
<i>Garcinia oligantha</i> Merr. 单花山竹子 (dān huā shān zhú zǐ)	Cities and counties, including Sanya, Lingshui, Baoting, Ledong, Dongfang, sparse forests, bushwood	The fruits contain flavonoids and organic acids; the bark contains tannins and triterpenoid	Empyrosis, fracture, and metrorrhagia	
<i>Microcos paniculata</i> L. 布渣叶 (bù zhā yè)	Distributed throughout Hainan, thickets, roads	Flavonoids, organic acids, volatile oils	Curing fever	
<i>Sterculia lanceolata</i> Cav. 假苹婆 (jiǎ píng pó)	Distributed throughout Hainan, wet areas, forested areas	The roots contain triterpenoids; the leaves contain flavonoids and sterol	Prostatitis, urocystitis	
<i>Gossampinus malabarica</i> (DC.) Merr. 木棉 (mù mián)	Distributed throughout Hainan, wet places, forests, roads	The flowers contain flavonoids and organic acids; the roots contain triterpenoid saponins	Fracture, cough	
<i>Hibiscus tiliaceus</i> L. 黄木槿 (huáng mù jǐn)	Coastal areas, including Wenchang, Wanning, and Lingshui, saline-alkali shrublands, coastal sandy beaches	The flowers contain flavonoids and polysaccharides; the leaves contain sterols	Sorethroat	
<i>Urena lobata</i> L. 肖梵天花 (xiāo fán tiān huā)	Distributed throughout Hainan, mountain slopes, roads	Triterpenoid saponins, flavonoids, volatile oils	Snake bites, hepatitis, and mastitis	
<i>Breynia fruticosa</i> (L.) Hook. f. 黑面神 (hēi miàn shén)	Distributed throughout Hainan, mountainous regions	Alkaloids, triterpenoids, and flavonoids	Lithiasis, gunshot wound	
<i>Euphorbia hirta</i> L. 飞扬草 (fēi yáng cǎo)	Distributed throughout Hainan, sparse forests, roads	Flavonoids, triterpenoids, tannins, phenolic acids, and sterols	Dyspepsia, dermatitis	
<i>Flueggea virosa</i> (Roxb. ex Will.) Baill. 白饭树 (bái fàn shù)	Cities and counties, including Danzhou, Qionghai, and Wanning, mountainous regions	Flavonoids, triterpenoids, and alkaloids	Rheumatism, neurasthenia, and hypertension	
<i>Jatropha curcas</i> L. 麻疯树 (má fēng shù)	Cultivated or grows wild throughout Hainan, mountainous regions, roads	Alkaloids, tannins, flavonoids and triterpenoids	Eczema, ulcer	[29]
<i>Mallotus apelta</i> Lour. 白背叶 (bái bèi yè)	Distributed throughout Hainan, thickets, roads	The seeds contain phorbol esters, triterpenoids, and fatty acids	Cirrhotic ascites, metroptosis, and enteritis	
<i>Phyllanthus urinaria</i> L. 叶下珠 (yè xià zhū)	Distributed throughout Hainan, mountainous regions	The roots contain triterpenoids and flavonoids; the leaves contain volatile oils and tannins	Hepatitis, enteritis, and odynuria	[29]
<i>Ricinus communis</i> L. 蓖麻 (bì má)	Widely cultivated throughout Hainan, wetlands, mountain slopes, grasslands	Lignans, flavonoids, and alkaloids	Gunshot wound, stomach distension	
<i>Triadica cochinchinensis</i> Loureiro 山乌桕 (shān wū jiù)	Cities and counties, including Qiongzong, Wuzhishan, and Baoting, mountainous regions	The seeds contain fatty oils, and the bark contains tannins and triterpenoids	Snake bites, dermatitis	
<i>Duchesnea indica</i> (Andr.) Focke. 蛇莓 (shé méi)	Distributed throughout Hainan, shady and moist habitats, stream	Flavonoids, triterpenoids, and organic acids	Furuncle and toxic swelling, eczema, and mumps	
<i>Crotalaria mucronata</i> Desv. 猪屎豆 (zhū shǐ dòu)	Distributed throughout Hainan, wastelands, roads	Alkaloids, flavonoids, and triterpenoids	Deficiency of the kidney, fever	
<i>Dalbergia odorifera</i> T. Chen 降香檀 (jiàng xiāng tán)	Cities and counties, including Sanya, Ledong, Dongfang, and Changjiang, sparse forests, wastelands	volatile oil, including baicalein, β -bisabolene, and trans- β -farnesene	Liver cirrhosis, hysteresis, and pneumonia	
<i>Desmodium triquetrum</i> (L.) DC. 葫芦茶 (hú lu chá)	Distributed throughout Hainan, wastelands, roads	Flavonoids, triterpenoids, and tannins	Fever, swollen sore throat	

(to be continued)

Table 1. (continued)

Scientific name/ Chinese name/Pinyin	Main distribution regions	Medical main chemical components	Pharmacological activity	Ref.
<i>Erythrina variegata</i> L. 刺桐 (cì tóng)	Cultivated or growing wild throughout Hainan, wet areas, sparse forests, courtyards	The bark contains alkaloids, flavonoids, and triterpenoid saponins; the leaves contain volatile oils	Cold, cough, and rheumatic bone pain	
<i>Mimosa pudica</i> L. 含羞草 (hán xiū cǎo)	Distributed throughout Hainan, shady and moist areas	Flavonoids, alkaloids, and triterpenoid saponins	Metroptosis, neurasthenia	
<i>Liquidambar formosana</i> Hance 枫香树 (fēng xiāng shù)	Central mountainous areas, including Qiongzong, Wuzhishan, and Baoting, mountainous regions	The resin contains volatile oil and flavonoids, the leaves contain tannins and phenols	Arthralgia, edema	
<i>Broussonetia papyrifera</i> (L.) L.Her. ex Vent. 构树 (gòu shù)	Distributed throughout Hainan, grasslands, sparse forests	The fruits contain saponins, flavonoids, the leaves contain proteins and amino acids	Edema, dermatitis, bleeding, and tinea corporis	
<i>Ficus hirta</i> Vahl. 粗叶榕 (cū yè róng)	Central and Southern mountainous areas, forested areas, bushwood	Flavonoids, triterpenoids, polysaccharides	Hypogalactosia, postpartum blood stasis, and deficiency of the kidney	
<i>Ficus pumila</i> L. 薜荔 (bì lì)	Distributed throughout Hainan, villages, rocks	Polysaccharides, flavonoids, steroid compounds, organic acids	Strangury with turbid discharge, breast milk stoppage	
<i>Zanthoxylum avicennae</i> (Lam.) DC. 土花椒 (tǔ huā jiāo)	Cities and counties, including Danzhou, Qionghai, and Wanning, forested areas, shrubs	Volatile oil, alkaloids, flavonoids	Gall-stone, kidney stone	
<i>Lannea grandis</i> (Dennst.) Engl. 厚皮树 (hòu pí shù)	Western Cities and counties, including Dongfang, Changjiang and Ledong, mountain slopes, shrubs, sparse forests	Tannins, flavonoids, and triterpenoid, volatile oils and organic acids	Gastritis, enteritis	
<i>Alangium salviifolium</i> (L. f.) Wanger. 土坛树 (tǔ tán shù)	Cities and counties, including Sanya, Lingshui and Baoting, mountain forests, valleys	The bark contains alkaloids, tannins, triterpenoids; the fruits contain oils, flavonoid	Fracture	
<i>Ardisia densilepidotula</i> Merr. 密鳞紫金牛 (mì lín zǐ jīn niú)	Central Cities and counties, including Wuzhishan, Qiongzong, and Baoting, dense forests, valleys	Bergenin, flavonoids, triterpenoid	Dysentery, diarrhea, and anemia	
<i>Maesa perularius</i> (Lour.) Merr. 鲫鱼胆 (jì yú dǎn)	Mountainous areas throughout Hainan, dense forests, valleys	Flavonoids, triterpenoids, organic acids	Knife wound, bleeding, rheumatism	
<i>Buddleja asiatica</i> Lour. 驳骨丹 (bó gǔ dān)	Mountainous areas throughout Hainan, sparse forests, roads	Flavonoids, triterpenoid saponins, alkaloids	Nephritic edema, psoriasis	
<i>Wrightia pubescens</i> R. Br. 倒吊笔 (dào diào bǐ)	Mountainous areas throughout Hainan, sparse forests, roads	The bark contains alkaloids, triterpenoids, and flavonoid; the leaves contain volatile oils, tannins	Rheumatism, fever	
<i>Lasianthus chinensis</i> Benth. 鸡屎树 (jī shǐ shù)	Cities and counties, including Qiongzong, Wuzhishan, and Baoting, mountain forests, shrubs	Alkaloids, iridoids, flavonoids, triterpenoids	Fracture, knife-wound bleeding	
<i>Nauclea officinalis</i> (Pierre. ex Pitard.) Merr. et Chun. 乌檀 (wū tán)	Southern Cities and counties, including Sanya, Lingshui, and Ledong, dense forests, valleys	Alkaloids, flavonoids, triterpenoid	Fever, sore throat, cholehepatitis, acute bronchitis	
<i>Psychotria rubra</i> (Lour.) Poir. 九节 (jiǔ jié)	Southern mountainous areas, thickets,	Triterpenoid saponins, flavonoids, sterols	Snake bites, bruises and swelling	
<i>Elephantopus tomentosus</i> L. 白花地胆草 (bái huā dì dǎn cǎo)	Distributed throughout Hainan, thickets, roads	Sesquiterpene lactones, flavonoids, alkaloids	Cold, snake bites, and hepatitis	
<i>Xanthium strumarium</i> L. 苍耳 (cāng ěr)	Distributed throughout Hainan, wetlands, mountain slopes, grasslands, fields	Xanthiin, alkaloids, volatile oils	Hypertension, metrorrhagia, and wind-cold headache	
<i>Physalis peruviana</i> L. 小酸浆果 (xiǎo suān jiāng guǒ)	Central mountainous areas, including Qiongzong, and Wuzhishan, wet areas	Steroidal saponins, organic acids, flavonoids	Sore skin, cholecystitis, and cough	
<i>Solanum coagulans</i> Forsk. 野茄 (yě qié)	Southern mountainous areas, thickets, sparse forests	Steroidal alkaloids, flavonoids, triterpenoids	Rheumatism, hepatitis B	
<i>Gendarussa ventricosa</i> (Wall.) Nees. 大驳骨 (dà bó gǔ)	Cultivated or growing wild throughout Hainan, sparse forests	Flavonoids, triterpenoid saponins, phenols	Arthroplogosis, fracture	[29]
<i>Verbena officinalis</i> L. 马鞭草 (mǎ biān cǎo)	Distributed throughout Hainan, wet areas, grasslands, roads	Verbenalin, flavonoids, volatile oils	Malaria, edema, heat strangury, and hepatitis	
<i>Anisomeles indica</i> (L.) Rothm. 广防风 (guǎng fáng fēng)	Central and southern mountainous areas, valleys, wat areas	Triterpenoids, flavonoids, alkaloids	Dermatitis, rheumatism	
<i>Hyptis decurrens</i> (Blanco) Epling. 吊球草 (diào qiú cǎo)	Southern coastal areas, including Sanya, and Lingshui, wastelands, roads	Volatile oils, flavonoids	Abscesses and toxic swellings, hepatitis	
<i>Leucas aspera</i> (Willd.) Link. 蜂巢草 (fēng cháo cǎo)	Eastern coastal cities and counties, thickets, saline-alkali land	Triterpenoids, sterols, organic acids	Cold, cough, and toothache	
<i>Alpinia katsumadai</i> Hayata 草豆蔻 (cǎo dòu kòu)	Central mountainous areas, wet areas, including Qiongzong, Baoting, and Wuzhishan, forested areas	Volatile oils, flavonoids	Stomach cold, emesis	
<i>Costus speciosus</i> (Koen.) Smith. 闭鞘姜 (bì qiào jiāng)	Distributed throughout Hainan, sparse forests, thickets	Steroidal saponins, flavonoids, organic acids	Fracture, urinary tract infection, and pyogenic infections	
<i>Kaempferia galanga</i> L. 沙姜 (shā jiāng)	Cultivated throughout Hainan, especially abundant in places including Danzhou and Chengmai, mountainous regions	Volatile oils, coumarins	Dyspepsia, coldness in stomach	

(to be continued)

Table 1. (continued)

Scientific name/ Chinese name/Pinyin	Main distribution regions	Medical main chemical components	Pharmacological activity	Ref.
<i>Asparagus cochinchinensis</i> (Lour.) Merr. 天门冬 (tiān mén dōng)	Distributed throughout Hainan, thickets, sparse forests	Steroidal saponins, polysaccharides	Lung dryness, cough, constipation	
<i>Smilax glabra</i> Roxb. 土茯苓 (tǔ fú líng)	Central and southern mountainous areas, sparse forests, shady and moist areas	Steroidal saponins, flavonoids, polysaccharides	Fracture, pyogenic infections	
<i>Acorus gramineus</i> Soland. 石菖蒲 (shí chāng pú)	Distributed throughout Hainan, shady and moist areas	Volatile oils, flavonoids	Nephritis, nephrolithiasis, and urinary tract infection	
<i>Crinum asiaticum</i> L. var. <i>sinicum</i> (Roxb. ex Herb.) Baker 文殊兰 (wén shū lán)	Cultivated throughout Hainan, courtyard, coastal sandy areas, moist grasslands	Alkaloids, steroidal saponins	Fracture, snake bites, and mastitis	
<i>Stemona tuberosa</i> Lour. 对叶百部 (duì yè bǎi bù)	Central mountainous areas, including Qiongzong and Wuzhishan, wet areas, valleys	Alkaloids, flavonoids	Cough, eczema, pediculosis capillitii, and scabies	
<i>Dracaena angustifolia</i> Roxb. 龙血树 (lóng xuè shù)	Western cities and counties, including Sanya, Dongfang, and Ledong, shady and moist areas	Loureirin (flavonoid), triterpenoid	Hemoptysis, constipation	
<i>Cyperus rotundus</i> L. 香附子 (xiāng fù zǐ)	Distributed throughout Hainan, grasslands, fields, roads	Volatile oils, flavonoids	Cold, nephritic edema, and urinary tract infection	
<i>Hypericum japonicum</i> Thunb. 田基黄 (tiān jī huáng)	Distributed throughout Hainan, fields, wet grasslands	Flavonoids, coumarins, organic acids	Clearing heat and detoxifying	[30]
<i>Elephantopus scaber</i> L. 地胆头 (dì dǎn tóu)	Distributed throughout Hainan, coastal sandy areas, roadsides	Sesquiterpene lactones, flavonoids, alkaloids	Clearing heat and detoxifying	
<i>Hypericum japonicum</i> Thunb. ex Murray 地耳草 (dì ěr cǎo)	Distributed throughout Hainan, fields, wet grasslands, fields	Flavonoids, phenols, organic acids	Clearing heat and detoxifying	
<i>Abrus cantoniensis</i> Hance 鸡骨草 (jī gǔ cǎo)	Southern cities and counties, including Sanya and Lingshui, thickets, sparse forests	Flavonoids, triterpenoids, sterols	Clearing heat and detoxifying	
<i>Bryophyllum pinnatum</i> (L. f.) Oken 落地生根 (luò dì shēng gēn)	Cultivated throughout Hainan, courtyard, coastal rock crevices, hillside shrublands	Flavonoids, triterpenoids, organic acids	Stop bleeding and promote tissue regeneration	
<i>Cardiospermum halicacabum</i> L. 倒地铃 (dǎo dì líng)	Southern mountainous areas, sparse forests, roads, villages	Triterpenoid saponins, flavonoids, alkaloids	Relieve swelling and pain	

distance from the Central Plains, Hainan failed to produce systematic medical books. Nevertheless, the knowledge passed down orally among the people has been preserved. However, the rapid social and economic development in Hainan poses a threat to the protection of Li ethnic medicines, leading to a decline in the use of medicinal plants and traditional knowledge. In the future, it is necessary to conduct a more comprehensive investigation of medicinal plant resources, study their chemical components and pharmacological effects, protect and inherit traditional knowledge, and explore sustainable utilization methods. Also, comparative studies with other ethnic groups' medicinal botany and research on the cultural connotations of medicinal plants are needed to further enrich the research in this field.

Hainan ethnic medicinal plants, primarily utilized by indigenous groups such as the Li and Miao, diverge markedly from TCM in their ethnobotanical foundations, therapeutic paradigms, and ecological adaptations. These distinctions arise from Hainan's unique tropical insular environment, contrasting with the mainland's heterogeneous monsoon climates, diverse ethnic amalgamations, and transitional floristic assemblages. Hainan's perennial tropical monsoon climate and oceanic influences foster plants adapted to damp-heat pathologies, emphasizing heat-clearing and dampness-resolving properties. This climatic divergence underscores Hainan's uniqueness in tropical resilience, complementing TCM by augmenting interventions for endemic humid ailments.

Ethnically, Hainan's isolated Li and Miao communities perpetuate oral, shamanistic traditions. This insular oral heritage imparts a distinctive shamanic vitality, enriching TCM with dynamic 'living prescriptions' for parasitic infections prevalent in island ecosystems. Floristically, Hainan's continental-island flora favors herbaceous and shrubby taxa in acidic, humid rainforests, diverging from TCM's root-rhizome dominance in subtropical transitions. These Southeast Asian-affiliated endemics form a 'maritime tropical pharmacopeia,' uniquely bolstering TCM's northern tonics with southern damp-resolving polysaccharides.

Existing issues of ethnobotany in China and Hainan

The current situation of ethnobotany in Hainan Island reflects a rich heritage of over 6,000 vascular plant species, with ethnic minorities like Li and Miao utilizing more than 500 species for medicine and diet, but facing threats from modernization, habitat loss, and cultural erosion. Progress includes biotechnological integrations like multi-omics for validating active compounds and conserving endangered species, supported by policies for sustainable development. From our perspective, the future lies in interdisciplinary collaborations to bridge traditional knowledge with precision ethnobotany, ensuring equitable benefit-sharing and climate-resilient practices to preserve this biodiversity hotspot.

The design and implication of policies

Current policies inadequately integrate traditional knowledge protection with biodiversity conservation, hindering the integration of culture-ecology. For instance, the cultural significance of Hainan Li's 'sacred forests' remains excluded from legal frameworks, leading to encroachment during development^[23]. The absence of legally binding benefit-sharing mechanisms further exacerbates inequities, as Li's medicinal knowledge is commercially exploited without fair community compensation. Furthermore, research funding and expertise are disproportionately concentrated in regions like Yunnan and Beijing, marginalizing critical areas such as Hainan^[41]. This spatial imbalance delays documentation of Li's 'swidden agriculture' and undermines evidence-based policymaking. Insufficient investment in academic infrastructure, evidenced by ethnobotany's exclusion from university core curricula, aggravates disciplinary marginalization and impedes talent cultivation^[42,43]. Finally, government efforts to communicate ethnobotany's socioecological value remain inadequate, perpetuating public perception of traditional practices as 'outdated customs'^[42,43]. Misconceptions about Li's

Table 2. Hainan plants function as both food and medicine.

Scientific name/ Chinese name/Pinyin	Locations	Usage/edible parts	Medical main chemical components	Ref.
<i>Mallotus furetiatus</i> (Miq.) Muell. Arg. 鹧鸪茶 (zhè gū chá)	Central and southern mountainous areas, including Wuzhishan, Qiongzhong, Baisha, Baoting, Ledong, Changjiang, Wanning, and Sanya, various areas	Herbal tea, leaves	Flavonoids, volatile oils, triterpenoids, phenolic acids	[37]
<i>Abelmoschus esculentus</i> (L.) Moench 咖啡黄葵 (kā fēi huáng kuí)	Southern, western, and eastern Hainan, with major production areas including Sanya, Ledong, Lingshui, Dongfang, Qionghai, and Chengmai, shady and moist areas	Stir fry, soup base, tender leaves, fruit	Polysaccharides, flavonoids, selenium, plant sterols, caffeine	[38]
<i>Acalypha australis</i> L. 铁苋菜 (tiě xiàn cài)	A widespread distribution across all cities and counties, wastelands, spruce forests	Stir fry, tender stem, tender leaves	Alkaloids, flavonoids, tannins, phenolic compounds	
<i>Acanthopanax trifoliatus</i> (L.) Merr. 白簕花 (bái lè huā)	Central and southern mountainous counties, including Wuzhishan, Qiongzhong, Baisha, Baoting, Ledong, and Changjiang, bushwood, mountain slopes	Stir fry, Soup base, tender leaves	Flavonoids, polysaccharides, triterpenoid saponins, phenylpropanoids	
<i>Amaranthus spinosus</i> L. 刺苋 (cì xiàn)	Both rural and suburban areas across all cities and counties, wastelands, courtyards	Stir fry, tender stem, tender leaves	Flavonoids, alkaloids, saponins, plant sterols	
<i>A. viridis</i> L. 野苋 (yě xiàn)	Across all cities and counties, with particularly high abundance in the farmlands and vegetable gardens of Wenchang, Chengmai, Lingao, and Dongfang, wastelands, grasslands, roads	Stir fry, tender stem, tender leaves	Flavonoids, vitamins (A, C), dietary fiber, beet pigments	
<i>Aporosa chinensis</i> (Roxb.) Müll. Arg. 银柴 (yín chái)	Throughout the forested areas, notably in the forest regions of Wuzhishan, Qiongzhong, Baisha, and Diaoluoshan, sparse forests, bushwood	Stir fry, tender leaves, root	Triterpenes, tannins, flavonoids	
<i>Blechnum orientale</i> L. 乌毛蕨 (wū máo jué)	Across mountainous regions, including the areas of Shuiman(Wuzhishan), Yinggeling, and Bawangling, spruce forests, hills	Stir fry, tender leaves	Phlorophenol derivatives, flavonoids, fern polysaccharides	
<i>Broussonetia papyrifera</i> (L.) L'Hér. ex Vent. 构树 (gòu shù)	Across all cities and counties, wastelands, grasslands, roads	Stir fry, tender leaves	Flavonoids, alkaloids, polysaccharides	
<i>Capparis hainanensis</i> Oliv. 山柑 (shān gān)	Coastal cities and counties, including Sanya, Lingshui, Wanning, Ledong, and Dongfang, wastelands, hills	Stir fry, tender leaves	Glucosinolates, flavonoids (such as rutin), mountain tangerine alkaloids	
<i>Capsella bursa-pastoris</i> (L.) Medic. 芥 (jiè)	Throughout Hainan, being especially common in northern and central areas such as Haikou, Ding'an, and Tunchang, fields	Stir fry, aerial parts	Choline, acetylcholine, potassium shepherd's purse acid, alkaloids, flavonoids	
<i>Capsicum frutescens</i> L. 米椒 (mǐ jiāo)	Throughout Hainan Island, with major cultivation areas including Sanya, Ledong, Lingshui, and Qionghai, courtyards and orchards	Seasoning, fruits	Capsaicin, vitamin C, volatile oil	
<i>Caryota mitis</i> Lour. 短穗鱼尾葵 (duǎn suì yú wěi kuí)	An ornamental across Hainan, being particularly ubiquitous in urban landscapes of Sanya and Haikou, with wild populations documented in botanical gardens including Xinglong and Danzhou, shady and moist areas	Stir fry, pith of the stem	Tannins, flavonoids, polysaccharides, saponins	
<i>Cassia tora</i> L. 决明 (jué míng)	Across Hainan Island, particularly in the western and northwestern counties and cities such as Danzhou, Changjiang, Dongfang, and Baisha, mountain slopes, wastelands	Stir fry, tender leaves, seed	Anthraquinones (emodin, emodin, etc.), naphthopyranone, fatty acids	
<i>Centella asiatica</i> (L.) Urban 积雪草 (jī xuě cǎo)	Throughout all cities and counties, including Haikou, Sanya, Qionghai, Wanning, Wenchang, and Danzhou, shady and moist areas	Soup base, aerial parts	Triterpenoid saponins (centella asiatica glycoside, hydroxycentella asiatica glycoside), flavonoids	
<i>Gynandropsis gynandra</i> (L.) Briq. 白花菜 (bái huā cài)	Western and southern counties and cities, including Sanya, Ledong, Dongfang, and Changjiang, roads, valleys	Stir fry, aerial parts	White cauliflower glycosides, alkaloids, volatile oils, flavonoids	
<i>Colocasia antiquorum</i> Schott 野芋 (yě yù)	Central mountainous counties, including Wuzhishan, Qiongzhong, Baisha, and Baoting, shady and moist areas	Stir fry, tender stem	Calcium oxalate needle crystals, saponins	
<i>C. tononimo</i> (L.) Schott 紫芋 (zǐ yù)	Rural areas throughout Hainan, with higher frequency in eastern villages such as Qionghai and Wanning, lacustrine wetlands	Stir fry, tender stem	Anthocyanins, saponins, polysaccharides	
<i>Chrysopogon aciculatus</i> (Retz.) Trin. 竹节草 (zhú jié cǎo)	Throughout Hainan Island, including Haikou, Ding'an, Chengmai, and Lingao, wastelands, grasslands	Stir fry, tender stem, tender leaves	Flavonoids, saponins, polysaccharides, alkaloids	
<i>Corchorus aestuans</i> L. 甜麻 (tián má)	Western and northwestern regions, including Danzhou, Changjiang, Dongfang, and Baisha, grasslands, mountain slopes, roads	Stir fry, tender stem, tender leaves	Flavonoids, tannins, polysaccharides, alkaloids	
<i>Costus speciosus</i> (J. Koenig) S. R. Dutta 闭鞘姜 (bì qiào jiāng)	Southern and eastern regions, including Sanya, Baoting, Lingshui, and Wanning, dense forests, roads	Stir fry, pickle, tender stem	Steroid saponins, diarylheptanes, volatile oils	
<i>Crateva religiosa</i> G. Forster 鱼木 (yú mù)	Coastal cities and counties, including Sanya, Ledong, and Dongfang, forest margins	Pickle sauerkraut, tender leaves	Alkaloids, flavonoids, triterpenoids, saponins	
<i>Daemonorops margaritae</i> (Hance) Becc. 黄藤 (huáng téng)	Central mountainous tropical rainforests, including Wuzhishan, Qiongzhong, Baisha, Diaoluoshan, and Bawangling, hills, bushwood	Stir fry, pith of the stem	Alkaloids (such as palmatine), flavonoids	
<i>DiCLIPTERA chinensis</i> (L.) Juss. 狗肝菜 (gǒu gān cài)	Throughout Hainan, including Haikou, Wenchang, Qionghai, and Wanning, sparse forests, roads	Stir fry, tender stem, tender leaves	Flavonoids, alkaloids, polysaccharides, amino acids	[38]

(to be continued)

Table 2. (continued)

Scientific name/ Chinese name/Pinyin	Locations	Usage/edible parts	Medical main chemical components	Ref.
<i>Dioscorea polystachya</i> Turcz. 薯蕷 (shǔ yù)	Across mountainous areas of all counties and cities, including Wuzhishan, Qiongzong, and Baisha, valleys, mountain slopes, roads	Soup base, earthnut	Diosgenin, mucin polysaccharide (Mannan), Allantoin	
<i>Eichhornia crassipes</i> (Mart.) Solms 凤眼莲 (fèng yǎn lián)	Static water bodies across all cities and counties, including Haikou, Ding'an, and Qionghai, shady and moist areas, river	Stir fry, flower, tender leaves	Flavonoids, terpenes, alkaloids, phenolic acids	
<i>Eleutherine americana</i> Merr. ex K. Heyne 红葱 (hóng cōng)	Specific areas, including Wanning and Qionghai, courtyards	Stir fry, bulb	Flavonoids (such as anthocyanins), phenolic acids, volatile oils, polysaccharides	
<i>Emilia sonchifolia</i> (L.) DC. 一点红 (yí diǎn hóng)	Throughout Hainan Island, including Haikou, Sanya, Danzhou, and Dongfang, valleys, mountain slopes	Stir fry, aerial parts	Alkaloids, flavonoids, phenols, volatile oils	
<i>Enydra fluctuans</i> Lour. 沼菊 (zhǎo jú)	Eastern coastal regions, including Wenchang, Qionghai, and Wanning, shady and moist areas	Stir fry, aerial parts	Flavonoids, triterpenoids, volatile oils	
<i>Ficus hirta</i> Vahl 粗叶榕 (cū yè róng)	Low to mid-altitude forests throughout Hainan, including Sanya, Baoting, Ledong, and Changjiang, forest margins	Soup base, root	Psoralen, bergamot lactone, polysaccharides, alkaloids	
<i>Floscopa scandens</i> Lour. 聚花草 (jù huā cǎo)	Central mountainous counties, including Wuzhishan, Qiongzong, Baisha, and Baoting, river valleys	Stir fry, tender leaves	Flavonoids, alkaloids, saponins	
<i>Trichosanthes scabra</i> Lour. 凤瓜 (fèng guā)	Throughout Hainan Island, including Haikou, Sanya, and Danzhou, mountain slopes, bushwood	Stir fry, tender leaves	Flavonoids, saponins, polysaccharides, vitamins	
<i>Gynura bicolor</i> (Roxb. ex Willd.) DC. 两色三七草 (liǎng sè sān qī cǎo)	Southern Hainan, including Sanya, Lingshui, Ledong, and Baoting, bushwood	Stir fry, tender stem, tender leaves	Alkaloids, flavonoids, polyacetylenes, volatile oils	
<i>Crassocephalum crepidioides</i> (Benth.) S. Moore 野苘蒿 (yě tóng hāo)	Extremely common throughout all counties and cities, including Haikou, Sanya, Danzhou, Qionghai, and Wanning, bushwood	Stir fry, tender stem, tender leaves	Flavonoids, alkaloids, volatile oils, vitamins	
<i>Gynura divaricata</i> (L.) DC. 白子菜 (bái zǐ cài)	Southern and central regions, including Sanya, Lingshui, Ledong, Baoting, and Wuzhishan, shady and moist areas, mountain slopes	Stir fry, tender stem, tender leaves	Flavonoids, alkaloids, triterpenoids, polysaccharides	
<i>G. Procumbens</i> (Lour.) Merr 蔓三七 (màn sān qī)	Southern Hainan, including Sanya, Lingshui, and Ledong, sparse forests, valleys	Stir fry, tender stem, tender leaves	Flavonoids, saponins, polysaccharides	
<i>Hylocereus undatus</i> (Haw.) Britt. et Rose 量天尺 (liáng tiān chǐ)	Western and southern coastal cities and counties, including Sanya, Ledong, Dongfang, and Changjiang, roads	Stir fry, soup base, flower, stem, fruit	Flavonoids, triterpenoids, plant sterols, mucopolysaccharides	
<i>Kleinhovia hospita</i> L. 鸚鵡麻 (zhè gǔ má)	Western and southern coastal areas, including Changjiang, Dongfang, Ledong, and Sanya, hills, sparse forests	Stir fry, tender leaves	Flavonoids, alkaloids, triterpenoids	
<i>Leonurus japonicus</i> Houtt. 益母草 (yì mǔ cǎo)	Throughout Hainan Island, with notable occurrences in the northern and eastern regions, including Haikou, Chengmai, Ding'an, and Wenchang, moist areas	Stir fry, soup base, tender stem, tender leaves	Alkaloids (such as motherwort alkaloids and sophocarpine), flavonoids, and volatile oils	
<i>Merremia umbellata</i> <i>subsp. orientalis</i> (Hall.f.) V. Ooststr. 山猪菜 (shān zhū cài)	Eastern and southern coastal regions, including Sanya, Lingshui, Wanning, Qionghai, and Wenchang, sparse forests, valleys	Stir fry, tender leaves	Flavonoids, alkaloids, saponins	
<i>Monochoria vaginalis</i> (Burm. f.) C. Presl 鸭舌草 (yā shé cǎo)	Aquatic habitats across all cities and counties, including Haikou, Ding'an, Qionghai, and Wanning, courtyards, wastelands	Stir fry, tender stem, tender leaves	Flavonoids, phenolic acids, polysaccharides, alkaloids	
<i>Morinda officinalis</i> How 巴戟天 (bā jǐ tiān)	Central mountainous counties, including Qiongzong, Baisha, Wuzhishan, and Baoting, sparse forests, valleys	Stir fry, tender leaves	Anthraquinones (such as emodin methyl ether), iridoid glycosides, oligosaccharides	
<i>Mucuna bracteata</i> DC. 黄毛黎豆 (huáng máo lí dòu)	Western and southern regions, including Sanya, Ledong, Dongfang, and Changjiang, mountain slopes, valleys, roads	Stir fry, inflorescence	Levodopa, alkaloids, flavonoids	
<i>Musa balbisiana</i> Colla 野蕉 (yě jiāo)	Central and southern mountainous regions, including Wuzhishan, Qiongzong, Baisha, Baoting, and Ledong, moist areas, valleys	Stir fry, inflorescence, pith of the stem	Polyphenols, carotenoids, vitamins, serotonin	
<i>Oenanthe javanica</i> (Blume) DC. 水芹 (shuǐ qín)	Aquatic habitats throughout all cities and counties, including Haikou, Ding'an, Qionghai, and Wenchang, river valleys, stream	Stir fry, tender stem, tender leaves	Flavonoids (such as apigenin), volatile oils, coumarins, phenolic acids	
<i>Opuntia dillenii</i> (Ker Gawl.) Haw. 仙人掌 (xiān rén zhǎng)	Western and southern coastal counties, including Sanya, Ledong, Dongfang, and Changjiang, sparse areas	Stir fry, tender stem	Polysaccharides, flavonoids, alkaloids, plant sterols	
<i>Ottelia balansae</i> (Gagnep.) Dandy 水车前 (shuǐ chē qián)	Northern and eastern regions, including Haikou, Wenchang, Qionghai, Wanning, and Ding'an, river, stream	Stir fry, tender stem, tender leaves	Flavonoids, terpenes, phenolic acids	
<i>Oxalis corniculata</i> L. 酢浆草 (cù jiāng cǎo)	Across all cities and counties, bushwood, river valleys, roads	Stir fry, aerial parts	Oxalates, flavonoids, organic acids such as citric acid and tartaric acid	[38]
<i>Paederia foetida</i> L. 鸡矢藤 (jī shǐ téng)	Across all cities and counties, bushwood, valleys, roads	Stir fry, tender leaves	Cycloterpenoid glycosides (such as chicken arrow vine glycosides), volatile oils (including nonanal, etc.), alkaloids	

(to be continued)

Table 2. (continued)

Scientific name/ Chinese name/Pinyin	Locations	Usage/edible parts	Medical main chemical components	Ref.
<i>Pentaphragma spicatum</i> Merr. 直序五膜草 (zhí xù wǔ mó cǎo)	Central mountainous regions, including Wuzhishan, Qiongzong, Baisha, and Diaoluoshan, dense forests	Stir fry, tender leaves	Flavonoids, saponins	
<i>Phoenix loureiroi</i> Kunth 刺葵 (cì kúí)	Western and southern coastal regions, including Sanya, Ledong, Dongfang, and Changjiang, hills, valleys	Stir fry, soup base, pith of the stem	Flavonoids, tannins, polysaccharides, saponins	
<i>Phyllostachys elegans</i> McClure 甜笋竹 (tián sǔn zhú)	Across all regions, particularly in areas including Qionghai, Wanning, Baisha, and Wuzhishan, wastelands, roads	Stir fry, bamboo shoot	Dietary fiber, polysaccharides, amino acids, flavonoids	
<i>Piper sarmentosum</i> Roxb. 假蒟 (jiǎ jǔ)	Common throughout all cities and counties, shady and moist areas	Stir fry, tender stem, tender leaves soup base	Volatile oils (such as eugenol methyl ether), amides, flavonoids	
<i>Pollia siamensis</i> (Craib) Faden ex Hong 长柄杜若 (cháng bǐng dù ruò)	Southern Hainan, including Sanya, Baoting, Lingshui, and Ledong, valleys	Stir fry, aerial parts	Flavonoids, saponins, polysaccharides	
<i>Polygala chinensis</i> L. 华南远志 (huá nán yuǎn zhì)	Western and central Hainan, including Danzhou, Changjiang, Baisha, and Qiongzong, moist areas	Stir fry, aerial parts	Saponins, ketones, alkaloids	
<i>Polygonum chinense</i> L. 火炭母 (huǒ tàn mǔ)	Common throughout all counties and cities, notably in Haikou, Wenchang, and Qionghai, wastelands	Stir fry, tender stem, tender leaves	Flavonoids (such as quercetin), anthraquinones, tannins	
<i>Persicaria lapathifolia</i> (L.) Delarbre 酸模叶蓼 (suān mó yè liǎo)	Northern Hainan, including Haikou, Chengmai, Ding'an, and Wenchang, courtyards, roads	Stir fry, soup base, tender stem, tender leaves	Anthraquinone, flavonoids, tannins, organic acids	
<i>Portulaca oleracea</i> L. 马齿苋 (mǎ chí xiàn)	Extremely common in farmlands and wastelands across all cities and counties, courtyards and orchards	Stir fry, aerial parts soup base	Norepinephrine, omega-3 fatty acids, flavonoids, polysaccharides	
<i>Pueraria montana</i> (Lour.) Merr. 野葛 (yě gē)	Throughout Hainan, commonly found in cities and counties such as Sanya, Ledong, Baisha, and Qiongzong, dense or sparse forests	Soup base, earthnut	Isoflavones (puerarin, daidzein), saponins, polysaccharides	
<i>Sauropus androgynus</i> (Linn.) Merr. 树仔菜 (shù zǎi cài)	Central mountainous regions, including Wuzhishan, Qiongzong, Baisha, and Baoting, dense or sparse forests	Stir fry, tender stem, tender leaves	Vitamins (rich in A and C), proteins, flavonoids, alkaloids	
<i>Senecio scandens</i> Buch.-Ham. ex D. Don 千里光 (qiān lǐ guāng)	Central and western regions, including Wuzhishan, Qiongzong, Baisha, and Changjiang, sparse forests, bushwood	Stir fry, tender stem, tender leaves	Pyrrrolidine alkaloids (hepatotoxic)	
<i>Smilax riparia</i> A. DC. 牛尾菜 (niú wěi cài)	The higher elevation mountainous areas of central Hainan, including Wuzhishan, Qiongzong, Baisha, and Diaoluoshan, dense or sparse forests	Stir fry, tender stem, tender leaves	Saponins, flavonoids, polysaccharides, alkaloids	
<i>Solanum americanum</i> Mill. 少花龙葵 (shǎo huā lóng kúí)	Across all cities and counties, shady and moist areas	Stir fry, tender stem, tender leaves	Solanine, saponins, flavonoids	
<i>Sonchus arvensis</i> L. 野苦蕒 (yě kǔ mài)	Northern and eastern regions, including Haikou, Chengmai, Wenchang, and Qionghai, forest margins, sparse forests, roads	Stir fry, tender stem, tender leaves	Flavonoids, triterpenoids, sesquiterpene lactones, volatile oils	[38]
<i>Talinum paniculatum</i> (Jacq.) Gaertn. 土人參 (tǔ rén shēn)	A broad distribution across all regions, wastelands	Stir fry, tender stem, tender leaves	Flavonoids, saponins, polysaccharides, alkaloids	
<i>Tetragonia tetragonioides</i> (Pall.) Kuntze 番杏 (fān xìng)	In coastal cities and counties, including Sanya, Ledong, and Dongfang, wastelands	Stir fry, tender stem, tender leaves	Saponins, flavonoids, polysaccharides, vitamins	
<i>Youngia japonica</i> (L.) DC. 黄鹌菜 (huáng ān cài)	Across all cities and counties, mountain slopes, valleys, wastelands	Stir fry, tender leaves	Flavonoids, triterpenoids, sesquiterpene lactones, phenolic acids	
<i>Zehneria japonica</i> (Thunb.) H. Y. Liu 马交儿 (mǎ jiāo er)	Eastern and northern regions, including Haikou, Wenchang, Qionghai, and Wanning, grasslands, sparse forests	Stir fry, fruit	Flavonoids, saponins, alkaloids	
<i>Zingiber zerumbet</i> (L.) Roscoe ex Sm. 红球姜 (hóng qiú jiāng)	Southern and central regions, including Baoting, Sanya, Ledong, and Wuzhishan, wastelands	Stir fry, tender stem	Diarylheptanes, volatile oils (such as gingerene), flavonoids	
<i>Dracaena angustifolia</i> Roxb. 龙血树 (lóng xuè shù)	Limestone mountainous areas of Sanya, Ledong, and Dongfang, shrub	Stir fry, tender stem	Flavonoids (dragon blood extract A/B/C), triterpenoids, phenolic resins	[39]
<i>Bidens pilosa</i> L. 三叶鬼针草 (sān yè guǐ zhēn cǎo)	Throughout all administrative divisions, wastelands, roads	Stir fry, leaves	Flavonoids, phenolic acids, polyacetyles, volatile oils	
<i>Thladiantha dubia</i> Bunge 赤廔 (chì páo)	Central high-altitude mountainous regions, with significant presence documented in Wuzhishan, Qiongzong, and Baisha, river valley	Stir fry, leaves	Triterpenoid saponins, flavonoids, polysaccharides, alkaloids	
<i>Phyllanthus emblica</i> L. 余甘子 (yú gān zǐ)	Dry-hot valleys of western and southern Hainan, including Changjiang, Dongfang, Ledong, and Sanya, sparse forests, bushwood	Stir fry, leaves	Phenolic acids (gallic acid, tannic acid), vitamin C, flavonoids	
<i>Ricinus communis</i> L. 蓖麻 (bì má)	Throughout Hainan in both cultivated and naturalized states, wetlands, mountain slopes, grasslands	Stir fry, seed	Ricin toxin protein, ricinine, fatty oil	
<i>Conandron ramondioides</i> S. et Z. 苦苣苔 (kǔ jù tái)	Central mountainous regions, including Wuzhishan, Qiongzong, Baisha, and Diaoluoshan, dense forests, valleys	Stir fry, tender leaves	Flavonoids, terpenes, alkaloids	
<i>Thysanolaena latifolia</i> (Roxb. ex Hornem.) Honda 粽叶芦 (zòng yè lú)	Throughout Hainan, used for zongzi in Qiongzong, Baisha, and Baoting, mountain slopes, valleys	Stir fry, flowers	Flavonoids, polysaccharides, saponins	

(to be continued)

Table 2. (continued)

Scientific name/ Chinese name/Pinyin	Locations	Usage/edible parts	Medical main chemical components	Ref.
<i>Garcinia yunnanensis</i> H. H. Hu 云南藤黄 (yún nán téng huáng)	Southern Hainan, including Sanya, Baoting, and Ledong, mountain slopes, hills	Stir fry, fruit, tender leaves, fruits	Ketones (such as rattan flavonoids), polycyclic isoprenoidization	
<i>Litsea pungens</i> Hemsl. 木姜子 (mù jiāng zǐ)	The higher elevation mountainous areas of central Hainan, including Wuzhishan, Qiongzong, Baisha, and Diaoluoshan, stream, forest	Fruit, fruits	Volatile oils (citral, eucalyptus oil), alkaloids, flavonoids	
<i>Tamarindus indica</i> L. 罗晃子 (luó huàng zǐ)	In multiple counties and cities, including Sanya, Ledong, Changjiang, and Dongfang, valleys	Fruit, fruits	Organic acids (tartaric acid, citric acid), flavonoids, polysaccharides	
<i>Lygodium longifolium</i> (Willd.) Sw. 掌叶海金沙 (zhǎng yè hǎi jīn shā)	Southern and eastern Hainan, including Sanya, Baoting, Lingshui, and Wanning, forest, thickets	Stir fry, tender leaves	Flavonoids, phenolic acids, triterpenoids	
<i>Ardisia densilepidotula</i> Merr. 密鳞紫金牛 (mì lín zǐ jīn niú)	Central mountainous regions, including Wuzhishan, Qiongzong, Baisha, and Bawangling, dense forests, valleys	Fruit, fruits	Cabbage extract, saponins, flavonoids, phenolic acids	
<i>Ardisia crenata</i> Sims 朱砂根 (zhū shā gēn)	Understory of central mountainous forests, including Wuzhishan, Qiongzong, Baisha, and Diaoluoshan, sparse forests, wastelands	Fruit, fruits	Saponins, colchicine, flavonoids, quinones	
<i>Syzygium jambos</i> (L.) Alston. 蒲桃 (pú táo)	Across Hainan, particularly around villages in Haikou, Wenchang, and Qionghai, various regions	Fruit, fruits	Flavonoids, tannins, volatile oils (including eugenol), triterpenoids	
<i>Mussaenda pubescens</i> W. T. Aiton 玉叶金花 (yù yè jīn huā)	All regions of Hainan, mountain slopes, roadsides, villages	Herb tea, leaves, flowers	Saponins, flavonoids (such as aucubin), alkaloids	
<i>Solanum torvum</i> Sw. 水茄 (shuǐ qié)	Throughout Hainan Island, roadsides, villages	Fruit, fruits	Steroid alkaloids (such as solanine), saponins, flavonoids	

swidden agriculture as 'primitive' overshadow its ecological merits, skewing policy toward modern intensive farming^[23]. Additionally, the lack of community empowerment mechanisms excludes Li residents from decision-making in sacred forest management, stifling integration of traditional governance into modern conservation systems^[23].

Hainan Province has established a comprehensive policy framework covering the entire industrial chain of medicinal ethnobotanical plants and southern medicinal herbs. The Hainan Provincial Development Plan for Southern Medicinal Herbs and Li Medicine Industry (2023–2030) explicitly aims to build the 'Top Ten Southern Medicinal Herbs' brand, with a target of exceeding 100,000 hectares of planting area by 2030. The Three-Year Action Plan for Accelerating High-Quality Development of Traditional Chinese Medicine Industry (2025–2027) proposes the construction of high-quality seed breeding bases and local processing centers, aiming to expand the planting area to over 66,667 hectares. The Interim Measures for the Protection and Management of Wild Plants regulates resource utilization, while standards such as the Geographical Indication Certification Trademark: Hainan Agarwood (Medicinal Agarwood) strengthen quality control. In terms of scientific research and innovation, the Implementation Plan for Comprehensively Deepening the Supervision Reform of Drugs, Medical Devices, and Cosmetics supports the research and development of in-hospital preparations, with a plan to promote the registration and filing of more than 15 preparations by 2027. In the evolving discipline of ethnobotany, quantitative metrics are paramount to elevating indigenous knowledge from anecdotal lore to empirical science, necessitating the establishment of standardized evaluation frameworks. Traditional indices such as the Use Value (UV) and Fidelity Level (FL) must be augmented with advanced quantitative ethnobotany indicators, including the Relative Importance Index (RI) and Informant Consensus Factor (ICF), to systematically assess plant utility across cultures. These metrics, calibrated against global databases like the Useful Plants Database, enable cross-cultural comparisons and validate therapeutic claims, fostering a robust, replicable paradigm that bridges ethnobotanical surveys with pharmacognostic validation.

Lagging research and technology related to ethnobotany

Critical gaps in the systematicness and technical depth of current ethnobotanical research in Hainan further constrain resource protection: (i) Lack of Systematic Research Frameworks. Current studies are largely scattered and topic-specific, failing to form a comprehensive research system. Research on ethnic plant use (e.g., Li bark cloth raw materials, Miao herbal tea) is often isolated from ecological and genetic studies. For example, while over 500 plant species used by the Li have been documented^[12], there is no systematic database linking their cultural use, genetic traits, and ecological functions—unlike Yunnan's Xishuangbanna, which has established a 'cultural-ecological-genetic' integrated ethnobotanical database^[38]. (ii) Insufficient Technical Depth in Research. Modern quantitative methods and biotechnologies are underutilized, limiting the scientific validation and application of traditional knowledge. For example, the hemostatic mechanisms of *Dracaena cambodiana* (used in Li medicine) remain unverified due to insufficient metabolomic studies, hindering its integration into modern pharmacology^[23]. Endangered endemic plants in Li sacred forests face extinction risks without tissue culture-based propagation^[43], while limited genomic sequencing obscures the genetic traits and adaptability of traditional crops^[44]. Despite its interdisciplinary nature (spanning botany, anthropology, and ecology), ethnobotany remains dominated by qualitative descriptions, lacking robust quantitative models. The carbon sequestration potential of Li swidden agriculture, for instance, cannot be quantified without integrating GIS spatial analysis and ecological-economic modeling^[23]. Disparities in disciplinary paradigms, such as anthropology's focus on cultural symbolism versus botany's species-centric approach, further fragment research outcomes^[43]. Key technologies for transforming traditional wisdom into sustainable productivity are underdeveloped. The eco-friendly fiber processing of Li bark cloth, though aligned with low-carbon principles, faces scalability challenges due to unresolved fiber modification techniques^[45]. Additionally, lagging digital technologies (e.g., blockchain) heighten risks of database tampering and resource exploitation, impeding intellectual property protection^[44]. Among the technologies mentioned, modern

biotechnology brings the greatest benefits to ethnobotany and represents the future of this discipline. The following part will focus on introducing the potential applications of biotechnologies, especially multi-omics in ethnobotany.

Multi-omics and biotechnologies: the future of ethnobotany

As one of the most cutting-edge technologies in contemporary biological research, multi-omics synthesizes information from genomics, transcriptomics, proteomics, and metabolomics and provides a powerful toolkit for the innovation of plant germplasm resources in ethnobotany, with significant application value in the following aspects. By leveraging artificial intelligence and machine learning algorithms, such as graph neural networks, for predicting bioactive pathways. These approaches dissect polypharmacological interactions, as exemplified in studies correlating Ayurvedic formulations with molecular docking simulations. Such data-driven correlations not only substantiate empirical uses but also accelerate lead compound discovery, mitigating the translational gap between folklore and clinical trials. Ensuring the fidelity of germplasm conservation demands rigorous genetic stability assessments for regenerated plants, encompassing phenotypic diversity via morphometric analyses and molecular profiling through SSR and SNP markers. Comprehensive reviews underscore that SSR-based genotyping reveals clonal fidelity in micropropagated medicinal species like *Withania somnifera*, while SNP arrays detect subtle allelic variations, safeguarding against somaclonal mutations and preserving chemotypic integrity in *ex situ* repositories. Looking ahead, frontier research in medicinal plants converges on bioactive compounds and heritable traits, propelled by CRISPR-Cas9 gene editing for enhanced secondary metabolite yields, synthetic biology for de novo pathway engineering, and GWAS to map quantitative trait loci (QTLs) underpinning pharmacological potency. These innovations herald a precision ethnobotany era, harmonizing cultural heritage with biotechnological stewardship to sustain biodiversity and therapeutic innovation.

The rapid development of multi-omics technologies offers a completely new perspective for ethnobotany research, enabling the molecular-level elucidation of the pharmacological basis and mechanisms of traditional herbal medicines. Metabolomics, when integrated with genomics, transcriptomics, and proteomics data, is becoming a core methodology in ethnopharmacology research by leveraging multi-dimensional integration to analyze the biosynthesis pathways and metabolic networks of plant active compounds. Scholars in the ethnobotany field in Hainan have started to use this method in their research. The application of multi-omics technologies in Hainan ethnobotany spans multiple domains, including molecular identification of medicinal plants, active compound characterization, genetic improvement, and ecological conservation, thereby providing a scientific foundation for the modernization of ethnobotanical resources. For instance, *Dracaena cambodiana*, historically used for promoting blood circulation, has its resin (dragon's blood) documented in the *Compendium of Materia Medica*. Recent metabolomic studies employing LC-MS/MS have identified *loureirin B* as a key active compound, confirming its anti-inflammatory and anti-tumor properties^[46]. Furthermore, genomic research has elucidated the biosynthetic pathway of *loureirin B* and completed the whole-genome sequencing of *D. cambodiana*, revealing that the CYP450 gene family plays a pivotal role in the biosynthesis of its active constituents^[47]. Additionally, evolutionary studies suggest that *D. cambodiana* underwent rapid diversification

during the Pleistocene epoch, significantly influenced by climatic fluctuations^[48].

The combination of Gas Chromatography-Mass Spectrometry (GC-MS), Liquid Chromatography-Mass Spectrometry (LC-MS), and Nuclear Magnetic Resonance (NMR) techniques allows researchers to accurately analyze the complex secondary metabolite profiles within plants. For instance, scientists utilized LC-MS and GC-MS in their study to delineate the spectral characteristics of medicinal plant metabolites, revealing key enzymatic nodes for terpenes, flavonoids, and alkaloids in antibacterial and antioxidant processes^[49]. Similarly, Karalija et al. systematically elucidated how exogenous elicitors activate defense metabolic pathways and promote the accumulation of medicinal secondary metabolites (such as phenolic acids and alkaloids) through a multi-omics and tissue culture integration strategy^[50]. The combined analysis of LC-MS and transcriptomics further clarifies the pharmacological mechanisms of plant active components. For example, Omics Studies of Medicinal Plants pointed out that multi-omics can reveal the regulatory roles of MAPK and PI3K/Akt signaling pathways in medicinal plants, providing molecular evidence for their anti-inflammatory and anticancer activities^[51]. In a specific case, metabolomic research on *Dracaena cambodiana* (dragon's blood) showed that the dracorhodin-type compounds in its resin, confirmed by GC-MS and NMR, exert significant anti-inflammatory and hemostatic activity by inhibiting the NF-KB signaling pathway. This provides a scientific basis for the modernization of traditional Li ethnic medicine in Hainan. Furthermore, fusing ethnobotanical databases with multi-omics data can construct a 'metabolic fingerprint' of medicinal plants, achieving a leap from traditional empirical knowledge to precision pharmacology^[49].

Beyond medicinal plants, other ethnobotanical resources in Hainan also benefit from multi-omics approaches. *Broussonetia papyrifera*, the primary raw material for traditional Li bark cloth, has been a focus of genetic improvement^[6]. Whole-genome sequencing has identified *CesA* genes associated with fiber length, providing a basis for molecular breeding^[52], while metabolomic studies have demonstrated a correlation between phenolic compounds in *B. papyrifera* bark and its resistance to degradation, enhancing its durability^[53]. Similarly, Hainan's traditional upland rice (*Shanlan rice*), which has played a crucial role in ecological agriculture, was recorded as early as the Ming Dynasty^[30]. Genomic resequencing has identified *DREB* genes conferring drought resistance, offering valuable genetic resources for breeding stress-tolerant rice varieties^[54]. Moreover, population genetics studies have revealed gene introgression between *Shanlan rice* and wild rice, underscoring its retention of critical resistance traits during evolution^[55].

In the realm of food plants, *Curcuma longa* (turmeric) is widely used in traditional Li cuisine, particularly in yellow rice, known for its anti-inflammatory and digestive properties^[14]. Metabolomic analysis has quantified curcumin levels and validated its antioxidant activity^[14], while transcriptomic studies have uncovered regulatory mechanisms of curcumin biosynthesis under heat stress, providing insights for breeding heat-tolerant turmeric varieties^[56]. Additionally, *Ficus spp.* holds significant cultural symbolism in Li communities, particularly in fengshui forests, where it plays an essential ecological role. Recent metagenomic analyses have characterized nitrogen-fixing microbial communities in the aerial roots of *Ficus*, contributing to a deeper understanding of biological nitrogen fixation^[57]. Furthermore, ecological genomics, combined with GIS-based analysis, has confirmed the correlation between *Ficus* distribution patterns and village site selection, offering scientific support for sustainable land-use planning^[58]. Coconut is a crop of significant ethnobotanical importance to Hainan; multi-omics research was

designed to address dwarfing and high-yield breeding needs. In a study on *Cocos nucifera*, 20 tall (traditional Li-grown) and 20 dwarf coconut varieties were selected, with three biological replicates per variety; samples included young leaves (for genomics/transcriptomics) and endosperm (for metabolomics), which were sampled at three developmental stages: one, three, and six months after pollination. Integrated multi-omics analysis revealed that altered gibberellin metabolism underlies the height differences between tall and dwarf coconuts, demonstrating convergent evolution in plant height selection across domesticated coconut species. The GA2ox gene, identified in this screen, has been adopted as a molecular marker for marker-assisted selection (MAS), shortening the breeding cycle of dwarf coconut from eight years to three years and increasing yield by 15% in pilot plantations^[59]. Moreover, the Palm Crop Database (MDB) serves as a valuable resource for ethnobotanical research by providing comprehensive genomic, metabolomic, and ecological datasets, thereby facilitating the conservation, genetic improvement, and medicinal compound exploration of traditional palm species in Hainan and beyond^[60].

Ethnobotanical plants in Hainan, particularly those used by indigenous communities such as the Li and Miao, present significant potential for biotechnological applications, including tissue culture and genetic transformation. Native ethnobotanical plant species, such as *Horsfieldia hainanensis*, have been identified as promising candidates for tissue culture-based propagation to support both *in situ* and *ex situ* conservation efforts^[61]. The tissue culture technology of *Areca catechu* has achieved positive results. An *in vitro* culture system has been successfully established using various explants, enabling asexual rapid propagation^[62]. As one of the most important ethnobotanical species in Hainan Province, the coconut holds great potential for the application of *in vitro* biotechnologies. The automation of coconut tissue culture, incorporating deep learning, temporary immersion systems, and other automated techniques, has significantly enhanced the efficiency of coconut *in vitro* propagation, providing innovative solutions for the rapid multiplication of elite coconut seedlings^[63–65]. The success of coconuts can also be replicated in other Hainan ethnobotanical plants. The use of these techniques on ethnobotanical species faces significant barriers. Key challenges include species-specific physiological responses that complicate protocol optimization, high contamination rates due to field-collected explants, and somaclonal variation that compromises genetic stability^[66]. Furthermore, limited infrastructure, technical expertise, and financial resources in local regions hinder large-scale implementation^[67]. A critical gap also exists in integrating traditional ethnopharmacological knowledge with standardized scientific methodologies, impeding the selection and authentication of suitable plant materials for culture^[30]. Examples illustrate the technical references and promoted development from research on other medicinal plants like ginseng and Fritillaria. For ginseng (*Panax ginseng*), multi-omics analyses, including transcriptomics and metabolomics, have revealed key mechanisms underlying phenotypic differences such as root morphology and ginsenoside accumulation, providing technical references for marker-assisted breeding and enhancing secondary metabolite yields through CRISPR-Cas9 editing, which promotes industrial scalability and sustainable cultivation^[68]. Similarly, for Fritillaria (e.g., *Fritillaria cirrhosa*), integrated multi-omics approaches have elucidated cadmium toxicity responses and alkaloid biosynthesis pathways under stress, offering insights into detoxification mechanisms and callus proliferation under different light qualities, thereby advancing propagation techniques and metabolite optimization for pharmaceutical applications^[69].

These new tools mentioned above enable the discovery of novel functional genes and bioactive compounds in traditionally utilized plant species, thus unlocking untapped resources for agriculture, medicine, and industry. Genomic analyses can unravel the evolutionary history and adaptive traits of ethnobotanical plants, providing insights into their resilience under climate change and guiding sustainable breeding strategies. Transcriptomic and metabolomic data further facilitate the identification of key regulatory networks underlying desirable traits (e.g., stress tolerance, secondary metabolite biosynthesis), supporting marker-assisted selection and precision breeding. Moreover, multi-omics approaches can assess the conservation status of endangered germplasm by quantifying genetic diversity and ecological interactions, ensuring the preservation of culturally and ecologically vital plant resources. In conclusion, multi-omics technologies, including genomics, metabolomics, and ecological genomics, offer a systematic and integrative approach to ethnobotanical research in Hainan, fostering the modernization of traditional medicinal and agricultural resources while contributing to global biodiversity conservation. Interdisciplinary collaborations between ethnobotanists, biotechnologists, and policymakers are essential to translate these insights into actionable strategies for climate-smart agriculture, bioprospecting, and the revitalization of indigenous knowledge systems. This framework not only bridges traditional practices with modern science but also paves the way for equitable and sustainable utilization of plant biodiversity.

The limitations of multi-omics include challenges in data integration due to a lack of standardized pre-processing, high computational demands requiring specialized bioinformatics expertise, potential biases from sample heterogeneity, and difficulties in functional validation of omics results, such as spatial resolution and causal inference in complex plant systems. Despite these, current progress in ethnic medicine in China emphasizes policy-driven integration of traditional knowledge with modern science, with advancements in protecting minority medicinal resources through expanded planting areas and innovations in drug development, though regional disparities persist^[69].

Conclusions

This study highlights Hainan Island's rich ethnobotanical heritage, shaped by its unique tropical biodiversity and the traditional knowledge of ethnic minorities like the Li and Miao, who utilize plants extensively in medicine, diet, and crafts. However, this knowledge faces threats from modernization and environmental changes. The research demonstrates that integrating traditional plant wisdom with multi-omics and biotechnologies offers solutions: it validates medicinal compounds, identifies adaptive traits, and supports conservation of endangered species. Ultimately, bridging indigenous knowledge with advanced biotechnologies is key to safeguarding Hainan's cultural and ecological diversity, fostering sustainable utilization of plant resources, and ensuring the longevity of this unique ethnobotanical legacy.

Author contributions

The authors confirm contribution to the paper as follows: study conception and design: Mu Z, Zhao L; information collection: Xu W, Deng K; draft manuscript preparation: Yang S, Mu Z; figure presentation: Yang S, Mu Z, Zhao L; manuscript review: Fan H, Hu X. All authors reviewed the results and approved the final version of the manuscript.

Data availability

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Acknowledgments

This paper was sponsored by the Technology and Innovation Project for Talent of Hainan (KJRC2023L09) and the Project of Sanya Yazhou Bay Science and Technology City (Grant No. SCKJ-JYRC-2024-35).

Conflict of interest

The authors declare that they have no conflict of interest.

Dates

Received 9 September 2025; Revised 10 December 2025; Accepted 13 January 2026; Published online 28 February 2026

References

- Mu Z, Yang Z, Xu H, Khongmaluan M, Arikrit S, et al. 2024. Prospects and challenges of elite coconut varieties in China: a case study of makapuno. *Tropical Plants* 3:e029
- Wang GQ, Scherson RA, Vera D, Bai YH, Wen J, et al. 2024. Spatial patterns and drivers of native plant diversity in Hainan, China. *Journal of Systematics and Evolution* 62:603–620
- Chen Y, Ren L, Lou Y, Tang L, Yang J, et al. 2022. Effects of climate change on climate suitability of green orange planting in Hainan Island, China. *Agriculture* 12:349
- Zhang YY, Lei C. 2008. 海南省黎族和苗族传统知识对农业生物多样性保护的影响 [The effect of traditional knowledge to the conservation of agricultural biodiversity in Li and Miao minority regions of Hainan Province]. *中央民族大学学报(自然科学版)* [Journal of the Central University for Nationalities (Natural Sciences Edition)] 27:9–14 (in Chinese)
- Huang W, Li P, Liu Y, Huang W, Ju Y, et al. 2016. Ethnobotanical study on medicinal plants used by Li people in Ledong, Hainan Island, China. *Acta Societatis Botanicorum Poloniae* 85:3485
- Gan BC, Li RT, Yang XQ, Du DL. 2007. 海南五指山区黎族药用民族植物学研究 [Ethnobotany Studies on Medicinal Plants Used by Li Nationality in Wuzhishan Area of Hainan Province]. *中国民族民间医药杂志* [Chinese Journal of Ethnomedicine and Ethnopharmacy] 4:194–198 (in Chinese)
- Guo LY, Nizamani MM, Harris AJ, Lin QW, Balfour K, et al. 2022. Sociological effects on the patterns of non-native plant distributions on Hainan Island. *Frontiers in Ecology and Evolution* 10:838591
- Ermakov DN. 2024. Legal status of national minorities in the People's Republic of China. *Sociopolitical Sciences* 14:125–130
- Li Y. 2009. Orientation of country tourism for ethnic minorities region in mid-hainan cultural ecological country tourism of Li and Miao ethnic minorities. *Science Technology and Industry* 9:12–15
- Li D, Sun Y, Lu Y, Mustavich LF, Ou C, et al. 2010. Genetic origin of Kadai-speaking Gelong people on Hainan island viewed from Y chromosomes. *Journal of Human Genetics* 55:462–468
- Saitou N, Omoto K, Du C, Du R. 1994. Population genetic study in Hainan Island, China II. Genetic affinity analyses. *Anthropological Science* 102:129–147
- Massing K. 2018. Safeguarding intangible cultural heritage in an ethnic theme park setting – the case of Binglanggu in Hainan Province, China. *International Journal of Heritage Studies* 24:66–82
- Zheng XL, Chen HF, Li RT, Xing FW. 2008. 海南润方言黎族药用民族植物学研究 [Medical Ethnobotany of the Run Dialect People of Li Minority in Hainan]. *云南植物研究* [Acta Botanica Yunnanica] 30:195 (in Chinese)
- Li DL, Xing FW. 2016. Ethnobotanical study on medicinal plants used by local Hoklos people on Hainan Island, China. *Journal of Ethnopharmacology* 194:358–368
- Wang M. 2011. Hainan regional characteristic of Li ethnic. *Journal of Educational Institute of Jilin Province* 27:127–129
- Harshberger JW. 1896. The purposes of ethno-botany. *Botanical Gazette* 21:146–154
- Rahman IU, Afzal A, Iqbal Z, Ijaz F, Ali N, et al. 2019. Historical perspectives of ethnobotany. *Clinics in Dermatology* 37:382–388
- McClatchey WC, Mahady GB, Bennett BC, Shiels L, Savo V. 2009. Ethnobotany as a pharmacological research tool and recent developments in CNS-active natural products from ethnobotanical sources. *Pharmacology & Therapeutics* 123:239–254
- Pandey A, Tripathi YC. 2017. Ethnobotany and its relevance in contemporary research. *Journal of Medicinal Plants Studies* 5:123–129
- Pei S. 1985. *Some effects of the Dai people's cultural beliefs and practices on the plant environment of Xishuangbanna, Yunnan Province, south-west China. Cultural values and human ecology in Southeast Asia*. Thesis. Ann Arbor: University of Michigan Press. pp. 321–339
- Zheng XL, Xing FW. 2009. Ethnobotanical study on medicinal plants around Mt. Yinggeling, Hainan Island, China. *Journal of Ethnopharmacology* 124:197–210
- Zhang L, Wang L, Cunningham AB, Shi Y, Wang Y. 2019. Island blues: indigenous knowledge of indigo-yielding plant species used by Hainan Miao and Li dyers on Hainan Island, China. *Journal of Ethnobiology and Ethnomedicine* 15:1–9
- Gan B, Li R, Yang X. 2006. 用民族植物学观点分析黎族与植物资源的关系 [Analysis of relationship between Li Nationality and plant resources on viewpoint of ethnobotany]. *植物资源与环境学报* [Journal of Plant Resources and Environment] 15:62–66 (in Chinese)
- Tian L, Huang S, Zeng J, Liu S, Jin H, et al. 2025. Ethnobotanical study of traditional medicinal plants used by the Miao people in Hainan, China. *Journal of Ethnobiology and Ethnomedicine* 21:43
- Wang A. 2012. 海南黎族传统黎药的民族植物学初步调查 [Preliminary ethnobotanical investigation on the Hainan Li traditional medicine]. 第六届中国民族植物学研讨会暨第五届亚太民族植物学论坛论文集 [Proc. The 6th Chinese Ethnobotany Symposium and the 5th Asia-Pacific Ethnobotany Forum], Yinchuan, Ningxia] 21:211–212
- Cun D, Zhu G, Song X, Zhong Y. 2014. 海南黎族药用兰科植物的民族植物学研究 [Ethnobotany of medicinal orchids by Li nationality in Hainan Island]. *热带作物学报* [Chinese Journal of Tropical Crops] 35:2025–2029 (in Chinese)
- Zhang D, Gao S, Zhang L, Zhang J, Mo W. 2016. Identification of original plant varieties of national Jiangzhenxiang conventionally used as medicine and incense in Hainan. *Journal of Anhui Agricultural Sciences* 44:147–150 (in Chinese)
- Zheng X, Chen H, Li R, Xin F. 2008. Medical ethnobotany of the Run Dialect people of Li minority in Hainan. *Plant Diversity* 30:195–210
- Gan B, Li R, Yang X, Du D. 2007. 海南五指山区黎族药用民族植物学研究 [Study on the pharmaceutical ethnobotanist used by Li nationality lived in the Wuzhi mountainous Area in Hainan Province]. *中国民族民间医药杂志* [Chinese Journal of Ethnomedicine and Ethnopharmacy] 89:315–321 (in Chinese)
- Guan YL, Pan Q, Huang MR. 2009. 民族植物学与海南黎药开发 [Ethnobotany and exploitation of medicinal plant resource in Hainan]. *南京林业大学学报(自然科学版)* [Journal of Nanjing Forestry University (Natural Sciences Edition)] 33:145–149 (in Chinese)
- Li DL, Zheng XL, Duan L, Deng SW, Ye W, et al. 2017. Ethnobotanical survey of herbal tea plants from the traditional markets in Chaoshan, China. *Journal of Ethnopharmacology* 205:195–206
- Yang D, Liu X, Fan P, Wu Y. 2020. Traditional usage of wild edible plants reflecting the dietary habits and the awareness of health care of LI minority in Baoting and Lingshui, Hainan Island, China: An ethnobotanical approach. *Bangladesh Journal of Botany* 48:279–287
- Liu Y, Ahmed S, Long C. 2013. Ethnobotanical survey of cooling herbal drinks from southern China. *Journal of Ethnobiology and Ethnomedicine* 9:82

- [34] Mu Z, Tran B-M, Xu H, Yang Z, Qamar UZ, et al. 2024. Exploring the potential application of coconut water in healthcare and biotechnology: a review. *Beverage Plant Research* 4:e018
- [35] Thalassinos G, Petropoulos SA, Antoniadis V. 2023. The response of Purslane (*Portulaca oleracea*) to soil-added Pb: is it suitable as a potential phytoremediation species? *Toxics* 11:153
- [36] Mortensen A, Aguilar F, Crebelli R, Di Domenico A, Frutos MJ, et al. 2017. Re-evaluation of konjac gum (E 425 i) and konjac glucomannan (E 425 ii) as food additives. *EFSA Journal* 15:e04864
- [37] Liu GM, Li JL, Wang XJ, He QX. 2007. 海南鸚鵡茶的民族植物学研究 [A study on ethnobotany of *Mallotus Oblongifolius* in Hainan]. *海南师范学院学报 (自然科学版) [Journal of Hainan Normal University(Natural Science Edition)]* 20:167–172 (in Chinese)
- [38] Zheng XL, Sun W, Li RT. 2013. Ethnobotanical study on wild vegetable resources of Li nationality. *Hubei Agricultural Sciences* 52:3856–3860 (in Chinese)
- [39] Huang W, Long C. 2014. 海南乐东野生食用植物的民族植物学初步调查 [Preliminary ethnobotanical study of wild edible plants in Ledong, Hainan Island, China]. *天然产物研究与开发 [Natural Product Research and Development]* 26:273–278 (in Chinese)
- [40] Mu Z, Peng H, Jayarathna SPNC, Indrachapa MTN, Yang C, et al. 2025. The coconut palm in China: distribution, germplasm, and sustainable development through genomic and biotechnological approaches. *Technology in Horticulture* 5:e005
- [41] Li G, Long C. 2019. 民族植物学研究新进展 [Advances in ethnobotany researches]. *科学 [Science]* 71:1–4 (in Chinese)
- [42] Pei S. 2011. 中国民族植物学研究三十年概述与未来展望 [General Introduction to Three-decades Development of Ethnobotany and Perspectives in China]. *中央民族大学学报 (自然科学版) [Journal of MUC (Natural Sciences Edition)]* 20:5–9 (in Chinese)
- [43] Geng YF, Wang YH. 2024. 浅谈中国民族植物学的研究思路 and 理论假设 [A brief synthesis of research approaches and theoretical hypotheses in Chinese Ethnobotany]. *生物多样性 [Biodiversity Science]* 32:1–12 (in Chinese)
- [44] Cheng Z, Zhang Q, Long C. 2022. 民族植物学研究现状 (2017–2022) [Research status of ethnobotany (2017–2022)]. *生物多样性 [Biodiversity Science]* 30:22372 (in Chinese)
- [45] Yang Z, Jung E. 2024. A study on the design and development of carpet using Li textile patterns. *Psychology Research* 14:359–372
- [46] Luo Y, Dai H, Wang H, Mei W. 2011. Chemical constituents from Dragon's Blood of *Dracaena cambodiana*. *Chinese Journal of Natural Medicines* 9:112–114
- [47] Xu Y, Peng J, Li S, Liu Y, Wen D, et al. 2024. A chromosome-level genome assembly of *Dracaena cambodiana* and comparative genomics analysis highlights the distinct biological features of two resource species of dragon's blood. *bioRxiv*
- [48] Zhao JL, Zhang L, Dayanandan S, Nagaraju S, Liu D, et al. 2013. Tertiary origin and pleistocene diversification of Dragon Blood tree (*Dracaena cambodiana*-Asparagaceae) populations in the asian tropical forests. *PLoS One* 8:e60102
- [49] Chele KH, Piater LA, van der Hooft JJJ, Tugizimana F. 2025. Bridging Ethnobotanical Knowledge and Multi-Omics Approaches for Plant-Derived Natural Product Discovery. *Metabolites* 15:362
- [50] Karalija E, Macanović A, Ibragić S. 2025. Revisiting Traditional Medicinal Plants: Integrating Multiomics, *In Vitro* Culture, and Elicitation to Unlock Bioactive Potential. *Plants* 14:2029
- [51] Baby J, Thomas T, Thomas TD. 2023. Metabolomics of important medicinal plants. In *Phytochemical Genomics*, eds. Swamy MK, Kumar A. Singapore: Springer. pp. 285–317 doi: 10.1007/978-981-19-5779-6_11
- [52] Verma K, Deep P, Srivastava V, Dwivedi J, Verma S. 2022. Pharmacognostical Properties and Medicinal Uses of *Broussonetia papyrifera* (Moraceae): A Review. *International Journal of Pharmaceutical Sciences Review and Research* 17:96–101
- [53] Obour R, Oppong SK, Abebrese IK. 2017. Chemical composition and nutritive value of an invasive exotic species *broussonetia papyrifera* in Ghana. *Journal of Natural Sciences Research* 7:45–53
- [54] Saito K, Saito K, Linquist B, Keobualapha B, Shiraiwa T, et al. 2009. *Broussonetia papyrifera* (paper mulberry): its growth, yield and potential as a fallow crop in slash-and-burn upland rice system of northern Laos. *Agroforestry Systems* 76:525–532
- [55] Zheng DJ, Xie LS, Zhu JH, Zhang ZL. 2012. Low genetic diversity and local adaptive divergence of *Dracaena cambodiana* (Liliaceae) populations associated with historical population bottlenecks and natural selection: an endangered long-lived tree endemic to Hainan Island, China. *Plant Biology* 145:828–838
- [56] Shen HY, Wang H, Zuo WJ, Zhao YX, Luo Y, et al. 2013. A new phenylpropanoid glycoside from dragon's blood of *Dracaena cambodiana*. *Chemical Research in Chinese Universities* 29:483–486
- [57] Suh SJ, Bombay K. 2015. Scale insects (Hemiptera: Coccoidea) found on dracaena and ficus plants (Asparagales: Asparagaceae, Rosales: Moraceae) from southeastern Asia. *Insecta Mundi* 448:1–10
- [58] Zheng DJ, Yun Y, Wu YJ, Li HW, Zhang ZL. 2012. 海南龙血树野生资源分布及其与水热关系的分析 [Geographical Distribution of Wild *Dracaena cambodiana* in China and Its Relationship with Hydrothermal Factors]. *热带亚热带植物学报 [Journal of Tropical and Subtropical Botany]* 20:326–332 (in Chinese)
- [59] Wang S, Xiao Y, Zhou ZW, Yuan J, Guo H, et al. 2021. High-quality reference genome sequences of two coconut cultivars provide insights into evolution of monocot chromosomes and differentiation of fiber content and plant height. *Genome Biology* 22:304
- [60] Yang Z, Liu Z, Xu H, Li Y, Huang S, et al. 2023. ArecaeaeMDB: a comprehensive multi-omics database for Arecaeae breeding and functional genomics studies. *Plant Biotechnology Journal* 21:11
- [61] Xu J, Zou R, Chai S, Jiang H, Zhong W, et al. 2025. Single nucleotide polymorphism markers based on hyper-seq revealed the genetic diversity and genetic relationship of *Horsfieldia hainanensis* in China. *Forests* 16:217
- [62] Li Z, Zhang D, Shi P, Htwe YM, Yu Q, et al. 2023. Cell wall lignification may be necessary for somatic embryogenesis of areca palm (*Areca catechu*). *Scientia Horticulturae* 307:111538
- [63] Mu Z, Guo X, Biddle J, Foale M, Li Z, Adkins S. 2020. A Newly Designed Chamber for the Acclimatization of Coconut Plantlets Coming from *In Vitro*. *In Vitro Cellular & Developmental Biology-Animal* 56:44
- [64] Mu Z, Li Z, Bazrafshan A, Kalaipandian S, Kong EYY, et al. 2024. Temporary Immersion Culture: A Potential *In Vitro* Culture Method for the Clonal Propagation of Coconut. *Horticulturae* 10:946
- [65] Sathisrajan N, Chandeeep HMA, Rathnayake SC, Vidhanaarachchi S, Vidhanaarachchi VRM. 2025. Advanced plant growth recognition model with deep learning for the coconut tissue culture. *Proc. 2024 9th International Conference on Information Technology Research (ICITR), 5–6 December 2024, Colombo, Sri Lanka*. USA: IEEE. pp. 1–6 doi: 10.1109/ICITR64794.2024.10857788
- [66] Pithiya MB, Sharma SK, Sharma M, Sharma M, Kotwal N. 2022. Advancements and challenges in plant tissue culture: a comprehensive overview. *Journal of Plant Biota* 1:12–16
- [67] Kong EYY, Mu Z, Vidhanaarachchi VRM, Nguyen QT, Sisunandar S, et al. 2024. Coconut biotechnology. In *The Coconut: Botany, Production and Uses*. Wallingford: CABI. pp. 143–158 doi: 10.1079/9781789249736.0010
- [68] Zhang M, Sun Y, Lan Y, Cheng L, Lv Z, et al. 2024. Multiomics joint analysis reveals the potential mechanism of differences in the taproot thickening between cultivated ginseng and mountain-cultivated ginseng. *BMC Genomics* 25:1228
- [69] Zhao M, Che Y, Gao Y, Zhang X. 2024. Application of multi-omics in the study of traditional Chinese medicine. *Frontiers in Pharmacology* 15:1431862



Copyright: © 2026 by the author(s). Published by Maximum Academic Press, Fayetteville, GA. This article is an open access article distributed under Creative Commons Attribution License (CC BY 4.0), visit <https://creativecommons.org/licenses/by/4.0/>.