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Ethnobotanical Potential of Different Medicinal Plants Used for the Prevention and Management of Diabetes Mellitus

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Abstract

Diabetes is an extensively prevalent disease worldwide, affecting all age groups patient and could be genetically inherited or acquired due to an unhealthy lifestyle that fluctuates the carbohydrate, fat, and protein metabolism. The types of diabetes known are of different types included mainly type 1 and type 2 diabetes commonly seen worldwide. The most prevalent type of diabetes found commonly in all patients is type 2 diabetes and can be treated with antidiabetic medications. Various chemically synthesized antidiabetic medicines are available in today's market but have many side effects. Therefore, natural antidiabetic agents are explored present in the indigenous herbs and spices and are known as phytochemicals. These phytochemicals found in the indigenous spices or herbs are secondary metabolites with beneficial bioactive properties. In this review article, various Indian herbs/spices known for their traditional medicinal benefits are reviewed that possess anti-diabetic properties and are utilized as an antidiabetic medication in the treatment of diabetes mellitus and also for its prevention. These spices and herbs are natural and traditional medications that could be beneficial even in the stage of pre-diabetes. These indigenous herbs and spices as medicinal sources are boon for the Indian population as well as for the entire globe.

Keywords: Antidiabetic Mechanism, Diabetes Mellitus, Ethno Pharmacology Medicinal Plants, Phytochemicals.

Introduction

Diabetes mellitus, a metabolic ailment, is of various types but mainly are insulin-dependent diabetes mellitus (Type1) and non-insulin-dependent diabetes mellitus (Type2) (1). Out of all, type II diabetes (non-insulin-dependent diabetes mellitus) occurs commonly in most patients globally. World Health Organization (WHO) estimated that the number of people with diabetes mellitus would grow nearly two-fold in the coming ten years. Type 2 diabetes mellitus is a condition represented by hyperglycaemia (high blood glucose level), insulin resistance, inappropriate insulin secretion, and raised hepatic glucose. Nearly every organ system gets badly impacted by complications of type 2 diabetes mellitus due to molecular-level flaws that are damaged insulin secretion via pancreatic β-cells dysfunction and inadequate insulin activity due to insulin receptor aberrations (2). The statistics of diabetic patients 422 million (2014) will increase to 578 million by the year 2030 and 700 million by the year 2045 which is very alarming for the population (3). Diabetes is more prevalent in low and middle-income countries as compared to the countries with high incomes. Early death from diabetes was raised by 5% from the year 2000 to 2016 and in the year 2019 diabetes became the 9th foremost reason for death evaluated 4.2 million deaths due to diabetes (4). Diabetes occurs due to the inappropriate functioning of beta-cells that leads to inadequate insulin activity as sugar cannot get metabolized. The condition occurs due to improper functioning of the pancreas that leads to insufficient production of insulin. In such situations, the body initiates the conversion of fat, protein, and glycogen molecule into sugar molecules, due to which sugar levels in the blood increases (1). Indians display a particularly elevated prevalence of diabetes concerning age factor when resembled with various other countries. Indians with higher insulin levels indicate peripheral insulin resistance, as per body mass index (BMI) and the reason is increased body fat percentage which leads to the prevalence of type II diabetes (3). Several changes in lifestyle like including exercise, a healthy diet, and other

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changes can slow and also control the type II diabetes mellitus development. There are numerous known anti-diabetic pharmaceutical medications, but the side effects associated with these drugs emphasize the urge to find more effective, economic, and safer medications with the increase in type II diabetes cases. The usage of complementary and alternative medicine globally for various diseases management like diabetes has rapidly grown over the past years (5). The traditional practice of medicine using plants, herbs, and plant extracts is known as Herbalism. Herbs and plants are the significant elements of the conventional medicine study, and these are the primary life forms on earth. Herbal medication, correspondingly named botanical medication, phytomedicine, directs to herbs, herbal materials, practices, and finalized herbal by-products that incorporate plants parts or other functional components (6). About ten percent of plants are of medicinal use out of all known vascular plants, which are calculated to be between 350,000 and nearly half a million species of vascular plants. Since old times, plants are part of medicine and yet in use in the modern era. In recent times, numerous higher plants are grown globally for the extraction of beneficial products in medicine and the field of pharmacy. The healing effects of plants offered advancement to therapeutic pharmaceuticals produced from certain plants including beneficial properties in Table 1 (7).

Table 1: List of Indigenous Herbs and Spices with Therapeutic Agents and Mode of Action

S.No	Indigenous Herbs and Spices	Plant Parts	Therapeutic Agents	Mode of Action (Antidiabetic Mechanism)	References
1.	*Azadirachta indica* (neem)	Fruit, Leaf	Limonoids and C-seco limonoids	Pancreatic Alpha amylase and alpha glucosidase inhibition	(8)
2.	*Cuminum cyminum* (cumin/jeera)	Seed	Cuminaldehyde	Pancreatic alpha amylase and alpha glucosidase inhibition	(9)
3.	*Trigonella foenum-graceum* (fenugreek/methi)	Seed	Flavonoids	Insulin sensitivity enhancement	(1)
4.	*Allium sativum* (garlic/lahsun)	Leaf and Bulb	Allicin, Allixin, Diallyl trisulfide	Stimulation of insulin secretion	(10)
5.	*Aloe vera*	Leaf	Anthraquinones, and phenolic compounds	Insulin secretion and pancreatic beta cell function enhancement	(11)
6.	*Cinnamomum zeylanicum* (cinnamon/dalchini)	Bark	Cinnamyl alcohol	Insulin secretagogue action and insulin resistance amelioration	(12)
7.	*Syzygium aromaticum* (clove/laung)	Bud	Isoeugenol, Eugenol	Inhibition of alpha amylase alpha glucosidase	(13)
8.	*Foeniculum vulgare* (fennel/saunf)	Seed	Fennel seed oil,	Alpha glucosidase and alpha amylase inhibition	(14)
9.	*Curcuma longa* (turmeric/haldi)	Rhizome	Curcumin	Stimulation of insulin sensitivity, inhibition of alpha amylase and alpha glucosidase	(15)
10.	*Ocimum tenuiflorum* (holy basil/tulsi)	Leaf	Kaempferol, Luteolin, Caffeic acid, 3,4-dimethoxycinnamic acid	Improvement in Insulin sensitivity and pancreatic beta cell mass preservation	(16)

Functional molecules dragged from plants known to be phytochemicals are beneficial in controlling and assisting the treatment of some pathological ailments, including diabetes mellitus. The herbal drug produced using herbs belongs to the class of alternative class of medication (17). The chance of glycaemic control enhancement without pharmaceutical medications or insulin injections becomes appealing to humans. Whereas lifelong pharmaceutical drug administration could

generate numerous side effects, and herbal medicines instead are toxicity-free with a favourable action and a minimal chance of contraindications or detrimental consequences (2).

Discussion

Indian Herbs as Antidiabetic Agents

***Azadirachta indica*:** *Azadirachta indicia*, commonly known as Neem is aboriginal to the Indian subcontinent and renowned for over 2000 years for its miscellaneous medicinal benefits. According to previous studies, the aqueous leaf extract of *Azadirachta indicia* (Neem) showed hypoglycaemic results in ordinary rats and reduced blood glucose levels in diabetic rats induced with streptozotocin. It is known as the richest source of secondary metabolites obtained through sequential extraction process using polar and non-polar solvents and especially contains tetranortriterpenoids known as limonoids. Neem limonoids are skeletally classified as; basic limonoids (azadirone, azadiradione, gedunin) and C-seco limonoids (azadirachtin, salannin, nimbin) (8). These compounds form complexes with enzymes, reduces their activity. The results conveyed from the study indicate that azadiradione and gedunin are leading human pancreatic alpha-amylase inhibitory molecules present in neem. Therefore, the hypoglycaemic effects displayed by *Azadirachta indicia* (neem) could be explained by human pancreatic alpha-amylase inhibition mechanism in (Figure 1 Mode of action shown by *Azadirachta indica* as antidiabetic agent). The bioactive compounds mimic the substrates of the alpha-glucosidase and alpha-amylase that leads to the binding to their active sites and prevents access to the actual substrate. Furthermore, the extensive study on *Azadirachta indicia* scientifically confirms that the natural products azadiradione and gedunin promote a better understanding concerning their structure-activity association. Animal models of diabetes treated with neem extracts demonstrate lower postprandial blood glucose levels, supporting its enzymatic inhibitory effects and highlighting its therapeutic potential (18). The analysis attains significance as the limonoids of neem could be utilized to develop more acceptable medication in the creation of unique inhibitors of human pancreatic alpha-amylase for regulating starch digestion to reduce hyperglycaemic condition after a meal (19). The administration of dose mentioned for the neem leaf extract is 500mg to 1g per day and neem oil should be used topically and not ingested to avoid potential toxicity. High doses may cause kidney and liver damage and not recommended to pregnant or breastfeeding women (18).

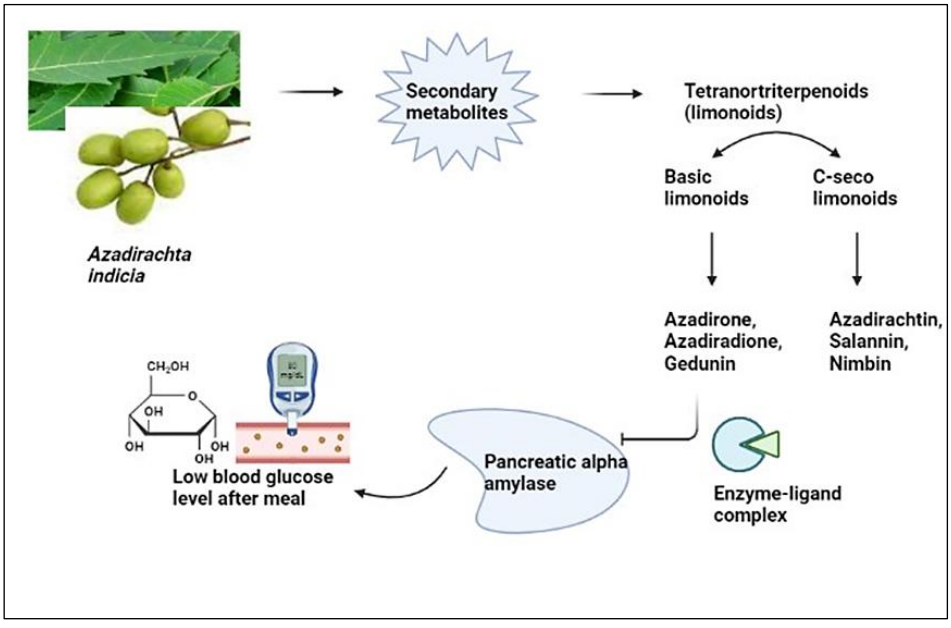

Figure 1: Mode of Action Shown by *Azadirachta indica* as Antidiabetic Agent (8)

***Cuminum cyminum L*:** *Cuminum cyminum L.* (cumin) is well-known for being consumed in immense amounts in India. Ayurveda has tremendous utilization of cumin for dyspepsia, jaundice, and diarrhoea treatment. Also, it has been documented that the seeds of cumin which

are considered a medicinal herb have an antidiabetic impact and hypolipidemic action on diabetic rats. The active compounds in cumin seeds changes the conformation of the enzyme alpha-glucosidase and alpha-amylase that reduces the activity. Cumin seed contains Cuminaldehyde, which is known for preserving aldose reductase and α-glucosidase inhibitory and antioxidant properties (20). The recent analysis of cumin displays 52.29% inhibition during amylase activity in the existence of chloroform extract of cumin seeds. Cumin seeds are even utilized as a spice because of the distinct aroma present in them and also as conventional medicine for the treatment of various ailments. The natural and biomedical properties of cumin seeds are credited to their active phytoconstituents like cuminaldehyde, thymol, apigenin, terpenes, phenols, and flavonoids (14). Cuminaldehyde interacts with catalytic residues, slowing carbohydrate breakdown. Flavonoids and phenolics inhibit enzyme-substrate interaction through competitive inhibition (21). Two peptides known as CSP4 (Cumin-seed peptides 4) and CSP6 (Cumin-seed peptides 6) are recognized as potent amylase inhibitory peptides extracted from cumin seeds (9). Cumin seeds may lead to allergic reactions and in some case hypoglycaemia due to high doses. The safe dose for administration is 1-3 grams of seeds daily and cumin oil should be used with caution due to its potency (22).

***Trigonella foenum-graecum*:** *Trigonella foenum-graecum* is a medicinal herb commonly called fenugreek (methi) and mostly the parts of it used are seeds and leaves. *Trigonella foenum-graecum L.* is cultivated throughout India and consumed as a part of vegetables and spices. Fenugreek has pungent aromatic properties and it is utilized as a flavouring agent and possesses strong antidiabetic properties based on various experimental models' study. Studies on humans have even demonstrated the capability of fenugreek to lower glucose and lipid levels. Based on several studies, fenugreek seed extract, seed mucilage, and leaves can reduce blood glucose levels and cholesterol levels in humans and diabetic animals used for the experiment (23). The medicinal potential of fenugreek is mainly because of the saponins, 4-hydroxyisoleucine, and trigonelline, an alkaloid, and high-fibre content. Fenugreek showed the antihyperglycemic impact due to the reduction in somatostatin and increased level of plasma glucagon. The activity of creatinine kinase shown in the various organs of diabetic rats gets normalized by the use of fenugreek seed powder. The antihyperglycemic impact shown by fenugreek might be due to the amino acid 4-hydroxyisoleucine functions by the insulin sensitivity enhancement and uptake of glucose molecules in peripheral tissues. The fenugreek steroids displayed blood glucose levels reduction when augmented with rats induced with diabetes. An examination of disaccharides in the organs of diabetic rats and a significant increase seen in the area of insulin immunoreactive beta-cells confirmed the useful impact of mucilage made from fenugreek seeds by enhancement of maltase activity reduction during diabetes (24). A substantial capability to lower down blood glucose levels was shown with the use of ethanol extract of *Trigonella foenum-graecum* seeds at various concentrations (0.1, 0.5, 1, and 2 g/kg) proved antidiabetic effects in diabetic rats. Furthermore, the *Trigonella foenum-graecum* seed's hydro alcohol extract showed a reduction in attributes of inflammation and oxidative stress with the enhancement of exocrine action in diabetic rats (1). The consumption of fenugreek seeds may cause gastrointestinal discomfort at some extent due to high dose. The recommended dosage mentioned is 5 to 30 grams daily.

***Allium sativum*:** *Allium sativum* is commonly known as garlic (lahsun) whose leaves and bulbs are the most used plant parts. In Ayurveda, it is a considered miraculous plant and recommended in various diseases according to traditional medicine. The major bioactive constituents found in garlic are allicin, allixin, ajoene, and other organosulphur components. The natural and medicinal roles of garlic are primarily due to the organosulphur components. These organosulphur components are known to display multiple biological impacts such as cholesterol and glucose reduction, precluding of cancer, and antimicrobial properties. Also, the studies demonstrate that garlic usage significantly lowered fasting blood glucose levels. Diallyl trisulfide present in the garlic enhances glycaemic control in diabetic rats proved in a study. Garlic is considered an antidiabetic agent as it boosts insulin secretion or bound insulin release. Allicin, the bioactive component is thought to improve serum insulin and an organosulfur

possessing antioxidant property. The precursor of allicin known as S-allyl cysteine sulfoxide is known for the regulation of lipid peroxidation and hyperglycaemic condition in rats. Cardiovascular problems related to diabetes are considered to be controlled by garlic consumption. Saponins and juice extract of garlic are reported to lower serum cholesterol levels and possess antioxidant and antihyperglycemic effects in diabetic rats respectively (24). Garlic showed a defensive impact regarding diabetic retinopathy in diabetic rats. Based on a meta-analysis conducted on patients having type 2 diabetes mellitus, displayed a considerable reduction in fructosamine and glycosylated haemoglobin by garlic supplements. Hence, garlic extract and bioactive molecules present in it are considered effective agents for the treatment of diabetes and complications associated with diabetes (Figure 2: Significance of bioactive compounds from Allium sativum (Garlic) as antidiabetic agent in the treatment of Type 2 Diabetes) (25). The garlic recommended daily dose is 2 to 5 grams and in the form extract 0.6 to 1.2 grams per day.

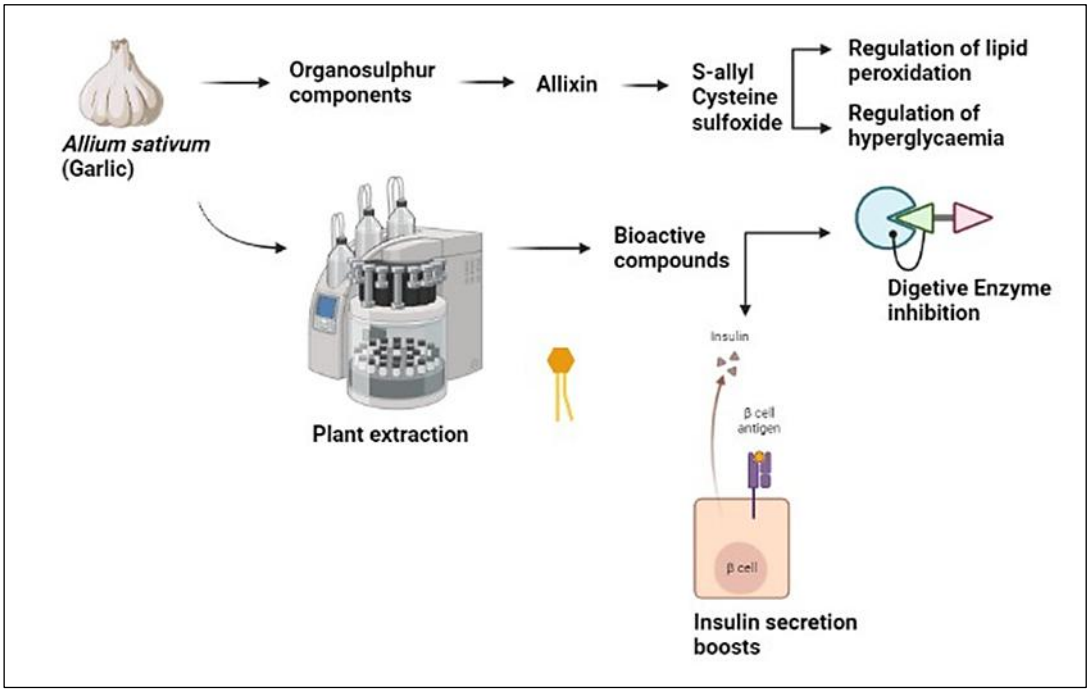

Figure 2: Significance of Bioactive Compounds from Allium sativum (Garlic) as Antidiabetic Agent in the Treatment of Type 2 Diabetes

***Aloe vera*:** Aloe vera contains compounds like lophenol and cycloartenol that reduce gluconeogenesis by activating Adenosine monophosphate (AMP)-activated protein kinase and peroxisome proliferator-activated receptors. This leads to decreased hepatic glucose production The extract of *aloe vera* was assessed in diabetic mice induced with streptozotocin and mouse embryonic cells (NIH/3T3) at a concentration of 130 mg/kg for four weeks daily (1). It resulted in a considerable reduction in blood glucose, triglycerides, LDL, and total cholesterol, an impact equivalent to that of metformin. Furthermore, the analysis revealed that a lyophilized aqueous aloe extract upregulated the synthesis of GLUT-4 mRNA mouse embryonic cells. In the latest analysis, *Aloe vera* extract of concentration 300 mg/kg tends to exert antidiabetic results through enhancing insulin secretion and pancreatic β-cell function by fixing pancreatic islet mass in streptozotocin-induced diabetic rats. Aloe vera juice should be consumed as recommended dose that is 30 ml to 50 ml per day (26).

***Cinnamomum zeylanicum*:** The extract of cinnamon with benzene showed the most increased inhibition ability, and aqueous extract conveyed an appreciable inhibitory result on pancreatic amylase (14). Cinnamon is considered an antidiabetic spice based on traditional medicine and, also, study display that adding cinnamon to the diet helps in reducing the blood glucose level (1). The antidiabetic activity shown by cinnamon in the various study reported due to the mode of action; insulin secretagogue action and insulin resistance amelioration (12). A randomized clinical trial demonstrated that cinnamon

supplementation improved glycaemic indices in patients with type 2 diabetes, with more pronounced benefits observed in individuals with higher baseline body mass index (BMI ≥ 27). The study also showed that the consumption of 3 grams of cinnamon daily for 90 days helped reduce LDL cholesterol levels and increase HDL cholesterol levels in diabetic patients, suggesting cardiovascular benefits. Cinnamon contains cinnamaldehyde, which enhances insulin release from pancreatic islets and increases uptake in peripheral tissues by promoting GLUT4 translocation. High doses may cause liver toxicity and the safe dose is 1-6 grams daily (27).

***Syzygium aromaticum (L)*:** Clove is a flower bud with aromatic characteristics, especially used as a spice in various dishes. Clove bud has properties such as antioxidant, antimicrobial, anti-diabetic, anti-inflammatory, anaesthetic, and insect repellent. It was analysed that the essential oil extracted from clove bud has a significant impact on alpha-amylase and alpha-glucosidase actions and discovered dose-dependent amylase and glucosidase inhibitory activities (Figure 3: Schematic representation of antidiabetic effects shown by indigenous herbs and spices) (14). Isoeugenol, a phytochemical found in cloves has powerful anticholinergic and antidiabetic effects as compared to standard components and it has a strong inhibition impact against digestion enzymes; alpha-amylase and alpha glycosidase. Accordingly, isoeugenol could be utilized for type II diabetes treatment (13). The dose recommended for the clove powder to consume is 2 to 5 grams daily.

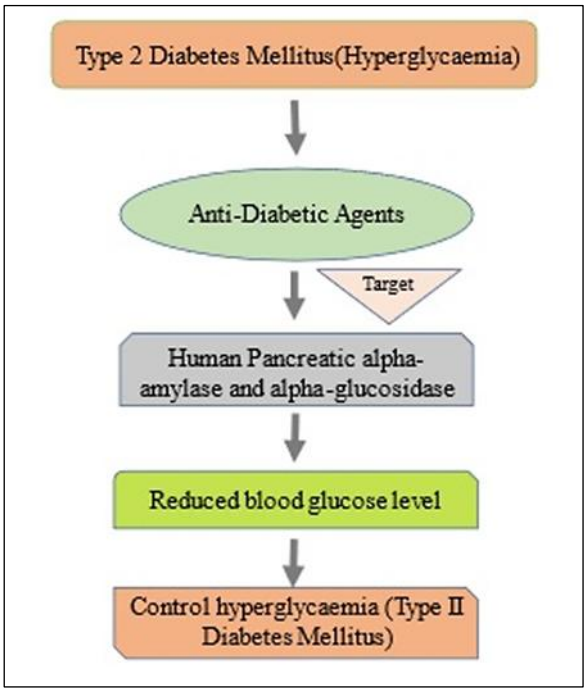

Figure 3: Schematic Representation of Antidiabetic Effects Shown by Indigenous Herbs and Spices (28)

***Foeniculum vulgare*:** Fennel is one of the extensive plants popular for its aromatic smell and large phenolic constituents but insufficient data is available regarding the anti-diabetic properties contained in it. Fennel extraction with various solvents and it's in vitro analysis to test the potential to inhibit the angiotensin-converting enzyme, alpha-amylase, and alpha-glucosidase actions. Methanol: acetone: water in 1:1:1 ratio and methanol: acetone in 1:1 ratio shows appropriate extraction of bioactive compounds needed for highest inhibition of the digestive enzymes (14). The seed extract of Foeniculum vulgare displayed outstanding anti-hyperglycaemic activities in diabetic rats induced with streptozotocin. It showed the capability of restoring the hepatic difficulty related to diabetes. Therefore, Foeniculum vulgare extract might be utilized in the future for herbal medications for the treatment of diabetes and diabetic complications (29). The fennel seeds can be taken daily as per recommended dose that is 5-7 grams daily.

***Curcuma longa*:** *Curcuma longa, as per Ayurvedic medicine* is a potent herb that has the fighting capability against diabetes and it is generally comprehended as Turmeric, Haldi, and

Haridra. *Curcuma longa* is aboriginal to India and is mainly grown in states like West Bengal, Tamil Nadu, and Maharashtra. The *Curcuma. longa* rhizomes include numerous phenolic compounds and its major bioactive constituents are Curcuminoids found in the rhizomes. Curcuminoids contain corresponding compounds termed Curcumin, Demethoxycurcumin, and Bisdemethoxycurcumin. Curcumin comprises approximately 60% of total curcuminoids (2). The bioactive principle component is curcumin accountable for most of the biological activity of *Curcuma. longa.* Curcumin, the active component of turmeric, exhibits anti-diabetic effects by inhibiting glycogen synthase kinase-3 (GSK-3), an enzyme involved in glucose metabolism. This inhibition enhances insulin sensitivity and promotes glucose uptake in tissues. The hypoglycaemic activity was shown by the rhizomes of *C. longa*. In various research and examined the glucose-lowering ability of curcumin of *Curcuma longa* in diabetic mice (Figure 4: A process in antidiabetic assay using plant parts as herbal agent). In an examination, animals treated with curcumin showed a substantial reduction in blood glucose levels and HbA1c (glycated haemoglobin) levels. Also, the insertion of curcumin in the other study conveyed the advancement in glucose homeostasis, glucose tolerance, and raised plasma insulin levels. even, the ethanolic extract of *Curcuma longa* showed the inhibition of raised blood glucose levels in Diabetic Mice (23). The daily recommended use of turmeric powder is 1-3 grams and curcumin extracts 400 to 600 mg thrice a day.

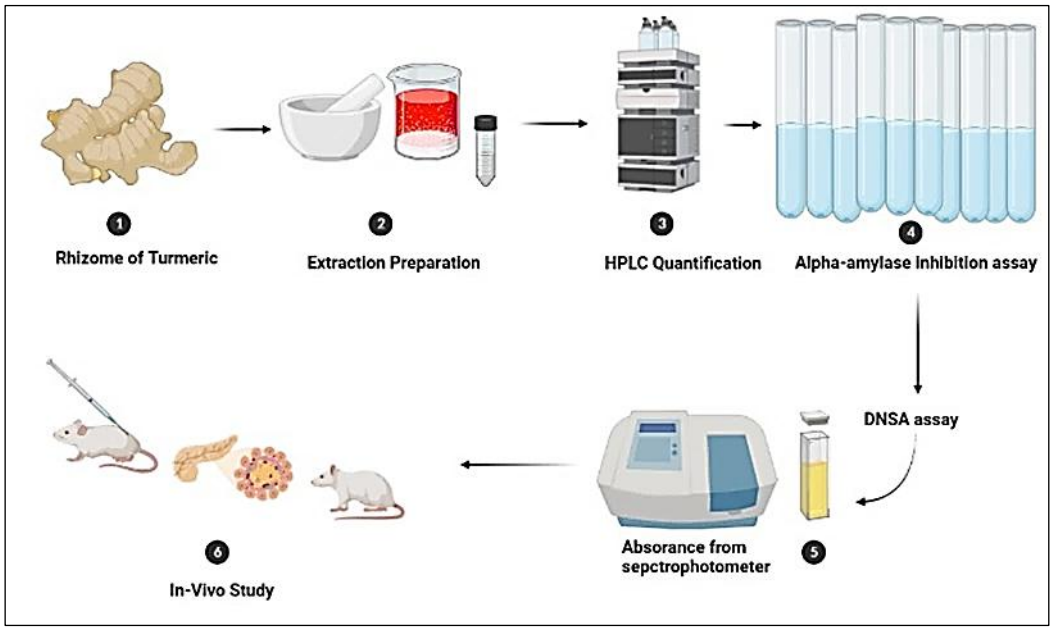

Figure 4: A Process in Antidiabetic Assay using Plant Parts as Herbal Agent (2)

***Ocimum tenuiflorum*:** *Ocimum* species is a perennial plant cultivated in India and South East Asia possesses various medicinal properties. *Ocimum* contains eugenol, which inhibits alpha-glucosidase enzymes, leading to reduced carbohydrate digestion and lower postprandial blood glucose levels. Diabetic rats induced with alloxan supplied with aqueous *Ocimum* leaf extract depicted a decrease in blood glucose levels, whereas other analyses conveyed a drop in fasting blood glucose levels, uric acid, total amino acid, total cholesterol, triglyceride, and total lipids (30). The study on the phytochemicals of *Ocimum tenuiflorum* found kaempferol, luteolin, caffeic acid, 3,4-dimethoxycinnamic acid, and rosmarinic acid (phenolic) as the main bioactive compounds extracted from it. The methanol crude extract, butanol, and ethyl acetate fractions of leaves of *Ocimum tenuiflorum* showed an antihyperglycemic activity in diabetic rats with various dose administrations by decreasing blood glucose and preventing diabetes (16). The methanolic extracts of *O. tenuiflorum* leave demonstrated a considerable decrease in fasting blood glucose levels in diabetic rats. The impact of fasting blood glucose decreased by ethyl acetate extract of O. tenuiflorum leaves was found more instantaneous as compared to other extracts. The methanol and

hexane extracts of *O. tenuiflorum* leaves displayed results similar to metformin in the subcutaneous glucose tolerance test. Furthermore, after the treatment of 14 days, the results of these extracts were parallel to metformin results. Thus, the outcomes obtained indicate the possibility of *O. tenuiflorum* leaves to be utilized in controlling the diabetic condition and in controlling diabetic complications. The recommended dose for the *Ocimum* leaf extract to consume is 0.3 to 2 grams daily (31). Here is a comparative analysis of the efficacy and safety of herbal remedies and conventional antidiabetic medications (Table 2: A comparative analysis of the efficacy and safety of herbal remedies and conventional antidiabetic medications) (32-34).

Table 2: A Comparative Analysis of the Efficacy and Safety of Herbal Remedies and Conventional Antidiabetic Medications

Factors	Herbal Medications	Conventional Antidiabetic Medications
Mechanism of actions	Improve insulin sensitivity, reduce glucose absorption, or stimulate insulin secretion.	Target multiple pathways: Metformin reduces hepatic glucose production; sulfonylureas stimulate insulin secretion; SGLT2 inhibitors enhance glucose excretion.
Efficacy	Modest glucose-lowering effects observed in various studies.	Well-documented short-term and long-term glycaemic control.
Adverse effects	Generally safe at traditional dosages, but side effects can occur.	Well-characterized side effects. Rare but significant risks (e.g., lactic acidosis with metformin).

Future Prospects

With the growing years, knowledge about herbal medicine is increasing, and thus, the use of herbs and spices increasing tremendously in the field of diabetic treatment and management. Indigenous herbs and spices being a source of natural inhibitors of pancreatic alpha amylase and alpha glycosidase, it may be cost effective and eco-friendly and with no side effects. Also, further research may provide new herbal drug development using indigenous herbs and spices for diabetes management. Future research work may focus on the phytoconstituents showing antidiabetic activity and new herbal formulations for better results. There is a need to research for potent inhibitor with higher antidiabetic activity and their pharmacological activities of bioactive phytochemicals present in the selected herbs and spices with antidiabetic properties. Clinical trials are essential to validate the therapeutic claims of Indian herbs and spices. Rigorous clinical studies can establish their effectiveness, safety, and mechanisms of action, which can lead to broader acceptance by the medical community. One of the biggest challenges in the herbal industry is the lack of standardized formulations. The development of standardized herbal products will ensure consistency, regulatory approvals, and develop formulation guidelines. There is an on-going need to isolate and identity the bioactive compounds present in Indian herbs and spices. Research should focus on molecular mechanisms, synergistic effects, and bioavailability. The integration of Indian herbs and spices into modern pharmaceutical systems could revolutionize healthcare. The future research study should focus on combining herbal remedies with conventional drugs to enhance therapeutic outcomes, reduce side effects, or lower drug dosages. Development of new forms of herbal supplements. Such as extracts or nanoparticles, for improved bioactivity and delivery.

Conclusion

A type of metabolic ailment known as Diabetes mellitus and one of its types known as type II diabetes mellitus is most prevalent globally and in India. The condition of high blood glucose level known as hyperglycaemia after the meal is a sign of diabetes and it occurs due to damaged pancreatic beta cells, known for the regulation of insulin secretion. The main reason for diabetes mellitus is the unhealthy lifestyle pattern followed by people, due to which the number of diabetic patients is increasing and thus, it has become the

main health crisis for the public. In Ayurveda, the Indian herbs have a great value due to the medicinal properties they possess and they are easily available in every Indian kitchen. These herbs and spices exert antidiabetic effects through various mechanisms, including enhancing insulin secretion, improving insulin sensitivity, inhibiting carbohydrate-digesting enzymes, and modulating glucose metabolism. Incorporating them into the diet may offer complementary benefits for managing blood glucose levels renowned for their diverse bioactive compounds, which interact with various biological targets to confer health benefits. Thus, these can be utilized in the control/treatment of diabetes as a part of traditional medicine and pharma formulations and the utilization of indigenous herbs and spices as potent antidiabetic agents becomes safe as it is part of herbal medicine. While these findings are promising, variability exists in study designs, dosages, and preparations used, making it challenging to establish standardized recommendations. Additionally, the long-term safety and efficacy of these supplements require further investigation. However, more extensive and standardized clinical trials are necessary to confirm these effects and to develop clear guidelines for their therapeutic use.

Abbreviations

WHO: World health organisation, BMI: Body mass index, CSP: Cumin-seed peptide, GSK-3: Glycogen synthase kinase-3, AMP: Adenosine monophosphate.

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Author Contributions

The corresponding author Vikas Shrivastava and Rajesh Singh Tomar provided the conceptual idea and content briefing and Pratibha Navik wrote the article and Vikas Shrivastava then commented on the drafted article that was corrected by Pratibha Navik. Vikas Shrivastava, and Akhilesh Kumar Pandey finalized and approved the final draft of article.

Conflict of Interest

All contributing authors declare no conflicts of interest statement.

Ethics Approval

Not applicable.

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References

1. Salehi B, Ata A, Kumar NVA, Sharopov F, Ramírez-Alarcón K, Ruiz-Ortega A, et al. Antidiabetic potential of medicinal plants and their active components. Biomolecules. 2019;9(10): 551.
2. Blahova J, Martiniakova M, Babikova M, Kovacova V, Mondockova V, Omelka R. Pharmaceutical drugs and natural therapeutic products for the treatment of type 2 diabetes mellitus. Pharmaceuticals. 2021; 14(8). 1–32.
3. Banday MZ, Sameer AS, Nissar S. Pathophysiology of diabetes: An overview. Avicenna J Med. 2020;10(04):174–88.
4. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. Diabetes Res Clin Pract. 2019;157:107843.
5. Gupta RC, Chang D, Nammi S, Bensoussan A, Bilinski K, Roufogalis BD. Interactions between antidiabetic drugs and herbs: An overview of mechanisms of action and clinical implications. Diabetol Metab Syndr. 2017;9(1):1–12.
6. Pan SY, Litscher G, Gao SH, Zhou SF, Yu ZL, Chen HQ, *et al.* Historical perspective of traditional indigenous medical practices: the current renaissance and conservation of herbal resources. Evid Based Complement Alternat Med. 2014;2014(1):1-20.
7. Salmerón-Manzano E, Garrido-Cardenas JA, Manzano-Agugliaro F. Worldwide research trends on medicinal plants. Int J Environ Res Public Health. 2020;17(10):3376.
8. Sujarwo W, Keim AP, Caneva G, Toniolo C, Nicoletti M. Ethnobotanical uses of neem (Azadirachta indica A.Juss.; Meliaceae) leaves in Bali (Indonesia) and the Indian subcontinent in relation with historical background and phytochemical properties. J Ethnopharmacol. 2016;189:186–93.
9. Siow HL, Lim TS, Gan CY. Development of a workflow for screening and identification of α-amylase inhibitory peptides from food source using an integrated Bioinformatics-phage display approach: Case study – Cumin seed. Food Chem. 2017;214:67–76.
10. Salleh NH, Zulkipli IN, Mohd Yasin H, Ja'Afar F, Ahmad N, Wan Ahmad wan. Systematic Review of Medicinal Plants Used for Treatment of Diabetes in Human Clinical Trials: An ASEAN Perspective.

Evidence-based Complement Altern Med. 2021;2021:1-10. https://doi.org/10.1155/2021/5570939
11. Zinjarde SS, Bhargava SY, Kumar AR. Potent α-amylase inhibitory activity of Indian Ayurvedic medicinal plants. BMC complementary and alternative medicine. 2011 Dec;11(1):1-10.
12. Shihabudeen HMS, Priscilla DH, Thirumurugan K. Cinnamon extract inhibits α-glucosidase activity and dampens postprandial glucose excursion in diabetic rats. Funct Foods Connect Between Nutr Heal Food Sci. 2011;8(1):1-11.
13. Topal F. Anticholinergic and antidiabetic effects of isoeugenol from clove (Eugenia caryophylata) oil. Int J Food Prop. 2019;22(1):583–92.
14. Hemlata B, Pornima G, Tukaram K, Pankaj B. In vitro anti-amylase activity of some Indian dietary spices. J Appl Biol Biotechnol. 2019;7(4):70–4.
15. Nabavi S, Thiagarajan R, Rastrelli L, Daglia M, Sobarzo-Sanchez E, Alinezhad H, *et al*. Curcumin: A Natural Product for Diabetes and its Complications. Curr Top Med Chem. 2015;15(23):2445–55.
16. Mousavi L, Salleh RM, Murugaiyah V. Phytochemical and bioactive compounds identification of Ocimum tenuiflorum leaves of methanol extract and its fraction with an antidiabetic potential. Int J Food Prop. 2018;21(1):2390–9.
17. Shrivastava V, Tomar RS, Mishra RK, Jyoti A, Kaushik S. Medicinal potential of some mythologically important plants of India: A Review. 2014;2(1):99–103.
18. Yarmohammadi F, Mehri S, Najafi N, Amoli SS, Hosseinzadeh H. The protective effect of Azadirachta indica (neem) against metabolic syndrome: A review. Iran J Basic Med Sci. 2021;24(4):280–92.
19. Ponnusamy S, Haldar S, Mulani F, Zinjarde S, Thulasiram H, RaviKumar A. Gedunin and azadiradione: Human pancreatic alpha-amylase inhibiting limonoids from neem (Azadirachta indica) as anti-diabetic agents. PLoS One. 2015;10(10):1–19.
20. Navin S, Srivastava A, Prakash D, Kumari R, Kumar R. Management of Type-2 Diabetes Mellitus through Indian Medicinal Plants. J Diabetes Metab. 2021;12(8):1-4.
21. Pereira ASP, Banegas-luna AJ, Peña-garc J, Horacio P, Apostolides Z. Evaluation of the Anti-Diabetic Activity of Some Common Herbs and Spices: Providing New Insights with Inverse Virtual Screening. J Mol. 2019;24(22):1-42
22. Garza MC, Pérez-Calahorra S, Rodrigo-Carbó C, Sánchez-Calavera MA, Jarauta E, Mateo-Gallego R, *et al.* Effect of Aromatic Herbs and Spices Present in the Mediterranean Diet on the Glycemic Profile in Type 2 Diabetes Subjects: A Systematic Review and Meta-Analysis. Nutrients. 2024;16(6):1-44.
23. Gaonkar VP, Hullatti K. Indian Traditional medicinal plants as a source of potent Anti-diabetic agents: A Review. J Diabetes Metab Disord. 2020;19(2):1895–1908.
24. Rizvi SI, Mishra N. Traditional indian medicines used for the management of diabetes mellitus, J Diabetes Res. 2013;2013:1–31. https://doi.org/10.1155/2013/712092
25. Shang A, Cao SY, Xu XY, Gan RY, Tang GY, Corke H, *et al.* Bioactive compounds and biological functions of garlic (allium sativum L.). Foods. 2019;8(7):1–31.
26. Abuzaid H, Amin E, Moawad A, Usama Ramadan, Abdelmohsen, Hetta M. Liquid Chromatography High-Resolution Mass Spectrometry Analysis, Phytochemical and Biological Study of Two Aizoaceae Plants Plants: A New Kaempferol Derivative from Trianthema portulacastrum L. Pharmacognosy Res. 2020;10(10):24–30.
27. Zare R, Nadjarzadeh A, Zarshenas MM, Shams M, Heydari M. Efficacy of cinnamon in patients with type II diabetes mellitus: A randomized controlled clinical trial. Clin Nutr. 2019;38(2):549–56.
28. Navik P, Shrivastava V, Tomar R.S. Role of alpha amylase inhibitor in diabetes mellitus. Int J Biol Pharm Allied Sci. 2022;11(11):5062–79.
29. Banerjee P, Deb A, Bhadra P. An Anthology of Nutraceuticals. An Anthology of Nutraceuticals. 2021. 1-492. https://doi.org/10.30954/anthutraceuticals
30. Dandekar PD, Kotmale AS, Chavan SR, Kadlag PP, Sawant S V, Dhavale DD, *et al.* Insights into the Inhibition Mechanism of Human Pancreatic α-Amylase, a Type 2 Diabetes Target, by Dehydrodieugenol B Isolated from Ocimum tenuiflorum. ACS Omega. 2021;6(3):1780–1786.
31. Mousavi L, Salleh RM, Murugaiyah V, Asmawi MZ. Hypoglycemic and anti-hyperglycemic study of Ocimum tenuiflorum L. leaves extract in normal and streptozotocin-induced diabetic rats. Asian Pac J Trop Biomed. 2016;6(12):1029–36.
32. Bano K, Pharmacology MP, Prem R, Mishra K. A Review of Management and Treatment of Diabetes Mellitus. 2024;9(12):2525-2530.
33. Ekor M. The growing use of herbal medicines: Issues relating to adverse reactions and challenges in monitoring safety. Front Neurol. 2014;4(1)1–10.
34. Nezamodini ZS, Rezvani Z, Kian K. Electronic Physician. 2016;8(1):1832-1842.