

## Nutritional values, bioactive compounds, and biological activities of some edible indigenous plants from Thailand: A review

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### Abstract

Thai edible indigenous vegetables are used as traditional food and folklore medicines. This review aims to integrate consumption culture and functional health impact of eight edible plants, that are, *Gnetum gnemon* var. *tenerum*, *Gymnema inodorum* (Lour) Decne, *Albizia lebbeck* (L.) Benth, *Melientha suavis* Pierre, *Sauropus androgynus*, *Glochidion wallichianum*, *Piper sarmentosum* Roxb, and *Basella alba* L., which are commonly consumed by local Thai people. Reviews of all eight mentioned plants demonstrated essential pharmacological activity, including antioxidant activity, and health functions, such as antidiabetic, anti-obesity, antihypertensive, antimicrobial, anti-cancer, and anti-inflammatory usage; they also help prevent neurotransmitters from degrading. However, comprehensive animal tests and clinical trials are needed to further clarify the results to increase utilization and safety as well as commercialization of these plants.

**Keywords:** bioactive compounds; biological activity; edible indigenous plants; local foods; nutrition

### Introduction

Indigenous plants are found in a particular area or region that provides a specific ecosystem comprising climate, moisture, light, and soil conditions. These plants have survived for thousands of years and exhibit specific characteristics (Bean, 2007). Local Thai people have been consuming edible indigenous plants growing in forests, on mountains, and in gardens and backyards for hundreds of years and have accumulated knowledge about their characteristics, taste, flavor, and aroma for consumption as a side dish in cooking and as a folk medicine (Maneenoon *et al.*, 2015). Thailand has a tropical climate which supports a large biodiversity of plants, particularly indigenous edible plants that are important food sources and are rich in carbohydrates, fibers,

vitamins, minerals (Suttisansanee *et al.*, 2023), and proteins (Siripongvutikorn *et al.*, 2023b).

Several scientific documents have investigated diverse bioactive constituents and health functions of local plants. Fourteen species of southern Thailand local edible plants, such as *Champereia manillana*, *Lactuca indica*, *Glochidion perakense*, *Parkia timoriana*, *Diplazium esculentum*, *Portulaca oleracea*, *Amaranthus caudatus*, *Gnetum gnemon*, *Lasia spinosa*, *Citrus reticulata*, *Curcuma longa*, *Oenanthe javanica*, *Anacardium occidentale*, and *Alpinia conchigera*, were tested as sources of macronutrients, micronutrients, and bioactive compounds, including  $\beta$ -carotene, lutein, polyphenols, cyanidin, peonidin, and anthocyanidins (Kongkachuichai *et al.*, 2015). Twenty-eight edible local plants (*Oenanthe*

*javanica*, *Houttuynia cordata*, *Gymnema inodorum*, *Hapaline benthamiana*, *Aegle marmelos*, *Antidesma ghaesembilla*, *Eleutherococcus trifoliatus*, *Glochidion hirsutum*, *Glinus oppositifolius*, *Sphenoclea zeylanica*, *Basella alba* L., *Acmella oleracea*, *Polygonum odoratum*, *Glochidion sphaerogynum*, *Ocimum gratissimum*, *Bauhinia purpurea*, *Amaranthus lividus*, *Erythralum scandens*, *Ficus geniculata*, *Caesalpinia mimosoides*, *Clinacanthus nutans*, *Clausena excavata*, *Aspidistra sutepensis*, *Tiliacora triandra*, *Amomum* sp., *Schinus terebinthifolius*, *Coriandrum* sp., and *Dregea volubilis*) from the north of Thailand recorded antioxidant properties with high caffeic acid, gallic acid, chlorogenic acid (CGA), *p*-coumaric acid, *o*-coumaric acid, catechin, ferulic acid, protocatechuic acid (PCA), and quercetin, with *C. mimosoides* Lam., *D. volubilis* Benth., *A. ghaesembilla*, and *Houttuynia cordata* Thunb showing potential anti-diabetic properties (Dedvisitsakul and Watla-Iad, 2022).

In northeast Thailand, 33 species of edible local plants showed antioxidant activity and organoleptic flavors, such as sweetness, spiciness, sourness, and umami (Chantan *et al.*, 2023). Many tribes (Karen and Lawa community) rely on 12 species of wild edible indigenous leafy plants (i.e. *Lygodium flexuosum*, *Acmella paniculata*, *Clerodendrum glandulosum*, and *Ficus auriculata*) as sources of body minerals, particularly magnesium (Punchay *et al.*, 2020). The consumption method of each plant depends on plant type, personal likes, culture, region, circumstances, income, literacy, and facility support as well as local wisdom. For instance, southern Thais do not eat young mango leaves due to their latex, bitter, and astringent taste, compared to the raw materials available in southern region, where are source of durian, mangosteen, coconut, rambutan, and cashew, whereas northern hill tribes prefer leaves of young mango, which is the main crop and is used as the crucial component of salad and soup. It is pointed out that a number of plants are consumed due to village wisdom, availability, or other

conditions. In addition, some Thais eat fruits and young leaves of cashew, while others eat only seeds or nuts. Raw cashew seeds are used as an important ingredient for spicy curry and mixed vegetable soup as well as sweet items (Figure 1) found in southern Thailand, but not in other areas, where the plant is not grown.

Consumption of plants has gained momentum globally due to their health benefits, their capacity to combat several non-communicable diseases (NCDs) as well as infectious diseases, such as smallpox, plague, scarlet fever, cholera, typhoid fever, and malaria (Jiang and Wen, 2021). Edible indigenous plants, particularly in Thailand, which is known as the 'kitchen of the world', are now receiving increased attention due to their freshness, less chemical usage, and richness in phytochemicals as well as for purpose of food security. Therefore, this review attempts to integrate and illustrate eight indigenous Thai plants, such as *G. gnemon* var. *tenerum* (Liang), *G. inodorum* (Lour) Decne (Chiang-Da), *A. lebeck* (L.) Benth (Ta-Khuk), *M. suavis* Pierre (Pak-Wan-Pa), *S. androgynus* (L.) (Pak-Wan-Bann), *G. wallichianum*/*G. perakense* (Mon-Pu), *P. sarmentosum* Roxb. (Cha-Plu) and *B. alba* L. (Pak-Plang), to better understand food culture, biological activity, and health benefits. It is expected that this information will support the possibility of developing edible indigenous plants to become nutraceutical, functional ingredients, and food products.

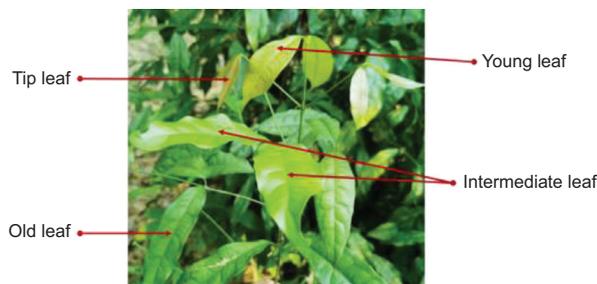
## Edible indigenous plants of Thailand

### *Gnetum gnemon* var. *tenerum* (Liang)

*G. gnemon* var. *tenerum* (Figure 2) is a popular indigenous edible plant of southern Thailand with local names *Liang* or *Miang*. Other countries, such as Indonesia, Malaysia, the Philippines, and Australia, have also reported the *Gnetum* plant but with different



**Figure 1.** (A, B) Raw cashew nut and its menus; (C) spicy curry dish; (D) mixed vegetable soup; (E) sweet snacks. *Source:* the authors.



**Figure 2.** Edible parts of *Gnetum gnemon* var. *tenerum* include tip, young, and intermediate leaves. Source: the authors.

sub-species, characteristics, and names, such as *Melinjo*, *Belinjau*, and *Bago* (Anisong et al., 2022). *G. gnemon* var. *tenerum* grows as a shrub, 3 m in height with small fruits, and sleek, smooth lanceolate, elliptical, and ovate oblong leaves. *G. gnemon* var. *gnemon* is a tree, with bigger fruit, larger seeds, and longer leaves than *G. gnemon* var. *tenerum* (Anisong et al., 2022). Four stages of plant leaf growth include (1) tip or apex; with brownish red-full-leaf, small and very soft, (2) young leaf; with brownish red or mixed with light green and soft, (3) Intermediate leaf (pe-slat); with light green to green and soft leaf, and (4) old leaves; dark green and inflexible that cannot be folded without breaking (Siripongvutikorn et al., 2023b). Most people in Thailand consume Liang leaves in stages of tips to intermediate as fresh, cooked, and side dishes. Popular menus are coconut milk curry, stir-fried with egg, and vegetable soup without coconut milk (Figure 3).

Recently, many researchers have attempted to develop value-added products to support busy lifestyles, health concerns, and global demand. Siripongvutikorn et al. (2023a) reported using *G. gnemon* var. *tenerum* leaves instead of sea algae to make dried seasoning added with shrimp and dried sesame seeds. Results obtained good sensory scores of  $7.10 \pm 1.24/9$  on hedonic scale. The product also provided total phenolic content (TPC) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) scavenging activity as  $2575.28 \pm 103.80$   $\mu\text{g}$  gallic acid equivalent (GAE)/g dry weight (DW) and  $0.677 \pm 0.0063$  mg Trolox equivalent (TE)/g DW. Several petty patents recorded in Thailand include crispy baked Liang vegetable (IPC A23B



**Figure 3.** Stir-fried Liang leaves with (A) egg, and (B) coconut milk curry. Source: the authors.

7/005, 2016), ice-cream milk with Liang (IPC A23L 1/00, 2023), and functional drink powder from Sangyod rice extract with Liang with probiotic (IPC A23L 2/385 and A23L 7/00, 2023) (Department of Intellectual Property, Ministry of Commerce, Thailand, 2024).

The nutritional composition of *G. gnemon* var. *tenerum* (intermediate leaves) includes carbohydrates, proteins, fat, and dietary fiber as  $65.63 \pm 2.63$ ,  $25.41 \pm 0.68$ ,  $2.30 \pm 0.10$ , and  $41.27 \pm 0.16$  g/100 g DW, respectively, with complete essential amino acids, vitamin A, vitamin C, calcium, copper, iron, magnesium, and zinc (Siripongvutikorn et al., 2023b). Suksanga et al. (2023) reported that *G. gnemon* var. *tenerum* powder contained TPC, ferric reducing antioxidant power (FRAP), DPPH radical scavenging activity, and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid (ABTS) radical scavenging activity at  $3548.78 \pm 346.25$ ,  $192.79 \pm 18.90$ ,  $152.90 \pm 7.83$ , and  $767.21 \pm 40.66$  GAE/g DW, respectively. Chlorophyll and chlorophyllin found in *G. gnemon* var. *tenerum* leaves inhibited gluconeogenesis, increased glucose uptake of rat muscle cells via GLUT 4, and decreased non-fasting blood glucose and hemoglobin A1c (HbA1C). However, the antidiabetic and antihyperglycemic mechanisms remained and required further study.

Testing of *G. gnemon* var. *tenerum* leaf extract on the gut model found that short chain fatty acids (SCFAs) produced during fermentation were propionic acid, butyric acid, and acetic acid as  $5.369 \pm 0.66$  mM,  $4.698 \pm 0.61$  mM, and  $23.503 \pm 4.51$  mM, respectively (Anisong et al., 2023). It is well known that SCFAs are linked to health improvement, including anti-inflammatory, anti-obesity, and immunoregulatory activity to protect against cardiovascular, antidiabetic, and neuroprotective conditions (Xiong et al., 2022). Suksanga et al. (2023) studied the acute and sub-chronic toxicity of *G. gnemon* var. *tenerum* powder in culture cells and *Wistar* rats. Results indicated no cytotoxicity based on cell viability higher than 80%. *Wistar* rats did not show any abnormal symptoms, noxious, and death after oral administration of 2 g/kg b.w. for 14 days during acute toxicity testing. It was observed that *Wistar* rats treated with 1.47 g/kg Liang leaves powder were 100% survivors and showed no toxic symptoms in both genders during sub-chronic toxicity testing for 90 days. Body weight, organ weight, and growth rate were normal, without significant differences, compared to the control group. Normally leaf plants contain some compounds that interact with various protease enzymes and nutrients leading to enzymes dysfunction and reduction in digestion of nutrients, decreased absorption (Samtiya et al., 2020). Some antinutrients included phytates, tannins, phenolic, oxalates, and hydrocyanic acid and were found in *G. africanum* and *G. buchholzianum* (Suzanne et al., 2017; Ekpo et al., 2012). Fresh leaves of *G. africanum* contained phytase, tannins, phenolics, and

oxalates as  $240.23 \pm 14.25$ ,  $298.09 \pm 13.70$ ,  $507.19 \pm 21.53$ , and  $50.10 \pm 0.71$  mg/100 g DW, respectively. In addition, *G. africanum* and *G. buchholzianum* had high protein but antinutrient inhibited protein digestibility that heat cooking can reduce antinutrient and increase protein digestibility (Suzanne *et al.*, 2017). Although *G. gnemon* var *tenerum* has not been documented for antinutritional compounds, in particular for phytate, self-awareness and caution of its over consumption must be considered.

### *Gymnema inodorum* (Lour) Decne (Chiang-Da)

*G. inodorum* (Lour) Decne (Figure 4) is mainly found in south China and southeast Asia, including Thailand, Indonesia, and the Philippines. *G. inodorum*, a local vegetable of northern Thailand, belongs to the Apocynaceae family with several local names such as *Jiang-Da*, *Chiang-Da*, *Pak-Kut*, *Pak-Muan Ki*, and *Pak-Seng*. *G. inodorum* (Lour) Decne is a woody climbing shrub with green or dark green smooth leaves. The leaf shape is ovate or elliptic, the leaf apex is cuspidate while the leaf base is obtuse (Norkumai *et al.*, 2023). Its flower inflorescence could be white, light-yellow, or yellow-orange as shown in Figure 4. The color of fruit and nib is green. *G. inodorum* (Lour) Decne has similar characteristics as that of *Gymnema sylvestri* (Asclepiadaceae) found in central and western India, tropical Africa, and Australia. *G. sylvestri* is used as a commercial supplement to treat or prevent diabetes and contains gymnemic acid as an important blood glucose level regulator (Tiwari *et al.*, 2014). *G. inodorum* in Thailand has the

potential for more applications and uses. The young *G. inodorum* (Lour.) Decne Leaves are used for cooking different dishes, such as stir-fried Chiang-Da with egg or other protein sources, Chiang-Da curry soup, Chiang-Da omelet as well as side dishes with chili paste (Figure 5). Petty patents include Chiang-Da with mulberry leaves tea (IPC; A23L 2/39). Thai inventors developed a low-sugar *Gymnema* jelly gummy prepared from Chiang-Da (Thailand Techshow, 2024). Chiang Mai University (2022) developed Chiang-Da instant curry as a university invention product champion.

The proximate composition of *G. inodorum* (Lour) Decne is shown in Tables 1 and 2. Jeytawan *et al.* (2022) reported that *G. inodorum* contained gymnemic acid in various preparations of its leaves, such as (1) fresh, (2) baked, (3) baked and roasted, (4) dried, (5) dried and roasted, (6) dried with roasted and fermented, (7) dried, roasted, and boiled for 30 s, and (8) dried, roasted, and boiled for 60 s as  $19.4 \pm 0.1$ ,  $102.0 \pm 12.2$ ,  $78.6 \pm 8.6$ ,  $64.2 \pm 6.4$ ,  $97.4 \pm 11.5$ ,  $125.8 \pm 15.7$ ,  $57.8 \pm 6.6$ , and  $46.0 \pm 3.7$  µg/g, respectively. Phytochemical compounds of *G. inodorum* (Lour.) Decne determined by Liquid chromatography-quadrupole time-of-flight tandem mass spectrometry (LC-Q-TOF/MS) included 6-hydroxykaempferol 7-rutinoside, ascorbyl stearate, adenosine, gymnemic acid I, phenethylamine, momordin Ia, saikosaponin L, isoorientin 2''-[feruloyl-(-)-6]-glucoside], and kaempferol 7-O-glucoside (Jeytawan *et al.*, 2022). The gas chromatography-mass spectrometry (GC-MS) analysis of volatile oil of *G. inodorum* (Lour.) Decne contained the following 16 compounds: linolenic

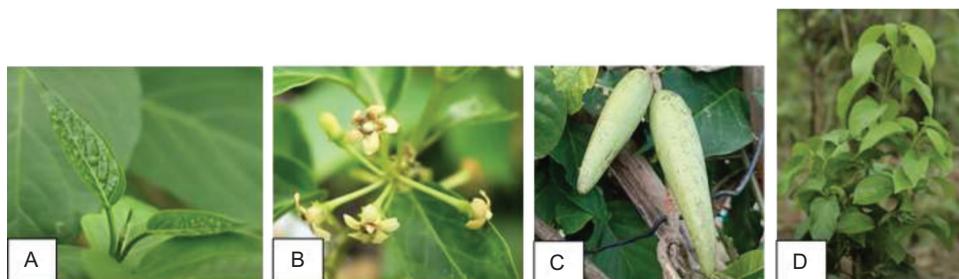


Figure 4. (A) Tip, (B) flowers, (C) fruits, and (D) tree of Chiang-Da. Source: the authors.



Figure 5. (A) Stir-fried Chiang-Da with egg, (B) Chiang-Da curry soup, and (C) Chiang-Da instant curry. Source: the authors.

acid, n-hexadecanoic acid or palmitic acid, methylparaben, 9,12,15-octadecatrienal, beta-monolinolein, phytol, glycerol beta-palmitate, 2,3-dihydrobenzofuran, tetradecanoic acid, stigmaterol, dl- $\alpha$ -tocopherol, octadecanoic acid,  $\gamma$ -tocopherol, olean-12-ene-3,28-diol, 2-methoxy-5-vinylphenol, and squalene (Dunkhunthod *et al.*, 2021). Saponins 34.50–81.60 mg/g dry extract was also found in this plant. Srinuanchai *et al.* (2021) reported that extract of *G. inodorum* leaves contained (3 $\beta$ ,16 $\beta$ )-16,28-dihydroxyolean-12-en-3-yl-O- $\beta$ -D-glucopyranosyl- $\beta$ -D-glucopyranosiduronic acid (GIA1) or triterpene glycoside, indicating anti- $\alpha$ -amylase and  $\alpha$ -glucosidase. *G. inodorum* improved glucose absorption in intestinal testing by a CaCo<sub>2</sub> cell model (epithelium cell from colon tissue) and increased sodium glucose co-transporter type 1 (SGT1), a transporter protein for moving glucose from the lumen into epithelium cells by sodium ion activation, leading to GIA1 and inhibiting SGT1, thereby reducing glucose uptake. The leaves extract of *G. inodorum* retarded hypoxia by decreasing free radical (reactive oxygen species [ROS]) production (Surinkaew *et al.*, 2024).

### *Albizia lebbbeck* (L.) Benth (Ta-Khuk)

*A. lebbbeck* (L.) Benth is distributed in Asian countries, such as Cambodia, Indonesia, Laos, Malaysia, Vietnam, and Thailand. This deciduous woody tree grows to 20–30-m height. The trunk is brown or gray and chapped lengthwise and crosswise (Figure 6A). The leaves are bipinnate or twice pinnate containing 2–4 pairs on each side, and obtuse in shape (Figure 6B). The flowers are white-yellow (Figure 6C) and the fruits are pods, ruler-shaped or flat (Figure 6D). Young fruit is green-yellow and old fruit is brown in color (Nanthapat, 2010). *A. lebbbeck* is also known as *Ta-khuk*, *Ma-kham-khok*, *Suk*, and *Phruet* in Thai. The local people mainly consume tips and young leaves. In Thailand, *A. lebbbeck* is used as a side dish after blanching, and in cooked menus, such as Ta-Khuk leaf with grilled frog curry, Ta-Khuk leaf sour curry, Khanom sommanat with Ta-Khuk leaf, and Ta-Khuk leaf salad.

The edible part (tip and young leaves) of *A. lebbbeck* contains protein, fat, available carbohydrates, ash, and fiber

as 28.43, 3.95, 34.81, 9.29, and 23.57 g/100 g DW, respectively. Vitamin C, calcium, phosphorus, magnesium, sodium, potassium, iron, copper, and zinc contents are 695.24, 885.71, 652.38, 295.24, 176.19, 2057.14, 4.05, 1.05 and 4.43 mg/100 g DW, respectively. This plant also contains various bioactive compounds, including  $\alpha$ -carotene 5.6 $\pm$ 0.4 mg/100 g fresh weight (FW),  $\beta$ -carotene 37.2 $\pm$ 5.7 mg/100 g FW, and total carotenoids 42.8 $\pm$ 5.6 mg/100 g FW with total polyphenol 383 $\pm$ 61 mg GAE/100 g FW (Sridonpai *et al.*, 2022). Sirichai *et al.* (2022) reported that the tips and young leaves of *A. lebbbeck* contained flavonoids, such as quercetin 61.87 $\pm$ 1.83, kaempferol 36.39 $\pm$ 3.30, luteolin 134.20 $\pm$ 8.00, apigenin 105.11 $\pm$ 7.63, and isorhamnetin 8.05 $\pm$ 0.27 mg/100 g DW, and TPC as 24.18–28.89 mg GAE/g DW. Antioxidant activities determined by DPPH scavenging, FRAP, and Oxygen Radical Absorbance Capacity (ORAC) assay were 0.052–0.055, 102.53–135.32, and 473.85–516.64  $\mu$ mol TE/g DW. Carbohydrate enzyme digestion was inhibited by  $\alpha$ -amylase and  $\alpha$ -glucosidase at 4.80–6.79% and 19.10–25.88%, respectively. Inhibition of carbohydrate digested enzymes of glucose absorption and blood level glucose provided anti-hyperglycemic and antidiabetic effects. However, nonenzymatic processes between reducing sugar and protein or protein glycation can cause diabetes due to changing membrane structure. The final advanced glycation end products (AGEs) generated oxygen free radicals that induced intra-cellular and extra-cellular inflammation causing diabetic complications (Singh *et al.*, 2014). Anti-glycation activities of *A. lebbbeck* were 55.65–60.89% determined by bovine serum albumin (BSA) induced by either sugar (D-glucose) or methylglyoxal (MG) as 30.07–33.57% (Sirichai *et al.*, 2022). Cholinesterase inhibition is related to acetylcholinesterase (AChE) and butyrylcholinesterase (BChE) enzymes degrading neurotransmitters. *A. lebbbeck* extract inhibited AChE and BChE activities at 38.10–40.72% and 68.77–74.67%, respectively (Sirichai *et al.*, 2022). Young leaf extracts of *A. lebbbeck* with different solvents included hexane (AHE), mixed solvent (AME), and 95% ethanol (AEE). The AHE and AME extract did not show any toxicity to HMC3 cells (cell viability > 80%) with a concentration of 1–100  $\mu$ g/mL, while AEE expressed toxicity to cells at 50–100  $\mu$ g/mL. Oxidative stress and endoplasmic reticulum tension are induced by glutamate, a major excitatory neurotransmitter involved

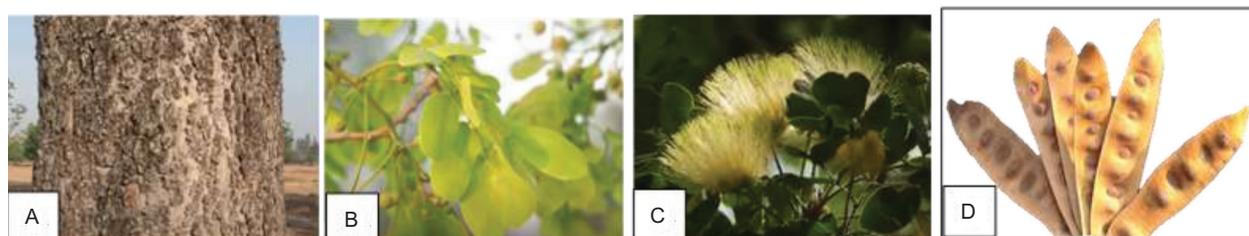


Figure 6. (A) Husk of the trunk, (B) tip and young leaf, (C) flower, and (D) pod of *Albizia lebbbeck* (L.) Benth. Source: the authors.

with increasing calpain-1 and caspase-12. Higher calpain-1 and caspase-12 indicate higher endoplasmic reticulum tension. Results showed that AHE reduced the expression of calpain-1 and cleaved caspase-12 more than the control group of HMC3 cells exposed to glutamate (Phoraksa *et al.*, 2023).

### ***Melientha suavis* Pierre (Pak-Wan-Pa)**

*Melientha suavis* Pierre (Figure 7) is called *Pak-Wan-Pa*, where *Pa* means 'forest', 'wild', or 'jungle'. This plant belongs to the family Opiliaceae. *M. suavis* Pierre is found in southeast Asian countries, including Malaysia, Cambodia, the Philippines, Vietnam, and Laos (Ruttanaphan *et al.*, 2022) and grows as a wild small deciduous tree with simple and alternate leaves—elliptical- and ovate-shaped. The inflorescent-type flowers are light green in color and grow on the trunk and branches. The young aggregate fruit is green and mature fruit is yellow in color (Thailand Institute of Scientific and Technological Research, 2015). The leaves of *M. suavis* have a sweet taste. The local people in northern and northeastern areas consume the leaf tip, young leaf, young flowers, and fruit either fresh or cooked. Popular menus of this plant include Pak-Wan-Pa salad, stir-fried Pak-Wan-Pa with egg, Pak-Wan-Pa soup, stir-fried spicy Pak-Wan-Pa, omelet Pak-Wan-Pa, and Pak-Wan-Pa curry. The Thailand Institute of Scientific and Technological Research (2015) created *Melientha* spicy curry. The extract of *M. suavis* leaves is used to develop sunscreen with antioxidant properties (Sansomchai *et al.*, 2021). An indigenous plant that shares similar characteristics, except the flower, with *M. suavis* is *Urobotrya siamensis*, but this plant is not consumed due to high toxicity (Bunakharasawat *et al.*, 2019). Up to 15 deaths are reported due to consumption of *U. siamensis* (Tourdjman *et al.*, 2009) with unidentified poisonous compound. The flower of *U. siamensis* is raceme type, while the flower of *M. suavis* is panicle-type, as shown in Figure 8.

Nutritional values of tips and young leaves of *M. suavis* are shown in Tables 1 and 2. Contents of vitamins and

minerals discovered in the fresh tips and young leaves of *M. suavis* included vitamin C, calcium, phosphorus, magnesium, sodium, potassium, iron, copper, and zinc as 1124.67, 206.90, 583.55, 297.08, 58.36, 1586.21, 7.96, 1.01, and 4.41 mg/100 g DW, respectively (Sridonpai *et al.*, 2022). Bioactive compounds of *M. suavis* include chrysoeriol, alkaloids, anthraquinone, coumarin, flavonoids, saponins, sterols, terpenoids, and tannins (Charoenchai *et al.*, 2013). Both tips and young leaves contain  $\beta$ -cryptoxanthin,  $\alpha$ -carotene, and  $\beta$ -carotene as  $3.0\pm 1.0$ ,  $4.0\pm 2.2$ , and  $21.0\pm 5.5$ . Total carotenoids, TPC, and antioxidant activities of tips and young leaves were  $28.0\pm 8.7$  mg/100 g FW,  $292\pm 86$  mg GAE/100 g FW, and  $10,643\pm 1721$   $\mu$ mol TE/100 g FW, respectively (Sridonpai *et al.*, 2022). Sansomchai *et al.* (2021) stated that the plant leaf extract exhibited  $IC_{50}$  values determined by ABTS and DPPH assays as  $64.17\pm 5.76$   $\mu$ g TE/mL and  $6.31\pm 1.73$   $\mu$ g ascorbic acid/mL, respectively, with TPC as  $149.87\pm 2.72$  mg GAE/g extract and total flavonoid content (TFC) as  $51.60\pm 4.12$  mg catechin/g extract.

### ***Sauropus androgynus* L. (Pak-Wan-Bann)**

*Sauropus androgynus* L., of the Phyllanthaceae family, is cultivated in Asia and Indochina countries, including India, Bangladesh, China, Indonesia, Malaysia, and Thailand. *S. androgynus* is a shrub with pinnately compound leaves (Figure 9A), ovule- and lance-shaped. The top side of the leaf is dark green and under side light green in color; the flowers are cymose-type (Figure 9B), dark red in color, and look like an umbrella or plate. The fruit (Figures 9B and 9C) is globular-shaped, with a red calyx. Young fruits are light yellow-green and turn light pink when mature. The seed (Figure 10C) is black or white in color and hard (Anju *et al.*, 2022). Local names in Thailand are *Ma-Yom-Pa*, *Kaan-Tong*, and *Pak-Wan-Tai-Bai*. The local people mostly consume its tips, young leaves, and fruits because of sweet taste and mild fragrance. Several menus, such as, soup, curry, stir-fried, and side dishes for chili paste are shown in Figure 10.



**Figure 7.** *Melientha suavis* Pierre: (A) tree, (B) tip and young leaves, and (C) fruits. Source: the authors.



**Figure 8.** Flowers of (A) *M. suavis*, and (B) *U. siamensis*. Source: the authors.

Nutritional values of *S. androgynus* (L.) leaves comprise 3.4–29.2% DW protein, 0.5–54.5% DW carbohydrates, 0.6–4.6% DW fat, 1.2–36.0% DW fiber, and 1.4–12.9% DW ash (Khoo *et al.*, 2015). Purba *et al.* (2022) found that *S. androgynus* contained vitamin C as 5.77–5.78 mg/g DW, total tannins as 0.04 mg/g DW, total flavonoids as 2.3–2.36 mg/g DW (catechin, rutin, myricetin, quercetin, apigenin, and kaempferol), total cinnamic acid as 0.18–0.20 mg/g DW (caffeic acid, syringic acid, *p*-coumaric acid, sinapic acid, and ferulic acid) and total essential oil as 0.32–0.33 mg/g DW. DPPH<sup>•</sup>, ·NO, and O<sub>2</sub><sup>•-</sup> scavenging in terms of IC<sub>50</sub> values were 13.14±0.055, 55.02±1.338, and 25.31±0.886 mg/mL, respectively. *S. androgynus* exhibited IC<sub>50</sub> values for inhibition activity, hemoglobin oxidation, and lipid oxidation as 11.96±0.011, 13.54±0.012, and 5.940±0.005 mg/mL, respectively. Moreover, the plant extract inhibited α-glucosidase at 9.83±0.032 mg/mL. For antimicrobial properties,

*S. androgynus* exhibited clear zones of *Staphylococcus aureus* and *Klebsiella pneumoniae* at 11.33±0.5774 mm and 13.66±0.577 mm, respectively (Paul and Anto, 2011).

Some research studies mentioned the side effects of *S. androgynus* consumption, with the contained papaverine causing bronchiolitis obliterans syndrome. Hsiue *et al.* (1998) reported that 49 patients who consumed 36–186 g/day *S. androgynus* for 12–150 days were associated with dyspnea. However, Ou *et al.* (2013) who conducted study after 15 years of Hsiue *et al.*'s (1998) findings, described 16 of the 49 patients who survived and could be contacted reported that none had a significant decline in lung functioning.

#### ***Glochidion wallichianum*/*Glochidion perakense* (Mon-Pu)**

Lemmens and Wulijarni-Soetjipito (1991) reported that *G. wallichianum* had different synonyms, such as *Glochidion glomerulatum* (Miq.) Boerl, while *Glochidion perakense* was a synonym of *Glochidion sumatranum*. In addition, the information stated that *G. perakense* and *G. wallichianum* were not from the same species. On the other hand, Yoon and Sakdiset, (2020) stated that *G. wallichianum* is a synonym of *G. perakense*. It is reported that *G. wallichianum* is referred by the local name of Mon-Pu (Chumsri *et al.*, 2022; Junsathian *et al.*, 2018), while some specified *G. perakense* as Mon-Pu (Kongkachuichai *et al.*, 2015).

**Table 1.** Nutritional values of the used parts of eight edible indigenous plants found in Thailand.

Scientific name	Parts	Proximate composition (g/100 g dry weight)					References
		Protein	Fat	Carbohydrate	Fiber	Ash	
<i>G. gnemon</i> var. <i>tenerum</i>	Tip, young and intermediate leaves	25.41–33.43	2.30–4.13	55.13–65.63	30.92–41.27	6.66–7.31	Siripongvutikorn <i>et al.</i> , 2023b
<i>G. inodorum</i> (Lour) Decne	Leaves powder	20.42–26.70	1.49–5.69	27.76–37.57	19.75–31.94	1.278–3.68	Norkumai <i>et al.</i> , 2023
<i>Albizia lebbbeck</i> (L.) Benth**	Tip and young leaves	28.43	3.95	34.81	23.57	9.29	Sridonpai <i>et al.</i> , 2022
<i>Melientha suavis</i> Pierre**	Tip and young leaves	40.85	3.61	21.96	28.38	5.25	Sridonpai <i>et al.</i> , 2022
<i>Sauropus androgynus</i>	Leaves	3.4–29.2	0.6–4.6	0.5–54.5	1.2–36.0	1.4–12.9	Khoo <i>et al.</i> , 2015
<i>Glochidion wallichianum</i> **	Leaves	13.40	0.71	79.05	ND*	ND*	Kongkachuichai <i>et al.</i> , 2015
<i>Piper sarmentosum</i> Roxb**	Leaves	26.50	8.42	9.40	39.34	16.17	Bureau of Nutrition, Department of Health, 2018
<i>Basella alba</i> L.**	Leaves	13.89	15.28	41.67	32	ND*	Kumar <i>et al.</i> , 2015
<i>Basella alba</i> L. var. <i>Rubra</i> **	Leaves	22.86	10.00	37.14	28.5	ND*	Kumar <i>et al.</i> , 2015

\*Not determined.

\*\*Means values are calculated on wet basis.

Table 2. Nutritional value of the used parts of eight edible indigenous plants found in Thailand.

Scientific name	Parts	Vitamins (mg/100 g dry weight)				Minerals (mg/100 g dry weight)							
		A	B9	C	Calcium	Copper	Iron	Magnesium	Zinc	Potassium	Sodium	Phosphorus	
<i>G. gnemon</i> var. <i>tenerum</i>	Tip, young and intermediate leaves	1.35–3.03	0.00–0.0375	2.71–5.25	374.11–450.71	0.47–0.56	3.63–4.46	193.1–196.76	3.18–4.58	ND*	ND*	ND*	
<i>G. inodorum</i> (Lour) Decne	-	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*	
<i>Albizia lebbeck</i> (L.) Benth**	Tip and young leaves	ND*	ND*	695.24	885.71	1.05	4.05	295.24	4.43	2057.14	176.19	652.38	
<i>Melientha suavis</i> Pierre**	Tip and young leaves	ND*	ND*	1124.67	206.90	1.01	7.96	297.08	4.41	1586.21	58.36	583.55	
<i>Sauropus androgynus</i> **	Leaves	18.60–132.88	ND*	555.45–2152.74	578.08	ND*	1455.48	4554.11	108.9	313.01	2097.95	419.18	
<i>Glochidion wallichianum</i> **	Leaves	ND*	ND*	89.62	400.57	ND*	2.74	266.40	ND*	1683.25	ND*	304.48	
<i>Piper sarmentosum</i> Roxb**	Leaves	9.34	ND*	120.22	2218.58	1.58	41.53	579.23	41.53	5060.11	234.97	163.93	
<i>Basella alba</i> L.**	Leaves	ND*	ND*	1027.78	1097.22	0.56	58.33	1027.78	2.78	7180.56	347.22	ND*	
<i>Basella alba</i> L. var. <i>Rubra</i> **	Leaves	ND*	ND*	971.43	1171.43	0.57	67.14	942.86	4.29	7114.29	271.43	ND*	

\*Not determined.

\*\*Mean values are calculated on wet basis under the mentioned references in Table 1A.

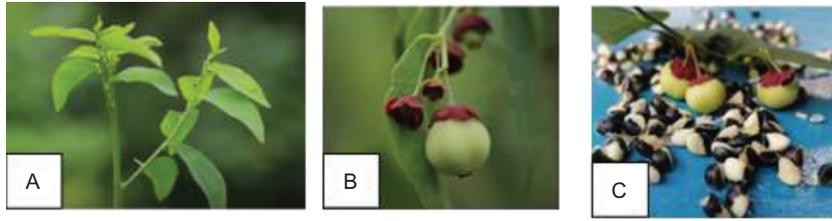


Figure 9. (A) Tip and young leaves, (B) flower and fruit, and (C) seeds of *Sauropus androgynus* (L.). Source: the authors.



Figure 10. Popular menus cooked from tips and young leaves of *S. androgynus* (L.): (A) stir fried, (B) coconut milk soup, and (C) spicy salad. Source: the authors.

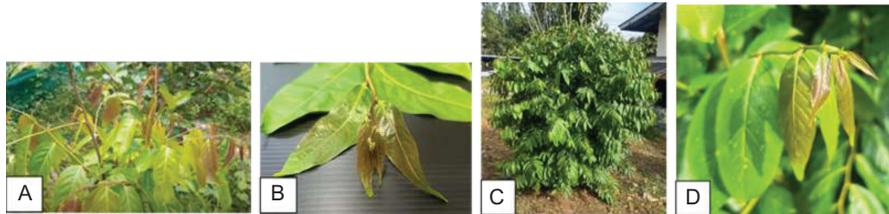


Figure 11. (A) Typical red type of tree; (B) tip and young leaves; (C) typical light green type of the tree; and (D) tip and young leaves of *Glochidion* plant. Source: the authors.

However, Supattra (2022) reported two typical tips or young leaves of Mon-Pu in Thailand that are red type (*G. perakense*) and white or green type (*G. wallichianum*), as shown in Figures 11 and 12. Interview data and market survey found that the light green tip type had a lesser bitter taste compared to the red tip, but variation of bitterness in each tip type was not consistent and could be due to various reasons, such as area of planting, light intensity, fertilizer, rainfall, and co-planting. No scientific data can explain the differences and typical characteristics of these species and further investigations are required. Mon-Pu is an indigenous plant of southern Thailand with different local names such as *Mon-Pu*, *Phung-Moo*, and *Yord-thaea*. Mon-Pu belongs to the Euphorbiaceae family and is found in Malaysia, Indonesia, northern Australia, and south China. Mon-Pu is a shrub or tree that grows to 8-m height, glossy, with ovate-oblong to ovate-lanceolate or elliptic-lanceolate leaves with acute or round base, brownish-green or green in color. The flower inflorescence is light green, separated between pistillate and stamen with six sepals and three stamens. The fruits are round, green when young and red when old with soft and short hair cover. The seeds are hemispheric

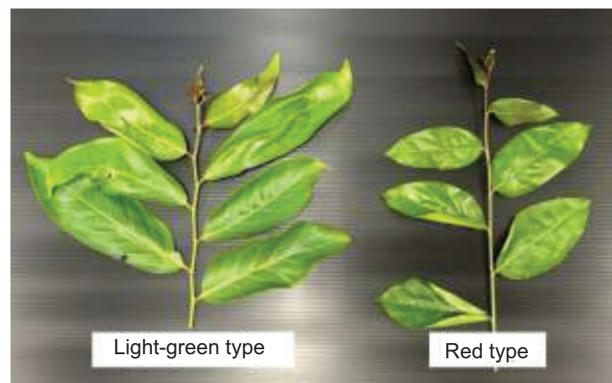


Figure 12. Characteristics of leaf and branches of the light green and red type of *Glochidion* plant. Source: the authors.

(Figure 13; Chheang et al., 2022; Sandhya et al., 2010). Local Thais consume young leaves as a side dish of vermicelli with spicy curry (Khanom-Jeen), chili paste, and curry. The plant leaves can be cooked in different menus, including stir-fried with egg and spicy salad, as shown in Figure 14.

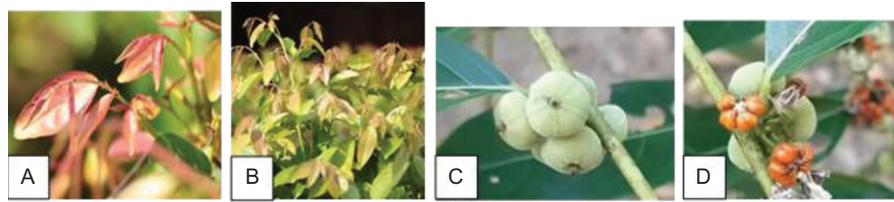


Figure 13. Characteristics of (A) tip, (B) edible leaves stage, (C) young fruits, and (D) seeds of *Glochidion* plant. Source: the authors.

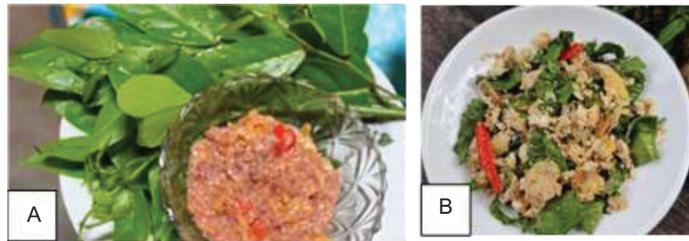


Figure 14. Popular cooked dishes or served with *Glochidion* plant leaves: (A) chili shrimp paste dip and (B) stir-fried with eggs. Source: the authors.

Kongkachuichai *et al.* (2015) reported that Mon-Pu (*G. perakense*/*G. wallichanum*) contained various nutritious compounds, such as vitamin C, vitamin E, calcium, phosphorus, potassium, magnesium, and iron (Tables 1 and 2). In terms of biological activity, Mon-Pu leaves are antioxidants due to  $\beta$ -carotene ( $1.41 \pm 0.017$  mg/100 g FW), lutein ( $3.43 \pm 0.094$  mg/100 g FW), cyanidin ( $13.29 \pm 0.85$  mg/100 g FW), gallic acid (26.75 mg/100 g), epicatechin gallate (ECG; 0.25 mg/100 g), and apigenin (0.039 mg/100 g); it also recorded the highest antioxidant activity based on hydrophilic (H-ORAC) and FRAP assay among 15 Thai indigenous vegetables, including *A. occidentale*, *O. javanica*, *G. gnemon*, and *P. timoriana* (Kongkachuichai *et al.*, 2015). This plant also showed TPC and TFC as  $248.33 \pm 7.72$  mg GAE /g crude extract and  $30.34 \pm 1.14$  mg quercetin equivalent/g crude extract, respectively, with DPPH scavenging activity of  $44.77 \pm 7.00$  mmol of TE/100 g crude extract and FRAP being  $364.12 \pm 32.28$  mmol of Fe (II)/100 g crude extract (Junsathian *et al.*, 2018). The plant extracts yielded antimicrobial properties determined by disc diffusion and tested with inhibition zones of *Staphylococcus aureus*, *Bacillus subtilis*, *Escherichia coli*, and *Pseudomonas aeruginosa* at 16 mm, 15 mm, 10 mm, and 13 mm, respectively. Results indicated minimum inhibitory concentrations (MICs) and minimum bactericidal concentrations (MIBs) as 0.78 and 25 (*S. aureus*), <1.56 and 25 (*B. subtilis*), 3.12 and 50 (*E. coli*), and 3.12 and 25 (*P. aeruginosa*) (Junsathian *et al.*, 2022). The antimicrobial activity of Mon-Pu ranged broadly for both Gram-positive and Gram-negative pathogenic bacteria. Interestingly, the plant extract also provided strong antioxidant activity by inhibiting A $\beta$  42 aggregate formation. Therefore, Mon-Pu

extract may be an alternative treatment to prevent or slow down dementia. The extract also promoted the viability of cells treated with hydrogen peroxide ( $H_2O_2$ ), demonstrating high potential to reduce oxidative stress (Junsathian *et al.*, 2018). Mon-Pu leaf extract improved rat liver damaged from ethanol (alcohol) via reduced secretion of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) functioning. Furthermore, the plant extract also decreased malondialdehyde (MDA) (the product of lipid peroxidation), referring to oxidative stress in cells. Results showed that the hepatic MDA level of rat fed with ethanol followed by Mon-Pu treatment was lower than fed with ethanol alone, and lessening in damaged tissue and reduction of triglycerides accumulation in the liver were also noticed (Samuhasaneeto *et al.*, 2022). Results indicated that adding Mon-Pu extract to rice starch led to improved retarding of starch digestibility, compared to brown rice starch because of high polyphenol content in the plant extract (Chumsri *et al.*, 2022). Fish sausage products with added Mon-Pu leaf extract also yielded lower values of lipid and protein oxidation during processing and storage, compared to the control (Wongnen *et al.*, 2022).

#### *Piper sarmentosum* Roxb. (Cha-Plu)

*Piper sarmentosum* Roxb. belongs to the Piperaceae family and is distributed in Malaysia, Thailand, Indonesia, Vietnam, China, the Philippines, and Myanmar (Akmal *et al.*, 2023; Ware *et al.*, 2023). In Thailand, *P. sarmentosum* is called by its local names such as *Cha-Plu* (central regions), *Nom-wa* (southern regions), *Pak-pu-na*,

*Plu-ling*, and *Pak-plu-nok* (northern regions), and *Pak-nang-leard*, *Pak-ei-leard*, and *Pak-care* (northeast regions). *P. sarmentosum* is a wiggle plant with a height of 20 cm. The leaves are light-green to dark-green in color, glossy and heart-shaped. The fruits are cylindrical and oval-shaped, thick and green with a sweet taste. The flowers are separated by gender, inflorescent type, oval-shaped and white as shown in Figure 15 (Mathew *et al.*, 2004; Othman *et al.*, 2022). Cha-plu is served as a side dish and cooked in coconut milk curry, spicy green mussel in coconut milk curry, and Miangkham or royal leaf wrap appetizer (Figure 16).

Ware *et al.* (2023) reported that dried leaves of *P. sarmentosum* contained 31 compounds comprising 2 flavonoids, 12 phenolics, 2 amides, 8 alkaloids, 2 terpenes, 3 lignans, and a sterol. Abundant biological compounds of this plant include caffeic acid, *p*-coumaric acid, ascorbic acid, gallic acid, catechin, syringic acid, rutin, sinapic acid, ferulic acid, cinnamic acid, myricetin, quercetin, apigenin, kaempferol, eugenol,  $\beta$ -sitosterol, naringenin, sarmentine, sesamin, 1-piperetyl pyrrolidine and pellitorine, quercetin, hesperidin, pipertiol, malvidin, and naringenin (Akmal *et al.*, 2023; Azelan *et al.*, 2022; Purba *et al.*, 2021). The highest component found in the plant leaf extract was 4H-pyran-4-one,2,3-dihydro-3,5-dihydroxy-6-methyl, followed by octanamide, N,N-dimethyl, and 3-(4-methoxyphenyl) propionic acid (Syed Ab Rahman *et al.*, 2014). *P. sarmentosum* leaf provided TPC as 10.98 mg GAE/g DW, TFC as 48.57 mg GAE/g DW, and DPPH scavenging activity as 46.84% (Wongsa *et al.*, 2012;

Ugusman *et al.*, 2012). Chaplu leaves contained oxalates as  $7026.6 \pm 76.9$  mg/100 g DW (Juajun *et al.*, 2012) and it caused a lower minerals (especially calcium) absorption and induced kidney stone (Petroski and Minich., 2020). However, antihyperglycemic properties of *P. sarmentosum* were reported and linked to anti- $\alpha$ -glucosidase activities but not to anti- $\alpha$ -amylase (Ugusman *et al.*, 2012).

By contrast, Sallehuddin *et al.* (2020) reported that *P. sarmentosum* did not show anti- $\alpha$ -glucosidase activity. However, *P. sarmentosum* reduced fasting blood glucose levels and increased insulin levels in diabetic mice (Luangpirom *et al.*, 2014). Diabetic Sprague-Dawley rats treated with plant extract displayed lower fasting blood glucose levels at 0.0232 mmol/mL, compared to non-treated groups at 231 mmol/L ( $p < 0.05$ ). The tested animals had higher body weight than the non-treated group of animals ( $p < 0.05$ ). They showed recovered cardiovascular system with improved nucleic size, and shape of cardiomyocytes as normal, reduced unregulated arrangements of myofibrils in the cardiac muscle, less dysfunctioning of mitochondria in the cardiac tissues, less endothelial injury, and decreased proliferation of the aorta tissue in the aortic wall, compared to the diabetic rat nontreated group (Thent *et al.*, 2012).

*P. sarmentosum* also improved liver tissue and recovered hepatocytes to normal size, reduced abnormal nucleic of hepatocytes, decreased necrotic cell (uncontrolled death cell occurs by cell injury resulting from the environment),



Figure 15. Characteristics of Cha-Pu include (A) wiggling and tipping leaves, (B) inflorescence, and (C) fruit. Source: the authors.

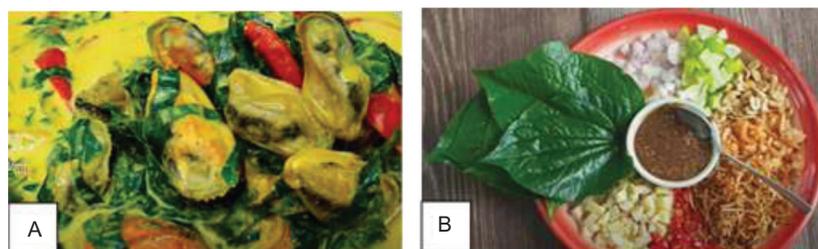


Figure 16. Popular menu of using Cha-Pu as a cooked ingredient or eaten as fresh leaves as a wrapping or side dish. (A) Spicy green mussel in coconut milk curry, and (B) Miangkham. Source: the authors.

and relieved bleeding from sinusoids, with increased liver weight (Thent and Das, 2015). The aqueous extract was given to spontaneous hypertensive rats (SHRs). Results showed lower systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) than the nontreated rats ( $p < 0.05$ ), with higher nitric oxide (NO) and reduced MDA levels (Zainudin *et al.*, 2015). Nitric oxide is released into vascular endothelium and helps to maintain vascular homeostasis, vasodilatation, proliferation of cell growth and regulation of endothelial function, which play a key role in blood flow and maintaining normal blood pressure (Zhu *et al.*, 2016). MDA is used as a biomarker of oxidative stress. Hypertensive patients have higher MDA levels than normal humans (Cristina *et al.*, 2007). NO is obtained from foods containing nitrate and/or nitrates, which are precursors of NO synthesis pathway. In addition, many leafy vegetables contain nitrates through roots absorption from soil into the xylem and sent to leaves for growth and development process, including regulation of biosynthesis, signaling, hormone, and transport (Vega *et al.*, 2019).

Fauzy *et al.* (2019) also reported a similar result for SHRs treated with *P. sarmentosum* aqueous extract, which reduced SBP, DBP, and MAP and promoted NO. However, the aqueous extract did not decrease serum lactate dehydrogenase (LDH) and creatine phosphokinase (CPK) in SHRs (Zainudin, *et al.*, 2015). Higher levels of LDH are linked to endothelial damage, while higher levels of CPK impacted shriveled vascular and promoted risk of hypertension (Brewster *et al.*, 2019; Cai *et al.*, 2023). *Sprague Dawley* stress-induced rats treated with *P. sarmentosum* showed reduced stomach lesions and interleukin (IL)-1, IL-6, and tumor necrosis factor- $\alpha$  (TNF- $\alpha$ ) in gastric tissues where cytokines were released as an acute inflammatory response (Akmal *et al.*, 2023).

Moreover, the plant extract showed potential against bacterial and fungal growth. The leaf extract reduced mycelial growth of *Rhizoctonia solani* and *Bipolaris oryzae* by 51.77% and 41.45%, respectively. The clear zone of *Xanthomonas oryzae* pv. *oryzae* at 6.8 mm could be due to the main bioactive compounds isolated from *P. sarmentosum* essential oil, including myristicin, sarmentine, brachystamide B, brachyamide B, and piperonal (Chanprapai *et al.*, 2017). Kadukoside, isoasarone, trans-asarone, piperolactam A, dehydroformouregine, and 5-hydroxy-7,40-dimethoxy flavone of *P. sarmentosum* showed antimicrobial activity against *Septoria tritici*, *Botrytis cinerea*, and *Phytophthora infestans* (Ware *et al.*, 2023).

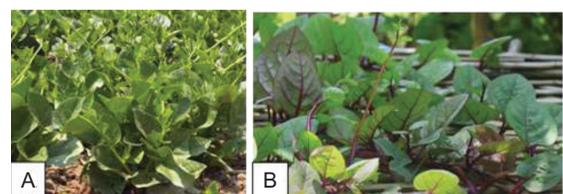
The anti-obesity property of *P. sarmentosum* extract was reported by Kumar *et al.* (2021) in studies on Wistar rats. Results showed that the extract exhibited a lower body weight and fat mass, compared to obesity Wistar

rats fed with fructose and olive oil ( $p < 0.05$ ). *P. sarmentosum* also improved leptin level, adiponectin level, and 3-hydroxy-3-methyl-glutaryl-coenzyme A (HMG-CoA) reductase level, compared to obese Wistar rats. The rats fed with fructose and olive oil showed excessive growth of adipocytes in adipose tissue, while adipocytes of Wistar rats treated with the plant extract were smaller in size. The extract of *P. sarmentosum* improved lipid profiles by increasing HDL level and decreasing LDL, triglycerides, and total cholesterol (Fadze *et al.*, 2018).

### **Basella alba L. (Pak-Plang-Khaw) and Basella alba L. var. Rubra (Pak-Plang-Dang)**

*Basella alba* L. and *Basella alba* L. var. *Rubra* or *Basella rubra* (Figure 17) belong to the Basellaceae family, with common names as Malabar Spanish, Indian spinach, Ceylon spinach, climbing spinach, East-Indian spinach, Chinese spinach, cyclone spinach, and vine spinach. They are cultivated in Indonesia, India, Malaysia, the Philippines, tropical Africa and tropical South America (Deshmukh and Gaikwad, 2014). In Thailand, the plant is called *Pak-Plang* (common name), *Pak-Plang-Khaw* (green stem type), *Pak-Plang-Dang* (red-purple stem type), and *Phak-Pang* (northern region). This climbing vine plant has simple, cordate-ovate-shaped, green and mucilaginous leaves. The stem is green (*Basella alba* L) or purplish (var. *Rubra*), branched and succulent. The flower is spiked and bisexual, with white-pink blossom in leaf axils. The fruit is oblong-shaped, small 7–8 mm in size, and dark violet in color. The seeds are black and rough (Figure 18). Mostly, Thai people consume tips and young leaf stems and young flowers as side dishes of spicy paste and curry as well as cooked items, such as salad, sour soup, and stir-fried with oyster sauce or eggs (Figure 19). The ripped seed coat is used as a natural colorant (betanin) (Paseephol *et al.*, 2012) in snacks or desserts, such as sweet-noodle in coconut milk syrup (Sarim), floral rice cake (Kanom-nam-dok-mai), and rice balls in coconut milk (Bua-loi) as shown in Figure 20.

The nutrition contents of *Basella alba* L. and *B. rubra* leaves are shown in Tables 1 and 2 (Kumar *et al.*, 2015). Fatty acid content of both species consisted of



**Figure 17. (A) Pak-Plang-Khaw; (B) Pak-Plang-Dang. Source: the authors.**

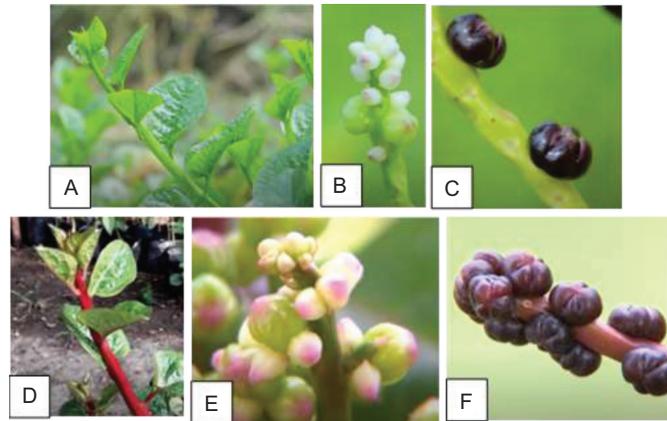


Figure 18. Pak-Plang-Khaw: (A) Tip and young leaves, (B) flower, and (C) fruits. Pak-Plang-Dang: (D) Tip and young leaves, (E) flower, and (F) fruits. Source: the authors.



Figure 19. Popular dishes of Pak-Plang-Khaw: (A) Stir-fired with oyster sauce; (B) soup with minced meat; and (C) deep-fried plant leaves with salad style. Source: the authors.

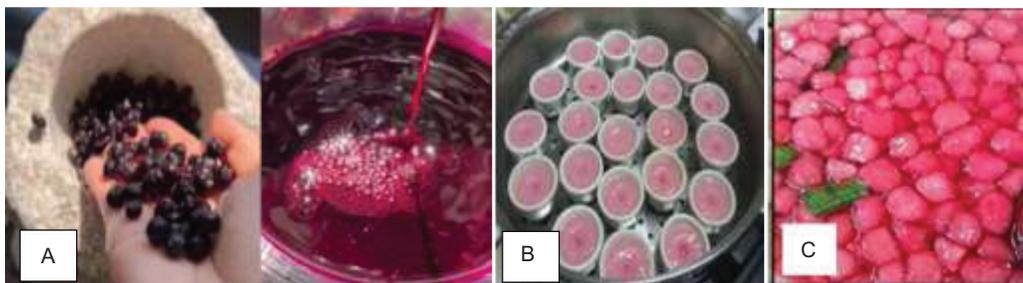


Figure 20. Natural colorant from the Pak-Plang-Dang seeds and its application in Thai desserts. Source: the authors.

monounsaturated fatty acids (MUFAs) as 1.19–1.24% and polyunsaturated fatty acids (PUFAs) as 72.5–73.8%, including linoleic acid and  $\alpha$ -linoleic acid, which promote health benefits (Adesina *et al.*, 2017). Vitamins and minerals included niacin, ascorbic acid, iron, zinc, copper, sodium, potassium, magnesium, and calcium as  $0.5 \pm 0.01$ ,  $68 \pm 5$ ,  $4.7 \pm 0.05$ ,  $0.2 \pm 0.02$ ,  $0.04 \pm 0.00$ ,  $19 \pm 1$ ,  $517 \pm 4.4$ ,  $66 \pm 1$ , and  $32 \pm 3$  mg/100 g FW. *B. alba* and *B. rubra* had chlorophyll a and b and  $\beta$ -carotene as 31–92, 15–47, and 1.9–5 mg/100 g FW, respectively (Kumar *et al.*, 2015).

The phytochemical compounds of *B. alba* are saponins, diterpenes, phenols, tannins, flavonoids, cardiac

glycosides, steroids ( $\beta$ -sitosterol and stigmasterol), phytosterols, and alkaloids ( $\beta$ -cyanine) (Bose *et al.*, 2023; Tongco *et al.*, 2015). Main polyphenolic compounds in *B. alba* and *B. rubra* are 4-hydroxyl benzaldehyde, gallic acid, *p*-coumaric acid, salicylic acid, caffeic acid, ferulic acid, trans-cinnamic acid, galloyl shikimic acid, diosmetin, kaempferol, rutin, and acacetin (Bose *et al.*, 2023; Kumar *et al.*, 2018). Betacyanin pigments in *B. rubra* are hydroxycinnamic acid, gandolin, globosin, basellin, and gomphrenin. The leaf extract expressed antioxidant properties determined by ABTS, FRAP, ORAC, and DPPH as 288.2 mg/L ( $EC_{50}$ ), 0.061 mmol TE/g DW, 0.26 mmol TE/g DW, and 1009 mg/L ( $EC_{50}$ ), respectively (Kozioł *et al.*, 2024).

*B. alba* plants expressed the IC<sub>50</sub> value of DPPH, H<sub>2</sub>O<sub>2</sub>, •OH, and phosphomolybdate scavenging activities as 46.6±0.0, 47.2±1.2, 380.3±0.9, and 918.5±0.1 µg/mL, respectively (Sheik *et al.*, 2023). *B. alba* leaves showed DPPH scavenging as 112.96±4.87 µg/mL (Islam *et al.*, 2018). When *B. alba* leaf extract was fed to rats, the results indicated a decrease in stomach ulcers via reduced total acidity value, increased pH of gastric juice, and decreased ulcer index. Reduced ulcer areas and smaller damage in the epithelium were also noticed (Kumar *et al.*, 2012).

Isovitexin obtained from *B. rubra* exhibited potent activity against human colon cancer cell lines (HT-29) with an IC<sub>50</sub> value of 0.0294 mg/mL. Characteristics of death of HT-29 cells included group cell, contraction cell, curling cell, and fragmentation of cells. The mechanism of isovitexin was enchantment enzyme of apoptosis in HT-29 cells, such as caspase-3 and procaspase-3, and inhibition of apoptotic inhibitor (Bcl-2 protein) (Kilari *et al.*, 2018). Sheik *et al.* (2023) reported that *B. alba* extract showed antiproliferation of human colon cancer cells in HT-29 and HCT-116 cell lines, with suppression of cyclin D and cyclin-dependent kinases-4 (Cdk4) in colon cancer cells, leading to retarded cell growth and proliferation. *B. alba* showed antidiabetic properties in diabetic rats after treatment with leaf extract (200 mg/kg b.w.) by reducing fasting blood glucose levels, compared to the control and diabetic rats without extract ( $p < 0.05$ ) (Bamidele *et al.*, 2015).

Interestingly, ripped seeds with red-purple color of *B. rubra* indicated antioxidant effect because of betacyanin pigment. The antioxidant activity of *B. alba* fruits because of IC<sub>50</sub> of DPPH and H<sub>2</sub>O<sub>2</sub> scavenging were 21.55–34.37 and 27.99–46.57 µg/mL, respectively (Ashaduzzaman Nur *et al.*, 2023). However, cyanogenic glycosides in the plant seeds exhibit toxicity for animals and humans. The leaves of *B. alba* L. contained 5.04±0.20 mg HCN/kg (Uhegbu *et al.*, 2011), which was higher than the World Health Organization's (WHO, 2011) reference dose level of 0.09 mg/kg b.w.. Some studies have reported that *Basella alba* L. leaves extract could be used as an antidote for cyanide poisoning in Wistar rat model (Dada *et al.*, 2020). However, reduction of cyanogenic compounds to a safe level could be achieved by processing, that is, by drying, soaking, boiling, fermentation, steaming, baking, and frying (Nambisan., 2011). Biological activities of eight indigenous plants are summarized in Table 3.

## Local foods

Edible indigenous plants of Thailand—Liang, Chiang-Da, Ta-Khuk, Pak-Wan-Pa, Pak-Wan-Bann, Horapha, Mon-Pu, Cha-Plu, and Pak-Plang—are consumed as fresh and/or

in cooked forms. However, cooking details and processes could be different, as shown in Table 4.

Some health benefits of the above-mentioned indigenous plants are purposed, and their weak points are also embedded, such as less scientific documents, periodic raw materials, safety protocol, and narrow/wide utilization. However, it was found that some indigenous plants were selected and grown for the purpose of commercialization after publishing of research papers. For instance, Chiang-Da is now considerably planted in Thailand for not only fresh consumption but also for nutraceutical and functional products used for controlling blood sugar. Laing leaves are intensively grown in the country for their umami taste and unique flavor as well as health benefits (Siripongvutikorn *et al.*, 2023., Suksanga *et al.*, 2023).

Regardless of how raw materials were investigated, the dishes produced are not well-studied, maybe due to food complications and less systematic financial support. Therefore, only a few scientific data dealing with dishes were addressed; for example, spicy coconut milk curry with Chaplu leaves revealed antioxidant and antimutagenicity activity (Tangkanakul *et al.*, 2011). Chiang Da curry with dried fish contained protein, fat, carbohydrate, dietary fiber, and ash as 6.48, 1.41, 2.36, 2.40, and 2.61 g/100 g edible portion, while Na, Ca, P, Fe, Zn, and Cu were 663.88, 102.58, 231.09, 1.34, 0.80, and 0.23 mg/100 g edible portion (Tangkanakul *et al.*, 2006). Spicy curry with Pak-Wan-Bann contained proteins, fat, carbohydrate, dietary fiber, and ash as 4.19, 0.91, 3.86, 1.20 and 1.38 g/100 g edible portion, while Na, Ca, P, Fe, Zn, and Cu were 386, 70.51, 128.24, 0.90, 0.90, and 0.29 mg/100 g edible portion, respectively (Tangkanakul *et al.*, 2006).

Owing to high acceptability, indigenous plants are a source of biological activities and health functions. In addition, cooking process, used ingredients, and seasonings could have both positive and negative effects on phytochemicals as well as health.

In Thailand, the most commonly used ingredient is fermented shrimp paste (Kapi). Intensive review indicated that Kapi contained proteins, fat, fiber, and carbohydrate as 27.0–29.9, 2.1–2.9, 1.2–1.3, and 16.5–18.4 g/100 g, respectively. In addition, Kapi showed antioxidant activity and angiotensin I-converting enzyme (ACE) inhibitory activity (Kleekayai *et al.*, 2015). Besides this, major herbals and spices, such as garlic, shallot, kaffir lime leaves, galangal, ginger, holy basil, and chili are good source of several bioactive compounds and pharmacological properties (Buathong and Duansrisai., 2023).

Moreover, coconut milk (Kathi), which is an essential ingredient of Thai spicy curry or soup contains proteins, fat, and carbohydrate as 4.13–5.83%, 1.83–3.11%, and

Table 3. Biological activity of eight edible indigenous plants in Thailand.

Scientific name	Parts	Model study	Biological activity	References
<i>G. gnemon</i> var. <i>tenerum</i>	Leaves powder extract	Gut model	– Short chain fatty acids – Gut microbiome improvement	Anisong <i>et al.</i> , 2023
		<i>In vitro</i>	– Antioxidant activity	Suksanga <i>et al.</i> , 2023
		Cell study	– Non-toxicity	
		<i>In vivo</i> (Ratsmodel)	– Antihyperglycemic – Antidiabetic – Non-toxicity	
<i>G. inodorum</i> (Lour) Decne	Leaves extract	<i>In vitro</i>	– Antioxidant activity – Anti-inflammatory	Jeytawan <i>et al.</i> , 2022
		<i>In vitro</i>	– Anti-alpha-amylase – Anti-alpha-glucosidase	Srinuanchai <i>et al.</i> , 2021
		Cell study	– Glucose absorption	
		Cell study	– Anti-inflammatory	Sakuljaitrong <i>et al.</i> , 2023
		Cell study	– Anti-hypoxia – Cardioprotective	Surinkaew <i>et al.</i> , 2024
<i>Albizia lebbek</i> (L.) Benth	Leaves extract	<i>In vitro</i>	– Antioxidant – Anti-alpha-amylase – Anti-alpha-glucosidase – Anti-alpha-lipase – Anti-glycation – Anti-Alzheimer's disease	Sirichai <i>et al.</i> , 2022
		Cell study	– Neuroprotective	Phoraksa <i>et al.</i> , 2023
<i>Melientha suavis</i> Pierre	Leaves extract	<i>In vitro</i>	– Antioxidant	Sridonpai <i>et al.</i> , 2022 Sansomchai <i>et al.</i> , 2021
<i>Sauropus androgynus</i> (L.)	Leaves extract	<i>In vitro</i>	– Antioxidant – Anti-alpha-glucosidase – Protection of oxidative damage in ruminant blood erythrocytes	Purba <i>et al.</i> , 2022
<i>Glochidion wallichianum</i> / <i>Glochidion perakense</i>	Leaves extract	<i>In vitro</i>	– Antioxidant – Neuroprotective	Paul and Anto, 2011 Junsathian <i>et al.</i> , 2018
		<i>In vitro</i>	– Antimicrobial	Junsathian <i>et al.</i> , 2022
		Cell study	– Oxidative stress reduction	Samuhasaneeto <i>et al.</i> , 2022
		<i>In vivo</i> (Rats model)	– Reduction of lipid accumulation	
<i>Piper sarmentosum</i> Roxb.	Leaves extract	<i>In vitro</i>	– Starch digestibility inhibition	Chumsri <i>et al.</i> , 2022
		<i>In vitro</i>	– Antioxidant	Wongsa <i>et al.</i> , 2012
		<i>In vitro</i>	– Anti-alpha-glucosidase	Ugusman <i>et al.</i> , 2012
		<i>In vivo</i> (Mice model)	– Antidiabetic	Luangpirom <i>et al.</i> , 2014
		<i>In vivo</i> (Rats model)	– Antidiabetic – Cardiovascular system improvement	Thent <i>et al.</i> , 2012
		<i>In vivo</i> (Rats model)	– Liver tissue repairing	Thent and Das, 2015
		<i>In vivo</i> (Rats model)	– Antihypertensive	Zainudin <i>et al.</i> , 2015 Fauzy <i>et al.</i> , 2019
		<i>In vivo</i> (Rats model)	– Anti-inflammatory – Oxidative stress inhibition – Prevention of stress-induced gastric ulcer	Akmal <i>et al.</i> , 2023
		<i>In vitro</i>	– Antimicrobial	Chanprapai <i>et al.</i> , 2017
<i>In vivo</i> (Rats model)	– Anti-obesity	Kumar <i>et al.</i> , 2021		

(continues)

Table 3. Continued.

Scientific name	Parts	Model study	Biological activity	References
<i>Basella alba</i> L. and <i>Basella alba</i> L. var. <i>Rubra</i>	Leaves extract	<i>In vivo</i> (Rats model)	– Antihyperlipidemic	Fadze <i>et al.</i> , 2018
		<i>In vitro</i>	– Antioxidant	Kozioł <i>et al.</i> , 2024 Sheik <i>et al.</i> , 2023 Islam <i>et al.</i> , 2018
		<i>In vivo</i> (Rats model)	– Stomach ulcers protection	Kumar <i>et al.</i> , 2012
		Cell study	– Anticancer	Kilari <i>et al.</i> , 2018
	Cell study	– Anticancer	Sheik <i>et al.</i> , 2023	
	<i>In vivo</i> (Rats model)	– Antidiabetic	Bamidele <i>et al.</i> , 2015	
	Fruits extract	<i>In vitro</i>	– Antioxidant	Ashaduzzaman Nur <i>et al.</i> , 2023

Table 4. Local foods prepared from some edible indigenous plants in Thailand.

Edible indigenous plants	Menus	Ingredients	Process	Proportion of plants per dish
Liang	Stir-fried Liang with egg	– Liang young leaves (70 g) – Eggs (1 egg = 50 g) – Minced garlic (1 g) – Oyster sauce (15 g) – Soybean sauce (15 g) – Sugar (5 g) – Oil (5 g)	1. Put the pan on fire and add oil. 2. Add minced garlic, until it changes to yellow in color. 3. Add egg and stir. 4. Add Liang leaves, oyster sauce, soybean sauce, and sugar, and stir to mix well.	≈43%
	Coconut milk curry with Liang	– Liang young leaves (150 g) – Coconut tip (100 g) – Climbing wattle (20 g) – Shrimp (200 g) – Chili (5 g) – Fish sauce (5 g) – Stink bean (10 g) – Shrimp paste (10 g) – Sliced shallots (20 g) – Concentrate coconut milk (240 g) – Dilute coconut milk (320 g) – Sugar (15 g)	1. Put the pot on fire and add diluted coconut milk 2. Add shrimp paste and mix. 3. Add sliced coconut tip. 4. When boiling add shrimp and stink bean. 5. Add fish sauce and sugar. 6. Add Liang, climbing wattle, and concentrated coconut milk. 7. Add shallots and chili.	≈14%
Chiang Da	Chiang Da curry with dried fish	– Chiang Da (100 g) – Dried fish (50 g) – Garlic (5 g) – Shallots (20 g) – Shrimp paste (5 g) – Small tomato (5 pieces ≈ 83 g) – Dried chili (5 g) – Salt (5 g)	1. Put the pan on fire and add water and heat until boiling, then add dried fish. Leave for a while and then lift it up. 2. Grill dried northern-natto. 3. Pound garlic, dried chili, shallots, salt, shrimp paste. 4. Strip dried fish. 5. Cut tomato. 6. Put (3) in the pan of (1). 7. Add dried fish, Chiang Da, and tomato in the pan.	≈36%
	Chiang Da salad with pork caps	– Chiang Da (125 g) – Shallots (20 g) – Garlic (5 g) – Dried northern natto (10 g) – Shrimp paste (8 g) – Dried chili (5 g)	1. Cut Chiang-Da, lettuce, tamarind young leaves, Bai-Som-Suk, Bai-Kawtong, young mini mango leaves, and Hog plum to small size. 2. Pound pork caps. 3. Roast dried chili.	

(continues)

Table 4. Continued.

Edible indigenous plants	Menus	Ingredients	Process	Proportion of plants per dish
		<ul style="list-style-type: none"> <li>– Oil (5 g)</li> <li>– Fish sauce (5 g)</li> <li>– Pork caps (20 g)</li> <li>– Lettuce (40 g)</li> <li>– Tamarind young leaves (40 g)</li> <li>– Bai-Som-Suk (<i>Saraca indica</i> L. leaves) (40 g)</li> <li>– Bai-Kawtong (<i>H. cordata</i> Thunb leaves)</li> <li>– Hog plum (20 g)</li> <li>– Young mini mango leaves (40 g)</li> </ul>	<ol style="list-style-type: none"> <li>4. Grill dried northern-natto.</li> <li>5. Pound dried chili, garlic, shallots, dried northern-natto, and shrimp paste.</li> <li>6. Put the pan on fire and add oil.</li> <li>7. Put minced garlic and (5) in the pan.</li> <li>8. Add water and wait until boiling. Add fish sauce. Then, pour into the pot.</li> <li>9. Add (1) into the pot and mix.</li> </ol>	≈32%
Ta-Khuk	Jungle curry with Ta-Khuk leaves and frog	<ul style="list-style-type: none"> <li>– Ta-khuk young leaves and flowers (120 g)</li> <li>– Dried chili (6 g)</li> <li>– Dried Karen chili (5 g)</li> <li>– Frog (200 g)</li> <li>– Galangal (2 g)</li> <li>– Lemon grass (2 g)</li> <li>– Garlic (2 g)</li> <li>– Kaffir lime leaves (5 g)</li> <li>– Kaffir lime peel (5 g)</li> <li>– Fingerroot (20 g)</li> <li>– Young peppercorn (5 g)</li> <li>– Leaves and flowersholy basil (5 g)</li> <li>– Chili spur pepper (10 g)</li> <li>– Cockroach berry (40 g)</li> <li>– Turkey berry (30 g)</li> <li>– Green brinjal (40 g)</li> <li>– Fish sauce (15 g)</li> <li>– Fish paste (20 g)</li> <li>– Salt (5 g)</li> </ul>	<ol style="list-style-type: none"> <li>1. Rip frog and separated offal to throw away. Then, washing with salt.</li> <li>2. Frog mix with salt and grill. Then, cutting.</li> <li>3. Shred garlic, galangal and lemon grass to small size.</li> <li>4. Soak dried chili and dried Karen chili in water and drain.</li> <li>5. Pick holy basil leaves and flowers from stem.</li> <li>6. Cut cockroach berry, green brinjal, fingerroot, kaffir lime leaves, and young peppercorn.</li> <li>7. Pound kaffir lemon peel, salt, dried chili, (3), flower holy basil, (4), and fish paste.</li> <li>8. Put the pan on fire and add water in the pan. Then, add (7).</li> <li>9. Add turkey berry, (6) and frog grill.</li> <li>10. Add fish sauce.</li> <li>11. Add Ta-Khuk young leaves and flowers.</li> <li>12. Add holy basil leaves and chili spur pepper.</li> </ol>	≈22%
	Spicy curry with Ta-khuk leaves and fish	<ul style="list-style-type: none"> <li>– Ta-khuk young leaves (120 g)</li> <li>– Fish (70 g)</li> <li>– Shrimp paste (5 g)</li> <li>– Sugar (5 g)</li> <li>– Fish sauce (15 g)</li> <li>– Cockroach berry (10 g)</li> <li>– Shallots (20 g)</li> <li>– Galangal (10 g)</li> <li>– Kaffir lime peel (2 g)</li> <li>– Lemon grass (2 g)</li> <li>– Garlic (1 g)</li> <li>– Dried chili (5 g)</li> <li>– Holy basil flowers (2 g)</li> </ul>	<ol style="list-style-type: none"> <li>1. Boil fish.</li> <li>2. Pound shrimp paste, dried chili, gallic, lemon grass, kaffir lime peel, shallots, galangal, and holy basil flowers to mix well.</li> <li>3. Cut cockroach berry and take out the inside seeds.</li> <li>4. Put the pan on fire and add oil.</li> <li>5. Add (2) and stir.</li> <li>6. Add water, fish sauce, and sugar.</li> <li>7. Add fish, Ta-Khuk leaves, and (3).</li> </ol>	≈50%
Pak-Wan-Pa	Spicy curry with Pak-Wan-Pa young leaves and red ant eggs	<ul style="list-style-type: none"> <li>– Pak-Wan-Pa young leaves (120 g)</li> <li>– lemon grass (2 g)</li> <li>– shrimp paste (15 g)</li> <li>– dried chili (5 g)</li> <li>– chili (5 g)</li> <li>– shallots (20 g)</li> <li>– garlic (2 g)</li> <li>– salt (5 g)</li> <li>– red ant eggs (100 g)</li> <li>– pickled fish sauce (5 g)</li> </ul>	<ol style="list-style-type: none"> <li>1. Pound lemon grass, chili, dried chili, shallots, gallic and shrimp paste to well mix (coarsely).</li> <li>2. Put the pot on the fire and add the water.</li> <li>3. Add (1), salt and pickled fish sauce.</li> <li>4. Add Pak-Wan-Pa young leaves and red ant eggs, wait until boiling.</li> </ol>	≈43%

(continues)

Table 4. Continued.

Edible indigenous plants	Menus	Ingredients	Process	Proportion of plants per dish
Pak-Wan-Bann	Jungle curry with Pak-Wan-Pa and fish grill	<ul style="list-style-type: none"> <li>– Pak-Wan-Pa young leaves (100 g)</li> <li>– Chili (5 g)</li> <li>– Shallots (20 g)</li> <li>– Garlic (10 g)</li> <li>– Shrimp paste (15 g)</li> <li>– Salt (5 g)</li> <li>– Fish sauce (15 g)</li> <li>– Pickled fish sauce (80 g)</li> <li>– Fish grill (80 g)</li> </ul>	<ol style="list-style-type: none"> <li>1. Pound dried chili, salt, garlic, shallots, and shrimp paste to mix well.</li> <li>2. Put the pot on fire and add water.</li> <li>3. Add (1) and wait until boiling.</li> <li>4. Add fish grill and wait until boiling.</li> <li>5. Add Pak-Wan-Pa young leaves.</li> <li>6. Add pickled fish sauce and fish sauce.</li> </ol>	≈30%
	Spicy curry with Pak-Wan-Bann	<ul style="list-style-type: none"> <li>– Pak-Wan-Bann young leaves (100 g)</li> <li>– Dried chili (10 g)</li> <li>– Shallots (20 g)</li> <li>– Garlic (2 g)</li> <li>– Lemon grass (5 g)</li> <li>– Shrimp paste (15 g)</li> <li>– Salt (5 g)</li> <li>– Pickled fish sauce (80 g)</li> <li>– Pickled fish (40 g)</li> <li>– Fish grill (80 g)</li> </ul>	<ol style="list-style-type: none"> <li>1. Pound dried chili, salt, lemon grass, garlic, shallots, pickled fish, and shrimp paste to mix well.</li> <li>2. Put the pot on fire and add water.</li> <li>3. Add (1) in the pot and wait until boiling.</li> <li>4. Add pickled fish sauce and fish grill. Wait until boiling.</li> <li>5. Add Pak-Wan-Bann.</li> </ol>	≈28%
	Stir-fried Pak-Wan-Bann with oyster sauce	<ul style="list-style-type: none"> <li>– Pak-Wan-Bann young leaves (200 g)</li> <li>– Garlic (15 g)</li> <li>– Oil (15 g)</li> <li>– Fish sauce (5 g)</li> <li>– Oyster sauce (30 g)</li> <li>– Sugar (10 g)</li> <li>– Soybean sauce (5 g)</li> </ul>	<ol style="list-style-type: none"> <li>1. Pan on fire and add oil.</li> <li>2. Add garlic and stir until changes to yellow color.</li> <li>3. Add Pak-Wan-Bann young leaves and stir.</li> <li>4. Add fish sauce, oyster sauce, sugar, and soybean sauce.</li> <li>5. Stir them to mix well.</li> </ol>	≈71%
Mon-Pu	Spicy salad local vegetables	<ul style="list-style-type: none"> <li>– Mon-Pu leaves (40 g)</li> <li>– Galangal (15 g)</li> <li>– Spring onion (20 g)</li> <li>– Coriander (10 g)</li> <li>– White turmeric (10 g)</li> <li>– Cowslip creeper (10 g)</li> <li>– Cashew nut leaves (20 g)</li> <li>– Hog plum leaves (20 g)</li> <li>– Peppermint (5 g)</li> <li>– Culantro (10 g)</li> <li>– Tomato (10 g)</li> <li>– Spring bitter cucumber seed (10 g)</li> <li>– Jelly mushroom (10 g)</li> <li>– Gray oyster mushroom (10 g)</li> <li>– Straw mushroom (10 g)</li> <li>– King oyster mushroom (10 g)</li> <li>– Golden needle mushroom (10 g)</li> <li>– Gallic (5 g)</li> <li>– Shallots (30 g)</li> <li>– Bird's eye chili (15 g)</li> <li>– Chili spur pepper (10 g)</li> <li>– Roasted pumpkin seeds (10 g)</li> <li>– Roasted cashew nuts (10 g)</li> <li>– Flower of salt (10 g)</li> <li>– Tamarind juice (30 g)</li> <li>– Palm sugar (15 g)</li> <li>– Lemon juice (15 g)</li> </ul>	<ol style="list-style-type: none"> <li>1. Cut Mon-Pu, spring onion, coriander, white turmeric, cowslip creeper, cashew nut leaves, hog plum leaves, peppermint, culantro, tomato, garlic, bird's eye chili, and shallots to small pieces.</li> <li>2. Slice jelly mushroom, gray oyster mushroom, straw mushroom, king oyster mushroom, and golden needle mushroom to thin and small pieces.</li> <li>3. Pound chili spur pepper and galangal.</li> <li>4. Soak spring bitter cucumber seeds, and squeeze. Then, remove the seeds.</li> <li>5. Put the pot on fire and add (4) into the pot.</li> <li>6. Add tamarind juice, (3), palm sugar, soybean sauce, and flower of salt, and mix.</li> <li>7. Add (2) and mix. Then, remove the pot from fire.</li> <li>8. Add Khao-khua, roasted pumpkin seeds, roasted cashew nuts, roasted coconut, and roasted peanuts.</li> <li>9. Add (1) and lemon juice. Then, mix.</li> </ol>	≈9%

(continues)

Table 4. Continued.

Edible indigenous plants	Menus	Ingredients	Process	Proportion of plants per dish
Cha-Plu	Spicy coconut milk curry with Chaplu leaves and shellfish.	<ul style="list-style-type: none"> <li>– Roasted coconut (10 g)</li> <li>– Khao Khua (roasted rice powder) (20 g)</li> <li>– Roasted peanuts (10 g)</li> <li>– Soybean sauce (15 g)</li> <li>– Cha-Plu leaves (120 g)</li> <li>– Minced dried chili (20 g)</li> <li>– Salt (5 g)</li> <li>– Minced shallots (20 g)</li> <li>– Garlic (5 g)</li> <li>– Minced galangal (5 g)</li> <li>– Minced lemon grass (5 g)</li> <li>– Minced turmeric (5 g)</li> <li>– Shrimp paste (15 g)</li> <li>– Coconut milk (360 g)</li> <li>– Fish sauce (5 g)</li> <li>– Palm sugar (5 g)</li> <li>– Shellfish (80 g)</li> <li>– Oil (15 g)</li> </ul>	<ol style="list-style-type: none"> <li>1. Pound dried chili, salt, shallots, galangal, lemon grass, turmeric, garlic, and shrimp paste and mix well.</li> <li>2. Put the pot on fire and add oil and (1) into the pot, then stir well mix.</li> <li>3. Add coconut milk and wait until boiling.</li> <li>4. Add salt, fish sauce, and palm sugar.</li> <li>5. Add Cha-Plu leaves and keep stewing for 5 min.</li> <li>6. Add shellfish and mix.</li> </ol>	≈18%
	Miang-Khum (royal leaf wrap appetizer)	<ul style="list-style-type: none"> <li>– Miang sauce</li> <li>– Minced galangal (15 g)</li> <li>– Minced lemon grass (10 g)</li> <li>– Minced shallots (30 g)</li> <li>– Minced ginger (15 g)</li> <li>– Roasted coconut (80 g)</li> <li>– Roasted peanuts powder (80 g)</li> <li>– Shrimp paste (5 g)</li> <li>– Fish sauce (30 g)</li> <li>– Palm sugar (100 g)</li> <li>– Wrapping ingredient</li> <li>– Cha-Plu leaves</li> <li>– Minced shallots</li> <li>– Roasted coconut</li> <li>– Cube young ginger</li> <li>– Dried shrimp</li> <li>– Roasted peanuts</li> <li>– Minced bird's eye chili</li> <li>– Cube lemon</li> </ul>	<p>Miang sauce</p> <ol style="list-style-type: none"> <li>1. Put the pan on fire.</li> <li>2. Add galangal and ginger, and stir until it changes to yellow color</li> <li>3. Add lemon grass and stir until changes to yellow color. Then, add shallots and stir.</li> <li>4. Pour it into a mortar and pound.</li> <li>5. Add shrimp paste in the mortar and mix well.</li> <li>6. Put the pot on fire.</li> <li>7. Add fish sauce and palm sugar, mix until dissolve in to a homogenous mixture.</li> <li>8. Add (5) and mix. Keep stewing 3–5 min.</li> <li>9. Turn off fire. Add roasted coconut and roasted peanuts powder.</li> </ol> <p>Wrapping</p> <ol style="list-style-type: none"> <li>1. Bring Cha-Plu leaves roll into a cone.</li> <li>2. Add shallots, roasted coconut, ginger, dried shrimp, roasted peanuts, bird's eye chili, and cube lemon as per liking.</li> <li>3. Add Miang sauce.</li> </ol>	≈50% (1 piece of Miang-Khum)
Pak-Plang	Sour soup with Pak prang and Khaki	<ul style="list-style-type: none"> <li>– Pak-Plang leaves (120 g)</li> <li>– Dried chili (15 g)</li> <li>– Salt (5 g)</li> <li>– Pork leg (Khaki) (50 g)</li> <li>– Shrimp paste (15 g)</li> <li>– Fish sauce (15 g)</li> <li>– Cucumber (20 g)</li> <li>– Fingerroot (15 g)</li> <li>– Shallots (20 g)</li> <li>– Palm sugar (10 g)</li> <li>– Tamarind juice (30 g)</li> <li>– Preserved bamboo tip (20 g)</li> </ul>	<ol style="list-style-type: none"> <li>1. Pound salt, dried chili, shallots, fingerroot, and shrimp paste.</li> <li>2. Gril pork leg and cut into small size</li> <li>3. Cut cucumber into two pieces.</li> <li>4. Wash preserved bamboo tip.</li> <li>5. Put the pot on fire and add water.</li> <li>6. Add (1) in the pot and mix.</li> <li>7. Add pork leg and stewing until soft.</li> <li>8. Add bamboo tips.</li> <li>9. Add tamarind juice, fish sauce, and palm sugar.</li> <li>10. Add cucumber and Pak-Plang.</li> </ol>	≈35%
	Stir-fried Pak-Plang with oyster sauce	<ul style="list-style-type: none"> <li>– Pak-Plang young leaves (120 g)</li> <li>– Minced garlic (5 g)</li> <li>– Oyster sauce (30 g)</li> <li>– Soybean sauce (5 g)</li> <li>– Sugar (5 g)</li> <li>– Oil (15 g)</li> </ul>	<ol style="list-style-type: none"> <li>1. Put the pot on fire and add oil.</li> <li>2. Add minced gallic and Pak-Plang.</li> <li>3. Add oyster sauce, sugar, and soybean sauce.</li> <li>4. Stir them to mix well.</li> </ol>	≈66%

1.94–2.21%, respectively. Phenolic compounds discovered in coconut milk included gallic acid, chlorogenic acid, parahydroxybenzoic acid, caffeic acid, vanillic acid, syringic acid, and ferulic acid related to antioxidant activity by reducing oxidative stress in cells. However, rats fed with coconut milk showed an increment of total cholesterol and triglycerides, compared to baseline, but not significantly different from the control group (Karunasiri *et al.*, 2020). Indigenous plants and other ingredients support health benefits, however, amount of overdose of seasoning particularly sugar, table salt, monosodium glutamate, fish sauce, soy source as well as oyster sauce may dilute the positive effects such as amount of high sugar in food risk to hyperglycemia and diabetic disease for long term, and high salt is risk to hypertensive.

## Conclusion

Thai people have been consuming edible indigenous plants as side dishes and in cooked forms as well as for folk medicine purposes since ancient times. Several edible indigenous plants of Thailand contain high nutrients and various bioactive compounds, such as vitamins, minerals, fiber, phenolics, flavonoids, anthocyanidins, carotenoids, and triterpenes, which have antidiabetic, antibacterial, and anti-inflammatory properties and protect neurotransmitters. Eight Thai edible local plants displayed good health benefits with no negative health issues. Antioxidant, antidiabetic, and antimicrobial properties are reported for *G. gnemon*, *G. inodorum*, *A. lebbeck*, *P. sarmentosum*, *S. androgynus* and *B. alba*. Antihypertensive properties are displayed in the case of *A. lebbeck* and *P. sarmentosum*. *G. wallichianum* and *P. sarmentosum* were related to reduced lipids accumulation and anti-obesity. *B. alba* showed a strong anticancer activity. However, a research lacuna exists for *M. suavis* Pierre because of scant documented health research. Moreover, the eight selected plants are not grown commercially due to the lack of systematic records and intensive research. Future scientific studies should concentrate on health functions using animal models and clinical trials to enhance the utilization and application of indigenous plants for the purpose of local foods and related global products.

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## Declaration of Interest

The authors declared no competing interests.

## Author Contributions

All authors read and approved the final version of the manuscript.

## Conflicts of Interest

The author's declare no conflicts.

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