



A Comprehensive Review on *Allium Fistulosum* (Welsh Onion): Botany, Distribution, Medicinal Uses, Phytochemistry, and Pharmacological Activities

Rekha Jethi¹, Jasmeen Syan², Anoop Singh Negi³, Anupriya Sundriyal⁴, Mahalaxmi Muskan², Sayantan Mukhopadhyay², Ankit Kumar^{2*}

¹JBIT College of Pharmacy, Dehradun, 248197, India

²College of Pharmacy, Shivalik Campus, Dehradun, 248197, India

³ Department of Pharmacology, School of Pharmaceutical Sciences and Technology, Sardar Bhagwan Singh University, Balawala, 248161, Dehradun, Uttarakhand, India

⁴ Siddhartha Institute of Pharmacy, Dehradun - 248001, Uttarakhand, India

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KEYWORDS

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ABSTRACT:

Introduction: *Allium fistulosum* L., commonly referred to as Welsh onion, is a perennial herbaceous plant of the *Amaryllidaceae* family. It is native to Eastern Asia, particularly China and Japan, it has long been cultivated for both culinary and medicinal purposes. It is characterized by its hollow, tubular leaves and mild onion-like flavor, the species has garnered attention for its diverse therapeutic applications.

Objectives: The primary objective of this review is to comprehensively compile and analyze the existing literature on the botany, geographical distribution, traditional medicinal uses, phytochemical constituents, and pharmacological activities of *A. fistulosum*, with the aim of establishing its significance as a medicinal plant and identifying potential areas for future research.

Methods: An exhaustive literature survey was conducted to collect and review relevant data from online scientific databases such as Scopus, PubMed, and Google Scholar, as well as from offline sources including ethnobotanical books, floras, pharmacopeias, and Ayurvedic texts. Keywords including "*Allium fistulosum*", "Welsh onion", "phytochemistry", "traditional medicine", "bioactive compounds", and "pharmacological activity" were used. The studies published up to 2024 were considered in present review. The collected data were critically analyzed to produce information related to plant morphology, taxonomy, ethnomedicinal applications, phytoconstituents, and experimental pharmacology.

Results: *A. fistulosum* is rich in various bioactive compounds, including flavonoids (quercetin, kaempferol), phenolic acids (ferulic acid, p-coumaric acid), sulfur-containing compounds (allicin, diallyl disulfide), saponins, and essential vitamins. These constituents contribute to its pharmacological activities such as antimicrobial, antioxidant, anticancer, anti-inflammatory, anti-obesity, antihypertensive, and cardioprotective effects. The plant has been traditionally used for treating colds, digestive issues, wounds, and hypertension. Although widely cultivated in East Asia, its use and recognition in other parts of the world remain limited.

Conclusions: The compiled literature highlights *A. fistulosum* as a nutritionally and pharmacologically significant plant with a rich ethnomedicinal background. Its diverse range of bioactive constituents offers promising potential for therapeutic applications and functional food development. However, further experimental and clinical studies are necessary to validate its efficacy,



elucidate mechanisms of action, and promote its integration into global medicinal and agricultural systems.

1. Introduction

Allium fistulosum was first time taxonomically described by Carl von Linnaeus in 1753. Its name Welsh onion actually means ‘foreign onion’^[1]. It was introduced into Europe from central Asia towards the end of the middle Ages. It is not known in the wild state but possibly evolved in eastern Asia from *A. altaicum*. The crop has been known in China and Japan since ancient times and was the principal onion grown but, in Japan, it has been overtaken by the common onion (*A. cepa*)^[2]. Welsh onion is believed to have been unknown in China before the 6th Century and first mentioned in Japanese literature in 1918. Authorities note that Welsh onion was introduced to England in 1629 but attracted little or no attention at that time. Superficially there is a strong resemblance to *A. cepa*^[3]. Also, it is very similar in taste and odour to the bulb onion^[4]. Foliage leaves of *A. fistulosum* are somewhat rounder in cross-section, not flattened adaxially. Differences are more prominent in the inflorescence: *A. fistulosum* lacks bracteoles, has flowers about twice the size of *A. cepa*, the filaments of the stamens are more protruded, they lack basal teeth and are not broadened at the base. Moreover, *A. cepa* has a much better developed bulb. *A. fistulosum* hybridizes readily with the related wild species *A. altaicum*. These hybrids have high pollen and seed fertility. *A. × wakegi* Araki (synonym: *A. fistulosum* var. *caespitosum* Makino) is a hybrid between *A. fistulosum* and *A. 'cepa* cv. group *Aggregatum* (shallot), with *A. fistulosum* as the female parent. It is a perennial plant forming small bulbs. Its inflorescence forms only bulbils, no fertile seeds. In the vegetative stage it is morphologically similar to *A. fistulosum*. Its leaves are slender, 60-70 cm long. One bulb may produce 20-30 tillers. Other commercial hybrids between *A. fistulosum* and *A. cepa*, grown for their green tops, include "Beltsville Bunching", "Louisiana Evergreen", and "Delta Giant". These hybrids are fertile and normally propagated by seed^[5]. Specific name of species derived from Latin ‘*fistulosus*’ means “tube-like or hollow” pipe-like or a narrow duct or passage’ with reference to a part of the plant which is hollow: hollow, cylindrical leaves (hence the species name *fistulosum*)^[6].

2. Botanical Description

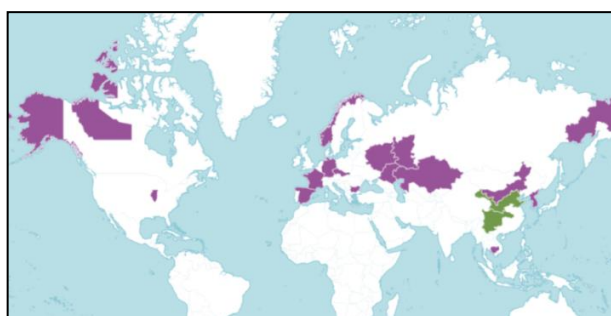
Leaves 6-6 cm, bluish-green, distichously alternate, persistent, upright, 1 terete hollow, cylindrical, sheathing lower 1/4 of scape; blade terete, fistulose, 10–40 cm × 1.0–2.5 cm, glaucous, acute at apex. Scape persistent, solitary, erect, fistulose, inflated in middle, tapering to umbel, 15–40 cm × 0.8–2.5 cm. Inflorescence umbel persistent, globose to ovoid, erect, compact, 3–7 cm in diameter, 50-70 greenish-white to white tepals flowered, sometimes flowers entirely replaced by bulbils; spathe bracts 1–2, hyaline, persistent, up to 1 cm long, splitting into 1–3 parts, 1–3-veined, ovate, ± equal, apex acute. Flowers pedicellate, pedicel slender, up to 3 cm long; hermaphrodite, narrowly campanulate to urceolate, 6–9 mm long. tepals 6, in 2 whorls, free, erect, yellowish white with greenish midvein, ovate-oblong to oblong-lanceolate, unequal, withering in fruit, margins entire, apex acute; stamens 6, long-exserted, connate at base and adnate to tepals, much longer than tepals, anthers white to yellow, pollen white; ovary crestless, superior, 3-celled, style slender, linear, equalling stamens, stigma capitate, obscurely 3-lobed. Fruit globular capsule, 5 mm in diameter, few-seeded. Seeds 3–4 mm × 2–2.5 mm, black, seed coat shining, cells 4–6-angled, rectangular^[7].

3. Geographical Distribution

It grows in full sun or partial shade, prefers fertile loam, preferably moist soil. It is native to China, Japan, Siberia, Magnolia, Eurasia and North America. Probable origin in Asia from Northwestern China, but nowhere truly wild; cultivated all over the world including India, several parts of China at an altitude ranging between 1000-4000m^[8]. It is sometimes grown in the United Kingdom. It is naturalized in Subarctic America, Northern America: United States, Canada; Africa-Northeast Tropical Africa: Sudan; East Tropical Africa: Kenya; West-Central Tropical Africa: Cameroon, Congo, Zaire; West Tropical Africa: Ghana; Sierra Leone; South Tropical Africa: Zambia, Zimbabwe; Asia-Temperate: Caucasus, Russian Federation - Ciscaucasia, Siberia; Eastern Asia: China, Japan, Korea, Taiwan; Indo-China: Thailand, Indonesia, Malaysia,



Philippines and also in Europe. It is a crop throughout the world, but the main area of cultivation remains East Asia from Siberia to Indonesia. In other parts of the world, it is mainly a crop of home gardens [9]. It is native to China North-Central, China South-Central [10]



Native ■ Introduced ■

Figure 1: Geographical Distribution of *A. fistulosum*
[10]

4. Phytochemistry

The plant contains β -carotene, flavonoids as isoquercitrin, kaempferol, quercitol, quercitrin; phenolic compounds as ferulic acids, p-coumaric acid, Sterols as β -Sitosterol, campesterol, stigmasterol, daucosterol, steroidal saponin (Yuccagenin) sulphur compounds as allicin, allyl monosulfide and allyl sulfide; cyclic sulphur compounds as cis-3,5-diethyl-1,2,4-trithiolane, trans-3,5-diethyl-2,4-trithiolane, trans and cis-3-methyl-5-ethyl-1,2,4-trithiolane. Also contains pectin, tridecan-2-one, 2,3-dihydro-2-octyl-5-methyl-3-furanone, N-trans-feruloyl-3'-methoxytyramine, N-cis-feruloyl-3'-methoxytyramine, N-trans-p-coumaroyl tyramine, and 3,5,7-trihydroxyflavone (kaempferol), quercetin, rutin, kaempferol, baicalin [11,12].

Table 2: Phytochemical reported in *A. fistulosum*

S. No.	Constituent	Phytochemical
1.	Indole Alkaloid	Fistulosin (octadecyl 3-hydroxyindole) [13]
2.	Sulfoxide	Allicin [14]
3.	Organosulfur compound	allyl propyl disulfide and diallyl disulfide [15]
4.	Phenolic compound	ferulic acid [16]

5.	Saponin	Furostanol, fistulosaponins A-F, protogracillin [17]
6.	Polyphenols	Cholorogenic acid, Gallic Acid, Sinapic acid [18]
7.	Fructose Polymers	Fructan [19]

5. Therapeutic Properties

It is anhydrotic, antibacterial, antifungal, anthelmintic, antibiotic, anti-inflammatory, pungent, tonic, decongestant, diuretic, expectorant, febrifuge, neurostimulator, stomachic. Roots are antiseptic, diuretic, stomachic, vermifuge and vulnerary. Whole plant (specially bulbs) is anti-bacterial, neurostimulator and stomachic. Bulbs are antibacterial, antifungal, antimicrobial, antipyretic, antiseptic, diaphoretic, diuretic, expectorant, decongestant, galactagogue, stomach, vermifuge and vulnerary. White stalks and rootlets, fresh plant only, are antiseptic, diaphoretic and stomachic [20,21].

6. Pharmacological Activity

Anthelmintic activity: Ethanolic and aqueous extracts of *A. fistulosum* leaves were investigated for their ability to protect against *Ascaris lumbricoides* worms. At room temperature for 7 hours, 3 concentrations of the ethanolic and aqueous extracts of *A. fistulosum* leaves (50, 100, and 200 mg/ml) were evaluated independently against *A. lumbricoides*. After 7 hours, the worm's times to paralysis and death were recorded in order to assess the anthelmintic activity. The positive control was pyrantel pamoate (6 mg/ml), whereas the negative and vehicle controls were sodium chloride (0.9% w/v) and carboxymethyl cellulose (0.5% w/v), respectively. Anthelmintic action was demonstrated by the ethanolic and aqueous extracts at concentrations of 50, 100, and 200 mg/ml. Both extracts caused paralysis when *A. lumbricoides* died. In comparison to pyrantel pamoate, the leaf ethanolic and aqueous extracts were more effective at paralyzing and killing the worms at a concentration of 200 mg/ml. The findings showed that as the extract dosage increased, the worms' times to paralysis and death decreased. The leaves of *A.*



fistulosum showed possible wormicidal efficacy in both ethanolic and aqueous extracts [22].

Anti-microbial activity: Allicin, isolated from *A. fistulosum*, showed anti-bacterial activity. Extracts from roots, stems and leaves of *A. fistulosum* were evaluated for anti-bacterial property against *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Bacillus subtilis*. Extract of stem was active against *Bacillus subtilis*, with MIC (Minimum Inhibitory Concentration) and MBC (Minimum Bacterial Concentration) of 0.2 and 0.4mg/ml. Inhibitory activity of *Allium* extract against bacteria was greater than that of 10µg/mL allicin. Anti-bacterial activities of commercial rice wine extracts obtained from different plant parts of *A. fistulosum* were evaluated using agar disc diffusion and tube dilution tests. Extract contained 28.3-95.9µL/mL allicin and exhibited significant anti-bacterial activity. All extracts exhibited activity against *Bacillus subtilis*, *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa* [23]. Essential oils from *A. fistulosum* were evaluated for anti-fungal effects against three *Trichophyton* species responsible for severe mycoses in humans by broth dilution method and disk diffusion assay. Oil exhibited mild inhibition of growth of *Trichophyton rubrum*, *Trichophyton erinacei* and *Trichophyton soudanense*. Inhibiting activities of oils on Sabouraud agar plates were dose dependent against *Trichophyton* species. Oil showed significant synergistic anti-fungal activity when combined with ketoconazole in checkerboard titer test and disk diffusion test. Anti-fungal activity of compound, fistulosin (octadecyl 3-hydroxyindole) isolated from roots of *A. fistulosum* L. was tested. Fistulosin primarily inhibited protein synthesis and found highly active against *Fusarium oxysporum* [24]. Fructan, acts as anti-influenza A virus substance, was isolated from hot water extract of green leafy part of welsh onion (*A. fistulosum*). It did not show anti-influenza A virus activity, *in vitro*, but it demonstrated inhibitory effect on virus replication, *in vivo*, when it was orally administered to mice. Polysaccharide enhanced production of neutralising anti-bodies against influenza A virus [25].

Anti-cancer activity: Inhibitory effect of *A. fistulosum* L oil (AFLO) was evaluated for anti-cancer activity on

growth of human gastric cancer transplanted subcutaneously in mice. Tumour growth was inhibited by 36.07% at 10mg/ml. AFLO could also inhibit DNA index and average DNA contents [26]. Effects of *A. fistulosum* oil (ALFO) was evaluated for anti-cancer activity on gastric cancer cell line MGC80-3 (human gastric cancer cell line) and possible signal molecular mechanism underlying apoptotic process induced by AFLO. It was observed that with increasing concentration of AFLO, cell growth inhibitory rates went up correspondingly 24 hours after treatment with AFLO and reached 5.71%, 36.33%, 44.34%, 54.52% and 74.15%, respectively with $IC_{50} \approx 65 \mu\text{g/ml}$. Hoechst 33258 fluorescent staining showed that apoptosis appeared in some cells treated by AFLO (100µg/mL). When MGC80-3 cells were incubated in presence of AFLO (100µg/mL) from 1 to 12 hours, total apoptotic rates were 50.16%, 53.48%, 77.84%, 83.71% and 41.34%, respectively and early apoptotic rates were 50.15%, 33.25%, 11.69%, 4.65% and 0.84%, respectively [27]. The effect of *A. fistulosum* extracts on cell cyclical a characteristic of MGC 803 was tested *in vitro*. The results of the study showed that, after the treatment of extract MGC 803 cell membrane retained completely, cell ultrastructure changed with typical apoptosis and differentiation. The treatment with 1.25% *A. fistulosum* extract, apoptotic rates of MGC 803 were 0.6%, 1.6%, 6.1%, 13.5% respectively, diploid rates were 0%, 0.3%, 35.8%, 93.9% respectively at 24 hours, 48 hours, 72 hours, 96 hours. At 24 hours, apoptotic rates of different groups (1.25%, 2.5%, 5.0%, 10.0%) treated with extracts of *A. fistulosum* were 0.61%, 4.1%, 6.2%, 24.9% respectively, diploid rates were 0%, 10.6%, 34.7%, 72.2% respectively. Low concentration of extract induced differentiation of MGC 803 cells mainly, but high concentration of extract induced both differentiation and apoptosis of MGC 803 cells simultaneously. The conclusion of this study was that, the extracts of *A. fistulosum* could inhibit gastric cancer cell's growth and proliferation, induce both differentiation and apoptosis of gastric cancer cell line and its anti-tumour effect has no cyclical specialty [28]. Cytotoxic effect of hexane, chloroform, chloroform:methanol (9:1), butanol and water extracts (500, 200, 100 and 50µg/ml) from Subterranean part of *A. fistulosum* was evaluated on HepG2 cell line by MTT (3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyl tetrazolium



bromide) assay method. Percentage of inhibition by extracts did not exceed 50% at concentration extracts of 500µg/ml and below, therefore no IC₅₀ was registered thus reflecting those extracts was not active against HepG2 cell line [29]. The cytotoxic activity methanol, ethanol and water extract from leaves or bulb of *A. fistulosum* were evaluated on MCF-7 cells (Breast Cancer) by assay. Various concentration (1-30µM) of the extracts were used. Results of this study showed that, the ethanolic and methanolic extract from leaves showed inhibition activities against MCF-7 cells as 49.61 and 28.68 %, respectively. Similarly, the extracts from bulbs revealed inhibition activities as 10.03 & 31 %, respectively [30].

Anti-glycation activity: The ethanolic extract from *A. fistulosum* (scallion) was evaluated for anti-glycation activity by using In vitro glucose bovine serum albumin (BSA) assay in which Aminoguanidine (20 mM) was used as a positive control. *A. fistulosum* exerted marked inhibition of fluorescent AGEs formation. The glycation was monitored over 2 weeks 27.9% inhibition was found. The positive control aminoguanidine inhibited formation of fluorescent AGEs by 75.9 %. [31].

Anti-hypertensive activity: Allicin, isolated from *A. fistulosum*, shows anti-hypertensive activity. Two varieties of *A. fistulosum* (Welsh Onion) named as Green Welsh Onion (green-leafy) and White Welsh Onion (white-sheath) were evaluated for antihypertensive effects on male Sprague-Dawley rats. According to experimental protocol, animals were divided into four test groups (n=6). Group I (Control), received a control diet, group II, received high-fat sucrose diet (HFS), group III received high-fat sucrose diet containing 5.0% of the green *A. fistulosum* (HFS-G) and group IV received high-fat high-sucrose diet containing 5.0% of white species of *A. fistulosum* (HFS-W). Urine was collected during the last 3 days of the growing period for further analysis. After the 4-week growing period, the rats were starved overnight, anesthetized and their blood was collected. The plasma was separated and used to measure the nitric oxide (NO) metabolites and lipid peroxides. Immediately after blood sampling, the thoracic aorta was harvested and used for measuring NADH/NADPH oxidase activity [32].

Anti-hypoxic activity: Saponins, isolated from seeds of *A. fistulosum* were evaluated for anti-hypoxic activity against H/R-induced HUVEC injury using MTT assay. It showed that H/R significantly decreased cell viability to (54.3±4.4) % compared to control [(100.3±2.2) %], and treatment with compounds fistulosaponin A-F, protogracillin and other steroidal saponins significantly improved survival of these H/R-treated HUVEC. All saponins exhibited good anti-hypoxic effect in dose-dependent manner [33].

Anti-inflammation activity: Anti-inflammatory activity of *A. fistulosum* extract, obtained from Plant Extract Bank (PEB) was evaluated. The methanol, ethanol and water extract from leaves or bulb of *A. fistulosum* were prepared and evaluated for their anti-inflammatory activity in male Wistar rats by using carrageenan induced rats paw edema model. 0.5 ml extract of *A. fistulosum* in 0.5% CMC (carboxymethylcellulose) were given to test group. Indomethacin (5 mg/kg) was used as standard drug and given to the standard group (in 0.5% CMC). As a vehicle 0.5 ml of 0.5% CMC was given to the control group. Paw edema volume was measured by water plethysmometer. For every group, the percent of inhibition of edema was recorded against the group vehicle-treated control. Results of the study showed that, the ethanol and methanol extracts from bulb showed the highest inhibition percentage as 10.45 ±1.04% & 8.53 ± 0.85%, respectively. Similarly, the inhibition percentages of ethanol and methanol extracts from leaves were 2.03 ± 0.20 & 5.23 ± 0.29%, respectively [34].

Anti-obesity activity: 70% ethanol extract from *A. fistulosum* (400mg/kg/day, orally) was evaluated for anti-obesity activity in high-fat diet-induced obese mice. AFE (Amniotic fluid embolism) treatment significantly reduced body weight and white adipose tissue (subcutaneous, epididymal and retroperitoneal) weight as well as adipocyte size compared to high-fat diet-induced control mice. *A. fistulosum* extract also significantly decreased triglyceride, total cholesterol, low density lipoprotein-cholesterol and leptin concentrations in serum of mice but increased adiponectin levels. It suppressed mRNA expression of transcription factors, such as sterol regulatory element



binding protein-1c and peroxisome proliferator activated receptor γ , as well as fatty acid synthase in subcutaneous adipose tissue. Anti-obesity activity of cereal bars containing *A. fistulosum* extract of roots and bulbs in high-fat diet-induced obese mice was evaluated. Oral treatment of AFB (*A. fistulosum* bar) in obese mice reduced body weight, lipid accumulation in liver and adipose tissue as well as adipocyte size, compared to high fat diet control mice. Additionally, the AFB raised HDL cholesterol and adiponectin levels while lowering serum triacylglycerol, glucose, and insulin concentrations. In visceral adipose tissue, 5% AFB significantly raised the mRNA expression of the β 3-adrenoreceptor, uncoupling protein-2, and peroxisome proliferators activated receptor- γ . This finding implies that the anti-obesity properties of the cereal bar containing *A. fistulosum* extract may be facilitated by the antioxidant properties of quercetin and ferulic acid [35,36].

Anti-oxidant activity: Anti-oxidant activity and phenolic compounds from methanolic extract of fruit of *A. fistulosum* was evaluated using ABTS + method to assess total anti-oxidant capacity (TEAC) of extract. TEAC values and total phenolic content for extract were 43.4 μ mol Trolox equivalent/100g dry weight (DW) and 0.42g of gallic acid equivalent/100g DW, respectively. Leaf of *A. fistulosum* was used for evaluating radical scavenging activities for DPPH radical. The DPPH scavenging activity was 98.9 μ mol, *A. fistulosum* showed moderate anti-oxidant activity [37,38].

Cardiac activity: *A. fistulosum* extracts (green or white portion, raw or boiled) was evaluated for vascular responses, *in vitro*, in thoracic aortae of Sprague-Dawley rats by applying various inhibitors, such as N^o-nitro-L-arginine, tetraethylammonium and SQ29548. On precontracted vessel rings, extracts of Welsh onions produced vasodilation. These effects were most noticeable in vessel rings treated with raw green-leaf extract (RG). Endothelium-derived nitric oxide acted as a mediator to cause vasorelaxation in response to low dosages of RG. Vasorelaxation without endothelium was brought on by high dosages of RG. Additionally, endothelium-derived constricting factor, possibly thromboxane A₂, was prompted to be released by boiled Welsh onion extract [39].

Immuno-modulatory activity: Using betamethasone (4 mg/kg) as a control, the effects of methanolic and chloroform of *A. fistulosum* bulbs on the mice's cell-mediated immune response were assessed. Chloroform and methanolic extracts significantly decreased paw thickness at doses of 100 and 1000 mg/kg in the intrinsic immunity model, but no discernible dose-response was seen. In the acquired immunity model, they significantly decreased paw thickness at doses of 10, 100, and 1000 mg/kg [40].

7. Medicinal Uses

A. fistulosum have been used as traditional medicine for the treatment of various diseases such as arthritis, cold, cancer, insomnia, skin diseases, fever, microbial infection, etc. It is used in folklore medicine system [41]. Traditional preparations of *A. fistulosum* involve various formulations used in folk medicine for diverse ailments. One such remedy is Chung-bark, a traditional preparation where the fresh bulb is mashed with sesame oil (*Sesamum indicum*) and used as a medicinal drug. Another common formulation is an ointment made by mixing a paste of the fresh herb (*A. fistulosum*) with honey, applied topically. As a tea, this plant has been traditionally consumed to treat conditions such as ascariasis, catarrh, and cholera. Additionally, its applications extend to managing external conditions like boils, abscesses, frostbite, and wind-chills, reflecting its versatile therapeutic use in traditional medicine systems [46–48].

Table 2: Medicinal Uses of *A. fistulosum*

S. No.	Plant Part	Uses
1.	Roots and bulbs	Traditionally stomach ache, Febrile disease, common colds, Dampness, Earache, Fever, Decongestant, Insomnia, Kidney stone and dysfunction, Metriopatheia and Nasal Stuffiness, Skin Diseases, Worm infestation or internal parasites. [42,43]



2.	Whole plant	Arthritis, Cardiovascular disorders, Coryza, Diarrhoea, Dyspepsia and Dysuria, Headache, Hypercholesterolemia, Intestinal obstruction, Microbial Infections, Respiratory Infections, Sinuses, Toothache ^[44, 45]
4.	Seeds	Dizziness, Erectile dysfunction, Eye diseases ^[49]
5.	Flowers	Elephantiasis, Indigestion, loss of appetite ^[50]
6.	Leaves	Neurological Disorders ^[51]

8. Conclusion

A. fistulosum is an underutilized yet highly promising plant species with a long-standing history in traditional medicine and culinary practices. The growing body of scientific literature highlights its diverse pharmacological properties, including antioxidant, antimicrobial, antihypertensive, anticancer, and anti-inflammatory effects. These biological activities are primarily attributed to its rich content of sulfur-containing compounds, flavonoids, and phenolic acids, with allicin being the most prominent bioactive molecule.

As consumer interest in natural remedies and functional foods increases, welsh onion presents a compelling case for further exploration as both a dietary supplement and a therapeutic agent. Preliminary studies demonstrate encouraging results in the management of cardiovascular diseases, metabolic disorders, and microbial infections. More research on this plant may contribute to further developments.

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