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REVIEW ARTICLE

A review of the multifunctional benefits of herbal products in the management of diabetes

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Abstract: Diabetes mellitus (DM) has emerged as a major health challenge all over the world. DM is a metabolic disorder characterized by high blood glucose levels induced by insufficient or ineffective insulin secretion (hyperglycemia). The history of the disease "Madhumeha" has been recorded in traditional systems of treatment such as Ayurveda. For the treatment of diabetic conditions, several single herbs, Bhasma metals and minerals, herbo-mineral formulations, herbal formulations, Taila (oil), Asava-aristas (fermented syrup), and Guggulu (Commiphora mukul) preparations have been mentioned in Ayurveda. Diabetes is a diverse collection of syndromes. The mechanism of high glucose that leads to diabetes and the impact of Moringa on diabetes progression. The higher glucose level in the blood causes glycolysis in the mitochondria of beta cells, resulting in reactive oxygen species. This causes beta cell apoptosis, which results to decreased insulin secretion, hyperglycemia,and, eventually, Type 2 diabetes. The use of Moringa oleifera, on the other hand, can prevent beta cell death. Moringa contains antioxidants that combine with reactive oxygen species to avoid cell damage and subsequent consequences. Studies reporting blood glucose or lipid levelsin diabetic rodents with and without receiving extracts of Moringa oleifera were included. Forty-four studies enrolling 349 diabetic rodents treated with extracts of Moringa oleifera and 350 diabetic controls reported blood glucose levels. The pooled effect size was 3.92 (95% CI: −4.65 to 3.19) with a substantial heterogeneity. This effect was likely to be, at least in part, modified by the type of diabetic models.

Keywords: Diabetes mellitus; Moringa oleifera; Hyperglycemia; Herbal; Antioxidants; Glucose

1. Introduction

Diabetes is a systemic metabolic disorder characterised by hyperglycemia, hyperlipedemia, hyperaminoacidemia, and insulin resistance. Hypoinsulinaemia decreases both insulin secretion and insulin action. It is usually linked to the development of micro and macrovascular disorders such as neuropathy, nephropathy, cardiovascular disease, and cerebrovascular disease.

The illness has been linked to reduced quality of life as well as increasing risk factors for death and morbidity. Long-term hyperglycemia is a major contributor to the emergence and progression of micro- and macrovascular problems. Diabetes was anticipated to affect 2.8% of people worldwide in 2000, and it is expected to affect 5.4% by 2025. Diabetes treatments currently accessible include insulin and a variety of oral diabetes medications such as sulfonylureas, biguanides, -glucosidase inhibitors, and glinides. [1-3]

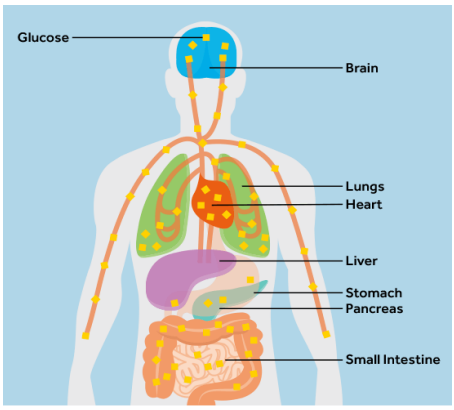

Figure 1 Every cell in the uses glucose for energy

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Currently, there is a growing interest in herbal therapies due to the side effects associated with oral hypoglycemic medicines (therapeutic agents) for diabetes. Diabetes therapy. As a result, traditional herbal treatments derived from plants are mostly used, and they play an essentialrole in the management of diabetes mellitus [4] Herbal medications have grown in popularity as a source of hypoglycemic drugs in recent years. According to Marles and Farnsworth, around1000 plant species are utilised as traditional medicine for diabetes. Though a moringa leaf extract has been found to be efficient in decreasing blood sugar levels within 3 hours of intake, Glibenclamide, the main hypoglycemic medication, acts less effectively. [5-8] The ethnobotanical literature reports on over 1000 plants that may have anti-diabetic properties; this review article lists a few of them. Table 1 lists the key anti-diabetic potential herbal plants and their active components.

Table 1 List of some Botanical name, family, parts used and its compounds

S. No.	Botanical Name	Family	Parts used	The primary active components
1	*Moringa oleifera*	Moringaecea	Whole plant	Tannins, Saponins, fatty acids.
2	*Allium sativum*	Alliaceae	Bulbs	Allyl propyl disulphide, allicin
3	*Annona squamosa*	Annonacae	Fruits	Liriodenine, moupinamide
4	*Areca catechu*	Arecaceae	Seed	Arecaine and arecoline
5	*Artemisia pallens*	Asteraceae	Leaves & flowers	Germacranolide
6	*Azadirachta indica*	Meliaceae	Leaves, flowers & Seed	Azadirachtin and nimbin
7	*Bauhinia forficata*	Laguminosae	Leaf	Astragalin, Kaempferitrin
8	*Beta vulgaris*	Amaranthaceae	Root	Phenolics, betacyanins
9	*Boerhavia diffusa*	Nyctaglnaceae	Whole plant	Punaranavine and ursolic acid
10	*Camellia sinensis*	Theaceae	Leaves	Caffeine and catechins
11	*Capparis decidua*	Capparidaceae	Fruit	Spermidine Isocodonocarpine
12	*Cinnamomum zeylanicum*	Lauraceae	Bark	Cinnamaldehyde, eugenol
13	*Combretum micranthum*	Combretaceae	Leaves	Polyphenols
14	*Elephantopus scaber*	Asteraceae	Whole plant	Terpenoid and 2,6,23-trienolide
15	*Ficus bengalenisis Linn*	Moraceae	Bark	Leucodelphinidin and leucopelargonin
16	*Gymnema sylvestre*	Asclepiadaceae	Root	N, N-diethyltoluamide
17	*Lantana camara*	Verbenaceae	Leaves	Lantanoside, lantanone
18	*Liriope spicata*	Liliaceae	Root	Beta-sitosterol, stigmasterol
19	*Momordica charantia*	Cucurbitaceae	Leaves	Charantin, Sterol
20	*Ocimum Sanctum*	Labiatae	Whole pant	Eugenol
21	*Panax Quinquefolius*	Araliaceae	Root	Ginsenosides, protopanaxadiol
22	*Parinari excelsa*	Chrysobalanacea	Bark	Myricetin, quercertin
23	*Phyllanthus amarus*	Phyllanthceae	Whole Plant	Phyllanthin
24	*Prunus amygydalus*	Rosaceae	Seeds	Amygdalin
25	*Pterocarpus marsupium*	Leguminosae	Whole plant	Kenotannic acid, Pyrocatecbin
26	*Punica granatum*	Lythraceae	Fruit	Punicalagin, Punicalin
27	*Ricinus communis*	Euphorbiaceae	Root	Ricinolic acid
28	*Salacia oblonga wall*	Celastraceae	Root bark	Salacinol
29	*Sarcopoterium spinosum*	Rosaceae	Root	Catechin and epicatechin
30	*Smallanthus sonchifolius*	Asteraceae	Leaves	Sonchifolin, Uvedalin, Enhydrin, Fluctuanin
31	*Swertia punicea*	Gentianaceae	Whole pant	Methyl swertianin and bellidifolin
32	*Tinospora cordifolia*	Menispermaceae	Root	Tinosporone, Tinosporic acid

Diabetes management without side effects is still a problem for the medical community today.A wide range of plant-derived active principles have been shown to have anti-diabetic action. Alkaloids, glycosides, galactomannan gum, polysaccharides, peptidoglycan, hypoglycans, guanidine, steroids, carbohydrates, glycopeptides, terpenoids, amino acids, and inorganic ions are the principal active ingredients of these plants [9]. Common nutritional uses/benefits of Moring oleifera Lam. tree parts [10-12]

Table 2 Parts of plant uses and its phytochemistry

S. No.	Plants Parts	Nutritional uses/benefits	Phytochemistry
1	Leaves	Moringa leaves are a highly rich source of vitamin A, C, Calcium, Potassium, protein, and importantelements when compared to locally accessible market foods such as carrots, oranges, cow milk, and bananas. The leaves can be used as a complement to vital foods and as an alternative to tea leaves. The leaves can be used to combat hunger in the impoverished. With 35 elements, it is a nutraceutical and an effective treatment for a variety of illnesses. To decrease gastrointestinal and respiratory sickness, leaf powder is used as a hand washing product-hand hygiene. Tender twigs and immature pods are utilised as cattle feed to improve milk production. To decrease gastrointestinal and respiratory sickness, leaf powder is used as a hand washing product-hand hygiene. Tender twigs and immature pods are utilised as cattle feed to improve milk production. Pregnant women eat plants and flowers to improve milk production for their babies. Leaf powder is utilized as a biocontrol agent in crops, as well as fertilisers and pesticides.	Calcium 440 mg - cow's milk:120 mg; Potassium 259 mg -banana: 88 mg; Protein6.6 mg - cow's milk: 3.2 mg; 14 macro elements and 21 microelements (total 35 elements). In comparison to nonmedicated liquid soap, mechanical friction caused by dry leaf powder lowers bacterial effect during hand washing. Having a greater proportion of vitamins, minerals, and proteins. Iron, minerals, vitamins, and proteins are found in the leaves.
2	Stem	Picking sticks, newspaper, and textile sectors all use stem pulp. Corky bark stem yield Fibbers are used to make mats, paper, cordages, and other items.	Having cellophane
3	Pods	Immature pods with strong nutritional and therapeutic qualities, eaten as a vegetable or pickled.	Having a larger percentage of vitamins, vital minerals, glycosides, and other nutrients.
4	Seed	Seed powder paste is used as a water purifier to enhance drinking water quality by absorbing heavy metals including as cadmium, copper, chromium, lead, and zinc, which are highly hazardous to humans. The seeds can be used as nutritional supplements as well as in industrial and agricultural applications. It is also utilized in the perfume industry, cosmetics, lubricants, and soap as an antioxidant activity oil in body cream. It can also be consumed as a vegetable on a delay basis	Moringa is a cationic polyelectrolyte with a short chain length and a low molecular weight. Heavy metals have more charges. Seed oil, often known as "ben oil," is similar to olive oil and high in palmetic, stearic, behenic, and oleic acids. The oil is transparent, odourless, and resistant to rancidity; it contains 75% oleic acid.

2. Management of diabetes mellitus using herbal products

One of the primary causes of Diabetes Mellitus is a defect in insulin secretion. Several botanicalherbs have recently showed anti-diabetic properties. Insulin secretion is regulated. Because long-term use of traditional secretagogues such as glibenclamide in diabetes patients causes b- cell destruction due to pancreatic islet overstimulation, There are various categories of antidiabetic medications on the market for the remedial action, which include insulin analogues, sulphonylureas, biguanides, dipeptidyl peptidase4 inhibitors, thiazolidiones, a- glucosidase inhibitors, and so on, with each category's mechanism of counteracting this increased glucose level being different. However, the long-term treatment and side effects of the present hypoglycemic drugs are creating a significant demand for effective, low-side-effect, and cost-effective treatments for the treatment of diabetic conditions.

Most investigations on herbal and natural products have found that they have greater anti- diabetic effects at a lower cost and with fewer adverse effects than synthetic medications. Most anti-diabetic herbs can improve -cell activity and increase insulin release from the islets of Langerhans, which have a high antioxidant capacity.

2.1. Nopal (Opuntia fuliginosa, Opuntia streptacantha)

Nopal (plural nopales or nopalitos in Mexico) is a member of the Opuntia genus and is often known as the prickly pear cactus in the United States. The plant produces a vegetable called nopal as well as a red, egg-shaped fruit called tuna. Nopal can be found growing in the dryparts of the Western Hemisphere. It is widely available in various locations in the southwestern United States. Nopal is utilised as a food source in salads, soups, casseroles, sandwiches, and blended drinks. When used as a hypoglycemic, nopal can be produced in either of these ways, or it can be purchased as a dry powder in bulk or capsules.

This famous herbal is primarily used by people of Mexican heritage. It is consumed as part ofa regular diet or on an as-needed basis, i.e., when blood glucose levels are elevated. According to a 1999 survey, 75% of physicians in a Sonora, Mexico, urban health care centre employed herbal medications as part of their routine treatment armament, with nopal being one of the top four agents. Sonora is located in northern Mexico and borders Arizona.

The plant's high soluble fiber content is suggested to contribute to the mechanism of action for hypoglycemic activity. Nopal pulp fibres contain both soluble and insoluble fibres and are high in vitamin C, calcium, potassium, and iron. Because fasting blood glucose levels are changed, fiber content is most likely not the only mechanism of action. [13-16]

Figure 2 Nopal (Opuntia fuliginosa, Opuntia)

2.2 Fenugreek (Trigonella foenumgraecum)

Fenugreek is an example of a traditional herb that is gaining popularity among people of all ages. Fenugreek is an annual herb native to southern Europe and Asia that is now widely grown in the Mediterranean, Argentina, France, India, North Africa, and the United States. Early summer sees the appearance of white blooms, which grow into long, thin yellow brown pods carrying the brown seeds that are used medicinally and as a food source. Fenugreek is an herb that is used to treat diabetes, migraines, allergies, high cholesterol, constipation, and as an appetite stimulant. The pungent seeds are used as a spice and have a maple syrup-like aroma.

If fenugreek seeds are defatted, they provide around 50% nutritional fibre. Fibres in the seeds, like nopal, may slow stomach transit time. Slowing the rate and extend of glucose absorption in the gut is unlikely to be the only mechanism resulting in hypoglycemic. [17,18]

Figure 3 Fenugreek (Trigonella foenumgraecum)

2.3 Gymnema (Gymnema sylverstre)

Gymnema is a woody climbing shrub endemic to India's central and southern regions. The leaves have been used to treat madhu meha, often known as "honey urine," for over 2,500 years. When the leaves are chewed, they remove the taste of sweetness, earning the plant the common name gur mar, or "sugar killer." It's also used as an antimalarial, digestive aid, diuretic,cough reliever, and snake bite antidote. [19]

Figure 4 Gymnema (Gymnema sylvestre)

2.4 Ginseng (Panax quinquefolius and Panax ginseng)

Ginseng comes in a variety of varieties. American ginseng (Panax quinquefolius) and Asian ginseng (Panax ginseng) studies have demonstrated that the herb has the capacity to reduce glucose levels. Panax has the same etymology as "panacea," which represents the ginseng's cure-all qualities. The claimed benefits include increased longevity, improved memory, serving as an aphrodisiac, aiding in blood pressure and cholesterol control, boosting endocrine function, and use as a general tonic.

Ginseng is a perennial plant that produces tiny, berry-like fruits. The slow-growing spindly root of the plant is utilised medicinally. Plant makeup varies depending to species, growing location,curing or drying process, harvest season, and age. Triterpenoid saponins glycosides, also known as ginsenosides or panaxosides, are thought to be the main components responsible for causing hypoglycemic action. Isolated panaxan compounds have been shown in studies to havea hypoglycemic impact. [20,21]

5

Figure 5 Ginseng (Panax quinquefolius and Panax ginseng)

2.5 Karela (Momodica chaantia Linn)

The majority of studies on herbal and natural products have demonstrated greater anti-diabetic results at a lower cost and with fewer adverse effects than synthetic medications. Most anti- diabetic herbs can improve -cell activity and increase insulin release from the islets of Langerhans, which have great antioxidant power.

It is well-known for its anti-diabetic effects. It is also high in micronutrients, which are necessary for the prevention of diabetes problems. Bitter melon, sometimes known as balsam pear, is a tropical vegetable grown in Asia, Africa, and South America that has long been usedin traditional medicine as a diabetic treatment. Both experimental and clinical research have convincingly demonstrated the blood sugar reducing activity of fresh juice or extract of the unripe fruit.

Bitter melon contains numerous chemicals that have been shown to have anti-diabetic effects. Charantin is a hypoglycemic medication made up of mixed steroids that is more effective than the medicine tolbutamide, which is commonly used in the

treatment of diabetes. Momordica also contains polypeptide-P, an insulin-like polypeptide that decreases blood sugar levels in type 1 diabetes patients. In clinical trials, oral treatment of 50-60 mL of the juice produced positive outcomes.

Bitter melon juice taken in large quantities can cause gastrointestinal pain and diarrhoea. Bitter melon should not be consumed by small children or anyone suffering from hypoglycemia, since it has the potential to cause or worsen low blood sugar, or hypoglycemia. Furthermore, diabetics taking hypoglycemic medicines (such as chlorpropamide, glyburide, or phenformin) or insulin should exercise caution when consuming bitter melon because it may increase the efficiency of the drugs, resulting in severe hypoglycemia. [22-24]

Figure 6 Karela (Momodica chaantia Linn)

2.6 Pyaz/Lehsan (Alliumcepa Linn and Allium Sativam Linn)

Onion and garlic have blood sugar reducing properties. The main active ingredients are thought to be allyl propyl disulphide (APDS) and diallyl disulphide oxide (allicin), but other constituents such as flavonoids may also play a role. According to experimental and clinical evidence, APDS decreases glucose levels by competing with insulin for insulin-inactivating sites in the liver. This causes an increase in free insulin. APDS at 125 mg/kg doses was found to elicit a significant drop in blood glucose levels and an increase in serum insulin in fasting adults. Allicin doses of 100 mg/kg had a comparable impact.

During oral and intravenous glucose tolerance, onion extract was proven to lower blood sugar levels. The effect became stronger as the dosage was raised; nonetheless, favourable effects were detected even at modest levels employed in the diet, such as 25 to 200 grammes. Bothraw and boiling onion extracts had similar effects. Onions influence hepatic glucose metabolism and/or promote insulin release and/or delay insulin breakdown. [25,26]

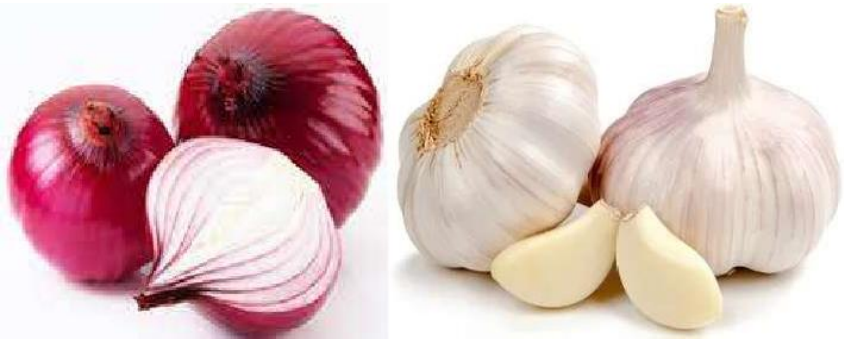


Figure 7 Pyaz/Lehsan (Alliumcepa Linn and Allium Sativam Linn)

2.7 Darchini (Cinnamon Zylanicum Linn)

Cinnamon, which is extracted from the inner bark of a tropical evergreen tree, possesses insulin-like characteristics. This herbal diabetes medication can help lower blood glucose, cholesterol, and triglycerides, and some research suggest that cinnamon can help boost antioxidants in the body and may help prevent metabolic syndrome. The spice is known to promote glucose intake in cells. Cinnamon consumption stimulates the production of insulin from the pancreas and increases insulin sensitivity, resulting in improvements in glucose metabolism. It contains anti-diabetic chemicals that aid in decreasing the rate at which glucose enters our bodies. This helps in the maintenance of fasting blood sugar levels in persons with Type 2 diabetes. Cinnamon helps the digestive system, which is directly related to the diabetes condition. To keep blood sugar levels under control, a healthy digestive tract will process, digest, and drain out excess sugar. [27,28]

Figure 8 Darchini (Cinnamon Zylanicum Linn)

2.8 Jamun (Eugenia Jambolana Linn)

Jambul tree fruit and seeds have long been employed in Eastern traditional medicine. The jamun pulp extract demonstrated hypoglycemic action within 30 minutes of treatment, whereas the seeds of the same fruit required 24 hours. Serum insulin levels increased, and the extract blocked insulinase activity in the liver and kidney. Jamun is a tried-and-true fruit that is suitablefor those with type 2 diabetes. Jamun has antioxidant and anti-diabetic properties, according toa well-established study published in the Journal of Food Science and Technology.

It means that Jamun can slow the conversion of sugar to starch. It lowers the probability of experiencing an increase in blood sugar levels while the starch in your food is metabolised. Patients withtype 2 diabetes have lower insulin concentrations. Jamun seeds contribute to an increase in insulin supply by enhancing insulin synthesis or preventing it from deteriorating fast. [29]

Figure 9 Jamun (Eugenia Jambolana Linn)

2.9 Ghekwar (Aloe vera)

Aloe vera, a common houseplant, has a long history of usage as a multifunctional folk medicine. The plant can be divided into two categories: gel and latex. The leaf is Aloe Vera gel.Aloe latex, sometimes known as "aloe juice," is a bitter yellow secretion from the pericyclic tubules just beneath the outer epidermis of the leaves. Aloe gum extracts effectively improve glucose tolerance in both normal and diabetic patients. [30]

Figure 10 Ghekwar (Aloe vera)

2.10 Mango Leaves (Mangifera Indica Linn)

The effect of Mangifera indica leaves on diabetic nephropathy is favourable. It dramatically reduced glomerula extracellular matrix expansion and accumulation, as well as transforming growth factor-beta-1 overexpression in diabetic nephropathic patients' glomeruli. Mangiferin has an immunestimulant effect on both the cellular and hormonal immuno systems. Mangiferin is a natural metabolite present in mango leaves.

Mangiferin pharmacokinetics in the blood after oral administration: A minor amount of free Mangiferin is found in the blood

plasma following a single dose of Mangiferin ranging from 50 mg/kg to 1000 mg/kg. Over a 24-hour period, the plasma level of Mangiferin is less than 0.05 g/ml. Within 24 hours of oral dosing, no metabolite of mangiferin is detectable in the blood. Within 24 hours, free Mangiferin excretion in the urine is less than 0.1%. [31]

Figure 11 Mango Leaves (Mangifera Indica)

3. Traditional diabetes treatment

Plants were used in the earliest known treatments for diabetic mellitus. A high-fiber diet of wheat grains and ochre was recommended by the Papyrus Ebers of 1550 BC. a plethora of herbs, spices, and other plant materials for the treatment of diabetes have been recorded all over the world. Folklore treatments for diabetes have practically vanished in Western countries since the introduction of insulin, yet remaining the cornerstone of treatment in undeveloped areas. Renewed interest in alternative medicines and natural therapies has sparked a new waveof research interest in traditional practises, and the World Health Organisation expert committee on diabetes has recommended that traditional methods of diabetes treatment be investigated further. [32-34]

Traditional anti-diabetic herbs may be a good source of new oral hypoglycemic chemicals for pharmaceutical development or as simple dietary supplements to established therapy. Sulfonylureas and metformin are effective therapies for hyperglycemia in non-insulin- dependent diabetic mellitus (NIDDM), but they are frequently unable to return glucose concentrations to normal or to restore a normal pattern of glucose homeostasis. [35,36]

3.1 Traditional herbal Anti diabetic drugs

Medicinal plants and herbs are currently being used in extract form for their anti-diabetic properties. Several clinical research have proven that medicinal plant extracts have anti- diabetic efficacy and can restore pancreatic-cell function. [37]

Current diabetes medications keep blood glucose levels within normal ranges by supplementing insulin, enhancing insulin sensitivity, boosting pancreatic insulin secretion, lowering intestinal glucose absorption, and/or increasing glucose uptake by tissue cells. Glucose-lowering medications include insulin secretagogues (sulfonylureas, meglitinides), insulin sensitizers (biguanides, metformin, thiazolidinediones), and -glucosidase inhibitors (miglitol, acarbose). Exenatide, liraglutide, and dipeptidyl peptidase (DPP)-4 inhibitors arenew peptide analogues that enhance glucagon-like peptide (GLP-1) blood levels and slow gastric emptying. [38,39]

4. Traditional plants: A safe tool to treatment

Diabetes management with no side effects remains a problem for the medical community. Reports on global ethnobotanical facts about therapeutic plants that over 800 herbs are utilised in the treatment of diabetes. There are over 450 experimentally proved medicinal herbs with anti-diabetic effects, but only about 109 of them have a complete mechanism of action.

4.1 Azadirachta Indica

It is known as neem in India and is a member of the Meliaceae family. Itis sold in India and Burma. In large doses, ethanolic and aqueous extracts of Azadirachta indica reduce blood glucose levels. It can be supplemented with allopathic medications in type 2 diabetic patients whose diabetes cannot be managed solely with allopathic drugs.

Natural neem tablets are used to treat a huge number of patients worldwide. Its extract promotesblood circulation by expanding blood vessels and is beneficial in lowering blood glucose levels in the body. [40, 41]

Figure 12 Azadirachta Indica

4.2 Brassica Juncea

It is known as Rai and is a member of the Cruciferae family. It is commonly used as a spice in a variety of foods. Blood sugar levels can be reduced by using aqueous seed extract. [42]

Figure 13 Brassica Juncea

4.3 Carica Papaya

It is known as papaya and is a member of the Caricaceae family. Seed andleaf extract reduces blood sugar levels, lowers fat levels in the body, and promotes wound healing. [43]

Figure 14 Carica Papaya

4.4 Coriandrum Sativum

It is often known as coriander and is a member of the Apiaceae family. It is commonly used as a spice in a variety of foods. 200 mg/kg seed extract regularly boosts the action of Langerhans cells and decreases serum sugar in alloxan-induced diabetic mice, as well as insulin generation from pancreatic cells. Coriandrum sativum extract has blood sugar reducing and insulin synthesiser properties. [44]

Figure 15 Coriandrum Sativum

4.5 Ocimum Sanctum

Tulsi is a member of the Labiateae family. It is widely distributed throughout India. It is utilised in Indian ayurvedic medicines to treat a variety of ailments. Several animal investigations shown that an aqueous extract of Ocimum sanctum leaves (200 mg/kg) had hypoglycemic action in streptozotocin-induced rats. It is also used to treat viral infections, fungal infections, stress, tumours, and gastric ulcers. [45]

Figure 16 Ocimum Sanctum

4.6 Tinospora Cardifolia

It belongs to the Menispermaceae family and is often known as guduchi. T. cardifolia's active ingredients are diterpene substances such as tinosporone, tinosporic acid, Syringen, berberine, and giloin. T. cardifolia root extract (50-200mg/kg) reduces blood and urine sugar levels in streptozotocin-induced diabetic rats after 6 weeks of oral dosing. It is mostly used in Indian ayurvedic medicine to treat diabetes. Body weight lossis also inhibited by root extract. [46]

Figure 17 Tinospora Cardifolia

5 Commonly utilized herbs and their mechanism of action

Diabetes is treated with approximately 170 different natural treatments. Thousands of dietary supplements are also professionally promoted for diabetics. However, only a small percentageof these products have valid clinical evidence of efficacy. Phytochemicals act via multiple metabolic pathways that use glucose or its derivatives as a substrate or a product. They influence glucose metabolism (glycolysis, Kreb's cycle), pentose phosphate pathways, glycogenesis, glycogenolysis, gluconeogenesis, glucose absorption via the alimentary canal, and insulin release, synthesis, and efficiency.

Many of these alternative treatments affect blood sugar levels in a variety of ways. In some cases, their effects are similar to those of conventional medications. Several factors influence these results. Each herb contains a variety of constituents, only a subset of which may be medically useful. The constituent profiles of different portions of an herb will differ. Different extraction procedures might result in a variety of active compounds. Multiple plant herbal formulas may have synergistic effects. This article discusses some of the most common medicinal plants and their anti-diabetic benefits. [47,48]

Table 3 Conventional and Natural drugs used in the treatment of Diabetes

Category	Target tissue	Conventional drug	Natural medicine
Hypoglycemicagent	Pancres	Sulphonylurea, Miglitinides	Banaba (Lagerstroemia speciosa) Bitter melon (Momordica charantia) Gymnema (Gymnema sylvestre)
Insulin Sensitizers	Liver	Metformin, Thiazolidinedioe	Agaricus mushroom (Agaricus blazei) American ginseng (Panax quinquefolius) Panax ginseng
Carbohydrate absorption inhibitors	Intestine	α – glucosidase inhibitor	Bean pod (Phaseolus vulgaris) Blond psyllium (Plantago ovata) Ota bran (Avena sativa)

5.1 Ginseng

For its hypoglycemic properties, this is the most researched medicinal herb. Ginseng's efficacy is primarily determined by its geographical location, dosage, processing, and type of diabetes. The maximum therapeutic potency is found in Panax ginseng, often known as Chinese or Korean ginseng. Panax quinquefolius (American ginseng) has medium potency, but Panax japonicus

(Japanese ginseng) has low potency. Because of its excellent effectiveness, Panax ginseng is the most often used medicinal ginseng. Ginseng can lower blood glucose levels by influencing several mechanisms. [49]

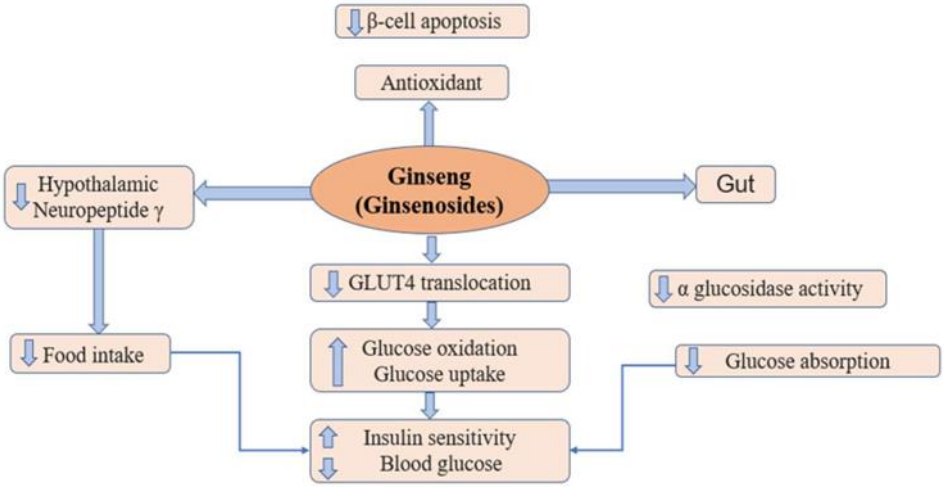
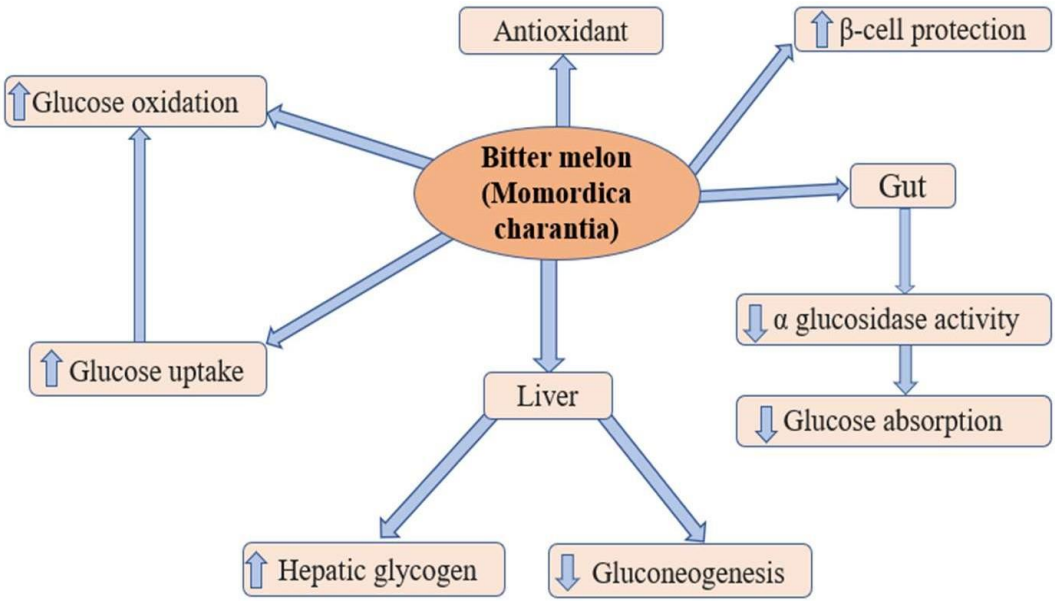


Figure 19 Mechanism of Action of Ginseng to Improve Glucose Metabolism

5.2 Bitter Melon (Bitter Gourd, Karallo, Momordica Charantia)

In China, it is both a vegetable and a herb. Bitter melon has been utilised as an herb in South China for at least 600 years. Bitter melon has been shown to have hypoglycemic effects in cell culture, animal models, and human research. Bitter melon contains anti-diabetic components such as charantin, vicine, polypeptide-p, alkaloids, and additional unspecified bioactive anti- oxidants. Polypeptide-p, a hypoglycemic peptide, has been isolated from the fruits, seeds, and tissue of Momordica charantia Linn. [50, 51]

Figure 19 Mechanism of Action of Bitter Melon in the reduction of blood glucose



5.3 Agaricus Mushroom

Agaricus is originated from Brazil, but it is now widely available in China, Japan, and other Asian countries.

It contains polysaccharides, particularly beta glucans, which appear to increase immune function markers and act as an immunostimulant, similar to other mushrooms. Agaricus mushroom contains compounds that may increase insulin utilisation and decrease insulin resistance in type 2 diabetic patients. It also appears to raise adiponectin levels, which can improve insulin resistance. [52]

Figure 20 Agaricus Mushroom

5.4 Moringa oleifera tree used as an herbal product

Herbal medicines are used as primary health treatment by about 80% of the world's population.They are also known as a multi-purpose medicinal plant (MMP), and their safety for eating has resulted in the development of a number of medical products derived from such herbs and plants. M. oleifera Lam encompasses a single genus "Moringa" as well as thirteen species belonging to the Moringaceae family, the most common of which being M. oleifera Lam tree. Moringaceae is a mono generic family that includes the sole genus Moringa. Moringa oleiferais also known as Sanjana, Horseradish tree, and drumstick, and the name Moringa is derived from the Tamil word murungai, which means "twisted pod." Currently, the plant is producedfor a variety of purposes due to its high nutritional content and wide range of medical benefits. [53] Every portion of M. oleifera contains valuable nutrients and anti-nutrients. M. oleifera leaves are high in minerals such as calcium, potassium, zinc, magnesium, iron, and copper. M. oleiferacontains vitamins such as beta-carotene of vitamin A, vitamin B such as folic acid, pyridoxine, and nicotinic acid, vitamin C, D, and E. Moringa leaves have a low calorific value and can be included in an obese person's diet. The fibrous seeds are useful for treating digestive issues and preventing colon cancer. [54]

Figure 21 Compression of Moringa oleifera leaves with other items & used parts

6. Poly herbal formulations for diabetes

Plant formulations and blended extracts of plants are utilised as a preferred medicine rather than individual plants. A variety of herbal diamed, coagent db, and diasulin are examples of formulations. Blood glucose, plasma insulin, tissue lipid profile, and lipid peroxidation in streptozotocin-induced diabetic rats treated with a polyherbal formulation of Annona squamosa and Nigella sativa.

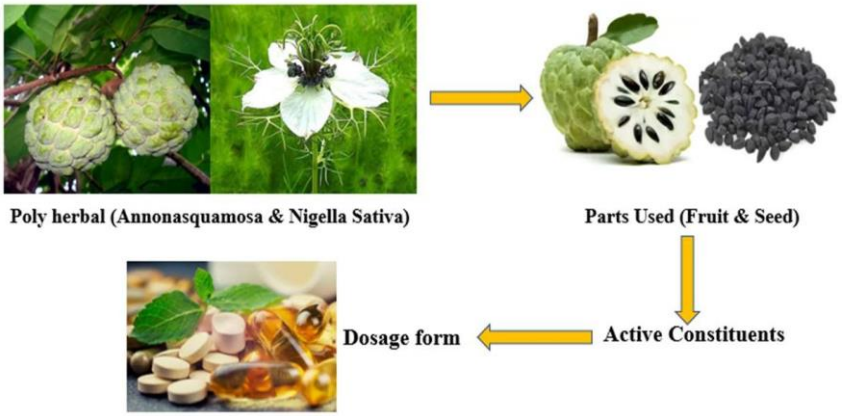


Figure 22 Poly herbal drug used for antidiabetic

For 30 days, an aqueous extract of Annona squamosa and Nigella sativa Polyherbal formulation was provided orally (200 mg/kg body weight). The effects of different doses of Polyherbal formulation on blood glucose and plasma insulin in diabetic rats were investigated, as well as the levels of lipid peroxides and tissue lipids in streptozotocin-induced diabetic rats. Polyherbal formulation and tolbutamide treatment resulted in a considerabledecrease in blood glucose and a rise in plasma insulin. [55]

8. Marketed herbal medication for diabetic's treatment: its composition [56-58]

Table 4 Herbal formulation and its composition

Formulation	Ingredients
Diabecon	Tribulus terrestris, Sphaeranthus indicus, Tinospora cordifolia, often known as Curcuma longa, Triphala Rumex maritimus is a species of Rumex. Aloe vera, chirata, Swertia Sacred ocimum, Gymnema sylvestre (Gymnema sylvestre), Indicus Sphaeranthus Phyllanthus amarus, Glycyrrhiza glabra, Commiphora wightii Boerhavia diffusa is a kind of Boerhavia. nigrum piper, Tribulus terrestris (T. terrestris), Pterocarpus marsupium, Cumini Syzygium, Tinospora cordifolia, often known as Gmelina arborea, Asparagus racemosus, Abutilon indicum, Berberis aristata Casearia esculenta, Berberis aristata, and Gossypium herbaceum are examples of plants.
Glyoherb	Gudmar (Gymnema sylvestre), Mahamejva, Katuki (Picrorhiza kurrooa), Chirayata (Swertia chirata), Karela (Momordica charantia), Indrajav (Holarrhena pubescens), Amala (Phyllanthus emblica), Gokshur (Tribulus terretris), Haritaki (Terminalia chebula Neem, Chandraprabha, Arogyavardhini, Haridra (Curcuma longa), Bang Bhasma, Devdar, Daruhaldi (Berberis aristata), Nagarmotha (Cyperus scariosus), Shuddha Shilajit, Galo are some of the herbs used.
Diabeta plus	Shilajit (Asphaltum), Vijayasar (Pterocarpus marsupium), Gurmar (Gymnema sylves), Jamun (Syzygium cumini), Karela (Momordica charantia).
Diasulin	Coccinia indica, Cassia auriculata Curcuma longa, turmeric Momordica charantia, Emblica officinalis, Gymnema sylvestre Scoparia dulcis is a kind of Scoparia. Cumini Syzygium, Trigonella foenum graecum, Tinospora cordifolia.
Dia-care	Sanjeevan Mool; Himej, Jambu beej, Kadu, Namejav, and Neem Chal.

7. Conclusion

Diabetes is a metabolic illness caused mostly by a defect in insulin synthesis or increasing resistance to its action. In the case of diabetes, the most important issue is the adverse effect caused by glucose accumulation. This extra glucose is transformed into a variety of chemicals as well as free radicals, which cause damage to essential organs and organelles. There are no specific medications available to treat these problems. Diabetes herbal therapy has been used successfully all around the world. Herbs are used to treat Type 1 and Type II diabetes, as well as related complications. As a result, medicines based on western medicine principles (allopathic) are frequently ineffective, risk severe effects, and are often prohibitively expensive, particularly in developing countries. People in developing nations were drawn to herbal therapy due to the growing cost effectiveness of modern medicine and its negative effects. This systematic study demonstrates that Nopal (opuntia fuliginosa), Darchini (Cinnamon Zylanicum Linn), Ghekwar (Aloe vera), Mango Leaves (Mangifera Indica Linn), Karela (Momodica chaantia Linn), Ginseng (Panax quinquefolius), Azadirachta Indica, Brassica Juncea, etc., have natural anti-diabetic action. When this substance is combined in a single formulation, the beneficial effects are amplified through synergistic amplification, giving it an advantage overa single isolated ingredient. The effectiveness of polyherbal formulations has yet to be proven due to a paucity of high-quality trials. Nonetheless, advanced well-designed clinical trials witha larger sample size are required to determine the greater therapeutic efficacy of polyherbal formulations in diabetic patients' blood sugar management.

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