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# HERBAL AND POLYHERBAL APPROACHES IN THE TREATMENT OF DIABETES: AN OVERVIEW

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**ABSTRACT**
Diabetes mellitus (DM) is a prevalent metabolic and endocrine disorder that affects people all over the world and can have significant adverse consequences on health. Numerous chronic illnesses, especially metabolic diseases like obesity, are brought on by recent significant changes in dietary patterns and modern lifestyle. Since ancient time, people have used plants to make medicines. Plants are extensively used in the Indian traditional medical system to treat diabetic disorders. According to the World Health Organization up to 90% of people in developing countries utilize plants and their products as traditional medicine for primary healthcare. There are about 800 plants which have been reported to showantidiabetic potential. Although several pharmaceutical medications are available to treat and manage diabetic individuals, complete recovery from the disease has not yet been shown. As an alternative to these synthetic substances, several natural Plants having hypoglycemic qualities are widely recognized worldwide. The present review providing comprehensive information on the antidiabetic potential and bioactive chemicals found in Trigonella foenum-graecum. Momordica charantia, Gymnema sylvestre, Eugenia jambolana, Garcinia cambogia and Coffea canephora.

**KEYWORDS:** Diabetes, Herbal drugs, Antidiabetic drugs, Insulin.

## INTRODUCTION

Diabetes mellitus is a systemic metabolic disease characterized by hyperglycemia, hyperlipedemia, hyperaminoacidemia, and hypoinsulinaemia it leads to decrease in insulin, secretion and insulin action.[1] Glucose homeostasis is a balance between hepatic glucose production and peripheral glucose uptake and utilization. Insulin is the most important regulator of glucose homeostasis.[2] Symptoms of diabetes mellitus include frequent urination, weight loss, blurry vision, frequent urination, fatigue, extreme thirst and hunger and may result in complications like high blood pressure, kidney failure, blindness, heart diseases, stroke, foot and leg infections, sexual dysfunctions, pregnancy problems etc.[3] Diabetes mellitus is broadly classified into Type I diabetes mellitus (T1DM) which was previously encom passed by the terms insulin-dependent diabetes, type 1 diabetes, or juvenile-onset diabetes, accounts for only 5–10% of the cases[10] and Type 2 diabetes mellitus (T2DM) previ ously referred to as non–insulin dependent diabetes, type 2 diabetes, or adult-onset diabetes accounts for approximately 90–95% of cases with diabetes.[11] Other types which include gestational diabetes mellitus (GDM), is defined as any degree of glucose intolerance with onset or first recogni tion during pregnancy.[4] Type 2 diabetes or non insulin-dependent diabetes mellitus, is the most common form of the disease, accounting for 90%-95% of cases in which the body does not produce enough insulin or properly use it.[4] According to World Health Organization the diabetic population is likely to increase up to 300 million or more by the year 2025.[5] A wide array of plant derived active principles representing numerous chemical compounds has demonstrated activity consistent with their possible use in the treatment of insulin dependent diabetes mellitus. Among these are alkaloids, glycosides, galactomannan gun, polysaccharides, peptidoglycans, hypoglycans, guani-dine, steroids, carbohydrates, glycopeptides, terpenoids, amino acids and inorganic ions. Even there is the discovery of widely used hypoglycemic drugs, metformin came from the traditional approach by using Galega officinalis. Thus, plants are a potential source of antidiabetic drugs (and others too) but this fact has not gained enough momentum in the scientific community.[6] About 800 plant species have been reported to possess antidiabetic properties. Several plant species have been used for prevention or management of diabetes by the

Native Americans, Chinese, South Americans and Asian Indians. The study showed that Asian and African continents have 56% and 17% share of the worldwide distribution of therapeutic herbal plants, respectively. Biological actions of the plants are related to chemical composition that are rich in phenolics, alkaloids, flavonoids, terpenoids, coumarins, and glycosides usually show positive effects.[7] Out of the several medicinal plants used in the treatment of diabetes, some were reviewed in the present study. Synthetic drugs are used to treat or prevent diabetes, but they have side effects. Due to this issue and their high costs, nowadays interests in finding effective natural ingredients has increased. In recent decades, many studies have been done on the therapeutic properties of herbs and these elements have been proposed for the treatment of various hard curable diseases such as athrosclerosis, cardiovascular diseases, neurological disorders and cancer. These conditions involve many changes, including alterations in redox state, and medicinal plants with antioxidant activity have the ability to counteract these situations and always been considered as a healthy source of health promotion.[8] The mechanisms of medicinal plants for glucose control in diabetes include the inhibition of glucose absorption, improvement of insulin sensitivity, protection of β-cell damage, increase of insulin release, enhancement of antioxidant defense, attenuation of inflammation, modulation of carbohydrate metabolism pathway and regulation of insulin-dependent and insulin independent signaling pathways.[9]

**Antidiabetic activity of phytochemicals**

**Alkaloids:** Alkaloids induce antihyperglycaemic activity by improving insulin's pancreatic secretion from β-cells of islets or by increasing blood glucose transfer to the peripheral tissue.

**Flavonoids:** For alternatives to diabetic ally therapy, flavonoids can prove valuable as they help prevent appose in β cells, promote β cell proliferation, secretion of insulin, and increase the activity of insulin. Mangrove plants like Marina Avicenna and hexangular Bruguier have been reported to have a wealth of flavonoids with hypoglycemic activity.

**Phenolic compounds:** Phenol compounds can exhibit hypoglycaemic activity by raising serum insulin levels, increasing the tissue's sensitivity to insulin action, stimulating glucose enzyme activity and inhibiting α-amylase activity, Mangroves like B. racemosa have phenolic antidiabetic (for instance, gallic acid). Therefore, more in-vitro and in-vivo animal studies accompanied by toxic and clinical examinations should be conducted in thorough research of isolated active compounds that have demonstrated anti diabetes efficacy. This will provide a valuable compound for optimization and use in the development of new antidiabetic medicines.[10]

**Indian Medicinal Plants with Antidiabetic Potential**

Several Ayurvedic formulations have been used in the treatment of Diabetes mellitus for centuries. In addition to herbs, minerals find wide application in Ayurvedic prescription for diabetes. Medicinal herbs like Eugenia jambolana, Gymnema sylvestre, Momordica charantia, Trigonella foneum graceum and Garcinia cambogia are prescribed as single powder drugs or in combination (poly-herbal). Scientists have studied the chemical composition of the Antidiabetic medicinal herbs used in Ayurveda. The article deals with work done on Indian medicinal plants with anti-diabetic potential.[11]

***Trigonella foenum-graecum* L.**

Trigonella foenum-graecum is an angiosperm plant that belongs to Rosaceae order, Legouminosae family, subfamily of Papilonaceae and Trigonela L. genus of the Trifolia group. Fenugreek is an herbaceous and annual plant and its height reaches to 50 cm.[12]

**Taxonomy[12]**

Kingdom: Plant
Family: Fabaceae
Genus: Trigonella
Species: foenum-graecum
General name: Fenugreek
English name: Fenugreek
Arabic name: Hhulbah, Hhelbah
French name: Trigonelle, Senegrain, Foingrec
German name: Gemeiner, Hornklee, Bockshornklee
Indian name: Sagmethi, Methi, Kasurimethi
Italian name: Fienogreco, Erbamedica
Persian name: Shanbelileh

**Figure 1: *Trigonella foenumm-graecum* (or) Fenugreek.**

**Chemical Constituents**

Fenugreek seeds are a rich source of the polysaccharide galactomannan. They are also a source of saponins such as diosgenin, yamogenin, gitogenin, tigogenin, and neotigogens. About 30% of the seed weight is protein; 5.5–7.5%, lipids including linoleic acid and linolenic acid; and 15%, galactomannans. Fenugreek contains approximately 4–8% saponins and about 1% alkaloids, contributing to bitterness, gastric stimulation, increased acidity, and increased appetite. About 0.6% of the seed weight is a nonproteogenic amino acid, 4-hydroxyisoleucine (4-OH-Ile) and 0.1–0.15%, a pseudo-alkaloid, trigonelline.[13]

**Pharmacological Investigation on *Trigonella foenum-graecum* L**

Many investigators have indicated that crude as well as various extractions of Trigonella successfully decreased blood glucose levels in experimental animals as well as human diabetic patients. Out of a number of medicinal properties known of Trigonella, its hypoglycemic or antihyperglycemic effect has been studied the most and has also been utilized by diabetic patients.[14]

**Anti-hyperlipidemic Activity**

Trigonella foenum-graecum prevents dyslipidemia and hepatic damage following high cholesterol diet and acts as hypocholesterolemic agent by increasing LDLR gene expression.[15]

**Antioxidant Activity**

Several studies reported that fenugreek exhibited antidiabetic and neuroprotective effects due to its antioxidant properties. Fenugreek seed oil also demonstrated the improvement of cellular antioxidant defenses in alloxan-induced diabetic rats. (11*Z*)-11-eicosenoic acid 2, 3-bis [((9*Z*, 12*Z*, 15*Z*)-1-oxo-9, 12, 15-octadecatrien-1-yl)oxy] propyl ester prevented the autooxidation of glucose and reduced AGEs formation, resulting in an increase in antioxidant activity.[15]

***Momordica charantia (Linn)***

Momordica charantia (Fig. 1), is commonly known as bitter gourd, bitter melon, kugua, balsam pear or karela, and belongs to the Cucurbitaceae family. M. charantia is commonly consumed as a vegetable in the tropical and subtropical regions of the world.[16]

**Taxonomy**

**Kingdom:** Plantae
**Division :** Tracheophyta
**Class :** Magnoliopsida
**Order :** Cucurbitales
**Family:** Cucurbitaceae
**Genus:** Momordica
**Species:** charantia L.
**Common Name:** Karela, Karali, Bitter Gourd

**Figure 2: *Momordica Charantia* Plant and fruits.**

**Chemical Constituents**

Momordica charantia contains biologically active chemicals that include glycosides, saponins, alkaloids, fixed oils, triterpenes, proteins and steroids. The immature fruits are a good source of Vitamin C and also provide Vitamin A, phosphorus, and iron. Several phytochemicals such as momorcharins, momordenol, momordicilin, momordicins, momordicinin, momordin, momordolol, charantin, charine, cryptoxanthin, cucurbitins, cucurbitacins, cucurbitanes, cycloartenols, diosgenin, elaeostearic acids, erythrodiol, galacturonic acids, gentisic acid, goyaglycosides, goyasaponins, multiflorenol, have been isolated. The hypoglycemic chemicals of Momordica charantia are a mixture of steroidal saponins known as charantins, insulin-like peptides and alkaloids and these chemicals are concentrated in fruits of MC, therefore fruit of MC has shown more pronounced hypoglycemic/antihyperglycemic activity.[17]

**Pharmacological Investigation on Momordica charantia**

**Hypoglycemic Activity**

Rats were rendered diabetic by single injection (60 mg/kg body weight) of streptozocin. One week after injection, treated animals were fed with juice of M.charantia (10 ml/kg) daily for three in glucose uptake and it attenuated the insulin induced increase in glucose uptake.[11]

**Antidiabetic activity**

A poly-herbal preparation containing MC showed a significant reduction in blood glucose, glycosylated haemoglobin, and an increase in plasma insulin and total haemoglobin in animals.[17] The possible mechanism(s) by which MCE brings about its antihyperglycemic action may be through potentiation of pancreatic secretion of insulin from the intact β-cells of islets (which was clearly evidenced by the increased level of insulin in diabetic rats treated with MCE and glibenclamide) coupled with extra-pancreatic mechanisms like decreased glycogenolysis and enhanced glycogenesis by the liver and/or enhanced transport of blood glucose to peripheral tissues (as seen by the stimulatory effect on glucose uptake in rat diaphragm).[18]

**Anti-hyperlipidemic Activity**

Momordica charantia decreases "bad" cholesterol and increases "good" cholesterol. Momordica charantia proved hypolipidemic as well as hypoglycemic effects of Momordica charantia fruit in the STZ-induced diabetic rat.[19]

**Antioxidant Activity**

The aqueous extract of MC is a polar solvent with a high concentration of phenols and flavonoids, which have significant free radical scavenging activity. Thus, phenols and flavonoids are important components of this plant, and some of its antidiabetic and antioxidative effects could be attributed to the presence of these valuable constituents.[20]

***Gymnema sylvestre* Retz.**

Gymnema Sylvestre R. Br. is a valuable herb belonging to the family Asclepiadaceae, and widely distributed in India, Malaysia, Srilanka, Australia, Indonesia, Japan, Vietnam, tropical Africa and the southwestern region of the People's Republic of China.[21]

**Taxonomy**

Kingdom Plantae
Subkingdom Tracheobionta
Superdivision Spermatophyta
Division Magnoliophyta
Class Magnoliopsida
Subclass Asteridae
Order Gentianales
Family Asclepiadaceae
Genus Gymnema
Species sylvestre

**Figure 3: Gymenam sylvestre plant and leaves.**

**Phytochemistry of G. sylvestre**

G. sylvestre leaves contain triterpene saponins belonging to oleanane and dammarene classes. Oleanane saponins are gymnemic acids and gymnemasaponins, while dammarene saponins are gymnemasides. Besides this, other plant constituents are flavones, anthraquinones, hentri-acontane, pentatriacontane, α and β-chlorophylls, phytin, resins, dquercitol, tartaric acid, formic acid, butyric acid, lupeol, βamyrin related glycosides and stigmasterol. Leaves of this species yield acidic glycosides and anthroquinones and their derivatives. Gymnemic acids have antidiabetic, anti-sweetener and anti-inflammatory activities.

**Pharmacological Investigation on Gymnema sylvestre**

**Antidiabetic Activity**

G. sylvestre decreases fasting blood glucose in streptozotocin diabetic rats that may be due to increase the activity of enzymes responsible for utilization of glucose by insulin-dependent pathway or regenerate cells in pancreatic islets.[22] Gymnemic acid IV isolated from G. sylvestre leaves has antihyperglycemic, glucose uptake inhibitory, and gut glycosidase inhibitory activity. Gymnemic acid of leaf and callus extracts of G. sylvestre significantly increases the regeneration of β-cells in treated rats compared to the control rats.[23]

**Anti-hyperlipidemic Activity**

G. sylvestre leaf extract resulted in significantly decreased total cholesterol and serum triglycerides and significantly increased HDL-cholesterol level. This

indicates that leaf extract had favorable effects, on lipid metabolism of diabetic rats.[22]

**Antioxidant Activity**

The ethanolic extract of Gymnema sylvestre showed considerable dose dependent antioxidant activity with IC50 of Gymnema sylvestre was found to be 74.8 µg/ml and 83.8 µg/ml by ABTS and DPPH assay respectively.[23]

***Eugenia jambolana***

Eugenia jambolana is being widely used to treat diabetes by the traditional practitioners over many centuries. It belongs to family Myrtaceae, (called Black plum/Black berry in English and Jamun in Hindi in India).[24]

**Taxonomy**

**Kindom:** Plantae
**Division:** Magnoliophyta
**Class:** Magnoliopsida
**Order:** Myrtales
**Family:** Myrtaceae
**Genus:***Eugenia*
**Species:***jambolanaLam*.
**Common Name**: Black plum, Jamun, Jambhul.

**Figure 4: *Eugenia jambolana* plant and fruits.**

**Phytochemistry of Eugenia jambolana**

Jamun plant is known to possess diverse phytochemicals. The leaves are known to contain β-sitosterol, betulinic acid, mycaminose, crategolic (maslinic) acid, n-hepatcosane, n-nonacosane, n-hentriacontane, noctacosanol, n-triacontanol, n-dotricontanol, quercetin,myricetin, myricitrinandthe flavonol glycosides myricetin 3-O-(4″-acetyl)-α-L-rhamnopyranosides, acylated flavonol glycosides. The essential oil from the leaves is shown to contain the phytochemicals pinocarveol, α-terpeneol, myrtenol, eucarvone, muurolol, α-myrtenal, cineole, geranyl acetone, α-cadinol and pinocarvone. The stem bark is reported to possess friedelin, friedelan-3-α-ol, betulinic acid, β sitosterol, kaempferol, β-sitosterol-D-glucoside, gallic acid, ellagic acid. Studies have shown that the pulp of Jamun contains the anthocyanins, delphinidin, petunidin, malvidin-diglucosides, and these compounds are responsible for their bright purple color. The seeds contain jambosine, gallic acid, ellagicacid, corilagin, 3,6-hexahydroxy diphenoylglucose, 4,6-hexahydroxydiphenoyl glucose, 1-galloylglucose, 3-galloylglucose, quercetin, β-sitoterol.[25]

**Pharmacological Investigation on Eugenia jambolana**

**Antidiabetic activities**

Antidiabetic activities of jamun revealed by the investigations and seed, pulp and bark have shown an effective antidiabetic action, while the leaf shows no activity. Aqueous and alcohol extracts of Jamun seed in various doses given to rats with fructose diet shown concentration dependent beneficial effects. For 15 days rats were fed with fructose, then triglycerides, insulin and serum glucose levels were increased and this was confirmed by comparing with normal control models. When rats were treated with jamun aqueous extract (400 mg/ day) for 15 days, preventive effects prevented high glucose level and hyperinsulinemia.[26]

**Hypolipidemic effect**

Diabetic rats showed hypolipidemic effects when these were fed with ethanolic seed extract (with dose 100 mg/kg body weight). The modification of plasma lipoproteins and composition of fatty acid which were shown by rats (diabetic), this alteration is reversed after administration of the extract.[26]

**Antioxidant Activity**

The antioxidant property of the fruit skin may come in part from the antioxidant vitamins, phenolics or tannins and anthocyanins present in the fruit. In vitro antioxidant activity of Eugennia jambolana was studied for total phenolic content and antioxidant activity by DPPH method. It showed a high total phenol content (72-167.2 mg/g) and high antioxidant activity (69.6-90.6 %).[27]

***Garcinia cambogia***

Garcinia cambogia (Gaertn.) Desr. famously known as Malabar tamarind or Kodampuli is a member of the family Clusiaceae (Guttiferae) and is distributed throughout the world. Africa and Malaysia appear to be the main regions with large number of endemic species

of the genus Garcinia. The fruits of Garcinia cambogia are yellowish, large and globular with deep vertical grooves enclosing six to eight multi-lobed seeds. Seeds are usually connected tothe fruit rind by white acidic pulp called Aril. Many species belonging to the genus Garcinia have commercial value as medicines and cosmetics.[28]

**Taxonomy**[29]
Kingdom: Plantae
Division: Angiosperms
Sub division: Eudicots
Order: Malpighiales
Family: Clusiaceae
Subfamily: Clusioideae
Tribe: Garcinieae
Genus: Garcinia
species cambogia
Botanical Name: Garcinia cambogia
Latin Name: Garcinia cambogia
Vernacular Names: Brindle berry, brindall berry, garcinia, malabar tamarind, hydroxycitric acid (HCA), citrin, gambooge, gorikapuli, uppagi, garcinia kola, mangosteen oil tree.
Synonyms: Gutta gamba. Gummigutta. Tom Rong. Gambodia. Garcinia Morella.

***Figure 5: Garcinia cambogia* plant and fruits.**

**Phytochemistry of *Garcinia cambogia***
The phytochemistry of G. cambogia has not been studied and reported comprehensively. Preliminary phytochemical studies revealed the presence of alkaloids, flavanoids, phenolic compounds, saponins, tannins, carbohydrates and proteins.[36] Up to date, a few xanthones, benzophenones and organic and amino acids have been isolated from various parts of the plant.[30] The fruit contains about 30 per cent acid calculated as citric acid on dry wt. basis. The organic acids present have been mistakenly identified in the past as tartaric and citric acids. The evidence which has led to the identification of the acid as (->hydroxycitric acid is presented here. The principal acid of G. cambogia has been found to be (2)-hydroxycitric acid (HCA; 1,2-dihydroxypropane-1,2,3-tricarboxylic acid)[6] and it is found in fruit and rind of G. cambogia. G. cambogia contains 16–18% of HCA and both citric and malic acids in minor quantities.[31] The phyto chemical constituent present are citric acid lactone, Ascorbic acid, tartaric acid, malic acid, Garcinol, isogarcinol, cyanidin and Xanthone. The latex of Garcinia cambo gia contains two polyisoprenylated benzophenone derivatives, camboginol (I) and cambogin (II). The major phytoconstituents in Garcinia cambogia is Hydroxycitric acid. This principal acid has been found to suppress the fatty acid synthesis, lipogenesis, food intake, and promotes glycogenesis, gluconeogenesis and induced weight loss.[29]

**Pharmacological Investigation on *Garcinia cambogia***
**Anti Diabetic activity**
Garcinia cambogia rind extracts possess potent anti diabetic activity. The study was investigated in normal and obese streptozotocin induced diabetic rats and was found to produced significant reduction in glucose level, lipid profile and body weight.[29]

**Anti Obesity activity**
Garcina cambogia is potent herbal medicine for the management of Obesity.(-)-Hydroxycitric acid (HCA) is a compound found in Garcinia cambogia, a type of fruit. HCA has a chemical structure similar to that of citric acid (the primary acid in citrus fruits). Preliminary research in the laboratory and in animal research, suggests that HCA may be a useful weight loss aid.24, 25 HCA has been demonstrated that HCA has been demonstrated in the laboratory (but not yet in trials with people) to reduce the conversion of carbohydrates into stored fat by inhibiting certain enzyme processes.26, 27 Animal research indicates that HCA suppresses appetite and induces weight loss.28, 29, 30, 31. One case report found that eating 1 gram of the fruit containing HCA before each meal resulted loss of 1 pound in the per day.32 A double-blind trial that provided either 1,500 mg of HCA or a placebo per day to 135 overweight men and women, who also were on a calorie-restricted diet, found after 12 weeks that the HCA supplementation did not produce a significant change in weight loss.33

Uncontrolled and/or preliminary evidence from several other human trials suggests the possibility that weight loss might occur; 34 however, none of these studies is as methodologically strong as the negative trial previously mentioned. These less-rigorous studies used a similar calorie-restricted diet and a similar amount of HCA as the negative trial. However, the double-blind study used a high-fibre diet not used in the prior studies. It has been suggested that such a diet might limit absorption of HCA.[30]

**Hypolipidemic activity**

A strong lipid-lowering effect was recorded for a rich flavonoid extract prepared from the fruit rind after oral administration of 10 mg/kg BW/day for 45 days in rats. It was noted that the flavonoid extract, at higher doses, showed lesser activity in reducing lipid levels in serum and tissues. This indicated that the hypolipidaemic activity of the flavonoid-rich extract is perhaps due to lower lipogenesis and higher degradation rates.[88,89] Garcinia cambogia fruit extract, at an oral dose of 1000 mg/kg BW/day for 8 days, showed a notable hypolipidaemic effect on dexamethasone-treated rats. It normalised the increased levels of triglycerides and cholesterol, as well as free acids formed as a result of dexamethasone in the plasma and liver. Weak preventive activity was recorded for the fruit extract (4.5% w/w with diet) against lipid metabolism and serum activity of alanine aminotransferase, aspartate aminotransferase and γ-glutamyl transferase in highlipid diet-fed rats. A clinical trial conducted on obese women receiving G. cambogia extract (50% HCA) at oral doses of 800 mg 3 times a day for 60 days revealed a reduction in triglycerides. However, other variables of the lipid profile, and leptin and insulin levels remained unchanged. The study concluded that G. cambogia has a hypotriglyceridaemic effect that is unrelated to changes in leptinaemia.[30]

**Coffea Canephora**

Coffee is a member of the Rubiaceae family. It grows in rainy places with typical temperatures of 18 - 24°C. Green coffee is an unroasted bean from the Coffee fruit that contains more bioactive phytochemicals than roasted coffee beans. Chlorogenic acid (CGA), a polyphenol, is abundant in green coffee beans. The ester of caffeic and quinic acids forms chlorogenic acid, a naturally occurring chemical compound. Chlorogenic acid contains anti-cancer, anti-inflammatory, anti lipidemic, anti-hypertensive, and anti-diabetic activities, according to research. Caffeine, theophylline, theobromine, cafestol, kahweol, tocopherols, trigonelline, chlorogenic acids and their derivatives, are associated to these properties.[32]

**Taxonomy**

**Kingdon:** Plantae
**Division:** Tracheophyta
**Order:** Gentianales
**Class:** Magnoliopsida
**Family**: Rubiaceae
**Genus**: Coffea
**Species**: canephora
**Common Name**: Robusta coffee

**Figure 6:** ***Coffea canephora seeds.***

**Phytochemistry of Coffea canephora**

The chemical composition of green coffee bean is defined by the amount of caffeine ranging from 1.45%-2.38% in C. arabica and C. canephora respectively. Green coffee consists of various primary components respectively. These primary components include polysaccharides, lipids, proteins, chlorogenic acid (CGA), caffeine, simple sugars and free amino acids. Polysaccharides account for nearly half of the dry weight of coffee beans. The Green Robusta bean has 48 percent polysaccharide, which is mostly made up of arabinogalactan, mannan, and cellulose. Arabica and Robusta green coffee beans have comparable polysaccharide profiles.

**Pharmacological Investigation on *Coffea canephora***

**Anti-diabetic Activity**

A better activity similar of the glibenclamide was observes with the coffea canephora seed extract ethanolic 70%. The presence of antioxidants (polyphenols, flavonoids and alkaloids) in the extract may provide an explanation for the hypoglycemic and anti-hyperglycemic effects observed.[33] Green coffee beans acting as an alpha-glucosidase inhibitor, chlorogenic acid appears to reduce, but not stop, glucose absorption from the human stomach, lowering the insulin surge after meals in type 2 diabetic patients. Chlorogenic acid also affects gluconeogenesis and glycogenolysis by blocking the enzyme glucose-6-phosphatase. Coffee chemicals also decrease the absorption of glucose in the intestine by modulating the levels of glucose-dependent insulinotropic polypeptide (GIP) and glucagon-like peptide-I (GLP-I), which enhance insulin secretion following oral glucose consumption.[32]

**Anti-obesity Activity**

The green coffee beans activate the liver, causing it to create more bile and speed up the metabolic process while also releasing glucose into the bloodstream. Caffeine also slows fat absorption by releasing fatty

acids from stored body fat. Chlorogenic acid helps the liver process fatty acids more efficiently and lowers hepatic triglyceride levels, leading in weight loss. Green coffee bean extract decreases hepatic triglyceride levels while chlorogenic acid suppresses fat absorption. Other phenolic components in green coffee beans, such as neochlorogenic acid and feruloylquinic acid, increase the activity of hepatic carnitine palmitoyltransferase (CPT). In addition to suppressing hepatic triglyceride accumulation, antiobesity effects are mediated by changes in plasma adipokine levels, body fat distribution, and downregulating fatty acids and cholesterol biosynthesis and upregulating fatty acids oxidation and expression of PPAR in the liver.[32] Green coffee bean extract showed the decrease in weight, plasma lipids, glucose levels and insulin resistance. The mechanism for decrease in plasma glucose level was stimulation of GLUT4 translocation to the plasma membrane in white adipose tissue and decrease in the regulation of genes which involved in adipogenesis were WNT10b, galanin-mediated and TLR4-mediated proinflammatory pathway.[34] caffeine is effective in weight-loss diets through e.g. thermogenesis and fat oxidation.[35]

**Anti-oxidant Activity**

Caffeine, a key component of coffee, is a powerful antioxidant with the ability to prevent oxidative DNA damage, alter the apoptotic response, and regulate the cell cycle checkpoint function. Furthermore, the coffee constituents cafestol and kahweol are two diterpenes that have been demonstrated to have a wide carcinogen-induced genotoxicity. Green coffee contains chlorogenic acid, a phenolic molecule with antioxidant properties and the potential to trap superoxide anions or hydroxyl radicals. Cholorogenic acids are excellent scavengers of reactive oxygen species (ROS).[32] Green coffee bean extract decreased the body fat mass and suppressed the high dietary fat induced obesity. The mice fed with green coffee beans extract with high fat diet which showed decrease in weight gain, liver weight and also suppress the genes of adipogenesis. Anti-obesity activity of green coffee beans on male Sprague-Dawley rats fed with normal diet which showed that green coffee bean extract decreased the fatty acid synthetic enzyme in liver and fatty acid oxidative enzyme increased in hepatic mitochondrial.[34]

Here we enlisting (table 1) some of the medicinal plants with potential antidiabetic and other beneficial properties.

**Table No. 1: Indian medicinal plants with antidiabetic and related beneficial properties.**

| Sr. No. | Plant Name | Ayurvedic / Common Names | Antidiabetic and other related beneficial action in traditional medicines |
|---|---|---|---|
| 1 | *Acacia arabica* Linn (Leguminoceae) | Babul | Hypoglycemic |
| 2 | *Annona squamosa* | Sugar apple | Hypoglycemic, antihyperglycemic |
| 3 | *Artemisia pallens* | Artemisia pallens | Hypoglycemic, GTT |
| 4 | *Arca catechu* | Supari | Arca catechu |
| 5 | *Acacia catechu*, Wild (Leguminoceae) | Khai | Hypoglycemic, Antipyretic, Antidiarrhoeal |
| 6 | *Azadiracta indica* (Meliaceae) | Azadiracta indica (Meliaceae) | Azadiracta indica (Meliaceae) |
| 7 | *Aegle marmelos* | Beal | Antidiabetic |
| 8 | *Aloe vera* and *Aloe barbadensis* | Korphad | Antidiabetic |
| 9 | *Boerhavia diffusa* | Boerhavia diffusa | Antioxidant activity, Antidiabetic |
| 10 | *Caesalpinia bonduc* | Sagargota,Fevernut | Antidiabetic |
| 11 | *Coffea canephora* (Rubiaceae) | Robusta coffee | Antiobesity, Antihyperglycemic |
| 12 | *Curcuma longa*, Linn (Zingiberaceae) | Haldi | Antioxidant,Antiseptic, Antidiabetic |
| 13 | *Coccinia indica* (Cucurbitaceae) | Bimb or Kanturi | Hypoglycemic |
| 14 | *Capparis deciduas* | Karir or Pinju | Hypoglycemic,antioxidant,hypolip idemic |
| 15 | *Emblica officinalis* | Amla, Dhatriphala | Antioxidant,Hypoglycemic |
| 16 | *Eugenia jambolana* (Myrtaceae) | Jambhul | Hypoglycemic and hypolipidemic |
| 17 | *Garcinia cambogia* (Clusiaceae) | Malabar tamarind | Antiobesity, Antidiabetic |
| 18 | *Gymnema sylvestre* (Apocynaceae) | Gudmar or Medsingi | Antihyperglycemic and hypolipidemic |
| 19 | *Mangifera indica* | Amba | Antihyperglycemic and Antihyperlipidemic |

| | | | |
|---|---|---|---|
| 20 | *Momordica charantia* (Cucurbitaceae) | Karela | Antioxidant, Antidiabetic |
| 21 | *Momordica dioica* (Cucurbitaceae) | Momordica dioica (Cucurbitaceae) | Antidiabetic, Astringent, Febrifuge, Antiseptic, Anthelmintic |
| 22 | *Murraya koenigii* | Kadhi patta | Antidiabetic,Tonic, Stomachic, Carminative, Internally in Dysentery, Vomiting |
| 23 | *Ocimum sanctum*Linn. (Labiatae) | Tulsi | Antidiabetic, Antifungal, Antimicrobial |
| 24 | *Pterocarpus marsupium* (Leguminosae) | Indian Kino Tree, Malabar Kino | Anti-hyperglycemic and hypoglycemic effect |
| 25 | *Punica granatum* | Anar | Anti-hyperglycemic , Antioxidant |
| 26 | *Swertia chirayita* | Chirata | Antidiabetic |
| 27 | *Tinospora cordifolia* | Gudvel | Antihyperglycemic |
| 28 | *Terminalia chebula* | Hirda | Antibacterial, hypoglycemic |
| 29 | *Trigonella foenum graecum* (Apocynaceae) | Methi | Antidiabetic |
| 30 | *Withania somnifera* | Ashvagandha,winter cherry | Ashvagandha, Winter cherry |
| 31 | *Withania coagulans* (Solanace ae) | Panner Dodi, Indian cheese maker | Antidiabetic, Blood purifier, Wasting diseases and Insomnia. |

Hypoglycemic activity of several plants has been scientifically proved and some hypoglycemic phytoconstituents have been identified from them. Many polyherbal formulations having anti-diabetic activity are available in the market which consist of dried plant extracts. Following are some polyherbal formulations which exist in the market for the treatment of diabetes that contain drug in powder form or as extracts.

**Hyponidd tablets:** Momrdica charantia, Melia azadiracta, Emblica officinale, Curcuma longa, Swertia chirata, Tinospora cordifolia, Gymnema sylvestre, Eugenia jambolana, Cassia auriculata, Enicostemma litterole.

**Dianex:** Gymnema sylvestre, Momordica chharantia, Aegle marmelos, Eugenia jambolana, Withania somnifera, Azadirachta indica, Cassia auriculata and Curcuma longa.

**Glucomap tablets:** Phyllanthus niruri, Gymnema sylvestre, Eugenia jambolana, Momordica charantia, Melia azadiracta, Terminalia arjuna, Aegle mermelos.

**Diasulin:** Cassia auriculata, Curcuma longa, Gymnema sylvestre, Coccinia indica, Emblica officinalis, Momordica charantia, Syzygium cumini, Trigonella foenum-grecum, Tinospora cordifolia, Scoparia dulcis.

**Dia-care:** Sanjeevan Mool, Himej, Jambu beej, Namejav, Neem chal, Kadu.

**Glucolev capsule:** Amalaki powder, Sudha shilajeet, Methika beej, Jasad bhasma, Jambu beej, Ashwagandha, Madhunashini.

**Diabecon:** Glycyrrhiza glabra, Gymnema sylvestre, Syzygium cumini, Pterocarpus marsupium, Casearia esculenta, Asparagus racemosus, Boerhavia diffusa, Tinospora cordifolia, Tribulus terestris, Phyllanthus amarus, Gossypium herbaceum. Gnelina arborea, Sphaeranthus indicus, Tribulus terrestris, Berberis aristata, Aloe vera, Triphala, Commiphora weightii, Shilajeet, Momordica charantia, Piper nigrum, Ocimum sanctum, Abutilon indicum, Curcuma longa, Rumex maritime.

**Diabeta:** Gymnema sylvestre, Cucuma longa, Vinca rosea, Azardirachta indica, Syzygium cumini, Accacia Arabica, Tinospora cordifolia, Zingiber officinale, Momordica charantia, Pterocarpus marsupium

**Madhumeha churna:** Azadirachta indica, Cassia auriculata, Cassia auriculata, Gymnema sylvestre, Eugenia jambolana, Zizyphus mauritiana, Curculigo orchioides, Melochia corchorifolia, Michelia champaca, Cynodon dactylon, Murraya koenegii, Acacia catechu, Cassua fistula, Salacia oblonga and Momordica charantia.

**Mersina capsules:** Gymnema sylvestre, Momordica charantia, Cassia auriculata, Syzigium cumini, Melia azadiracta, Phyllanthus emblica, Trigonella foenum-graecum, Coccunua indica, Potassi carbonas, Tinospora cardifolia.

**Diabecure:** Juglans regia, Berberis vulgaris, Erytherea centaurium, Millefolium, Taraxacum.

## CONCLUSION

Diabetes has been effectively treated with herbal medicine all around the world. Diabetes Types I and II, as well as its complications, are managed using herbs. Because of this, treatments created using the allopathic principles of modern medicine are frequently ineffective, risky, and prohibitively expensive, particularly for the poor countries. The researchers have conducted some initial study on the aforementioned plants in order to assess their potential hypoglycemic effects. Numerous Indian plant species have been scientifically validated for their ability to lower blood sugar levels, which suggests that they may have medicinal benefit. As a result, several plants have been utilized either alone or in combination to treat diabetes.

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