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Review Article

Flemingia strobilifera (L.) W. T. Aiton: A Holistic Review on Phytochemistry and Pharmacological Aspects

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ABSTRACT

Flemingia strobilifera (L.) W. T. Aiton (*Fabaceae*) commonly known as "Wild Hops" is an important ethnomedicinal shrub distributed worldwide throughout Asia, Central America and North Eastern Australia. An updated research evidences about this plant have been collected until 2023 from various peer-reviewed research articles through several online databases such as Scopus, Pub Med, Google Scholar, Science Direct and Research Gate. The keywords used during online search were *F. strobilifera*, plant description, habitat and ecology, ethnobotanical importance, phytochemistry and pharmacological activities. Chemical analysis report indicated the presence of various phytochemicals such as alkane, aurone glycoside, chalcones, epoxy chromenes, flavanones, flavonoid-O-glycosides, flavonols, isoflavonones and sterols. Prevailing studies on pharmacological functions of this plant explained several biological properties such as anthelmintic, analgesic, anti-inflammatory, antioxidant, anxiolytic, anticonvulsant, antiulcerogenic, antimicrobial, antidiabetic, wound healing and estrogenic. Overall, this review discusses the therapeutic promises explored in recent years and highlights the research gaps for forthcoming research.

Keywords: Ethnomedicinal value, *Fabaceae*, *Flemingia strobilifera*, Pharmacological activities.

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INTRODUCTION

Plant-derived natural products have been used to support manhood by sustaining human health since the emergence of medicine. Traditional medicine has been in existence since time immemorial and has been well accepted and exploited by the mankind throughout history. The use of certain plants as drugs can be derived from the earliest literature written in different languages such as Sanskrit, Hebrew and Greek etc. Herbal extracts contain several bioactive compounds or secondary metabolites that act against various ailments whose mode of action differs for each extract and phytocompound.[1] *Flemingia strobilifera* (L.) W. T. Aiton is one of the ethnobotanically important plants which come under *Fabaceae* family. This genus comprises of about 42 species. China, India, Burma, Thailand and Laos have maximum diversity of this species compared to other countries such as Vietnam, Bhutan, Bangladesh, Cambodia and Nepal.[2] It is an annual, erect shrub distributed worldwide throughout Asia, Central America and North Eastern Australia.[3] Leaves are three to four inch long, oblong or ovate-lanceolate, terminal acute with rounded base. Root is cylindrical or slightly twisted.[4] Flowers are bracteolate racemes with three to six inch long. Pods are dark brownish in colour and elliptic in shape with two seeds.[5] Various parts of this plant such as bracts, leaves, flowers and roots are used in folkloric medicine in different parts of India. Leaves and flowers are used to treat tuberculosis and root is used to treat ulcer, body swellings, epilepsy, hysteria, fever, diarrhoea and dysentery.[6-9] Many distinctive research studies have been carried out by validating the usefulness of this species in conventional medicine during the past few years.[10-12] For example, characterisation of anatomical features[5,13,14] ethnomedicinal importance[15-17] economic benefits,[18] phytoconstituents[19,20] and various pharmacological activities such as anthelminthic,[21] analgesic,[9,10] anti-inflammatory[10,22] antioxidant activity,[23,24] anti-anxiety activity,[25] anticonvulsant,[26] anti-ulcerogenic activity,[27] antimicrobial activity,[14,19] antidiabetic activity,[28] wound healing activity[29] and estrogenic activity.[11] So far, there is no complete library search has been carried out on *F. strobilifera* using available data collected from different published articles. Therefore, this review targets a broad and significant documentation on phytochemistry and pharmacological properties of *F. strobilifera* along with their habitat and ecology, distribution, taxonomical position, morphological characteristics, anatomical features, ethnomedicinal importance and economic benefits.

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MATERIALS AND METHODS

In this review, the overall information about the plant has been collected from several peer reviewed research articles fetched from various electronic sources such as ScienceDirect, Scopus, Google Scholar, Google, PubMed and Research Gate. The keywords used during online search comprises of *F. strobilifera*, plant description, habitat and ecology, ethnomedicinal importance, phytochemistry and pharmacological activities. *F. strobilifera* is used as an ethnomedicine for curing various diseases since ancient period due to the presence of various bioactive compounds; therefore, its therapeutic potential shows a tremendous future in both research and clinical purposes.

General description of *F. strobilifera* (L.) W. T. Aiton

Habitat and ecology

F. strobilifera is a widespread species that grows all over the world. It is noticed growing along the roads, in open forests and grasslands at an altitude of ca. 600-1500 m asl.[3] It is also found as deciduous and semi-evergreen forests in the plains.[29] In Jamaica, it is commonly found in fields and forming thickets along field borders. And also, they found along tracks, in waste regions near streams and in vacant pastures thriving from sea level upto 915 m.[18] In New Caledonia, it is found on tarnished pastures, bare land, disturbed land and roadsides.[30] In French Polynesia and Hawaii, it is found along the roadsides as ornamental plant.[31]

Global distribution

At global level, *F. strobilifera* is distributed in Bangladesh, Bhutan, Brunei, Cambodia, Caroline islands, Ceylon, China (Hubei, Yunnan), Indonesia (Java, Kalimantan, Lesser Sunda islands, Moluccas, Sulawesi, Sumatra, Timor), India, Loas, Malaysia, Myanmar, New Caledonia, Nepal, Papua New Guinea, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam, Australia (Queensland) and Central America.[3]

Indian distribution

In India, *F. strobilifera* is dispersed from Bengal to South India. Andaman and Nicobar Islands andhra Pradesh, Eastern Assam, Bihar, Chhattisgarh, Goa, Gujarat, Himachal Pradesh, Jharkhand, Karnataka (Chikmangalur, Coorg, Hassan, Mysore, North Kanara, South Kanara and Shimoga), Kerala-All Districts, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Orrisa, Rajasthan, Sikkim, Tamil Nadu (Coimbatore, Nilgiri, Salem, Tirunelveli), Tripura, Uttar Pradesh, Uttarakhand and West Bengal.[3]

Phenology

In mainland Asia, flowers formed from February to August, whereas fruiting is from April to November. In Indonesia, it produces flowers and fruits throughout the year.[32]

Description

Taxonomical classifications of *F. strobilifera* are shown in Table 1.

Synonyms

Flemingia bracteata (Roxb.) Wight; *Flemingia fruticulosa* Benth.; *Flemingia strobilifera* R.Br.; *Flemingia strobilifera* var *bracteata* (Roxb.) Baker; *Hedysarum bracteatum* Roxb.; *Hedysarum strobiliferum* L.; *Moghania bracteata* Hui-lin Li; *Moghania fruticulosa* (Benth.) Mukerjee; *Moghania strobilifera* (L.) J.St-Hil.; *Zornia strobilifera* (L.) Pers.[29,32]

Various vernacular names of *F. strobilifera* are mentioned in Table 2.

Morphology

F. strobilifera is an annual, erect shrub, growing to a height of about 1 m tall. Leaves are unifoliolate, 6.0-15x2.5-7 cm in size, ovate or elliptic to broadly angulate in shape with broadly wedge-shaped or rounded base and acute to acuminate apex (Figure 1). Upper portion of leaves are glabrous while the nerves underneath are of pubescent type and lateral nerves are about five to six pairs in number. Long petioles (1-1.5 cm) with hairs and long linear-lanceolate, scarious stipules are also present. Inflorescences are axillary and terminal racemes. Flowers are yellowish white with papilionaceous (1+2+2)), pedicellate, bracteate and bracteolate, complete, bisexual, zygomorphic, pentamerous, cyclic and hypogynous. Bracts are surrounded by large foliaceous bracteole (0.2 cm in size), flower has cylindrical pedicel (0.1-0.2 cm long) with synsepalous and valvate aestivation. Petals are of three forms such as standard petal (0.6x0.5 cm), the wing (0.3x0.5 cm) and keel (0.3x0.50 cm) with imbricate aestivation, diadelphous stamens and terminal style. Another is dithecuous, dorsifixed and ovary is superior, moncarpellary, unilocular with marginal placentation. Pods are dark-brownish, oblong-shaped and pubescent with two seeds.[29]

Anatomical features

Root

In the external view, epidermal cells are thin-walled and rectangular in outline. Transverse section of root showed the presence of 2-4 layered radially arranged, thin walled, polygonal shaped, tabular cork cells. Outer layer is made up of reddish-brown amorphous substance. Phelloderm is one to three layered with radially arranged parenchymatous cells. Secondary phloem consisted of slightly lignified fibres. Both protoxylem and metaxylem are present. Xylem is made up of xylem fibres, lignified xylem vessels and xylem parenchyma. Medullary rays are bi or multiseriate. Pith is absent in root. Microscopic studies of the powdered root showed the presence of fragments of vessels, fibres, cork cells, starch grains and numerous prismatic calcium oxalate crystals. Thin-walled, long and narrow heavily

lignified xylem fibres are also present. Starch grains are simple and oval shaped. Cork cells are thin-walled, polygonal in shape and made up of orange-brownish matter in both surface and cross-section.[5,13]

Leaf

In the external view, the epidermal cells of both surfaces are thin-walled parenchymatous. Upper epidermal cells are polygonal or more or less rectangular shaped. Both dorsal and ventral surfaces are wavy in nature. Stomata are present in large numbers in lower surface only. They are of paracytic types and somewhat oval shaped. Reniform-shaped guard cells with abundant chloroplasts present. Both uniseriate and glandular trichomes present on both surfaces. Transverse section of leaves showed cuticle on both surfaces. Thin-walled, parenchymatous, rectangular shaped single layered epidermal cells are present. Both upper and lower surfaces showed wavy epidermal cells. Palisade cells with one to two layers, chloroplast present with spongy cells, thin-walled parenchymatous cells with intercellular spaces are also observed. Collateral natured vascular bundles are present. Microscopy of the powdered leaves showed the presence of epidermal cells, stomata, trichomes, mesophyll and spongy cells, spiral and pitted vessels.[5]

Stem

In the surface view of the stem, thin-walled parenchymatous rectangular to polygonal shaped epidermal cells with thin cuticle are present. Glandular and uniseriate trichomes are also present. Transverse section of the young stem is triangular or irregular shaped. Epidermal cells are single layered, barrel shaped and thin walled. Parenchymatous cells are two to five layered and collenchyma cells are two to four layered, irregular shaped and thin-walled. Collateral vascular bundles are present. Microscopic reports of the powdered leaves showed the presence of remnants of epidermal cells and fibres.[5]

Figure 1: Morphology of *F. strobilifera*.

Table 1: Taxonomical classification of *F. strobilifera*.[30]

Kingdom	Plantae
Phylum	Tracheophyta
Class	Magnoliopsida
Order	Fabales
Family	Fabaceae
Genus	Flemingia
Species	Strobilifera

Table 2: Vernacular names of *F. strobilifera*.[30]

Language	Vernacular names of *F. strobilifera*
English	Wild Hops, Luck plant
Hindi	Clipti, Kanphuta
Kannada	Kumalu
Malayalam	Kanala, Kumbilteri, Kumalu
Marathi	Kanphuti, Nundar
Gujarati	Kasrut
Telugu	Nallabadu
Assamese	Makhiloti, Makhioti

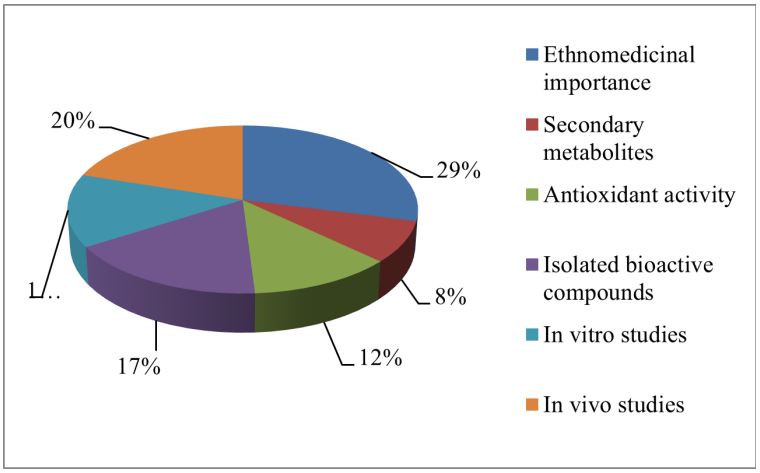

Figure 2: Pie chart represents the percentage of various studies completed in *F. strobilifera*.

Ethnomedicinal importance

F. strobilifera is an important traditional medicinal plant used for the treatment of several diseases. This plant is used by tribes of 17 different states of India. It shows repellent activity against mosquito and some other blood-sucking insects.[16] It is also used for malarial treatment.[33] It is also used as a fly repellent by Marma tribes. Decoction of the whole plant is given for haemorrhage.[15] Arabians use the leaves in cosmetics, as anthelmintic and as a remedy for coughs and cold.[24,34] In Java, decoction made from leaves is used both internally and externally as vermifuge for children and in Bangladesh, leaf juice is taken for worm infection.[15] In Malaysia, leaves are used to cure rheumatism.[35] Subanean tribes of Lapuyan, Zamboanga del Sur used pounded leaves for curing inflammation.[36] In Malaya, decoction made from leaves is administered after childbirth for bathing.[37] In the Philippines, a decoction made with flowers and leaves is used by "curanderose" for curing tuberculosis.[17] Tagakaulo people in Davao del Sur are using dried leaves for alleviating allergy. People of Philippines squeeze the water after burning the leaves and use it for rubbing abdominal area for curing colic.[29] Flowers are used by folkloric people as an antitubercular agent.[17] Pizon *et al.*[37] noted that Subanean tribe used the decoction of roots for the treatment of tuberculosis and diabetes. In Trinidad and Tobago, roots are used for kidney problems.[38] In Nepal, root juice is taken twice daily for one week for curing diarrhoea and dysentery.[5,15] According to Gahlot *et al.*[26] roots are used for treating epilepsy in Burma. And also root of this plant is being used in alleviating hysteria, insomnia and to ease pain by folk practitioners.[34,40] Decoction of root is taken for menstrual irregularities.[17,41] Paste form of root is applied locally for scabies by Darai tribe of Chitwan district, Nepal.[14,15] In Nepal, juice made from bark is taken daily. It is also used for treating inflammations.[17]

Economic benefits

F. strobilifera is a minor host of the lac insect.[42] It plays a role in agroforestry, soil conservation and land filling. It is a commonly used ornamental plant[43] and is used in decorations especially in making bouquet because of its beautiful exaggerated bracts. Floral bracts of this plant look similar to the true hop plant which eventually leads to the common name wild hops.[18] In Philippines, leaves and dried bracts are used for filling pillows and cushion. Burned wood residues of this plant are used for blackening the teeth.[35]

Phytochemical profile

F. strobilifera comprises of alkaloids, carbohydrates, coumarins, fats and oils, glycosides, phenols, quinines, saponins, steroids, tannins and terpenoids.[1,2,13,44,45] Flavonoids are the structurally varied secondary metabolites with a wide range of functions. Earlier studies reported the presence of flavonoids, flavonoid glycosides, chalcones, epoxy chromenes and pterocarpans[19,46,47] and a root-derived chalcone named as 3í, 6í-dihydroxy-2í,4í,5í,4í-tetramethoxychalcone.[48] Compounds isolated from this plant include lignoceryl lignocerate[49] and hydrocarbons such as nonadecane (6.31%), hexacosane (3.50%) and hexanedioic acid, bis(2-ethylhexyl) ester (2.71%) whereas thiocyanic acid, ethyl ester, limonene, phenol, 3,5-bis (1,1-dimethylethyl), eicosane and heptacosane were present in minor quantities.[19] Madan *et al.*[19] isolated compounds such as flavanone, genistin and β-sitosterol-D glucoside from methanol, butanol and dichloromethane root extracts of this plant. Other than these phytochemicals, various bioactive compounds present in *F. strobilifera* are shown in Table 3.

Pharmacological applications

Anthelminthic activity

Kumar *et al.*[21] evaluated anthelminthic activity of various solvent-based leaf extracts of *F. strobilifera* using adult Indian earthworm (*Pheretima posthuma*). Among various extracts, alcoholic extract at a dose of 100 mg/mL showed significant anthelminthic activity. For this, piperazine citrate was used as a

Table 3: Various chemical constituents present in *F. strobilifera*.

Alkane		
1.	n-Tritriacontane	[50]
Aurone glycoside		
2.	Leptosin	[51]
Chalcones		
3.	3',6'-Dihydroxyl-4,2',4',5'-tetramethoxychalcone	[52]
4.	Flemiculosin	[53]
Epoxy chromenes		
5.	Flemingin X, Y and Z	[45,54]
Flavanones		
6.	Flemingiaflavanone(8,3'-diprenyl5,7,4'trihydroxy flavanone)	[19]
Flavonoid-O-glycosides		
7.	Phlorizin	[45,47]
8.	Naringin	[45,54]
Flavonols		
9.	Quercetin-3-O-rhamnoside	[55,56]
10.	Quercitrin	
11.	Quercimeritrin	
12.	Rutin	
Isoflavonones		
13.	Genistein	[19]
14.	5,7,4í-Trihydroxy-8,2í,5í-tri(3-methylbut-2-enyl) isoflavone	[57]
15.	5,7,2í,4í-Tetrahydroxyisoflavone	
Sterols		
16.	β-Sitosterol	[58]

standard drug and 1% Tween 80 in normal saline was used as control.[21]

Analgesic activity

Kumar *et al.*[9] assessed root methanolic extracts of *F. strobilifera* (300, 500 and 1000 mg/kg b.wt) for analgesic activity using tail immersion method in albino mice. Acetylsalicylic acid in the dose of 300 mg/kg b.wt was used as standard drug. Of three concentrations, 300 mg/kg b.wt showed a significant analgesic activity. Kumar *et al.*[10] also evaluated ethanolic and aqueous root extracts of this plant at two different doses i.e., 400 and 600 mg/kg b.wt in albino rats of either sex by tail flick method. Dichlofenac sodium (10 mg/kg b.wt) was used as the standard drug. Ethanolic extract at 600 mg/kg b.wt showed significant analgesic activity compared to aqueous extract.

Anti-inflammatory activity

Itankar,[22] evaluated anti-inflammatory activity of methanolic and hydro-alcoholic aerial part extract (200 and 400 mg/kg b.wt) using carrageenan-induced paws oedema and cotton pellet-induced granuloma methods in Swiss albino mice. Of two extracts, hydro-alcoholic aerial part extract at 400 mg/kg b.wt showed potent anti-inflammatory activity. Kumar *et al.*[10] studied anti-inflammatory activity of ethanolic and aqueous root extracts of this plant at two different doses (400 and 600 mg/kg b.wt) using Carrageenan-induced paws oedema method in albino rats of either sex. Of these two extracts, ethanolic extract at 600 mg/kg b.wt showed significant anti-inflammatory activity.

Antioxidant activity

Swati *et al.*[23] evaluated antioxidant activity of methanolic leaf extract and butanolic, methanolic and dichloromethane root extracts of *F. strobilifera* using DPPH radical scavenging activity, nitric oxide free radical scavenging assay and p-NDA hydroxyl radical scavenging activity. Root methanolic and dichloromethane extracts showed low IC_{50} values of 11.4 and 19.0 µg/mL respectively in DPPH radical scavenging assay. Higher IC_{50} values were found for nitric oxide and hydroxyl free radical scavenging

by p-NDA method for all the extracts. Low IC_{50} values was found in methanolic root extract followed by dichloromethane root extract in DPPH radical scavenging activity compared to leaf methanolic extract. Hsieh *et al.*[28] noted the antioxidant activities of the aqueous extracts of four Flemingia species such as *F. macrophylla, F. prostrata, F. lineata* and *F. strobilifera* in Taiwan. Among the all extracts strongest antioxidant activity was showed by aqueous extract of *F. macrophylla*. And also, it had higher content of various secondary metabolites and *in vitro* antidiabetic activities than the other extracts.

Kumar *et al.*[59] evaluated antioxidant activity of chloroform leaf extract of *F. strobilifera* using nitric oxide scavenging assay and found that the extract did not exhibit potent NO free radical scavenging activity. Further, he showed this extract did not possess effective hepatoprotective and antioxidant activity against paracetamol induced hepatic injury in rats.

Gahlot *et al.*[39] reported ethanolic root extracts of three Flemingia species such as *F. macrophylla, F. chappar* and *F. strobilifera* can be a potential source of natural antioxidants (Total phenolic content, total flavonoid content) with strong antiradical efficiency ($ABTS^+$, DPPH, NO, SO and reducing power).

Pizon *et al.*[37] studied antioxidant activity of the hydromethanolic (80%) and aqueous leaf extracts of *F. strobilifera* at 4 different concentrations (0.25 mg/mL, 0.5 mg/mL, 1.0 mg/mL and 2.0 mg/mL). Of two concentrations, aqueous extract showed more significant activity with low IC_{50} value (0.25 mg/mL) concentration which is similar to the standard (ascorbic acid).

Anxiolytic activity

Mahajon *et al.*[25] evaluated the anxiolytic activity of aqueous root extract of *F. strobilifera* at the doses of 200 mg/kg and 400 mg/kg b.wt using elevated zero maze test and mirror chamber test in swiss albino mice. Diazepam was used as the reference standard drug. Significant anxiolytic activity was found in both concentrations compared to control.

Anti-convulsant activity

Gahlot *et al.*[26] evaluated the anti-convulsant activity of 95% ethanol extract and four succeeding fractions such as petroleum ether, chloroform, ethyl acetate and aqueous fractions of the roots of *F. strobilifera* against pentylenetetrazole and maximal electroshock-induced seizures in swiss albino mice. Diazepam (4 mg/kg b.wt) and phenytoin (20 mg/kg b.wt) were used as standard anti-convulsant drugs. Crude ethanol extract (200, 400, 600 mg/kg b.wt) and all the four fractions at 100, 200 and 300 mg/kg were administered for both tests. High doses of 95% ethanol crude extract (400 and 600 mg/kg b.wt) and high doses of ethyl acetate fraction (200 and 300 mg/kg b.wt) significantly lowered the duration of convulsions.

Anti-ulcerogenic activity

Kumar *et al.*[27] investigated the anti-ulcerogenic effect of the chloroform extract of *F. strobilifera* root by inducing stress ulcer in albino wistar rats of either sex at two different doses (15 and 30 mg/kg b.wt). For this, ranitidine (25 mg/kg b.wt) was used as a standard drug and 10% Tween 80 was used as control. Treatment with chloroform extract at a dose of 15 and 30 mg/kg body weight increased the gastric mucosal glutathione level, total protein content as compared to control group whereas there is significant reduction in gastric mucosal malonaldehyde levels when compared to control.

Antimicrobial activity

Grosvenor *et al.*[60] studied the antimicrobial activity of leaf, fruit and stem extracts of *F. strobilifera* which were potent against *Staphylococcus aureus.* According to Mahato and Chaudhary,[61] the root extract of *F. strobilifera* showed activity against *Staphylococcus aureus* and *Escherichia coli.* Madan *et al.*[19] evaluated antimicrobial activities of Flemingiaflavanone, Genistin and β-sitosterol-D glucoside isolated from *F. strobilifera* root extracts against Gram-positive (*Staphylococcus aureus, Staphylococcus epidermidis*, Methicillin resistant *Staphylococcus aureus*), Gram-negative bacteria (*Pseudomonas aeruginosa, Escherichia coli*) and fungi (*Candida albicans*). Flemingiaflavanone showed significant antimicrobial activity against all the six microorganisms whereas Genistin showed moderate activity.

Nemkul *et al.*[12] evaluated antimicrobial activity of hexane and aqueous-methanolic root extracts against eight bacterial strains such as *Pseudomonas aeruginosa* (ATCC 27263), *Staphylococcus aureus* (ATCC 25923), *Escherichia coli* (ATCC 25922), *Klebsiella pneumoniae* (ATCC 700603), *Enterococcus faecalis* (ATCC 29212), *Bacillus subtilis* (ATCC 6051), *Shigella dysenteriae* (ATCC 13313) and *Salmonella enteric* subsp. *enteric serovar typhi.* The aqueous-methanolic extract indicated stronger antimicrobial activity against *Escherichia coli* with lowest minimum inhibitory concentration and minimum bactericidal concentration values.

Anti-diabetic activity

Hsieh *et al.*[28] reported anti-diabetic activity of *F. strobilifera* aqueous root extract using *in vitro* assays such as α-glucosidase and aldose reductase inhibitory activity. Aqueous root extract showed higher IC_{50} value of 1468.60±2.10 µg/mL for α-glucosidase and 112.12±2.32 µg/mL for aldose reductase activity. Genistein was used as positive control for both the assays.

Wound healing activity

Wound healing activity of 70% ethanolic root extract of *F. strobilifera* was evaluated in excision wounds using male albino rats. Tetracycline ointment was used as the standard drug. The rate of epithelisation and complete wound closure was daily

recorded. The wound closure time was faster in both extract and standard treated groups than in control group.[29]

Estrogenic activity

Jeong *et al.*[11] evaluated the estrogenic activity of *F. strobilifera* methanolic extract and its bioactive compounds (isoflavones, pterocarpans and chalcones) using *in vitro* assays such as human Estrogen Receptor alpha (hERα) binding and estrogen response element luciferase reporter assays and *in vivo* uterotrophic assay. From this study, he concluded that extract and its derived compounds could be used as promising candidates for the treatment of post-menopausal symptoms.

From the above review, it is evident that various pharmaceutical activities of *F. strobilifera* have been carried out by researchers (Figure 2). So far 29% ethnobotanical survey was conducted to document the ethnomedicinal importance of this plant. The presence of various secondary metabolites such as phenols, flavonoids, tannins etc. was confirmed by 8% studies. *In vitro* antioxidant action of the plant was found as 12%. So far, 17% studies led to isolation of various bioactive compounds with validation of their pharmacological properties. Both *in vitro* (14%) and *in vivo* (20%) were carried out to confirm various pharmacological properties of various extracts of this plant species.

CONCLUSION

Traditionally used medicinal plants play a major role in health field due to its extensive source of phytocompounds. Bioactive compounds derived during secondary metabolism are the factors behind various pharmacological properties of *F. strobilifera*, a potent ethnomedicinal plant used by the tribes for alleviating several diseases. This review documented geographical distribution, botanical description, morphological characteristics, anatomical features, ethnomedicinal importance, economic benefits, phytochemical profile and pharmacological properties which may contribute to the isolation and characterisation of novel compounds and development of new drug for the betterment of society. It is noted that majority of the pharmacological studies so far done were limited to *in vitro* and *in vivo* screening of various extracts of this plant. However, the mechanism of action of isolated compounds and their pharmacokinetics are not examined so far. Thus, this review identify the research gap prevailing in this plant species which will be filled by future bioactive compounds isolation and understanding the mechanism of their action through various *in vitro* and *in vivo* models.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

DPPH: 2,2-diphenyl-1-picrylhydrazyl; **NO:** Nitric Oxide; **SO:** Superoxide; **ABTS:** 2,2 azino-bis(3-ethylbenzothiazolin e-6-sulfonic acid); **ATCC:** American Type Culture Collection.

REFERENCES

1. Das K. Ethnobotanical studies and phytochemical analysis of *Flemingia strobilifera* (L.) WT Aiton of Jorhat, Assam, India. Int J Sci Res Rev. 2018;7(7):556-64.
2. Narayanan A, Shenoy A, Shabaraya AR. A review on pharmacological activities of *Flemingia strobilifera*. Int J Pharm Sci Rev Res. 2020;60(1):70-2.
3. Kisan Gavade S, Van der Maesen LJ, Madhwanand Lekhak M. Taxonomic revision of the genus *Flemingia* (*Leguminosae*: *Papilionoideae*) in India. Webbia. 2020;75(2):141-218. doi: 10.36253/jopt-8767.
4. Madan S, Gullaiya S, Singh GN, Kumar Y. *Flemingia strobilifera*: review on phytochemistry and pharmacological aspects. Int J Phytopharmacol. 2013;4(4):255-62.
5. Soe SZ, Myint S. Study on morphological and histological characters of *Flemingia strobilifera* (L.) R. Br. Journal of the myanmar Academy of Arts and Science. 2018;16:235-46.
6. Bhattarai NK. Folk herbal medicines of Makawanpur district, Nepal. Int J Pharmacogn. 1991;29(4):284-95. doi: 10.3109/13880209109082899.
7. Manandhar NP. Plants and people of Nepal. Vol. 599; 2002.
8. Ghalot K, Lal VK, Jha S. Phytochemical and pharmacological potential of *Flemingia* Roxb. ex W.T. Aiton (*Fabaceae*). Int J Phytomed. 2011;3(3):294-307.
9. Kumar A, Gahlot K, Dora J, Singh P. Analgesic activity of methanolic extract of *Flemingia strobilifera* (R. Br.). Int J Res Pharm. 2011a;1(4):825.
10. Kumar A, Kavita G, Jyotsana D, Rishikant T. Anti-inflammatory and analgesic activities of *Flemingia strobilifera* (Linn). Res J Pharm Biol Chem Sci. 2011b;2(3):541-46.
11. Jeong SY, Chang M, Choi SH, Oh SR, Wu HH, Zhu Y, *et al.* Estrogenic effects of phytoestrogens derived from *Flemingia strobilifera* in MCF-7 cells and immature rats. Arch Pharm Res. 2018;41(5):519-29. doi: 10.1007/s12272-018-1027-1, PMID 29797242.
12. Nemkul CM, Bajracharya GB, Shrestha I. Phytochemical evaluation and *in vitro* antimicrobial activity of the roots of *Flemingia strobilifera* (L.) R. Br. Int J Plant Res. 2019;7(1):98-103.
13. Kavita G, Lal VK, Jha S. Comparative morpho-anatomical and preliminary phytochemical studies of *Flemingia strobilifera* (L.) R. Br. and *Flemingia macrophylla* (Willd.) Merr. (*Fabaceae*). Int J PharmTech Res. 2012;4(1):495-500.
14. Nemkul CM, Bajracharya GB, Shrestha SP, Patel BR. Ethnomedicinal uses of *Flemingia strobilifera* (L.). W.T., Aiton. Int J Pharm Biol Sci. 2018; 6: 1-5.
15. Mahajon B, Remadevi R, Sunil Kumar KN, Ravishankar B. Preliminary analysis of botanical and phytochemical features of Kamalu root of *Flemingia strobilifera* (L.) W.T Aiton. J Homeopath Ayurvedic Med. 2014;3(171):2167-1206.
16. Shreedevi P, Patel BR. Ethnomedicinal uses of *Flemingia strobilifera* (L.). W.T. Aiton. Int J Pharm Biol Sci. 2018;6:1-5.
17. Bhuyan C, Kalita B, Das T. Design and development of herbosomes cream for the prevention and treatment of black fly bites. J Pharm Innov. 2019;8(6):932-42.
18. Shital D, Anubha K, Jignyasha R. A Comprehensive review of *Flemingia strobilifera* (LAM.). Acta Sci Pharm Sci. 2021;5(6):105-10. doi: 10.31080/ASPS.2021.05.0736.
19. Madan S, Singh GN, Kumar Y, Kohli K, Singh RM, Mir SR, *et al.* A new flavanone from *Flemingia strobilifera* (Linn) R. Br. and its antimicrobial activity. Trop J Pharm Res. 2008;7(1):921-7. doi: 10.4314/tjpr.v7i1.14678.
20. Campbell K. *Flemingia strobilifera* (L.) W.T. Aiton. In: Aliens of Xamayca – a newsletter on non-indigenous species in Jamaica. Vol. 5(3); 2012.
21. Kumar A, Dora J, Gahlot K, Tripathi R. Anthelmintic activity of *Flemingia strobilifera* (R. Br.). Int J Res Pharm Biol Sci. 2011;2(3):1077.
22. Itankar PR. Evaluation of anti-inflammatory Activity of *Flemingia strobilifera* Linn. *Fabaceae*. Res J Pharm Technol. 2009;2(4):865-7.
23. Swati M, Singh GN, Yatendra K. Kanchan K. Phytochemical analysis and free-radical scavenging activity of *Flemingia strobilifera* (Linn) R. Br. research Journal of Pharmaceutical. J Biol Sci. 2010;1(4):183-90.
24. Pizon JR, Nuñeza OM, Uy MM, Senarath WT. GC-MS analysis and evaluation of *in vitro* antioxidant potential and total phenolics content of wild hops (*Flemingia strobilifera* (L.) W.T Aiton. Int J Biol Sci. 2016a;8(1):25-32.
25. Mahajon B, Nath R, Thakur SK, Demadevi R, Shankar RB. Anxiolytic effect of root extract of amazing folklore herb *Flemingia strobilifera* (L.) WT Aiton in albino mice. Int J Curr Res. 2017;9(11):60216-9.

26. Gahlot K, Lal VK, Jha S. Anticonvulsant potential of ethanol extracts and their solvent partitioned fractions from *Flemingia strobilifera* root. Pharmacogn Res. 2013;5(4):265-70. doi: 10.4103/0974-8490.118825, PMID 24174820.
27. Anil Kumar KA, Dewan B, Rama T. Evaluation of anti-ulcerogenic properties from the root of *Flemingia strobilifera*. J Basic Clin Pharm. 2010a;2(1):33-9. PMID 24826000.
28. Hsieh PC, Huang GJ, Ho YL, Lin YH, Huang SS, Chiang YC, *et al.* Activities of antioxidants, α-glucosidase inhibitors and aldose reductase inhibitors of the aqueous extracts of four Flemingia species in Taiwan. Bot Stud. 2010;51(293):302.
29. Soe ZS, Wai WT, Aye WO. Evaluation on wound healing properties of root extract of *Flemingia strobilifera* (L.). R. BR. in albino rat model. J Basic Clin Physiol Pharmacol. 2019;17(4):181-8.
30. Indiabiodiversityportal; 2023. Available from: https://indiabiodiversity.org/species/show/229764.
31. Blanfort V, Desmoulins F, Prospéri MJ, Le Bourgeois T, Grard P, Guiglion R, *et al.* 2010. 1.0: Principales Adventices et plantes à conflit d'intérêt des Pâturages de Nouvelle-Calédonie.
32. Space JC, Flynn T. Observations on invasive plant species in American Samoa. Honolulu: USDA Forest Service, Pacific Southwest Research Station, Institute of Pacific Islands Forestry; 2000.
33. Mustaqim WA. *Flemingia strobilifera* (L.) WT Aiton *Fabaceae*. Ethnobot Mt Reg S East Asia. 2020:1-7.
34. JU SK, MJ. KC, Semotiuk AJ, Krishna V. Indigenous knowledge on medicinal plants used by ethnic communities of South India. Ethnobot Res Appl. 2019;18:1-12.
35. Duthie JF. Flora of the upper Gangetic Plain. Off Superintendent Gov Print. 1915.
36. Burkill IH. A dictionary of the economic products of the Malay Peninsula. A Dictionary of the Economic Products of the Malay Peninsula, No. 2; 1966.
37. Pizon JR, Nuñeza OM, Uy MM, Senarath WT. Ethnobotany of medicinal plants used by the Subanen tribe of Lapuyan, Zamboanga del Sur. Bull Environ Pharmacol Life Sci. 2016;5(5):53-67.
38. Burkill IH. A dictionary of the economic products of the Malay Peninsula. Vol. II (IZ). London: Crown Publishing Group Agents for the Colonies; 1935.
39. Gahlot K, Lal VK, Jha S. Total phenolic content, flavonoid content and *in vitro* antioxidant activities of *Flemingia* species (*Flemingia* Chappar, *Flemingia macrophylla* and *Flemingia strobilifera*). Res J Pharm Technol. 2013;6(5):516-23.
40. Lans CA. Ethnomedicines used in Trinidad and Tobago for urinary problems and diabetes mellitus. J Ethnobiol Ethnomed. 2006;2:45. doi: 10.1186/1746-4269-2-45, PMID 17040567.
41. Kirtikar KR. Indian medicinal plants: Lalit Mohan Basu. Allahabad, India; 1935. p. 1-838.
42. Gogoi B, Zaman K. Phytochemical constituents of some medicinal plant species used in recipe during â€˜ Bohag Bihuâ€™ in Assam. J Pharmacogn Phytochem. 2013;2(2):30-40.
43. Kumar P, Srivastava SC. Record of *Flemingia strobilifera* as a lac host. Indian Forester. 1993;119(9):762-4.
44. Neal MC. In gardens of Hawaii. Bernice Bishop Museum Special Publication 50, HI, USA. Bishop Museum Press; 1965.
45. Saxena VK, Nigam SS, Singh RB. Glycosidic principles from the leaves of *Flemingia strobilifera*. Planta Med. 1976;29(1):94-7. doi: 10.1055/s-0028-1097635.
46. Dhar DN, Singh RK, Munjal RC. Chemical examination of *Flemingia* Chappar ham: root constituents. Monatshefte für Chemie/chemical monthly. 1971;102:1777-81.
47. Gumula I 2014. Phytochemical Investigation of Three *Leguminosae* Plants for Cancer Chemopreventive Agents (Doctoral dissertation, University of Nairobi).
48. Bhatt S. Quercetin glycosides from *Flemingia strobilifera*. Indian J Chem. 1976;14(3):230-1.
49. Cardillo G, Merlini L, Mondelli R. Natural Chromenes-III: colouring matters of wars: the structure of flemingins a, b, c and homoflemingin. Tetrahedron. 1968;24(1):497-510. doi: 10.1016/0040-4020(68)89049-0.
50. Rao KN, Srimannarayana G. Flemiphyllin, an isoflavone from stems of *Flemingia macrophylla*. Phytochemistry. 1984;23(4):927-9. doi: 10.1016/S0031-9422(00)85070-0.
51. Nigam SS, Saxena VK. Isolation and study of the aurone glycoside leptosin from the leaves of *Flemengia strobilifera*. Planta Med. 1975;27(1):98-100. doi: 10.1055/s-0028-1097768, PMID 1161882.
52. Adhikarla S. Root flavonoids. Bot Rev. 1984;56:29-37.
53. Khattri PS, Sarathi Khattri P, Sahai M, Dasgupta B. Flemiculosin, a novel chalcone from *Flemingia fruticulosa*. Heterocycles. 1984;22(2):249-52. doi: 10.3987/R-1984-02-0249.
54. Saxena VK. Epoxy Chromenes: The Therapeutic Agents from *Flemengia strobilfera*. Asian J Chem. 1995;7(2):307.
55. Hu SY. An enumeration of Chinese materia medica. Chinese University Press; 1999.
56. Rastogi RP, Mehrotra BN. Compendium of Indian medicinal Plants, Central drug research institute Lucknow, publications and information directorate. 1st ed. New Delhi: COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH; 1993. p. 444.
57. Madan S, Singh GN, Kohli K, Ali M, Kumar Y, Singh RM, *et al.* Isoflavonoids from *Flemingia strobilifera* (L.) R. Br. roots. Acta Pol Pharm. 2009;66(3):297-303. PMID 19645330.
58. Prasad JS, Varma RS. 5, 7, 2′, 4′-tetrahydroxyisoflavone in Moghania *macrophylla*. Phytochemistry. 1977;16(7):1120. doi: 10.1016/S0031-9422(00)86768-0.
59. Kumar KA, Satish R, Rama T, Anil K, Babul D, Samhitha J. Hepatoprotective effect of *Flemingia strobilifera* R. Br. on paracetamol induced hepatotoxicity in rats. Int J PharmTech Res. 2010b;2(3):1924-31.
60. Grosvenor PW, Gothard PK, McWilliam NC, Supriono A, Gray DO. Medicinal plants from Riau province, Sumatra, Indonesia. Part 1: uses. J Ethnopharmacol. 1995;45(2):75-95. doi: 10.1016/0378-8741(94)01209-i, PMID 7776664.
61. Mahato RB, Chaudhary RP. Ethnomedicinal study and antibacterial activities of selected plants of Palpa district, Nepal. Sci World. 2005;3(3):26-31.

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