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Review article

FLEMINGIA VESTITA BENTH-A HIGHLY VALUED MEDICINAL AND EDIBLE TUBER OF MEGHALAYA

Generous Muliar*, Arpita Paul, Md. Kamaruz Zaman

Department of Pharmaceutical Sciences, Faculty of Science and Engineering, Dibrugarh University, Dibrugarh 786004, Assam, India

Abstract

Flemingia vestita Benth and Hooker, commonly known as 'Soh-phlang' is a less explored medicinal plant found in the Khasi and Jantia hills of Meghalaya. Apart from its consumption as a vegetable by the local communities its tubers are used to treat stomach ailments and menstrual problems. The comprehensive review aims to provide an updated information on the ethnomedicinal use, phytochemistry and pharmacological evaluations carried out till date. Scientific investigation led to the identification of formononetin, genistein, pseudobaptigenin and diadzein as the active bioactive compounds present in the tubers of F. vestita. However, limited studies on the pharmacological profile of F. vestita such as the antioxidant, antibacterial, antihelminthic and estrogenic potential have been carried out. Therefore, in-depth research should be carried out to explore the chemical constituents present in the plant which might contribute in the development of new drug candidates in the treatment of various diseases. Further, the pharmacological profile of the plant should be explored at molecular, preclinical and clinical levels in order to uncover the medicinal value of the less known plant of Northeast India.

Keywords: Soh-phlang, medicinal plant, Northeast India, root tuber, less explored

Introduction

Plants with medicinal properties have been employed since the Vedic era. It has been reported that two-thirds of the world's plant species contain medicinal property. They have been used to cure and prevent a variety of diseases and epidemics [1]. They are considered as the key constituents of traditional and alternative systems of medicine. These medicinal plants contain several components

*Corresponding author's E-mail: generousmuliar9@gmail.com

of therapeutic value that can be used to develop formulations to treat various pharmacological disorders [2]. In addition, the declining efficacy of synthetic medications, as well as the number of side-effects associated with them, has brought back the use of natural drug to the spotlight.

Numerous indigenous plants of Northeast India, particularly of Meghalaya, are employed for their therapeutic properties. Meghalaya is endowed with a great biodiversity of tuber crops. FlemingiavestitaBenth and Hooker, often known as 'Soh-phlang,' is a little trailing legume with crisp, white edible root tubers with sweet, nut-like flavor. It belongs to the Fabaceae family. This root crop is commonly farmed as a cash crop in Meghalaya's Khasi and Jaintiahills, and is consumed by the indigenous tribal population. Generally the raw tubers are eaten raw as a snack with salt and chilli flakes, or with powdered perilla seeds (Perillafrutescens or Neilieh in khasi), after the outer skin has been removed [3]. In addition, the local communities use the fleshy tuberous roots as well as the peel of the plant to treat stomach ailments and fight helminthes [4].

The tubers of the plant are rich in protein, iron, and phosphorus, and are highly valued by the Garo, Khasi and Jaintia tribes of Meghalaya. Therefore these tubers have a lot of potential to provide a cost-effective source of energy [5]. Genistein, daidzein, formononetin, and pseudo-baptigenin are amongst the major bioactive isoflavones found in it. However, complete assessment of this plant is yet to be carried out in order to establish its efficacy across all aspects. This review aims to provide a thorough and up-to-date information on F. vestita with emphasis on its cultivation process, phytochemistry and pharmacological properties in order to gain the interest of the researchers to investigate the therapeutic efficacy of this less explored species of Northeast India.

Plant profile

Taxonomic classification [6,7]

Kingdom : Plantae
Phylum : Magnoliophyta
Class : Angiospermae
Category : Fabids
Order : Fabales
Family: Fabaceae or Leguminosae
Sub-family : FaboideaePapilionoideae
Tribe : Phaseoleae
Sub-tribe : Cajaninae
Genus : Flemingia
Species : *F. vestita*

Common names: *Flemingia procumbens* Roxb; *Moghania procumbens* (Roxb.); *Moghania vestita* (Benth) ex Baker Kuntze*; Maughania vestita*, *Maughania procumbens.*

(A) (B)

Fig 1: (A) Soh-phlong with the tuberous roots, (B) Consumable raw tubers without the outer skin

Fig 2: Dried root tubers of soh-phlong with peeled and unpeeled outer skin

Morphological studies

The plant *F. vestita* Benth, also known as 'SohPhlong,' in Khasi, which means grass fruit. It is a trailing herb with tuberous roots that takes 7 months to mature [8]. *Flemingia* is a nitrogen-fixing perennial herb with a tuberous root and with a prostrate but weak, extensively branched stem that grows up to 60 cm in length. The leaves are hairy, pinnately compound, with obovate, cuneate leaflets. The lateral leaflets are slightly smaller and obliquely elliptic. The inflorescence is a raceme that is either axillary or terminal, measuring 2–10 cm in length and densely

pubescent, with lanceolate bracts. Calyx has five lobes, each of which is linear-lanceolate and longer than the tube. The corolla is oval and somewhat longer than the calyx. The flowers are a vibrant crimson color. The fruits are in the form of hairy sub-cylindrical pods. The seeds are globose and can be black or brown in color. Flowering occurs after the monsoon season, in August and September, and sometime in the autumn [3,9]. The tubers grow from mid-October to mid-February and from November through March they are harvested.

Geographical distribution

F. vestita a wild herb that grows along the Himalayan mountain ranges. It was first cultivated in the Khasi hills (Meghalaya), from which it further spread to the Jaintiahills due to increased demand [10]. It is currently grown in Cherrapunji, near Shillong, and Jawai. It is also found in Sichuan and Yunnan provinces of China, Khasi highlands of Nepal, Laos, the Philippines, and in Vietnam [8].

Cultivation Process

The crop is farmed between 1,000 and 1,600 meters in the undulating terrain of the Khasi and Jaintia hills using the shifting cultivation method (Jhuming). Steep slope lands are chosen over gradual sloping areas with tiny undulations spanning several hectares. It is preferable to have sandy loam rather than rocky ground. Small holes, about 20 to 25 cm apart, are dug in the raised beds, the little tubers are dropped down in each of the holes or pits below 10 to 15 cm deep, and decomposed manure is added. It's planted in February-May and harvested in September-December, with the tubers being pulled out after around seven months. The tubers are physically collected by digging them up with a shovel and storing them in an earthen pit, from which tubers are taken out as needed on the market. The produce is available for eating by local/tribal people from September onwards, depending on the time of sowing, and it is available until May. No irrigation is required because the crop is rain-fed. In local marketplaces of Meghalaya, polished tubers are sold for Rs 250-400 per kg [11].

There are no well-defined kinds, but tribal or cultivators divide the produce into two groups: roundish tuberous types and elongate tuberous types, the latter being the most frequent. There is also a belief that certain locations produce sweeter varieties than others, but there is no hard evidence for this. Approximately 4 quintals of seeds in the form of little tubers sowed per hectare can generate 30-40 quintals of commercial output. The yield in Jawai is substantially larger, maybe exceeding 60 quintals per hectare. According to the Block Development Officer of the Jawai Development Block in Thadleskein (Jaintia Hills), Meghalaya, the production could reach 100 quintals per hectare. The low yield in some areas could be due to a disease that affects the tubers, making them filthy, unappealing, and eventually

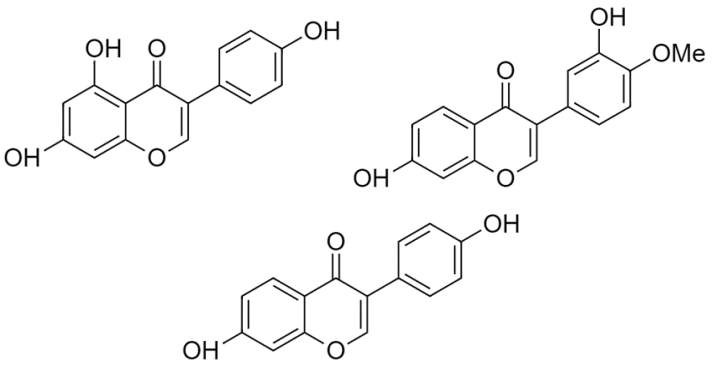
rotten. The disease is similar to the potato scab disease, however more research is required [3,10,11,12].

Folkloric uses

The soft, fleshy tuberous root just below the crown is the part of the plant that is consumed. It has a pleasant taste, is sweet and juicy, and is eaten raw once the upper delicate skin has been removed. Iron and phosphorus are abundant in the tubers, and also includes a good amount of protein, calcium, and carbohydrates [10]. The raw tuber is immediately consumed by the Meghalayans to eliminate the parasitic soft-bodied worms that infest the gastrointestinal tract. The unpeeled tubers are used for deworming by the Khasiindigenous. The tuber extract was also found to be effective against the zoonotic intestinal digenetic flukes *Artyfechinostomum sufrartyfex* and *Fasciolopsis buski* found in pigs. Major isoflavones such as formononetin, diadzein, genistein, and others can be found in these tubers. Genistein has a wide range of biological actions, with estrogenic activity being one among the most notable [13, 14]. The in-vitro activity of tuber peel extract was tested against various helminth parasites in 1996, including nematodes like *Ascaris suum, Ascaris lumbricoides, Ascaris diagalli, Heterakis gallinarum*, a cestode called *Raillietina echinobothrida*, and trematodes like *Paramphistomum sp., Artyfechinostomum sufrartyfex*. This plant extract has vermifuge efficacy against trematodes and cestodes, according to the findings [15]. The main anti-helminthic principle is genistein, which is particularly effective against trematodes and cestodes and may be isolated from tubers. Human tapeworms such as *Echinococcus multilocularis* and *Echinococcus granulosus* metacestodes were also found to be efficient against this chemical [16,17]. Furthermore, *F. vestita* can be utilised as an alternate treatment for menopausal syndrome [14].

Phytochemical studies

Isoflavonoids such as formononetin, genistein, pseudobaptigenin and diadzein were present in the root extract of *F. vestita* [18]. The major isoflavone, genistein (4′,5,7trihydroxyisoflavone) was found to be eluted at benzene: ethylacetate,7:3 fraction [19]. Marbohand Mahanta (2020) reported that the nutrient presents in *F. vestita* tubers contain protein, fat, carbohydrate, dietary fibre, starch, amylase, ascorbic acid, cyanide and reducing sugar. The minerals potassium, sodium, magnesium, calcium, phosphorus, iron copper, manganese and zinc were also reported to be present in the tubers of the plant [20].



Genistein **Formononetin** **Diadzein**

Pharmacological studies

Antioxidant activity

Marboh and Mahanta(2020) evaluated the nutritional and antioxidant qualities of cultivated 'soh-phlong' (CS) and marketed 'soh-phlong' (MS). Total phenolic content (TPC), total flavonoid content (TFC), and antioxidant activities (AA) were measured in the flours using conventional-assisted-extraction (CAE), microwave-assisted-extraction (MAE), and ultrasound-assisted-extraction (UAE). The antioxidant activity of both samples were determined using 2,2-diphenylpicrylhydrazyl (DPPH), 2,2'-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) and ferric reducing antioxidant power (FRAP). MAE had the most anti-oxidant activity in FRAP and DPPH among the three extraction techniques, whereas UAE had the highest ABTS radical scavenging activity. Except for DPPH and ABTS of CAE extracted sample, CS flour sample exhibited substantially ($p>0.05$) larger level of antioxidant capabilities than MS flour sample for all extraction techniques. The higher readings for the CS flour sample might be due to the fact that the flour was made from newly harvested tubers, whereas MS flour was made from stored tubers. The IC50 values of the samples were compared to the IC50 value of the reference ascorbic acid standard, which had a DPPH IC50 value of 0.0255 mg/mL and an ABTS IC50 value of 8.75 mg/mL dry. CS and MAE flour samples had the lowest IC50 values for both DPPH and ABTS across the sample and extraction procedures. The lower IC50 values of the CS flour and MAE extracted flour samples suggest that just a little quantity of sample is required to achieve 50% inhibition, emphasizing their efficacy as free radical scavengers. Furthermore, MAE had the lowest IC50 value due to its higher extraction efficiency of total phenols and flavonoids, indicating that it has a higher potential for free

radical scavenging than UAE and CAE [20].

Anthelmintic activity

Pal *et al.*,(1998) investigated the anthelminthic activity of *F. vestita* by testing the active chemical component of the crude root-tuber peel extract i.e. genistein, against soft-bodied helminth parasites from the trematode and cestode families. The impact of the plant-derived component on the parasite's tegumental enzyme activity was investigated in order to determine the mechanism of action. Acid phosphatase (AcPase), alkaline phosphatase (AlkPase), adenosine triphosphatase (ATPase), and 59'-nucleotidase (59' Nu) were found mostly in the tegument, subtegument, and somatic musculature.The visible stain intensity decreased dramatically following exposure to the the crude extract (50 mg/ml) or genistein (0.5 mg/ml), demonstrating little or no activity in these areas. Following genistein administration, the activity of AcPase, AlkPase, ATPase, and 59' Nu were found to be inhibited by 97, 95, 88, and 57 percent, respectively. They also discovered that the reference standard, praziquantel (PQZ) (0.01 mg/ml), reduced enzymatic activity in a similar way as genistein therapy. These findings imply that the parasite's tegumental enzymes might be a key target for genistein, which appears to act trans-tegumentally [21]. Das *et al.*,(2009) examined the function of phytochemicals from *F. vestita* and *S. glabra* to figure out how these plant-derived components work as anthelmintics. The researchers tested the efficacy of nitric oxide synthase (NOS), nitric oxide (NO) efflux, and guanosine 3',5'-cyclic monophosphate (cGMP) concentration in the cestode (*Raillietina echinobothrida*) using crude peel extract and purified portion of *F. vestita*, as well as the crude rhizome extract and fractions of *S. glabra*. The parasites were also given pure genistein, sodium nitroprusside (SNP – a known NO donor), and the comparative standard, PZQ. When compared to the controls, the treated parasites had a large increase (32–87 %) in NOS activity and a two to three-fold increase in NO efflux into the incubation medium at the time of paralysis onset. The content of cGMP in the tissue of the treated parasites were likewise elevated by 44–103 %. There was no rise in cGMP levels in parasite tissue in the availability of NG-nitro-L-arginine methyl ester, a powerful NOS inhibitor. The phytochemicals from *F. vestita* and *S. glabra*, in particular genistein and tetrahydropalmatine, disrupt the downstream signalling pathway of NO, by the alterating the cGMP levels in parasite tissue. Under the anthelmintic stress, the raised cGMP level might also be blamed for additional negative consequences in the cestode parasite *R. echinobothrida*. These preliminary findings offer insight into the possible creation of novel plant-based anthelmintic medications [22]. Another study was carried out to investigate avermicidal/vermifugal impact in the fowl tapeworm *R. echinobothrida* by processing the alcoholic crude root-peel extract of *F. vestita* and its principle

compounds viz. isoflavone and genistein. In addition, the cestode *R. echinobothrida* was examined in terms of glucose metabolism using the root-tuber peel of *F. vestita* and its active component genistein. When compared to control worms, there was a considerable drop in glycogen concentration, as well as a fall in glucose of 14-32 %, and an increase in malate concentration of 49-134 % respectively [23,24]. Further, Roy and Tandon(1996) investigated the effects of ethanol root-tuber extract of *F. vestita* on *Artyfechinostomum sufrartyfex* and *Fasciolopsis buski* on a leguminous plant using scanning electron microscopy. Within 1.1-1.4, 0.8-1.0, and 0.3-0.5 hours, *A. sufrartyfex* was paralyzed. On the tegumental surface of treated *A. sufrartyfex* (20 mg extract/ml phosphate-buffered saline), stereo scanning observations indicated that majority of the spines have sloughed off or were disorted, as well as creases and rupture of the general tegument were observed. *F. buski* showed severe tegumental changes and malformations when subjected to 20 mg extract/ml phosphate-buffered saline [13].

Antibacterial activity

The antibacterial activity of *F. vestita* tuber skin was investigated by Madara*et al.,* (2021) Methanol extract of tuber skin was tested against gram-negative bacteria such as *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and gram-positive bacteria such as *Mycobacterium tuberculosis* and *Bacillus subtilis* using the Agar well diffusion method at various concentrations. The positive control was ampicillin, whereas the negative controls were sterile distilled water and methanol. At 0.5 mg/ml, *F. vestita* methanol extracts was found to be effective against *M. tuberculosis* and *B. subtilis*, with zones of inhibition of 13.3±0.57 mm and 16.3±4.9 mm, respectively. However, inhibition zones were not seen against *P. aeruginosa*, *K.pneumoniae*, or *E. coli* [25].

Estrogenic potential

Using an ovariectomized rat model, Shailajan*et al.*,(2016) investigated the estrogenic activity of the ethanolic extract of *F. vestita*Benth tubers. When compared to the ovariectomized control group, glycogen levels, uterine weight, glucose-6-phosphate dehydrogenase (G6PDH) levels, progesterone and oestrogen levels increased dosage dependently after treatment with the ethanolic extract of *F. vestita* tubers. The authors concluded that an ethanolic extract of F. vestita tubers (500 mg/kg body weight) might have good estrogenic action in an ovariectomized rat model based on their findings. The authors also speculate that the extract may be used as a base for phytotherapeutic formulations, thereby increasing the market value of *F. vestita* tubers [14].

Conclusion

The demand for herbal medicines is increasing across the world and is simultaneously supported by more laboratory research into the pharmacological evaluation of the bioactive components and their capacity to cure various ailments. Northeast India is one such region of the nation that is home to a plethora of remarkable and yet to be discovered plants that might be used to treat a variety of maladies. *F. vestita* is a plant that can only be found in the Khasi and Jaintia Hills of Northeaster India. It is a less explored plant that has been traditionally used only as an anthelminthic. The existing knowledge on this medicinal plant might be used as a starting point for doing comprehensive research in order to uncover new powerful chemicals and further investigate their biological functions. The purpose of this review was to provide an overview of the plant, and trigger an interest amongst the researchers to conduct in depth research on a variety of biological functions that might be exhibited by this plant. Furthermore, exploration of the chemical constituents present in the plant species might help in the identification of new therapeutic leads thereby contribute in the drug discovery process.

Conflict of Interest

The authors declare no conflicting interests.

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