Sagittaria trifolia

Scientific Name

***Sagittaria trifolia* L.**

Synonyms

Sagittaria chinensis Sims, *Sagittaria doniana* Sweet, *Sagittaria edulis* Schltdl., *Sagittaria hastata* D. Don (illeg.), *Sagittaria hirundinacea* Blume, *Sagittaria japonica* H. Vilm., *Sagittaria leucopetala* (Miq.) Bergmans, *Sagittaria macrophylla* Bunge (illeg.), *Sagittaria obtusa* Thunb. (illeg.), *Sagittaria sagittata* Thunb., *Sagittaria sagittifolia* var. *alismifolia* Makino, *Sagittaria sagittifolia* var. *diversifolia* M. Michel, *Sagittaria sagittifolia* var. *edulis* (Schltdl.) Siebold ex Miq.

Sagittaria sagittifolia var. *leucopetala* Miq., *Sagittaria sagittifolia* subsp. *leucopetala* (Miq.) Hartog, *Sagittaria sagittifolia* var. *longiloba* Turcz., *Sagittaria sagittifolia* f. *sinensis* (Sims) Makino, *Sagittaria sagittifolia* var. *subaequilonga* Regel, *Sagittaria sinensis* Sims, *Sagittaria trifolia* f. *albida* Makino, *Sagittaria trifolia* var. *angustifolia* Kitag., *Sagittaria trifolia* f. *caerulea* Makino, *Sagittaria trifolia* var. *edulis* (Schltdl.) Ohwi ex W.T. Lee, *Sagittaria trifolia* f. *heterophylla* Makino, *Sagittaria trifolia* var. *leucopetala* Miq., *Sagittaria trifolia* subsp. *leucopetala* (Miq.) Q.F. Wang, *Sagittaria trifolia* var. *longiloba* (Turcz.) Kitag., *Sagittaria trifolia* var. *retusa* J.K. Chen, X.Z. Sun & H.Q. Wang, *Sagittaria trifolia* var. *sinensis* (Sims) Makino, *Sagittaria trifolia* f. *subhastata* Makino, *Sagittaria trifolia* f. *suitensis* Makino

Family

Alismataceae

Common Names

Arrowhead, arrow-head, Arrow-Weed, Chinese Arrowhead, Chinese Potato, Duck Potato, Old World Arrowhead, Swamp Potato

Vernacular Names

Arabia: Kewi
Chinese: Kunai, Ci-Gu, T'zu-Ku, Bai-Di-Li, Pai-Di-Li, Jian-Dao-Cao, Chien-Tao-Ts'ao, Jiao Bai, Tzi Koo, Ngah Ku, Ya Ku Ye Ci Gu
Cuba: Malanga China
Czech: Šípatka Střelolistá, Šípatka Střelovitá, Šípatka Vodní
Danish: Almindelig Pilblad, Pilblad
Dutch: Pijlkruid
Eastonia: Jõgi-Kõõlusleht
Esperanto: Akvosago, Sagherbo Granda, Sagitario Granda
Finnish: Pystykeiholehti, Yleinen Keiholehti

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French: Fléchière Commune, Fle D'eau, Flèche D'eau, Fli, Sagittaire À Feuilles En Fleche, Sagittaire De Chine, Sagittaire Nageante
Gaelic: Rinn Saighde
German: Brutblatt, Chinesisches Pfeilkraut, Echtes, Gemeines Pfeilkraut, Gewöhnliches Pfeilkraut, Pfeilkraut, Spitzes Pfeilkraut
Hungarian: Nyílfű
India: Jathipotia (Assamese), Koukha (Bengali), Chotokut, Muya-Muya (Hindi)
Indonesia: Bea-Bea, Eceng Genjer, Kalopak
Italian: Erba Saetta, Erba Saetta Chinese, Sagittaria Commune
Japanese: Kuwai, Konwai Shiro-Guwai, Omodaka
Khmer: Slok Lumpaeng
Korean: Soeguenamul, Soegwinamul
Laotian: Phak Sob
Malaysia: Béa-Béa, Ètjèng, Keladi Ubi, Keladi Chabang (Malay) Tse Koo (Cantonese)
Norwegian: Pilblad
Philippines: Gauai-Gauai (Bisaya), Tikog (Bikol)
Polish: Strzałka Wodna
Portuguese: Erva Frecha Chinesa, Espadana, Sagitária
Russian: Strelolist Trekhlistnistnyi, Strelolist
Slovaščina: Streluša Navadna
Slovencina: Šípovka Vodná
Spanish: Flecha Chinesa, Flecha De Agua, Saeta, Saeta Chinesa, Saeta De Agua
Swedish: Pilblad
Thailand: Kha Khiat, Taokiat, Phakkhangkai
Vietnamese: Rau Mac, Tu Coo, Cu Choc
Welsh: Saethlys, Saethlys Saethffeilaidd

Origin/Distribution

Sagittaria trifolia is widespread from south European Russia to Japan and Malaysia as well as in several provinces of China and is indigenous to Afghanistan; Cambodia; China (Anhui, Beijing, Chongqing, Fujian, Gansu, Guangdong, Guangxi, Guizhou, Hainan, Hebei, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Jilin, Liaoning, Nei Mongol, Ningxia, Qinghai, Shaanxi, Shandong, Shanghai, Shanxi, Sichuan, Tianjin, Xinjiang, Yunnan, Zhejiang); Hong Kong; India (Assam); Indonesia (Sulawesi, Sumatera); Iran, Islamic Republic of; Japan; Kazakhstan; Kyrgyzstan; Lao People's Democratic Republic; Macao; Malaysia; Myanmar; Nepal; Philippines; Russian Federation (Amur, Buryatiya, Chita, Khabarovsk, Krasnoyarsk); Taiwan, Province of China; Thailand; Turkmenistan; Uzbekistan; and Vietnam (Zhuang 2011).

Agroecology

Being an aquatic herb, it can be found growing in ponds, lakes, marshes, paddy fields and water channels. It prefers shallow, still or slowly flowing water up to 30–60 cm deep although it will grow in a moist or wet loamy soil in a sunny position. It grows best in warm weather and require at least a 6-month growing season in order to produce a crop and is fairly cold tolerant surviving temperatures down to at least −10 °C, though the top growth is damaged once temperatures fall below zero.

Edible Plant Parts and Uses

The petioles and the starchy corms are cooked and eaten in Manipur and Southeast Asia. In Vietnam young petiole leaf and corms are used for soups (Tanaka and Nguyen 2007). The plant is cultivated in China and Japan for starch-containing corms which have been used in a variety of cooked and fresh dishes for centuries. The corms are eaten on its own after boiling, baking, cooking or roasting. The corms can also be dried and ground into a powder, and the powder can be used as gruel and porridge or be added to cereal flours and used in making bread. Young leaves are eaten as vegetables.

Botany

Aquatic, acaulescent, glabrous perennial herb (Plate 1) with fleshy rootstock giving rise to numerous thick, axillary stolons bearing

Plate 1 Arrowhead plant in situ

Plate 2 Arrowhead leaf close-up

somewhat subglobose corms (Plate 3) (tubers) 3–6 cm by 2–5 cm at the tips. Leaves in a radical rosette, mostly emerged, upright, up to 40 cm long by 15 cm wide, sagittate or somewhat hastate, blade ovate or linear-lanceolate, with acute, basal lobes triangular or linear-lanceolate, often longer than the blade, sharply acute (Plate 2); petiole 60–75 cm long, triangular. Inflorescence an unbranched scapose terminal raceme, 30–50 cm long. Flowers in 2–6 whorls of 3 flowers each, unisexual, 1–2 cm across, white; pedicels 8–15 mm long, staminate flowers above, pistillate ones below; sepals and petals 3, petals white, suborbicular, unguiculate, stamens 20 with yellow anthers. Fruit an oblate head, 1 cm diameter consisting of numerous triangularly obovate achenes 3–5 mm by 1.5–3 mm with laterally bent beak and subcrenate to entire wings.

Plate 3 Arrowhead corms

Nutritive/Medicinal Properties

Proximate food value of the raw corm per 100 g edible portion was reported as energy 107 cal, moisture 70.6 %, protein 5 g, fat 0.3 g, total carbohydrate 22.4 g, fibre 0.9 g, ash 1.7 g, Ca 13 mg, P 165 mg, Fe 2.6 mg, K 729 mg, thiamine 0.16 mg, riboflavin 0.04 mg, niacin 1.4 mg and ascorbic acid 5 mg (Leung et al. 1972). The corm starch contained a high level of amylose (25.6 %) and 53 ppm of organic phosphorus and showed Ca X-ray diffraction pattern (Suzuki et al. 1993). Starch granules were oval, deformed sphere or potato tuber-like with about 15 pm in length on average. The number-average degree of polymerisation and apparent degree of polymerisation and distribution of amylose were 2,840, 7,080, and 570–21,300, respectively. The chain length (ratio of total carbohydrate/non-reducing residue) of amylose and amylopectin were 420 and 20.2, respectively. Arrowhead starch showed a little lower pasting temperature and higher breakdown than sweet potato starch. The retrogradation tendency of the aqueous paste showed also similar to that of sweet potato starch. Sugimoto et al. (2001) found that the amylose content of three cultivars of Chinese arrowhead tuber starches determined by amperometric iodotitrimetry were in a range of 28.2–29.9 % and 26.6–31.3 % by gel permeation chromatography of isoamylase-debranched starches. The starches had unique amylopectin short-chain length distributions of increased amounts of chains with DP (degree of polymerisation) 6 and 7 and decreased amounts of chains with DP 9 compared with waxy maize amylopectin. The X-ray diffractograms of the starches showed A-type patterns. Zhao et al. (2011) found that as *S. trifolia* corm enlarged to about 90 days, the sugar content increased to 28.05 mg/g (Zhao et al. 2011). Fructose and glucose also increased and then decreased. Total starch, amylose and amylopectin content increased, and changes of amylopectin/amylose ratio were always less than 1.

D-raffinose, D-stachyose, D-verbascose, D-fructose, D-galactose and glucose, asparagine and vitamin B were reported by Li (2008).

From *S. trifolia* tubers, four bioactive diterpene ketones, trifoliones A, B, C and D; two diterpene glucosides, sagittariosides a and b; and a nitroethylphenol glycoside, arabinothalictoside were isolated, together with six known diterpenes: isoabienol, 13-episclareol, *ent*-13-epimanoyl oxide (6-deoxyandalusol), *ent*-19-hydroxy-13-epimanoyl oxide, *ent*-kaur-16-en-19-ol and *ent*-kaur-16-en-19-oic acid (Yoshikawa et al. 1993, 1996). A terpenoid, sandaracopimaric acid was isolated from the methanol extract (Yuan et al. 1993). From the methanol extract of the plant ergosterol peroxide, icariside D_2, thalictoside and 4-nitrophenyl β-D-glucopyranoside were isolated (Kim et al. 1998). Seven new entrosane diterpenoids, sagittines A–G (1–7), together with one new labdane diterpene, 13-epimanoyl oxide-19-*O*-α-L-2′,5′-diacetoxyarabinofuranoside (8), were isolated from the whole plant (Liu et al. 2006). Ten diterpenoids were isolated including new compounds sagittine H, sclareol and 19-β-L-3′-acetoxyarabinofuranosyl- *ent*-kaur-16-ene-19-oate (Liu et al. 2009).

Starch from the corm of *Sagittaria trifolia* L. var. *sinensis* Makino (arrowhead) contained 31.65 % of amylose and 0.0897 mg/g of phosphorus (Chang 1988). It had a gelatinization temperature range of 56.1–61.7–64.9 °C, a mixed type of Brabender viscosity pattern, a one-stage swelling pattern, 99.6 % water binding capacity, low solubility in dimethyl sulfoxide and high α-amylase susceptibility. The amylose was found to be a branched molecule of DP 2,202 and was hydrolyzed 86.6 % with β-amylase. Its amylopectin had an average chain length of 24.5 and was hydrolyzed 65.5 % with β-amylase.

Sagittariol a new diterpene was isolated from *S. sagittifolia* and characterised as labda-7,14-dien-13(*S*),17-diol (Sharma et al. 1975). Later, sagittariol was considered to be 17-hydroxymanool, as it possessed an A-B *cis* clerodane skeleton (Sharma et al. 1984).

Twenty-eight compounds were identified in the essential oil of *Sagittaria trifolia*; the major components were found hexahydrofanesyl acetone (62.3 %), tetramethylhexadecenone (5.8 %), myristaldehyde (4.7 %), *n*-pentadecane (2.9 %) and 2-hexyldecanol (2.9 %) (Zheng et al. 2006). Other minor compounds were n-pentylfuran 0.3 %, *n*-decaldehyde 0.4 %, *n*-tetradecane 0.4 %, isocaryophyllene 0.9 %, longifolene 1.2 %, caryophyllene 0.8 %, *trans*-geranylacetone 0.7 %, methyl pentadecane (2.1 %), β-caryophyllene 0.6 %, dimethylundecenol 1.4 %, *n*-cetane 1.1 %, caryophyllene 0.9 %, tridecyl aldehyde 0.6 %, *n*-heptadecane 1.3 %, tetramethylpentadecane 0.6 %, myristic acid 2.1 %, *n*-octadecane 0.6 %, tetramethyl pentadecanol 0.8 %, 2-hexyl-1-decanol 1.2 %, *n*-nonadecane and phenanthrenol 0.8 %.

Diuretic Activity

The alcoholic extract of S. *sagittifolia* was reported to show diuretic activity (Sharma et al. 1975).

Immunomodulatory Activity

A terpenoid, sandaracopimaric acid isolated from the plant exhibited good immunosuppressive activity (Yaun et al. 1993). Several diterpenes trifoliones A, B, C and D exhibited inhibitory effects on the histamine release from rat mast cells induced by compound 48/80 or calcium ionophore A-23187 (Yoshikawa et al. 1993, 1996).

Antimicrobial Activity

The antimicrobial activity of the essential oil was evaluated against seven microorganisms. Studies showed that *S. trifolia* oil had a significant antimicrobial effect on several microorganisms (Zheng et al. 2006). This antimicrobial activity can partly explain why the oil is used medicinally during childbirth and for skin diseases in Chinese traditional medicine. Another study reported that four ent-rosane diterpenoids, sagittines A–D, isolated from the whole plant, exhibited antibacterial activity against the oral pathogens, *Streptococcus mutans* and *Actinomyces naeslundiis*, with MIC values between 62.5 and 125 μg/mL (Liu et al. 2006). Sagittine E was active against only *A. naeslundiis*, with an MIC value of 62.5 μg/mL. Sagittine H, a new *ent*-rosane glycoside, demonstrated antibacterial activity against *Streptococcus mutans* and *Actinomyces naeslundiis* with MIC of 62.5 μg/mL (Liu et al. 2009). The other diterpenoid, 19-β-L-3′-acetoxyarabinofuranosyl-*ent*-kaur-16-ene-19-oate, exhibited strong activity against *S. mutans* and *A. naeslundiis* with MIC of 15.6 μg/mL.

Proteinase Inhibitory Activity

Arrowhead was reported to contain double-headed and multifunctional proteinase inhibitors APIA and APIB consisting of 179 amino acid residues with three disulfide bonds (Yang et al. 1992; Xu et al. 1993; Luo et al. 1997). Earlier studies by Chi et al. (1985) found that APIB consisted of 141 amino acid residues; 20 pairs amino acid residues were repeated in the molecule of this inhibitor. Three of these pairs even occurred three times, suggesting that this arrowhead inhibitor may belong to a new family. Inhibitor APIA inhibited an equimolar amount of trypsin and chymotrypsin simultaneously and weakly inhibited kallikrein, while inhibitor APIB inhibited two molecules of trypsin simultaneously and inhibited kallikrein more strongly than did inhibitor APIA (Yang et al. 1992). Both inhibitors consisted of 150 amino acid residues with three disulfide bonds (Cys 43-Cys 89, Cys 110-Cys 119, and Cys 112-Cys 115) and share 90 % sequence identity, with 13 different residues. Both inhibitors were found having the same cDNA sequence and genomic structures. Though they share 91 % homology, they are different in inhibitory activities (Xie et al. 1997). Lys-44 and Arg-76 were found to be the reactive site of APIB and Ser-82 and Leu-87 for APIA. Studies by Li et al. (2002b) confirmed that Arg-76 and Arg-87 but not Lys-44 were definitely the reactive sites of APIB and Leu-87 in APIA. Subsequent studies by Li et al. (2002a) found that the inhibitory specificity of arrowhead protease inhibitors A and B (APIA and APIB) were modulated by conformation around tryptophan residues. Jiang et al. (2008) reported that arrowhead protease inhibitor A (API-A), a member of the serine protease inhibitor family, could inhibit two trypsin molecules simultaneously. Further studies by Bao et al. (2009) found that the ternary structure revealed that the two trypsins bind on opposite sides of API-A and were 34 A apart. The two P1 residues were unambiguously assigned as Leu(87) and Lys(145), and their identities were further confirmed by site-directed mutagenesis.

Traditional Medicinal Uses

The plant is antiscorbutic, laxative, tonic and diuretic. The leaf is used to treat a range of skin problems (Duke and Ayensu 1985). The tuber is regarded as discutient and galactagogue and may induce premature birth. *S. trifolia* essential oil is used medicinally during childbirth and for skin diseases in Chinese traditional medicine (Zheng et al. 2006). In Vietnam, the plant is used to treat dizziness or to apply on pimples (Tanaka and Nguyen 2007).

Other Uses

Aerial parts of Chinese arrowhead are fed to cattle in parts of India and Southeast Asia and also to pigs.

Comments

Most specimens determined as *Sagittaria sagittifolia* are, in fact, this taxon (Wang et al. 2010).

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