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Therapeutic Potential of Allium Fistulosum in the Management of Diabetes Mellitus: A Comprehensive Review

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ABSTRACT
Diabetes mellitus is a chronic metabolic disease itidentify by increased in hyperglycemia its results to impaired insulin secretion and action. That increasing global prevelance for diabetes and the necessity it produces novel it describes cost effective and Diabetes is becoming more and more common in worldwide, which calls for the creation of innovative, affordable, and secure treatment options. The Welsh onion, or Allium fistulosum, is a species of the Allium genus that has long been used for its anti- inflammatory, antioxidant, and hypoglycemic effects.Through a variety of mechanisms, including improving insulin sensitivity, regulating glucose metabolism, and lowering oxidative stress, recent research has investigated its potential to improve diabetic conditions.This review supports Allium fistulosum's role as a promising supplemental agent in the management of diabetes by thoroughly evaluating its phytochemical constituents, pharmacological actions, and potential mechanisms through which it may exert antidiabetic effects.

Keywords: Allium fistulosum, Welsh onion, green onion, Diabetes Mellitus, hyperglycemia, insulin sensitivity, antioxidant, anti-inflammatory, α-amylase, α-glucosidase, traditional medicine.

I. INTRODUCTION

Diabetes Mellitus (DM) is a complicated metabolic disease that causes long-term high blood sugar levels. It comes from either the body not making enough insulin Type IDiabetes or not using the insulin it makes well Type II Diabetesor a mix of the two. Uncontrolled hyperglycemia causes a number of microvascular (retinopathy, nephropathy, neuropathy) and macro-vascular (cardiovascular diseases, stroke) problems that greatly lower quality of life and raise death rates.The current way to manage diabetes is through medicines, changes to lifestyle, and changes to diet. The status of the patient at the time of diagnosis determines the classification of diabetes mellitus. A diabetic person is typically unable to be assigned to a certain class. Sometimes, even after giving birth, people with gestational diabetes mellitus (GDM) experience hyperglycemia. In these cases, Type II diabetes mellitus is typically diagnosed in the patient.[1],[2]

There are many traditional medicines can have bad side effects, which has led to a growing interest in natural products that help with diabetes.

The genus Allium includes many plants, such as garlic (A. sativum), onion (A. cepa), and chives, all of which are known for their culinary and medicinal uses. People from many different cultures have traditionally used these plants for their supposed health benefits, such as helping with metabolic disorders. Allium fistulosum, commonly utilized as a vegetable and seasoning, has attracted interest due to its possible therapeutic properties. This review seeks to furnish a thorough examination of the scientific evidence endorsing the application of A. fistulosum in the management of diabetes mellitus, encompassing its phytochemical composition, mechanisms of action, and results from experimental investigations.[3],[4]

II. BOTANICAL DESCRIPTIONS AND TRADITIONAL USES OF ALLIUM FISTOLUSUM

2.1 Taxonomy and morphology of Allium fistolusum

Allium fistulosum, commonly known as Welsh onion or green onion, is a widely cultivated perennial plant belonging to the large and economically important Allium genus. Its classification places it within the monocotyledonous flowering plants, and its morphology is characterized by features that distinguish it from its close relatives like common onions or garlic, primarily the absence of a distinct, swollen bulb and its hollow, cylindrical leaves.[5],[6]

Taxonomy of Allium fistolusum

- **Kingdom:** Planatae (Plants)
- **Clade:**Angiosperms
- **Order:** Asparagales

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- **Family:**Amaryllidaceae , Liliaceae or Alliaceae, depending on classification system)
- **Subfamily:**Allioideae
- **Genus:** Allium L.
- **Species:**Allium Fistolusum L.
- **Common name:**Welsh onion, Green onion, Scallion, Japanese bunching onion, Spring onion,"spring onion".

Morphology of Allium Fistolusum

- **Growth Habit:**Allium fistulosum is a perennial herbaceous plant, often grown as an annual. It forms clumps of slender, upright stems.
- **Stem/base:**Unlike bulb onions (Allium cepa), A. fistulosum does not form a large, swollen bulb. Instead, it has a slightly thickened, cylindrical to conical white base that is continuous with the hollow leaves. This base is typically consumed along with the green tops.
- **Leaves:** The most distinctive feature they are hollow, cylindrical, and slender. Typically bright green and erect growing from base. The leaves are referred to as "tubular".
- **Roots:**Possesses a fibrous root system that spreads outwards from the base, anchoring the plant firmly in the soil.
- **Flowers:**When allowed to flower, it produces a globe-shaped (umbel) cluster of small, greenish-white or yellowish-white flowers atop a long, hollow scape (flower stalk).The inflorescence is typical of the Allium genus, appearing in late spring to summer.
- **Size:**Varies depending on variety and growing conditions, but typically reaches a height of 30-60 cm (12-24 inches) with slender leaves about 1-2 cm (0.4-0.8 inches) in diameter.[6],[7]

Figure 1: Graphical image of Allium fistolusum[7]

III. TRADITIONAL MEDICINAL APPLICATION:

Table 1: Traditional uses of Allium fistolusum on different diseases

Disease	Traditional uses
Respiratory Ailments	Treating headaches, colds, and influenza is one of its most popular traditional applications. It is thought to help relieve congestion and have warming effects. Its stem and roots have been used as an antipyretic (fever reducer).[8]
Gastrointestinal issue	used historically to treat diarrhea/dysentery, constipation, stomach aches, and abdominal pain. This implies a calming or digestive-assistance effect.[9]
Cardiovascular Health	traditionally acknowledged for its potential to improve heart health and prevent cardiovascular diseases, perhaps as a result of effects on lipid profiles or blood circulation.[10]
Skin conditions	Applied topically for wounds**,** sores**,** andulcers, suggesting antiseptic or healing properties.[11]
Eye health	The bulbs have been used to improve vision in certain traditions.[12]
Immunity booster	In traditional Chinese and Japanese medicine, it is thought to enhance the body's metabolism and general immunity.[13]
General metabolic support	Better metabolic and circulatory health generally improves general health, which can help diseases like diabetes.[14]

IV. PHYTOCHEMICAL COMPOSITION OF ALLIUM FISTULOSUM

Numerous bioactive substances found in abundance in Allium fistulosum contribute to its medicinal qualities. Allium species' sulfur-containing compounds are largely responsible for their distinctive flavor and therapeutic properties. In addition to these, A. fistulosum has a wide variety of other phytochemical, such as:

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Table 2: Phytochemical of Allium fistolusum

Phytochemical Class	Major compounds	Biological/ Antidiabetic significance
Organosulfur Compounds	S-alk(en)ya-l-cysteinesulfoxide(ACSOs), thiosulfinates, thiosulfonates, sulfides	Enhance insulin sensitivity, lower blood sugar, and have anti-inflammatoryand antioxidantproperties; bioactivated when tissue is damagedcutting/chopping.[15]
Flavonoids	Quercetin,Isoquercitrin, Quercitrin	Antioxidant,antiinflammatory, enhances insulin secretion, reduces insulin resistance.[16]
Phenolic acid	Caffein acid, p-coumarin acid, Ferric acid	Scavenge free radicals, protect β-cells, reduce oxidative stress.[17]
Sterol	β-Sitosterol, Campesterol, Stigma-sterol	Improve lipid profile, support cardiovascular health, manage diabetes-related dyslipidemia.[18]
Other constituents	D-Limonene, amino-acids, glycosides, coumarins	D-Limonene:anti-inflammatory & lipid-lowering; Glycosides and amino acids may contribute to metabolic regulation.[19],[20]

These various phytochemical synergistic action probably adds to Allium fistulosum's multifaceted therapeutic potential in the treatment of diabetes.

V. PROPOSED MECHANISMS OF ANTIDIABETIC ACTION

The antidiabetic effects of Allium fistulosum are mediated through several mechanisms, primarily involving glucose metabolism, insulin sensitivity, oxidative stress, and inflammation.

5.1. Modulation of Glucose Metabolism

- **Inhibition of Carbohydrate-Digesting Enzymes:**

In vitro, extracts of A. fistulosum, especially the fibrous root, have demonstrated strong inhibitory activity against α-glucosidase and, to a lesser degree, α-amylase. Two essential enzymes that break down complex carbohydrates into absorbable monosaccharides are α-glucosidase and α-amylase. A. fistulosum can lessen postprandial blood glucose spikes by slowing down the gastrointestinal tract's absorption of glucose by blocking these enzymes. This mechanism is comparable to acarbose and other traditional antidiabetic medications.[21],[22]

- **Enhancement of Insulin Secretion and Sensitivity:**

According to some research, some of the compounds found in Allium species, such as A. fistulosum, may increase the sensitivity of peripheral tissues to insulin or stimulate the secretion of insulin from pancreatic ß-cells. Either direct effects on β- cell function or indirect effects on insulin signaling through the reduction of inflammation and oxidative stress may be involved.[23],[24]

- **Glucose Uptake and Utilization:**

Extracts from A. fistulosum have been shown to enhance the uptake of glucose by peripheral tissues, including muscle and adipose tissue, possibly through the activation of pathways such as AMP- activated protein kinase (AMPK). AMPK activation is essential for controlling lipid and glucose metabolism, which enhances insulin sensitivity and lowers the liver's production of glucose. According to in-silico studies, some tyramine derivatives present in A. fistulosum may even inhibit Sodium- Glucose Co-transporter-2 (SGLT2), which would decrease the kidneys' ability to reabsorb glucose.[25],[26]

5.2 Antioxidants properties

Diabetes complications are exacerbated by hyperglycemia, which damages pancreatic ß-cells, disrupts insulin signaling, and increases the production of reactive oxygen species (ROS) and oxidative stress. Strong antioxidant activity is provided by A. fistulosum's high flavonoid and phenolic acid content. These substances have the ability to scavenge free radicals, lower lipid per-oxidation, and increase the activity of endogenous antioxidant enzymes, such as glutathione peroxidase, catalase, and superoxide dismutase. A. fistulosum can prevent damage to pancreatic ß-cells, maintain insulin function, and lower the risk of diabetic complications by reducing oxidative stress.[27],[28]

5.3 Anti-inflammatory effects

Type 2 diabetes is characterized by persistent low-grade inflammation, which also

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leads to insulin resistance and ß-cell dysfunction. Because of its flavonoid and organosulfur compounds, Allium fistulosum has anti-inflammatory qualities. These substances can decrease the synthesis of pro-inflammatory cytokines like TNF-a, IL-6, and IL-1β and alter inflammatory pathways like the NF-κB pathway. A. fistulosum can enhance insulin sensitivity and general metabolic health by reducing inflammation.[28],[29]

5.4 Lipid profile improvement

Elevated triglycerides, low HDL cholesterol, and LDL cholesterol are the hallmarks of dyslipidemia, which is commonly linked to diabetes and increases the risk of cardiovascular problems. By promoting lipid metabolism and preventing the biosynthesis of cholesterol, certain species of Allium have shown hypolipidemic effects.Compared to garlic or onions, A. fistulosum has less direct evidence regarding its effects on lipid profiles in diabetic modelshowever, its phytosterol content and general Allium properties point to the possibility of positive effects on lipid parameters, which could help manage diabetes indirectly.[30],[31]

VI. EXPERIMENTAL EVIDENCE IN-VIVO AND IN-VITRO STUDIES

- **Animal studies:**

One noteworthy study used an animal model of diabetes mellitus to examine the hypoglycemic effects of Welsh onions (A. fistulosum). In diabetic rats, oral administration of Welsh onion fibrous root extract dramatically reduced the area under the postprandial glucose response curve and incremental plasma glucose levels following starch ingestion.Similar to the effects of acarbose, the Welsh onion group's blood glycated hemoglobin (HbA1c) and plasma glucose levels were significantly lower than those of the control group. This study demonstrated how A. fistulosum may help manage hyperglycemia, especially by inhibiting a- glycosides.

- These results are generally collaborated by other research on Allium species, which shows that extracts can decrease oxidative stress, increase insulin sensitivity, and improve glucose metabolism in diabetic animal models.Due to comparable bioactive compound profiles, A. fistulosum most likely shares the mechanisms seen in A. sativum and A. cepa, such as enhanced insulin secretion, glucose uptake, and antioxidant defense.[32],[33]

- **In-vitro studies**

Several in vitro experiments have confirmed that extracts from A. fistulosum inhibit carbohydrate-digesting enzymes, such as a-glucosidase, supporting its role in lowering postprandial hyperglycemia.

- Antioxidant assays have consistently shown that A. fistulosum extracts possess significant free radical scavenging activity and can protect cells from oxidative damage.
- Its cellular mechanisms would be further clarified by cell-based investigations examining how A. fistulosum affects insulin signaling pathways and glucose uptake in different cell lines.[34],[35]

VII. CLINICAL RELEVANCE AND FUTURE DIRECTION

There aren't many strong clinical trials specifically on Allium fistulosum for the treatment of diabetes in humans, despite encouraging preclinical data. Studies on Allium sativum (garlic) and A. cepa (onion) provide a large portion of the clinical data pertaining to the antidiabetic potential of Allium species.These studies, which are frequently used as a supplement to conventional therapy, have demonstrated varied degrees of success in lowering fasting blood glucose, HbA1c, and improving lipid profiles in diabetic patients.A. fistulosum's traditional use and extrapolation from research on other Allium species provide the majority of the current evidence supporting its use in the treatment of human diabetes. The following are essential to proving that A.fistulosum is a useful medicinal agent.[36]

- **Well-designed Randomized Controlled Trials (RCTs):**To assess the effectiveness, ideal dosage, and long-term safety of A. fistulosum extracts or particular isolated compounds in diabetic patients, large-scale, placebo-controlled RCTs are required.Key glycemic parameters (fasting blood glucose, postprandial glucose, and HbA1c), insulin sensitivity, lipid profiles, oxidative stress markers, inflammatory markers, and quality of life outcomes should all be evaluated in these trials.[37]
- **Standardization of extracts:**Growing conditions, processing techniques, and plant parts used can all affect the chemical makeup and potency of A. fistulosum extracts. For consistent and repeatable therapeutic effects, extracts must be standardized according to their active ingredients.[38]

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- **Pharmacokinetics and pharmacodynamics studies:** It's critical to comprehend how the active ingredients in Afistulosum are absorbed, distributed, metabolized, and excreted (ADME) in humans. The biological effects in vivo in human subjects can be verified by pharmacodynamic studies.[39]
- **Safety and toxicity profile:**Alliums fistulosum is generally regarded as safe for consumption, prolonged supplementation or high dosages may result in adverse effects or drug interactions. Extensive toxicological and safety research is required.[40]
- **Combination therapies:** Examining the possible synergistic effects of A. fistulosum with traditional antidiabetic drugs may result in new and improved treatment approaches, possibly enabling lower dosages of pharmaceutical medications and fewer adverse effects.[41]

VIII. DISCUSSION

The Welsh onion, Allium fistulosum, and its potential as an additional therapeutic agent in the treatment of diabetes mellitus are thoroughly assessed in this review. The need for innovative and supplemental treatments is highlighted by the rising prevalence of diabetes worldwide and the drawbacks of traditional pharmaceutical treatments, including their high cost, side effects, and limited ability to reverse insulin resistance or ß-cell dysfunction. Natural products made from plants that have been used traditionally for medicinal purposes present a promising substitute in this natural products made from plants that have been used traditionally for medicinal purposes present a promising substitute in this regard, and A. fistulosum stands out for its wide range of pharmacological actions and nutritional worth.Numerous bioactive substances, such as organosulfur compounds, flavonoids, phenolic acids, phytosterols, and trace amounts of D-limonene and coumarins, are found in A. fistulosum's phytochemical profile. Many of these substances are well- known for their lipid-lowering, hypoglycemic, anti-inflammatory, and antioxidant properties-effects that are closely related to the pathophysiology of diabetes. Flavonoids like quercetin and its derivatives play a major role in reducing oxidative stress and enhancing insulin action, while organosulfur compounds like S-alk(en)ll-l-cysteine sulfoxides (ACSOs) are particularly interesting because of their insulin-sensitizing and anti-inflammatory qualities. These substances support important diabetes management processes such as better glucose metabolism, increased insulin sensitivity, antioxidant defense, and anti-inflammatory effects. There is currently little clinical evidence, despite promising preclinical research. To validate its function as a secure, reasonably priced, and efficient adjunct in the treatment of diabetes, future studies should concentrate on standardized extracts, carefully planned clinical trials, and safety evaluations.

IX. CONCLUSION

As a natural, affordable, and versatile herb in the treatment of diabetes mellitus, allium fistulosum exhibits great promise. Its phytochemicals work in a variety of ways, such as by inhibiting the enzymes that hydrolyze carbohydrates, increasing insulin secretion and sensitivity, protecting against oxidative stress, and regulating inflammation. Although there is currently little clinical evidence, experimental studies support these effects. Conducting thorough clinical trials, standardizing extracts, assessing safety profiles, and investigating potential synergistic effects with traditional medications should be the main goals of future research. Allium fistulosum may be a useful supplemental treatment for diabetesif it has enough scientific support, particularly in areas where people have access to traditional herbal medicine.

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