

**Anti diabetic potential medicinal plants**Arabinda Nayak<sup>1</sup>, Subrata De<sup>2</sup><sup>1</sup>School of Pharmacy, RK University, Rajkot, India, Atmiya Inst. of Pharmacy, Rajkot (Parent institute)<sup>2</sup>R. M.D. research & Development Center, India**Received on:17-09-2012; Revised on: 19-10-2012; Accepted on:10-12-2012****ABSTRACT**

Diabetes mellitus is caused due to deficiency in production of insulin by the pancreas, or by the ineffectiveness of the insulin produced. It is a global problem and number of those affected is increasing day by day. The plants provide a potential source of hypoglycemic drugs because many plants and plant derived compounds have been used in the treatment of diabetes. Several medicinal plants have found potential use as hypoglycemic in the Indian system of medicines, including ayurveda. Many Indian plants have been investigated for their beneficial use in different types of diabetes and reports occur in numerous scientific journals. This article aims to provide a comprehensive review on various plant species from Indian biosphere and their constituents, which have been shown to display potent hypoglycemic activity. Ayurveda and other Indian literature mention the use of plants in treatment of various human ailments. India has about 45000 plant species and among them, several thousands have been claimed to possess medicinal properties. Research conducted in last few decades on plants mentioned in ancient literature or used traditionally for diabetes have shown anti-diabetic property. Indian plants which are most effective and the most commonly studied in relation to diabetes and their complications are: *Allium cepa*, *Allium sativum*, *Aloe vera*, *Cajanus Cajan*, *Coccinia indica*, *Caesalpinia bonducella*, *Ficus bengalensis*, *Gymnema sylvestre*, *Momordica charantia*, *Ocimum sanctum*, *Pterocarpus marsupium*, *Swertia chirayita*, *Syzigium cumini*, *Tinospora cordifolia* and *Trigonella foenum graecum*. Among these we have evaluated *M. charantia*, *Eugenia jambolana*, *Mucuna pruriens*, *T. cordifolia*, *T. foenum graecum*, *O. sanctum*, *P. marsupium*, *Murraya koeingii* and *Brassica juncea*. All plants have shown varying degree of hypoglycemic and anti-hyperglycemic activity.

**Keywords:** Indian; Ayurveda; Diabetes mellitus; Plants; Herbal medicine**1. INTRODUCTION**

Diabetes mellitus is a clinical syndrome characterized by inappropriate hyperglycemia caused by a relative or absolute deficiency of insulin or by a resistance to the action of insulin at the cellular level. It is the most common endocrine disorder, affecting 16 million individuals in the United States and as many as 200 million worldwide. Diabetes has been a clinical model for general medicine. The primary defect in fuel metabolism results in widespread, multi-organ complications that ultimately encompass virtually every system of the body and every specialty of medicine. It has been said that to know diabetes is to know medicine and health care. Although from a clinical standpoint this may be true, our increasing knowledge of the pathophysiology of the syndrome, together with the mechanisms of long-term complications, has placed diabetes research at the frontier of immunology and molecular biology.

There are two main types of diabetes, namely type I and type II (World Health Organization. Definition, Diagnosis and Classification of Diabetes mellitus and its Complications. Part 1: Diagnosis and

Classification of Diabetes Mellitus (Department of Noncommunicable Disease Surveillance, Geneva, 1999). Type I diabetes, that is called insulin-dependent diabetes mellitus (IDDM) or juvenileonset diabetes develops when the body's immune system destroys pancreatic  $\beta$ -cells, the only cells in the body that produce the hormone insulin that regulates blood glucose. This type of diabetes usually strikes children and adults and the need for insulin administration is determinant for survival. Type I diabetes accounts for 5% to 10% of all diagnosed cases of diabetes and the risk factors may be autoimmune, genetic, or environmental. On the other hand, type II diabetes, also called non-insulin-dependent diabetes mellitus (NIDDM) or adult-onset diabetes, accounts for about 90% to 95% of all diagnosed cases of diabetes. It usually begins as insulin resistance, a disorder in which the cells do not use insulin properly and as the need for insulin rises; the pancreas gradually loses its ability to produce it. This type of diabetes is associated with older age, obesity, family history of diabetes, history of gestational diabetes, impaired glucose metabolism, physical inactivity, and race/ethnicity. It must be noted thought that in the last decay type II diabetes in children and adolescents is being diagnosed more frequently (Fagot-Gampagna & Narayan 2001). In the case of the IDDM, insulin is of crucial importance for the survival of the patients. On the other hand, in the case of NIDDM the treatment includes medicines, diets and physical training. Up to now, many kinds of antidiabetic medicines have been developed for the patients

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and most of them are chemical or biochemical agents aiming at controlling or/and lowering blood glucose to a normal level. Despite the impressive advances in health sciences and medical care, there are many patients who are using alternative therapies alone or complementary to the prescribed medication. Traditional plant remedies or herbal formulations exist from ancient times and are still widely used, despite all the controversy concerning their efficacy and safety (Huxtable 1990; Fugh-Berman 2000), to treat hypoglycemic and hyperglycemic conditions all over the world. It must be noted that many ethno-botanical surveys on medicinal plants used by the local population have been performed in different parts of the world and there is a considerable number of plants described as antidiabetic. In addition a variety of compounds have been isolated (alkaloids, glycosides, terpenes, flavonoids, etc) but further studies need to be done so as these 'leads' to develop into clinically useful medicines. To date, metformin (a biguanide) is the only drug approved for treatment of type II diabetes mellitus. It is a derivative of an active natural product, galegine, isolated from the plant *Galega officinalis* L. (Witters 2001).

Diabetes is a chronic disease affecting around 2-3 % of the population worldwide. Unfortunately, after the introduction of sulfonylurea and metformin about 50 years back no major lead has been obtained in this direction of finding a proper drug for diabetes. Plant materials which are being used as traditional medicine for the treatment of diabetes are considered one of the good sources for a new drug or a lead to make a new drug. Plant extract or different folk plant preparations are being prescribed by the traditional practitioners and also accepted by the users for diabetes like for any other diseases in many countries especially in third world countries. Now-a day's more than 400 plants are being used in different forms for hypoglycaemic effects all the claims practitioners or users are neither baseless nor absolutely. Therefore, a proper scientific evaluation a screening of plant by pharmacological tests followed by chemical investigations is necessary.

## 2. Plants with anti-diabetic potential

### 2.1. *Aegle marmelose*: Bael or Sirphal (Hindi), Holy Fruit Tree (English)

Bael (*Aegle marmelos*) (also known as *Bengal quince*, *stone apple*), Bilva is a species of tree native to India. It is present throughout Southeast Asia as a naturalized species. The tree is considered to be sacred by Hindus. Its fruits are used in traditional medicine and as a food throughout its range.

The *Aegle Marmelos* roots are sweet, astringent, bitter and antipyretic. They are useful in dyspepsia, dysentery, diarrhoea, especially for patients having diarrhoea alternating with spells of constipation, stomachalgia, cardiopalmus, uropathy, gastric irritability in infants, vomiting, intermittent fever, vitiated conditions of vata, seminal weakness, and swellings. The leaves of Bael fruit are astringent, febrifuge, laxative and expectorant, and are useful in inflammations, ophthalmia, deafness, catarrh, diabetes and asthmatic complaints.

Hypoglycemic effect of A.Marmelose root extract was seen in fasted

and OGTT of normal rats( Karunayake et al.,1984). Aqueous leaves extract also exhibited similar effect as of insulin on blood glucose,urea body weight,liver glycogen and serum cholesterol of alloxan diabetic rats(Poonachan et al., 1993). The hypoglycemic activity was reduced upon storage of extracts( Karunayake et al.,1984).It also normalized STZ induced histo-pathological alterations in the pancreatic and kidney tissue of rats (Das et al.,1996).

### 2.2. *Acacia arabica* or *nilotica*: Babul (Hindi), Indian Gum Arabic tree (English)

*Acacia nilotica* (gum arabic tree, babul, Egyptian thorn, Sant tree, Al-sant or prickly acacia; called thorn mimosa in Australia; lekkerruikpeul or scented thorn in South Africa) is a species of *Acacia* (wattle) native to Africa and the Indian subcontinent. It is also currently an invasive species of significant concern in Australia.

*A. nilotica* may also be used for medicinal purposes, as a demulcent or for conditions such as gonorrhoea, leucorrhoea, diarrhea, dysentery or diabetes. It is styptic and astringent. In Siddha medicine, the gum is used to consolidate otherwise watery semen. In an experimental study, ninety percent seed diet to normal rats showed significant hypoglycemia versus controls. However, the same diet failed to show any hypoglycemic effect any alloxanized rats (175mg/kg SC) indicating action through release of insulin (Singh et al., 1975). No acute toxicity and behavioral changes were observed at these doses (Wadood et al.,1989).

### 2.3. *Allium cepa*: Pyaj (Hindi) and Onion (English)

Onion has been an important constituent in the foods all over the world. In experimental studies it was observed that use of onions reduces blood sugar levels in experimental diabetes. Also it was observed that onions inhibit platelet aggregation and control higher lipid content in the blood (Hyperlipidaemia). In some other studies it was observed that ointment prepared from the onions minimize the scars formation in burn injury.

Decoction of the fresh bulb, administered intragastrically to mice at a dose of 0.5ml/animal, was active. Twenty-five percent aqueous extract was used and produced a maximal change in blood sugar of 28.2% vs alloxan-induced hyperglycemia. Ethanol (95%) extract of the bulb, at a dose of 250.0 mg/kg, was active in rabbits vs alloxan-induced hyperglycemia. A 18.57% drop in blood glucose was observed at 2 hours post-treatment. Ether and ethanol (95%) extracts of dried bulb, var. Behairy, administered by gastric intubation to rats at a dose of 50.0 gm/kg (expressed as dry weight of the bulb), were active vs alloxan- and epinephrine induced hyperglycemia. Ether extract of the aerial part, administered subcutaneously to rats at a dose of 0.5 ml/animal dailt for 10 days, was equivocal vs alloxan-induced hyperglycemia. The plant juice produced weak activity. Ether extract of the fresh bulb, administered intragastrically to rabbits at doses of 100 mg/animal for 7 days, and 250 mg/kg, was active vs alloxan-induced hyperglycemia. Water extract of the fresh bulb, taken orally by human adults at a dose of 100.0 gm/person, was active vs glucose- and adrenalin-induced hyperglycemia. Fresh bulb juice, administered intragastrically to rabbits at a dose of 25.0 gm/animal (expressed as

dry weight of plant), was active vs glucose-induced hyperglycemia. Petroleum ether extract of the fresh bulb, administered intragastrically to rabbits at a dose of 250.0 mg/kg, was active vs alloxan-induced hyperglycemia. Hot water extract of the dried bulb, administered by gastric intubation to mice at a dose of 0.5 ml (25% of the extract), was active vs alloxan-induced hyperglycemia. When administered orally to rabbits at a dose of 10.0 ml/animal, a 13.4 mg percent drop in blood sugar level was observed after 8 days of treatment. Water extract of the dried bulb, administered intravenously to mice at a dose of 70.0 mg/kg, was active vs alloxan-induced hyperglycemia (Ross, 2001).

#### 2.4. *Allium sativum*: Lahasun (Hindi) and Garlic (English)

Garlic is also extensively used for curing asthma, arthritis, sciatica, lumbago, backache, bronchitis, chronic fever, tuberculosis, rhinitis, malaria, obstinate skin disease including leprosy, leucoderma, discolouration of the skin and itches, indigestion, colic pain, enlargement of spleen, piles, fistula, fracture of bone, gout, urinary diseases, diabetes, kidney stone, anemia, jaundice, epilepsy, cataract and night blindness etc.

Garlic (*Allium sativum* L., Liliaceae) is a common spicy flavoring agent used since ancient times. Oral administration of garlic ethanolic extract (0.1, 0.25, 0.5 g/kg of body weight) showed anti-diabetic effect in diabetic rats. *In vivo* treatment with aqueous garlic extract (100mg/kg/day; intra-peritoneal, for 8 weeks) inhibited the development of abnormalities in vascular reactivity induced by diabetes in diabetic rats. Daily Oral administration of 1 ml of either onion or garlic juices/100mg body weight for four week showed hypoglycemic effects in alloxan diabetic Rats.

#### 2.5. *Artemisia pallens*: common name: Davana

*Artemisia pallens*, Dhavanam is an aromatic herb, In genus of small herbs or shrubs, xerophytic In nature. The flowers are racemose panicles bear numerous small yellow flower heads or capitula, but the silvery white silky covering of down gives the foliage a Grey or white appearance.

Davanam has alternate pinnasect leaves (leaf which is divided into opposite pairs of lobes cut almost to the midrib In narrow divisions) or palmatisect leaves (the green tissue is divided into several segments not fully separated At the base).

The leaves and flowers yield an essential oil known as oil of Davana. Several species yield essential oil and some are used as fodder, some of them are a source of the anthelmintic chemical santonin. Davana blossoms are offered to Shiva, the God of Transformation, by the faithful, and decorate his altar throughout the day. Oral administration of high doses aqueous/methanolic extract from the aerial parts of the plants was observed to reduce blood glucose levels in glucose-fed hyperglycemic and alloxan-treated rabbits and rats.

#### 2.6. *Aloe vera* or *Aloe barbadensis*: Ghee Kunwar and Kumar panthu (Hindi)

*Aloe vera* is a species of succulent plant that probably originated in northern Africa. The species does not have any naturally occurring

populations, although closely related aloes do occur in northern Africa. The species is frequently cited as being used in herbal medicine since the beginning of the first century AD. Extracts from *A. vera* are widely used in the cosmetics and alternative medicine industries, being marketed as variously having rejuvenating, healing or soothing properties. There is, however, little scientific evidence of the effectiveness or safety of *A. vera* extracts for either cosmetic or medicinal purposes, and what positive evidence is available is frequently contradicted by other studies. Medical uses of aloe vera are being investigated as well.

Ghee Kunwar and Kumar panthu (Hindi) – It is cultivated or grows wildly as hedgerows in the drier part of India. It is used in Ayurveda for managing painful conditions and is also mentioned in folk medicine of Arabian Peninsula for management of diabetes. Extracts of aloe gum effectively increased glucose tolerance in both normal and diabetic rats (AI-Awadi & Gumaa, 1987).

#### 2.7 *Areca catechu*: Supari (Hindi), Betelnut (English)

The betel nut is a nut that is chewed as a mild stimulant. It is probably used much more frequently than other masticatory agents including tobacco, chewing gum and cola. This very ancient practice was indulged in by all classes of people throughout history. Fresh, uncured betel nuts are intoxicating, producing giddiness in some people. But the dried and cured nut, in which form it is mostly used, is a stimulant, astringent and febrifuge i.e. remover of fever. Chewing the nut increases the formation of saliva. It decreases perspiration, sweetens the breath, strengthens the gums and generates a mild exhilaration giving the feeling of a good disposition. Since arecoline is readily absorbed into the body, it is not advisable to use it in a pure condition for destroying tape worms for which purpose it is often recommended. Instead, it is better to use the powdered nut. Pharmacologically the action of arecoline very much resembles that of muscarine, palleterine and pilocarpine all of which are violent stimulants of the parasympathetic nervous system. They stimulate the intestines, constrict the bronchi decrease the heart rate and lower blood pressure.

Arecoline also stimulates salivation and decreases sweating. The nut is used medicinally in various forms, as powders (in dosage of 10 – 30 grams), fluid extracts (doses of 10 to 30 minims) and tinctures (1 to 2 drachms). Arecoline hydrobromide is a statutory drug in the Indian, British, German and French pharmacopias. Taenine is a preparation containing areca nut extract, forming a liquid medicine used in veterinary practices against tape worms. The advised dosage of this medicine for a dog is one minim for every pound of body weight.

#### 2.8 *Azadirachta indica*: Nim or Neem (Hindi)

*Azadirachta indica* (also *Neem* (Hindi), *Vembu* (Tamil)) is a tree in the mahogany family Meliaceae. It is one of two species in the genus *Azadirachta*, and is native to India and Pakistan growing in tropical and semi-tropical regions. Its fruits and seeds are the source of neem oil. Other vernacular names include Neem (Nepali, Urdu), Nim (Bengali), Nimm (Punjabi), Arya Veppu (Malayalam), Azad Dirakht (Persian), Nimba (Sanskrit, Oriya), Limdo (Gujarati language) Kadu-Limba (Marathi), Dongoyaro (in some Nigerian languages), Margosa, Neeb

(Arabic), Nimtree, Vepu, Vempu, Vepa (Telugu), Bevu (Kannada), *Kodu nimb* (Konkani), (Kohomba, Sinhala), Tamar (Burmese), (Vietnamese), (Sdao, Khmer), (Sadaw, Thai), (Hebrew), Paraiso (Spanish), and Indian Lilac (English). In East Africa it is also known as *Muarubaini* (Swahili), which means *the tree of the 40*, as it is said to treat 40 different diseases, and in Somalia it is known as “Geed Hindi” which means “the Indian tree”.

In India, the plant is variously known as “Sacred Tree,” “Heal All,” “Nature’s Drugstore,” “Village Pharmacy” and “Panacea for all diseases”. Products made from neem trees have been used in India for over two millennia for their medicinal properties: neem products are believed to be anthelmintic, antifungal, antidiabetic, antibacterial, antiviral, contraceptive and sedative. Neem products are also used in selectively controlling pests in plants. It is considered a major component in Ayurvedic and Unani medicine and is particularly prescribed for skin disease.

Neem being bitter, stomachic, anti-pruritic, and revitalize works wonders in this disease. One table spoon of Neem leaves juice approximately 5 ml taken early in the morning on empty stomach for 3 months is helpful in diabetes. 10 Neem leaves chewed or powder taken daily in the morning also controls diabetes.

#### **2.9. *Biophytum sensitivum*: Lajjalu or Laksmana (Hindi)**

Lakshmana is a slender erect annual herb with a rosette of leaves on the top of the stem. Leaves are pinnate, sensitive, leaflets opposite, 6-12 pairs, and the terminal pair being the largest, oblong, apiculate in the apex, glabrous and pale beneath. Flowers are yellow, dimorphic, peduncles many, slender up to 10 cm long; fruits are ellipsoid capsules. Seeds are prominently ridged, transversely striate.

Ayurveda recommends Lakshmana in strangury, urinary calculi, hyperdipsia, wounds, abscess, gonorrhoea, asthma, phthisis and snakebite.

#### **2.10. *Beta vulgaris*: Chukkander (Hindi), Garden beet (English)**

The beet (*Beta vulgaris*) is a plant in the Chenopodiaceae family which is now included in Amaranthaceae family. It is best known in its numerous cultivated varieties, the most well known of which is the purple root vegetable known as the beetroot or garden beet. However, other cultivated varieties include the leaf vegetables chard and spinach beet, as well as the root vegetables sugar beet, which is important in the production of table sugar, and mangelwurz, which is a fodder crop.

The roots and leaves of the beet have been used in folk medicine to treat a wide variety of ailments. Ancient Romans used beetroot as a treatment for fevers and constipation, amongst other ailments. Hippocrates advocated the use of beet leaves as binding for wounds. Since Roman times, beetroot juice has been considered an aphrodisiac. From the Middle Ages, beetroot was used as a treatment for a variety of conditions, especially illnesses relating to digestion and the blood. Platina recommended taking beet root with garlic to nullify the effects of ‘garlic-breath’. It has been suggested the pigment molecule betanin in the root of red beets may protect against oxidative

stress and has been used for this purpose in Europe for centuries. All parts of the beet plant contain oxalic acid. Beet greens and Swiss chard are both considered high oxalate foods which have been implicated on the formation of kidney stones.

#### **2.11. *Bombax ceiba*: Semul (Hindi) and Red Silk Cotton Tree (English)**

*Bombax ceiba*, like other trees of the genus *Bombax*, is commonly known as cotton tree or tree cotton. This tropical tree has a straight tall trunk and its leaves are deciduous in winter. Red flowers with 5 petals appear in the spring before the new foliage. It produces a capsule which, when ripe, contains white fibres like cotton. Its trunk bears spikes to deter attacks by animals. Although its stout trunk suggests that it is useful for timber, its wood is too soft to be very useful.

The gum has aphrodisiac, astringent, demulcent, haemoptysis of pulmonary tuberculosis and influenza, malaena and menorrhagia and acute dysentery with beneficial results. Flowers are used for haemorrhoids. Root has stimulant, tonic and aphrodisiac properties.

#### **2.12. *Caesalpinia bonducella***

*Caesalpinia bonduc*, commonly known as Gray Nicker, is a species of flowering plant in the pea family, Fabaceae, that has a pantropical distribution. It is a vine-like shrub that reaches a length of 6 m (20 ft) and scrambles over other vegetation. Stems are covered in curved spines. Its 2 cm (0.79 in) gray seeds, known as nickernuts, are buoyant and durable enough to be dispersed by ocean currents.

The seed extracts of *Caesalpinia bonducella* were subjected to screening of antidiabetic activity in alloxan induced hyperglycemia. The oral administration of the extracts (300 mg/kg) produced significant antihyperglycemic action as well as it lowered the BUN levels significantly. In the same study the action of the extracts on diabetes induced hyperlipidemia was analyzed where the extracts significantly lowered the elevated cholesterol as well as LDL level. The antihyperglycemic action of the extracts may be due to the blocking of glucose absorption. The drug has the potential to act as antidiabetic as well as antihyperlipidemic.

#### **2.13. *Brassica juncea*: Rai (Hindi)**

*Brassica juncea*, also known as mustard greens, Indian mustard, Chinese mustard, and leaf mustard, is a species of mustard plant. Subvarieties include southern giant curled mustard, which resembles a headless cabbage such as kale, but with a distinct horseradish-mustard flavor. It is also known as green mustard cabbage.

Reported to be anodyne, aperitif, diuretic, emetic, rubefacient, and stimulant, Indian Mustard is a folk remedy for arthritis, footache, lumbago, and rheumatism (Duke and Wain 1981). Seed used for tumors in China. Root used as a galactagogue in Africa. Sun-dried leaf and flower are smoked in Tanganyika to “get in touch with the spirits.” Ingestion may impart a body odor repellent to mosquitoes (Burkill, 1966). Believed to be aperient and tonic, the volatile oil is used as a counterirritant and stimulant. In Java the plant is used as an anti-

syphilitic emmenagogue. Leaves applied to the forehead are said to relieve headache (Burkill, 1966). In Korea, the seeds are used for abscesses, colds, lumbago, rheumatism, and stomach disorders. Chinese eat the leaves in soups for bladder, inflammation or hemorrhage. Mustard oil is used for skin eruptions and ulcers (Perry, 1980).

#### **2.14. *Cajanus cajan*: Tuar (Hindi) and Red gram or Pigeon pea (English)**

Perennial woody shrub, mostly grown as an annual for the legume; stems strong, woody, to 4 m tall, freely branching; root system deep and extensive, to about 2 m, with a taproot. Leaves alternate, pinnately trifoliolate, stipulate; stipels small, subulate; leaflets lanceolate to elliptic, entire, acute apically and basally, penninerved, resinous on lower surface and pubescent, to 15 cm long and 6 cm wide.

Morton (1976) lists many folk medicinal uses for pigeon pea. In India and Java, the young leaves are applied to sores. Indochinese claim that powdered leaves help expel bladderstones. Salted leaf juice is taken for jaundice. In Argentina the leaf decoction is prized for genital and other skin irritations, especially in females. Floral decoctions are used for bronchitis, coughs, and pneumonia. Chinese shops sell dried roots as an alexeritic, anthelmintic, expectorant, sedative, and vulnerary. Leaves are also used for toothache, mouthwash, sore gums, child-delivery, dysentery. Scorched seed, added to coffee, are said to alleviate headache and vertigo. Fresh seeds are said to help incontinence of urine in males, while immature fruits are believed of use in liver and kidney ailments. (Duke, 1981a).

#### **2.15. *Capparis decidua*: Kurel or Pinju (Hindi) and Caper plant (English)**

It is a small much branched tree or shrub of arid regions in Africa, Middle East and southern Asia, including the Thar desert. It bears a mass of slender, leafless branches, the small caducous leaves being found only on young shoots. It rarely exceeds a height of 5 meters (15 feet).

*Capparis decidua* is one of the traditional remedies used for various medicinal treatments in Pakistan. This study presents the determination of proximate composition, amino acids, fatty acids, tocopherols, sterols, glucosinolate and phenolic content in extracts obtained from different aerial parts of *C. decidua*, as well as their antidiabetic and antioxidant activity. All examined extracts were prominently rich in phenolics and glucosinates, and they showed potent antidiabetic and antihemolytic activity. The present study could be helpful in developing medicinal preparations for the treatment of diabetes and related symptoms.

Treatment of diabetic mice with AR fraction for 28 days significantly inhibited the acute elevation of blood glucose level during OGTT and also reduced total cholesterol (TC) and triglyceride (TG) content ( $p < 0.05$ ). Activity of glucose-6-phosphatase (G6Pase) was attenuated by 44%, also liver and muscle glycogen content showed significant improvement ( $p < 0.05$ ). The expression of different target genes like G6Pase, phosphoenolpyruvate carboxykinase (PEPCK), aldose

reductase and tumor necrosis factor-alpha (TNF-alpha) showed significant reduction whereas glucose transporter-4 (Glut-4), peroxisome proliferator activated receptor-gamma (PPAR-gamma) and glucokinase (GK) improved remarkably.

#### **2.16. *Citrullus colocynthis*: Badi Indrayan or Makkal (Hindi) and Bitter apple (English)**

*Citrullus colocynthis*, commonly known as the colocynth, bitter apple, bitter cucumber, egusi, or vine of Sodom ( Sanskrit : Gavakshi, Indarvaruni), is a viny plant native to the Mediterranean Basin and Asia, especially Turkey (especially in regions such as Ýzmir), Nubia, and Trieste. It originally bore the scientific name *Colocynthis citrullus*, but is now classified as *Citrullus colocynthis*.

It was used in herbal medicine, with drastic purgative properties, such as abortion and emagogo. It is a poisonous plant with an outcome or death in susceptible individuals may be treated as the toxic principles, including by respitoria causing mild intoxication that can be transmitted from cow have their babies through breast milk. The poisoning causes nausea, vomiting, intense gastroenteritis with severe colic pain, shock, blood and pain, anuria, cramps, convulsions and then death. In Libya and the Sahara in the zone for obstinate constipation problems they used to dig a large part of the fruit pulp removal, fill it with milk and let stand overnight was drunk in the morning accompanied by olive oil, this remedy is safe action. In addition, the heated juice was used to treat scabies of camels.

#### **2.17. *Coccinia indica*: Bimb or Kanturi (Hindi) and Ivy Guard (English)**

*C. indica* is a gourd plant native to India, where it is used as a vegetable. According to the researchers, a person would have to eat 50 grams (2 ounces) of the cooked vegetable per day to receive the same benefit as taking 1 gram of the extract.

Extracts of the Indian herb *Coccinia indica* reduced blood sugar levels by almost 20 percent in a study conducted by researchers from the Institute of Population Health and Clinical Research in Bangalore and published in the journal *Diabetes Care*. *C. indica* is also known by the scientific names *C. cordifolia* and *C. grandis* and the common names kundru, dondakaya, kovakkai and tindora, among many others.

#### **2.18. *Eucalyptus globulus*: Safeda (Hindi)**

Blue gum is one of the most extensively planted eucalypts. Its rapid growth and adaptability to a range of conditions is responsible for its popularity. It is especially well-suited to countries with a Mediterranean-type climate, but also grows well in high altitudes in the tropics. *Eucalyptus Globulus* is a powerful antiseptic and destructive to low forms of life, a stimulating expectorant and an efficient diaphoretic. Atonic dyspepsia, gastric and intestinal catarrh. A remedy with marked effects on catarrhal processes, malaria, and intestinal disturbance. Influenza. Fevers of a Relapsing character. Produces diuresis and great increase of urea. Hemorrhages internally and locally ( Haman.) typhoid. Symptoms of exhaustion and toxemia. Conditions of the

mucous surfaces of the air passages, genito-urinary organs and gastro-intestinal tract. A gastro-intestinal irritant with pain in stomach and upper intestines several hours after eating.

*Eucalyptus globulus* (eucalyptus) is used as a traditional treatment for diabetes. In this study, incorporation of eucalyptus in the diet (62.5 g/kg) and drinking water (2.5 g/L) reduced the hyperglycemia and associated weight loss of streptozotocin-treated mice. An aqueous extract of eucalyptus (AEE) (0.5 g/L) enhanced 2-deoxy-glucose transport by 50%, glucose oxidation by 60% and incorporation of glucose into glycogen by 90% in mouse abdominal muscle. In acute, 20 min incubations, 0.25–0.5 g AEE/L evoked a stepwise 70–160% enhancement of insulin secretion from the clonal pancreatic  $\beta$ -cell line (BRIN-BD11). The stimulatory effect of 0.5 g/L AEE was unaltered by the presence of 400  $\mu$ mol diazoxide/L and prior exposure to AEE did not alter subsequent insulin secretory response to L-alanine, thereby negating detrimental effect on cell viability. The effect of AEE was not potentiated by glucose or demonstrable in cells exposed to a depolarizing concentration of KCl. Further study of the insulin-releasing effects of AEE revealed the activity to be heat stable, acetone insoluble, stable to acid, but abolished by exposure to alkali. Sequential extraction with solvents revealed activity in both methanol and water fractions, indicating the presence of more than one biologically active extract constituent. These data indicate that *Eucalyptus globulus* represents an effective antihyperglycemic dietary adjunct for the treatment of diabetes and a potential source for discovery of new orally active agent(s) for future therapy.

#### 2.19. *Ficus bengalensis*: Indian Banyan tree or Bur (Hindi)

A very large tree, with spreading branches. The stem bark contains  $\beta$ -sitosterol, a-D-glucose and meso- inositol. The leaves contain petunidin di-glycoside and quercetin 3-galactoside. The fruits contain cyanidin rhamnoglucoside and polysaccharides. Various parts of the plant are considered medicinal. The milky juice is externally applied for pains and bruises and as an anodyne in rheumatism and lumbago. It is also used as a remedy for toothache. The leaves are heated and applied as poultice to abscesses. The bark is tonic, astringent and cooling. The seeds are also considered as cooling and tonic. The dose of 300 mg kg(-1) showed the maximum fall of 43.8 and 40.7% in BGL during FBG and glucose tolerance test (GTT) studies of normal rats, respectively. The same dose showed a marked reduction in BGL of 54.3% in sub- and 51.7% in mild-diabetic rats during GTT. The concentration of Mg (1.02%) and Ca (0.85%) identified through laser induced breakdown spectroscopy (LIBS) in the most effective dose could be responsible for this high percentage fall in BGL as they take part in glucose metabolism.

#### 2.20. *Eugenia jambolana*: (Indian gooseberry, jamun)

In India decoction of kernels of *Eugenia jambolana* is used as household remedy for diabetes. This also forms a major constituent of many herbal formulations for diabetes. Antihyperglycemic effect of aqueous and alcoholic extract as well as lyophilized powder shows reduction in blood glucose level. This varies with different level of diabetes. In mild diabetes (plasma sugar >180 mg/dl) it shows 73.51%

reduction, whereas in moderate (plasma sugar >280 mg/dl) and severe diabetes (plasma sugar >400 mg/dl) it is reduced to 55.62% and 17.72% respectively. The extract of jamun pulp showed the hypoglycemic activity in streptozotocin induced diabetic mice within 30 min of administration while the seed of the same fruit required 24 h. The oral administration of the extract resulted in increase in serum insulin levels in diabetic rats. Insulin secretion was found to be stimulated on incubation of plant extract with isolated islets of Langerhans from normal as well as diabetic animals. These extracts also inhibited insulinase activity from liver and kidney.

#### 2.21. *Gymnema sylvestre*: Gudmar or Merasingi (Hindi) and Periploca of the woods (English)

*Gymnema sylvestre* is an herb native to the tropical forests of southern and central India. Chewing the leaves suppresses the sensation of sweet. This effect is attributed to the presence of the eponymously named gymnemic acids. *G. sylvestre* has been used as a natural treatment for diabetes for nearly two millennia. Common names include miracle fruit, gymnema, cowplant, Australian cowplant, gurmari, gurmarmbooti, gurmarm, periploca of the woods, and meshasringa.

*Gymnema sylvestre* is regarded as one of the plants with potent anti diabetic properties. This plant is also used for controlling obesity in the form of *Gymnema* tea. The active compound of the plant is a group of acids termed as gymnemic acids. It has been observed that there could be a possible link between obesity, Gymnemic acids and diabetes. This review will try to put forth an overall idea about the plant as well as present a molecular perspective linking the common medicine to the most common metabolic disorders.

#### 2.22. *Hibiscus rosa-sinensis*: Gudhal or Jasson (Hindi) and Shoe-flower (English)

*Hibiscus* is a genus of flowering plants in the mallow family, Malvaceae. It is quite large, containing several hundred species that are native to warm-temperate, subtropical and tropical regions throughout the world. Member species are often noted for their showy flowers and are commonly known as hibiscus, sorrel, and flor de Jamaica, or less widely known as rosemallow. The genus includes both annual and perennial herbaceous plants, as well as woody shrubs and small trees. The generic name is derived from the Greek word ἵβισκος (*hibiskos*), which was the name Pedanius Dioscorides gave to *Althaea officinalis*.

Blood glucose and total lipid levels were determined in streptozotocin induced diabetic rats after oral administration of an ethanol flower extract of *Hibiscus rosa sinensis*. A comparable hypoglycemic effect was evidenced from the data obtained after 7 and 21 days of oral administration of the extract and glibenclamide. Maximal diminution in blood glucose (41–46%) and insulin level (14%) was noticed after 21 days. The extract lowered the total cholesterol and serum triglycerides by 22 and 30%, respectively. The increase in HDL-cholesterol was much higher (12%) under the influence of the extract as compared to that of glibenclamide (1%). The hypoglycemic activity of this extract is comparable to that of glibenclamide but is not mediated through insulin release.

### 2.23. *Ipomoea batatas*: Sakkargand or Mitha Alu (Hindi)

The sweet potato (*Ipomoea batatas*) is a dicotyledonous plant that belongs to the family Convolvulaceae. Its large, starchy, sweet-tasting, tuberous roots are an important root vegetable. The young leaves and shoots are sometimes eaten as greens. Of the approximately 50 genera and more than 1,000 species of Convolvulaceae, *I. batatas* is the only crop plant of major importance—some others are used locally, but many are actually poisonous. The sweet potato is only distantly related to the potato (*Solanum tuberosum*).

A trailing herb cultivated for its succulent tuberous roots. Oral administration of *Ipomoea batatas* reduces hyperinsulinemia in Zucker fatty rats by 23, 26, 60 and 50% after 3, 4, 6 and 8 weeks, respectively. In addition, inhibition of blood glucose level after glucose loading was observed after 7 weeks of treatment along with regranulation of pancreatic beta cells and reduction in insulin resistance (Kusano and Abe, 2000).

### 2.24. *Lantana camara*: Caturang or Ghaneri (Hindi)

*Lantana camara*, also known as Spanish Flag or West Indian Lantana, is a species of flowering plant in the verbena family, Verbenaceae, that is native to the American tropics. It has been introduced into other parts of the world as an ornamental plant and is considered an invasive species in many tropical and sub-tropical areas.

*L. camara* is sometimes known as “Red (Yellow, Wild) Sage”, despite its classification in a separate family from sage (Lamiaceae), and a different order from sagebrush (Asterales).

A large aromatic shrub found throughout India. It is mentioned in Ayurveda for treatment of various vitiated body conditions. Once daily administration of *Lantana camara* leaves juice (1500 mg/kg/day for 14 days) showed significant hypoglycemic effect in rats ([Garg et al., 1997] and [Sachdeva and Khemani, 1999]). However, the plant is hepatotoxic in nature (Sharma et al., 1992).

### 2.25. *Memecylon umbellatum*: Anjani or Alli (Hindi)

*Memecylon umbellatum*, commonly known as Ironwood, Anjani (Tamil), or Alli (Hindi), is a small tree found in India, the Andaman islands and the coastal region of the Deccan. It is also found in Sri Lanka, where it is called *Blue Mist*, *Kora-Kaha* (Sinhala language) and *Kurrikaya* (Tamil language). The leaves contain a yellow dye, a glucoside, which is used for dyeing the robes of Buddhist monks and for colouring reed mats (Dumbara mats). Medicinally, the leaves are said to have anti-diarrhoeal properties.

A bushy small tree found in the hilly areas of Western Ghats. Shade dried leaf powder is mixed with cup of water and boiled rice and kept overnight and taken orally. Dosage: One teaspoon is taken early in the morning for forty days or until cure.

### 2.26. *Mangifera indica*: Aam or Amb (Hindi) and Mango (English)

*Mangifera indica* is a species of mango in the Anacardiaceae family. It is found in the wild in India and cultivated varieties have been

introduced to other warm regions of the world. It is the largest fruit-tree in the world, capable of a height of one-hundred feet and an average circumference of twelve to fourteen feet, sometimes reaching twenty.

The species appears to have been domesticated about 4,000 years ago. The species was brought to East Asia around 400-500 BCE from India; next, in the 15th century to the Philippines; and then, in the 16th century to Africa and Brazil by the Portuguese. Mangiferin (a pharmacologically active flavonoid, a natural xanthone C-glycoside) is extracted from Mango at high concentrations from the young leaves (172 g/kg), bark (107 g/kg), and from old leaves (94 g/kg). Mangiferin shows an exceptionally strong antioxidant capacity. It has a number of pharmacological actions and possible health benefits. These include antidiabetic, antioxidant, antifungal, antimicrobial, anti-inflammatory, antiviral, hepatoprotective, hypoglycemic, anti-allergic and anticancer activity. Along with *Salacia* it is being investigated for its possible anti-obesity action.

### 2.27. *Momordica cymbalaria*: Kadavanchi and Athalaki (Vernacular)

*Momordica cymbalaria* (Hook., Fenzl ex Naud.) is a vine of the *Momordica* genus found in the Indian states of Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra and Tamil Nadu. It is used in the local folk medicine as an abortifacient and for the treatment of diabetes mellitus. It is a relative of the bitter melon plant (*M. charantia*) which is also used against diabetes. The plant has also been named *Luffa tuberosa* (Roxb.) or *Momordica tuberosa* (Roxb.)

Pharmacological studies indicate possible action of extracts of the plant on several medical conditions. The water extract was reported to have hypoglycemic activity in diabetic rabbits but not in normal rabbits. The ethanol extract was reported to protect rats from isoproterenol-induced myocardial injury.

The oral treatment with the aqueous extract of *Momordica cymbalaria* fruit (MC) (0.5 g/kg) for 6 weeks showed a significant antihyperglycemic as well as antihyperlipidemic effects in the alloxan-induced diabetic rats.

### 2.28. *Momordica charantia*: Karela (Hindi) and Bitter Gourd (English)

*Momordica charantia*, called bitter melon or bitter gourd in English, is a tropical and subtropical vine of the family Cucurbitaceae, widely grown in Asia, Africa, and the Caribbean for its edible fruit, which is among the most bitter of all fruits. There are many varieties that differ substantially in the shape and bitterness of the fruit.

Bitter melon is used to treat diabetes and its complications in traditional Chinese and Ayurvedic medicine. We and others have demonstrated that besides improving glucose and lipid metabolism, BMJ is also effective in improving hyperlipidemia in diabetic and obese rodents as well as reduces body weights in mice fed high-fat diet. However, the effects of bitter melon on human adipocytes have

not been investigated. Transition of undifferentiated fibroblastic preadipocytes into mature adipocytes involves differential regulation of adipogenic genes as well as lipid accumulation. Increase in fat mass is a result of not only increase in adipocyte number due to proliferation, but also induction of differentiation that stimulates mitotic clonal expansion and irreversible commitment to differentiation. Therefore, reduction in fat mass during weight loss may involve inhibition of adipogenic process and lipid accumulation due to dedifferentiation, lipid mobilization (lipolysis) and/or programmed cell death (apoptosis). Higher concentrations of BMJ at 5% and 10% demonstrate significant reduction in cell viability as indicated by reduced cellular ATP levels and increased LDH release. It is therefore possible that higher concentration of BMJ induces apoptosis in maturing preadipocytes and adipocytes, which requires further investigation.

**2.29. Morus alba: Shetut or Tut (Hindi) and White Mulberry (English)**  
*Morus alba*, known as white mulberry, is a short-lived, fast-growing, small to medium sized mulberry tree, which grows to 10–20 m tall. The species is native to northern China, and is widely cultivated and naturalized elsewhere. The white mulberry is widely cultivated to feed the silkworms employed in the commercial production of silk. It is also notable for the rapid release of its pollen, which is launched at over half the speed of sound.

**Dental caries:** The root bark of *Morus alba* (Moraceae) has been used as a traditional medicine in Asian countries and exhibits antibacterial activity against food poisoning micro-organisms. Using activity against *S. mutans* in bioassay-guided fractionation of a methanol extract of dried root bark, and organic solvent fractions of this extract, the active antibacterial constituent was identified as kuwanon G. The compound displayed an MIC of 8 µg ml<sup>-1</sup> against *S. mutans*, which was comparable to chlorhexidine and vancomycin. Time-kill assays indicated that *S. mutans* was completely inactivated by 20 µg ml<sup>-1</sup> kuwanon G within 1 min, while testing against other bacteria suggested that the compound displayed preferential antimicrobial activity against cariogenic bacteria. Electron microscopic examination of *S. mutans* cells treated with kuwanon G indicated that the mode of antibacterial action was inhibition or blocking of cell growth, as treated cells showed a disintegrated surface and an unclear cell margin.

Hypolipidemic and antioxidant effects from freeze-dried powder of mulberry (*Morus alba* L.) fruit. Albanol A(1), isolated from the root bark extract of *Morus alba* may be a promising lead compound for developing an effective drug for treatment of leukemia.

Moracin M, Steppogenin-4'-O-β-D-glucoside, Mullberroside A were isolated from the root bark of *Morus alba* L. and all produced hypoglycemic effects.

A methanol extract of *Morus alba* roots showed adaptogenic activity, indicating its possible clinical utility as an antistress agent.

*Morus alba* leaf extract help restore the vascular reactivity of diabetic rats. Free radical-induced vascular dysfunction plays a key role in the

pathogenesis of vascular disease found in chronic diabetic patients. An ethanolic extract of mulberry leaf had antihyperglycemic, antioxidant and antiglycation effects in chronic diabetic rats, which may suggest its use as food supplement for diabetics.

### **2.30. Musa sapientum: Kela (Hindi) and Banana (English)**

*Musa sapientum* L. ('Ney Poovan') commonly known as 'banana' is mainly used in Indian folk medicine for the treatment of diabetes mellitus. Oral administration of 0.15, 0.20 and 0.25 g/kg of chloroform extract of the *Musa sapientum* flowers (MSFET) for 30 days resulted in a significant reduction in blood glucose, glycosylated haemoglobin and an increase in total haemoglobin, but in the case of 0.25 g/kg the effect was highly significant. It also prevents decrease in body weight. Oral glucose tolerance test was also performed in experimental diabetic rats in which there was a significant improvement in glucose tolerance in animals treated with MSFET and the effect was compared with glibenclamide. Thus the study shows that MSFET has hypoglycaemic action.

The antihyperglycemic effect of ethanolic extract of flowers of *Musa sapientum* (Musaceae), a herb (used in Indian folklore medicine for the treatment of diabetes mellitus) in alloxan induced diabetic rats. Oral administration of the ethanolic extract showed significant ( $p < 0.001$ ) blood glucose lowering effect at 200 mg/kg in alloxan induced diabetic rats (120 mg/kg, i.p.) and the extract was also found to significantly ( $p < 0.001$ ) scavenge oxygen free radicals, viz., superoxide dismutase (SOD), catalase (CAT) and also protein, malondialdehyde and ascorbic acid in vivo. *Musa sapientum* induced blood sugar reduction may be due to possible inhibition of free radicals and subsequent inhibition of tissue damage induced by alloxan. The antidiabetic activity observed in this plant may be attributed to the presence of flavonoids, alkaloids, steroid and glycoside principles.

### **2.31. Mucuna pruriens: Kavach (Hindi) and Cowitch (English)**

*Mucuna pruriens* is a tropical legume known as velvet bean or cowitch and by other common names (see below), found in Africa, India and the Caribbean. The plant is infamous for the extreme itchiness it produces on contact, particularly with the young foliage and the seed pods. It has value in agricultural and horticultural use and has a range of medicinal properties.

Results showed that the administration of 5, 10, 20, 30, 40, 50, and 100 mg/kg of the crude ethanolic extract of *M. pruriens* seeds to alloxan-induced diabetic rats (plasma glucose > 450 mg/dL) resulted in 18.6%, 24.9%, 30.8%, 41.4%, 49.7%, 53.1% and 55.4% reduction, respectively in blood glucose level of the diabetic rats after 8h of treatment while the administration of glibenclamide (5 mg/kg/day) resulted in 59.7% reduction. Chronic administration of the extract resulted in a significant dose dependent reduction in the blood glucose level ( $P < 0.001$ ). It also showed that the antidiabetic activity of *M. pruriens* seeds resides in the methanolic and ethanolic fractions of the extract. Acute toxicity studies indicated that the extract was relatively safe at low doses, although some adverse reactions were observed at higher doses (8-32 mg/kg body weight), no death was recorded. Further-

more, oral administration of *M. pruriens* seed extract also significantly reduced the weight loss associated with diabetes.

### 2.32. *Murraya koeingii* (Curry Leaf)

Its leaves are used in almost all dishes in Tamil Nadu and Kerala. Often used in curries, the leaves generally go by the name “curry leaves”, though they are also called “sweet neem leaves”. The name itself in Tamil is pronounced ‘kariveppilai’ and in Malayalam ‘kariveppila’. Literally, ‘kari’ means ‘curry’, ‘veppu’ neem and ‘ilai’/‘ila’ ‘leaf’. In Kannada the name means “black neem”, since the appearance of the leaves is similar to the unrelated bitter neem tree. Similarly, in Gujarati it is known as ‘limdo’ or ‘meetho leemdo’ and in Hindi as ‘meetha neem’, meaning “sweet neem”. Again, in Hindi and Gujarati it is also called ‘karipatta’ where ‘patta’ means ‘leaf’.

The leaves are highly valued as seasoning in southern and west-coast Indian cooking, and Sri Lankan cooking, especially in curries, usually fried along with the chopped onion in the first stage of the preparation. They are also used to make thoran, vada, rasam and kadhi. In their fresh form, they have a short shelf life, and they don’t keep well in the refrigerator. They are also available dried, though the aroma is largely inferior.

The leaves of *Murraya koenigii* are also used as a herb in Ayurvedic medicine. They are much valued as an anti-diabetic, antioxidant, antimicrobial, anti-inflammatory, hepatoprotective, anti-hypercholesterolemic etc. They also contain iron.

The effect of daily oral administration of aqueous extract (600 mg/kg b.wt.) and methanol extract (200 mg/kg b.wt.) of *Murraya koenigii* Spreng leaves for a period of eight weeks was studied on blood glucose and plasma insulin level in alloxan-induced diabetic rats. Blood glucose levels of diabetic rats treated with aqueous and methanol extracts of *Murraya koenigii* Spreng showed significant reduction ( $P < 0.05$ ) as compared to diabetic control groups. Plasma insulin showed significantly high on 43rd and 58th days of treatment in aqueous and methanol extracts of *Murraya koenigii* treated groups. This suggests that the hypoglycemic effect may be mediated through stimulating insulin synthesis and/or secretion from the beta cells of pancreatic islets of Langerhans.

### 2.33. *Nelumbo nucifera*: Kamal (Hindi) and Lotus (English)

*Nelumbo nucifera*, known by a number of names including Indian Lotus, Sacred Lotus, Bean of India, or simply Lotus, is a plant in the monotypic family Nelumbonaceae. The Linnaean binomial *Nelumbo nucifera* (Gaertn.) is the currently recognized name for this species, which has been classified under the former names, *Nelumbium speciosum* (Willd.) and *Nymphaea nelumbo*, among others. Names other than *Nelumbo nucifera* (Gaertn.) are obsolete synonyms and should not be used in current works. This plant is an aquatic perennial. Under favorable circumstances its seeds may remain viable for many years, with the oldest recorded lotus germination being from that of seeds 1,300 years old recovered from a dry lakebed in north-eastern China.

A common misconception is referring to the lotus as a waterlily (*Nymphaea*), an entirely different plant as can be seen from the center of the flower, which clearly lacks the structure that goes on to form the distinctive circular seed pod in the *Nelumbo nucifera*.

Earlier studies showed that the extract of *Nelumbo nucifera* Gaertn., an aquatic Indian plant, produced hypoglycaemia and an improvement of glucose tolerance in normal rabbits. Further investigations were undertaken. Chronic administration of plant extracts (test drugs) to normal rats did not produce a sustained fall of fasting blood sugar levels although daily doses caused hypoglycaemia as an acute effect; concurrent glucose tolerance studies showed beneficial effects. *In vitro* studies with rat hemidiaphragms revealed that test drug treatment of donor animals significantly enhanced the effect of insulin. The improvement of glucose tolerance therefore may also be due to increased peripheral glucose utilization caused by increased sensitivity of skeletal muscles to endogenous insulin. Comparative studies were also carried out in moderately diabetic rabbits using test drugs (equivalent to 1000 mg/kg of crude material) and standard drugs phenformin and tolbutamide (100 mg/kg each). The test drugs showed acute and chronic effects in suppressing hyperglycaemia, but were less potent than standard drugs. However, test drugs significantly improved glucose tolerance in these animals. With severely diabetic rabbits, these drugs proved to be ineffective even at four-fold higher doses. Toxicity studies in normal rats did not show any deleterious effect on kidney, heart or liver during an 8-week study period.

### 2.34. *Ocimum sanctum*: Tulsi (Hindi) and Holy basil (English)

The medicinal plants are widely used by the traditional medical practitioners for curing various diseases in the irdaytoday practice. In traditional systems of medicine, different parts (leaves, stem, flower, root, seeds and even whole plant) of *Ocimum sanctum* Linn (known as Tulsi in Hindi), a small herb seen throughout India, have been recommended for the treatment of bronchitis, bronchial asthma, malaria, diarrhea, dysentery, skin diseases, arthritis, painful eye diseases, chronic fever, insect bite etc. The *Ocimum sanctum* L. has also been suggested to possess antifertility, anticancer, antidiabetic, antifungal, antimicrobial, hepatoprotective, cardioprotective, antiemetic, antispasmodic, analgesic, adaptogenic and diaphoretic actions.

*Ocimum sanctum* leaves have previously been reported to reduce blood glucose when administered to rats and humans with diabetes. In the present study, the effects of ethanol extract and five partition fractions of *O. sanctum* leaves were studied on insulin secretion together with an evaluation of their mechanisms of action. The ethanol extract and each of the aqueous, butanol and ethylacetate fractions stimulated insulin secretion from perfused rat pancreas, isolated rat islets and a clonal rat  $\beta$ -cell line in a concentration-dependent manner. The stimulatory effects of ethanol extract and each of these partition fractions were potentiated by glucose, isobutylmethylxanthine, tolbutamide and a depolarizing concentration of KCl. Inhibition of the secretory effect was observed with diazoxide, verapamil and  $Ca^{2+}$  removal. In contrast, the stimulatory effects of the chloroform and hexane partition fractions were associated with decreased cell

viability and were unaltered by diazoxide and verapamil. The ethanol extract and the five fractions increased intracellular  $Ca^{2+}$  in clonal BRIN-BD11 cells, being partly attenuated by the addition of verapamil. These findings indicated that constituents of *O. sanctum* leaf extracts have stimulatory effects on physiological pathways of insulin secretion which may underlie its reported antidiabetic action.

### 2.35. Picrorrhiza kurroa: Kutki (Hindi)

It is a small perennial herb from the Scrophulariaceae family. The rhizome of Picrorrhiza has been traditionally used to treat worms, constipation, low fever, scorpion sting, asthma and ailments affecting the liver. Current research on Picrorrhiza kurroa has focused on its hepatoprotective, anticholestatic, antioxidant, and immune-modulating activity.

An alcoholic extract of Picrorrhiza kurroa was found to lower blood glucose in basal conditions and after a heavy glucose load in normal rats. Maximum reduction in serum glucose was observed after 2 h at a dose level of 75 mg extract/kg of body weight. P. kurroa extract was also found to reduce the increase of blood sugar in alloxan-induced diabetic rats (43% at 75 mg/kg body weight and 60% at 150 mg/kg body weight). Chronic administration of the extract significantly reduced the blood sugar in alloxan-induced diabetic rats for several days (10 days). The extract was also found to reduce the increased blood urea nitrogen and serum lipid peroxides in alloxan-induced diabetic animals and to inhibit the body weight reduction and leukopenia induced by alloxan administration. These results indicate that P. kurroa extracts are able to ameliorate biochemical damages induced by alloxan in diabetic rats.

### 2.36. Phyllanthus niruri: Jangli Amla (Hindi)

The annual herb *Phyllanthus niruri* is best known by the common names Stonebreaker (Eng.), Chanca Piedra (Sp.) and Quebra Pedra (Port.), Seed-Under-Leaf (Eng.) but has many other common names in assorted languages, including dukonganak, dukongdukonganak, aminbuah, ramibuah, turihutan, bhuaionla, Meniran (Indonesia), (Malayalam) and Keela Nelli (Tamil). The herb is known as Nela Nelli in Kannada and "Nela Usiri" in Telugu. It is a widespread tropical plant commonly found in coastal areas. It is a relative of the spurges, belonging to the leafy genus of Family Phyllanthaceae.

The antidiabetic potentials of methanol extract (ME) of aerial parts of *Phyllanthus niruri* L (Euphorbiaceae) was evaluated in normal and alloxan diabetic rats. The results showed that ME significantly ( $P < 0.05$ ) reduced fasting blood sugar in a dose-related manner and suppressed the postprandial rise in blood glucose after a heavy glucose meal in normoglycaemic rats. Chronic oral administration of ME caused a significant ( $P < 0.05$ ) dose-related reduction in blood glucose levels as well as total cholesterol and triglycerides levels in diabetic and normoglycaemic rats. Sub-chronic toxicity study showed that ME-treated rats had significant ( $P < 0.05$ ) reductions in haemoglobin (Hb) levels, red blood cell (RBC) and white blood cell (WBC) counts followed by a gradual rise which did not, however, attain basal levels; however, there was a progressive rise in the WBC of ME-treated diabetic rats. Also ME-treated and control rats had increases in weight

throughout the study. Histological studies showed that ME-treated diabetic rats had the tissue architecture of their pancreas restored as against the control groups where there was evidence of necrosis. The acute toxicity and lethality test of ME in mice gave an oral LD50 of 471.2 mg/kg. Results suggest that extract of aerial parts of *P. niruri* has great potentials as anti-diabetic remedy.

### 2.37. Pterocarpus marsupium: Vijaysar or Bijasal (Hindi) and Indian Malabar (English)

*Pterocarpus marsupium*, or the Indian Kino Tree is a medium to large, deciduous tree that can grow up to 30 metres tall. It is native to India, Nepal, and Sri Lanka, where it occurs in parts of the Western Ghats in the Karnataka-Kerala region. It is also known by the names Malabar Kino, *Benga*, *Bijiayasal* (in western Nepal), *Piasal* (Oriya), *Venkai*, and many others.

Parts of the Indian Kino (heart wood, leaves, flowers) have long been used for their medicinal properties in Ayurveda. The heart wood is used as an astringent and in the treatment of inflammation and diabetes.

Similipal Kol tribes in Orissa, India pound a paste mixture of the bark of *P. marsupium* with the barks of *Mangifera indica*, *Shorea robusta* and *Spondias pinnata* to treat some dysentery illnesses. The plant is known as Honne or Kempu Honne in Kannada people in India make glass from the heartwood of this herb and its aqueous is used to cure diabetes.

The gum resin is the only herbal product ever found to regenerate beta cells that make insulin in the pancreas. Vijaysar is safe and cheap method to take care of Diabetics, weight control and reduce joints pain.

Vijaysar are found very encouraging. Vijaysar was first introduced by Sushruta (1000s of years ago) for this disease. About 50 C. C. Water extract should be given in divided doses for three times a day. It provides a sense of well being and keeps normal health along with prompt symptomatic relief. Science & truth are synonym to each other. Truth can be measured at any parameter. The description of Diabetes and its classification in Ayurvedic texts stand exactly true in the same way as during these days. Since ancient times, Ayurvedacharyas used blocks/pieces of Vijaysar to control diabetes. Pieces of Vijaysar were soaked in water overnight and in the morning, the same was sieved with cloth and given to the diabetes patient. Such a practice carried out regularly had dramatic results in controlling diabetes. Latin Ayurvedacharyas improved upon this method and prepared a glass of Vijaysar wood in which water was stored overnight and given to the patient in the morning. Herbal wood Glass are made of vijaysar (India Kinotree). A natural Ayurvedic treatment to control diabetes. It has a magnificent role in reducing excessive fat from the body. It also controls blood sugar level & purifies blood. Vijaysar anti- Diabetes herbal wood Glass is thus, a time tested and effective means of controlling diabetes. It is also a means of reducing excess fat from the body, controlling blood sugar and purifying blood. How to use:

1. Fill the wooden tumbler with drinking water at night.
2. When you wake up in the morning, empty the, now coloured water in to a  
Clean tumbler and drink it.
3. When Continue this for at least 30 days and when the colour of the water  
Stops changing the colour, scratch the inside of the glass carefully without hurting yourself and use again for 10-15 day
4. After this either break the tumbler into small pieces and use one small piece in one teacup of water till the colour of the water changes

### 2.38. *Punica granatum*: Anar (Hindi) and Pomegranate (English)

*Punica granatum*, is a fruit-bearing deciduous shrub or small tree growing between five and eight meters tall.

Native to the area of modern day Iran, the pomegranate has been cultivated in the Caucasus since ancient times. From there it spread to Asian areas such as the Caucasus as well as the Himalayas in Northern India. Today, it is widely cultivated throughout Turkey, Iran, Syria, Azerbaijan, Armenia, Afghanistan, India, Pakistan, Bangladesh, Iraq, Lebanon, Egypt, China, Burma, Saudi Arabia, Israel, Jordan, the drier parts of southeast Asia, the Mediterranean region of Southern Europe, and tropical Africa. Introduced into Latin America and California by Spanish settlers in 1769, pomegranate is also cultivated in parts of California and Arizona for juice production. Peroxisome proliferator-activated receptor (PPAR)-gamma activators are widely used in the treatment of type 2 diabetes because they improve the sensitivity of insulin receptors. *Punica granatum* flower (PGF) has been used as an anti-diabetic medicine in Unani medicinal literature. The mechanism of actions is, however, unknown. In the current study, we demonstrated that 6-week oral administration of methanol extract from PGF (500 mg/kg, daily) inhibited glucose loading-induced increase of plasma glucose levels in Zucker diabetic fatty rats (ZDF), a genetic animal model for type 2 diabetes, whereas it did not inhibit the increase in Zucker lean rats (ZL). The treatment did not lower the plasma glucose levels in fasted ZDF and ZL rats. Furthermore, RT-PCR results demonstrated that the PGF extract treatment in ZDF rats enhanced cardiac PPAR-gamma mRNA expression and restored the down-regulated cardiac glucose transporter (GLUT)-4 (the insulin-dependent isoform of GLUTs) mRNA. These results suggest that the anti-diabetic activity of PGF extract may result from improved sensitivity of the insulin receptor. From the in vitro studies, we demonstrated that the PGF extract enhanced PPAR-gamma mRNA and protein expression and increased PPAR-gamma-dependent mRNA expression and activity of lipoprotein lipase in human THP-1-differentiated macrophage cells. Phytochemical investigation demonstrated that gallic acid in PGF extract is mostly responsible for this activity. Thus, our findings indicate that PPAR-gamma is a molecular target for PGF extract and its prominent component gallic acid, and provide a better understanding of the potential mechanism of the anti-diabetic action of PGF.

### 2.39. *Salacia reticulata*: Vairi or Pitica (Vernacular)

*Salacia* is a genus of plants in the family Celastraceae. Several spe-

cies in this genus of plant have been used in traditional medical systems for thousands of years, particularly in the Ayurveda system from India. Extracts of *S. reticulata* have been reported to inhibit adipocyte differentiation in *in vitro* models.

The oral hypoglycemic activity of *Salacia reticulata* extract was evaluated in streptozotocin induced diabetic rats. The diabetic rats were orally administered an aqueous extract of *Salacia reticulata* and the plasma glucose concentration was determined at regular intervals following administration. The drug was effective as a hypoglycemic agent at all the doses tested (0.5 g/kg, 1.0 g/kg and 5.0 g/kg). The maximum percentage decrease in plasma glucose was observed between 1–5h following administration of the drug.

### 2.40. *Salacia oblonga*: Ponkoranti (Vernacular)

*Salacia oblonga* has a long tradition of use for thousands of years as an Indian Ayurvedic herb. A few studies have looked at the effects of *salacia oblonga* in humans and the early results are promising in terms of blood sugar control. In Japan it has been sold as a food supplement for several years. *Salacia oblonga* plant grows in limited regions of India and Sri Lanka, and it is not yet well known in the U.S. It is also known as Saptrangi and Ponkoranti.

An herb long used in traditional Indian medicine appears to control the rise in blood sugar that follows a meal — suggesting, researchers say, that it could help treat or even prevent type 2 diabetes. Their study of 39 adults without diabetes found that a beverage made from the herb, known as *Salacia oblonga*, stemmed participants' normal post-meal rise in blood sugar. There was a similar reduction in blood levels of insulin, which helps shuttle sugar from the blood and into cells to be used for energy. The herb, according to the study authors, seems to work similarly to oral diabetes drugs known as alpha-glucosidase inhibitors, which impede the body's absorption of carbohydrates. The study, which was funded by Columbus-based Abbott Laboratories, is published in the Journal of the American Dietetic Association. The next step is to test *Salacia oblonga*'s ability to slow post-meal sugar absorption in people with diabetes, study co-author Dr. Steven R. Hertzler an assistant professor of nutrition at Ohio State University in Columbus. For their study, the researchers had 39 healthy adults drink four different liquid meals on four separate days. Three of the beverages had varying doses of *Salacia oblonga*, along with generous portions of protein, carbohydrates, fat and fiber; the fourth beverage did not contain the herb. The researchers found that the drink with the largest *Salacia oblonga* dose — 1,000 milligrams — cut the participants' post-meal blood sugar rise by about one-quarter compared with sugar levels after the herb-free drink. An even larger decline was seen in insulin levels. Good blood sugar control is vital in diabetes because it reduces the risk of long-term complications such as kidney dysfunction, heart disease, vision loss and nerve damage. The hope is that *Salacia oblonga* can help diabetics maintain healthy blood sugar levels over time, and thereby help prevent complications. Journal of the American Dietetic Association, January 2005.

### 2.41. *Swertia chirayita*: Chirata (Hindi)

*Swertia* is a genus in the gentian family containing plants sometimes

referred to as the felworts. Some species bear very showy purple and blue flowers.

Plants of genus *Frasera* are sometimes considered part of this genus, sometimes as a separate genus, and sometimes as synonymous. The *Swertia chirayita* plant extract produced significant blood sugar lowering potential in fasted, fed and glucose loaded models and a very significant blood sugar lowering effect in diabetic model. Bitter principles of plant are hepatobiliary stimulant. In present series of experiments it is clear that 95% ethanolic extract of plant have a potential blood sugar lowering effect in male albino rats of different backgrounds of blood sugar level.

#### **2.42. *Syzygium cumini* (Eugenia jambolana): Jamun(Hindi) and Black Berry (English)**

Jambul (*Syzygium cumini*) is an evergreen tropical tree in the flowering plant family Myrtaceae. Jambul is native to Bangladesh, India, Nepal, Pakistan, Sri Lanka, and Indonesia. The name of the fruit is sometimes mistranslated as blackberry, which is a different fruit in an unrelated family.

Jambul is also known as Jambhul/jambu/jambula/jamboola, Java plum, jamun, jaam/kalojaam, jamblang, jambolan, black plum, Damson plum, Duhat plum, Jambolan plum, or Portuguese plum. Malabar plum may also refer to other species of *Syzygium*. This fruit is called Neredu Pandu in Telugu and Naaval Pazham or Navva Pazham in Tamil.

*Syzygium cumini* (Myrtaceae) is widely used traditional system of medicine to treat diabetes in India. The present study was carried out to isolate and identify the putative antidiabetic compound from the *S. cumini* [SC] seed. A compound, mycaminose was isolated from SC seed extract. The isolated compound mycaminose (50 mg/kg) and ethyl acetate [EA] and methanol [ME] extracted compounds of *S. cumini* seed (200 and 400 mg/kg) was undertaken to evaluate the antidiabetic activity against streptozotocin (STZ)-induced diabetic rates. The compound 'Mycaminose' and ethyl acetate and methanol extracted produced significant ( $p < 0.05$ ) reduction in blood glucose level. The standard drug, glibenclamide (1.25 mg/kg) also produced significant ( $p < 0.05$ ) reduction in blood glucose level against STZ-induced diabetic rats. The results of this experimental study indicate that isolated compound 'Mycaminose', ethyl acetate and methanol extracts possess anti-diabetic effects against STZ-induced diabetic rats.

#### **2.43. *Trigonella foenum graecum*: Methi or Mutti (Hindi) and Fenugreek (English)**

Fenugreek (*Trigonella foenum-graecum*) is a plant in the family Fabaceae. Fenugreek is used both as a herb (the leaves) and as a spice (the seed, often called *methi* in Urdu/Hindi/Nepali). The leaves and sprouts are also eaten as vegetables. The plant is cultivated worldwide as a semi-arid crop and is a common ingredient in many curries.

Several human intervention trials demonstrated that the antidiabetic effects of fenugreek seeds ameliorate most metabolic symptoms associated with type-1 and type-2 diabetes in both humans and relevant animal models by reducing serum glucose and improving glu-

ucose tolerance. Fenugreek is currently available commercially in encapsulated forms and is being prescribed as dietary supplements for the control of hypercholesterolemia and diabetes by practitioners of complementary and alternative medicine. Fenugreek contains high dietary fiber, so a few seeds taken with warm water before going to sleep helps avoiding constipation.

Adjunct use of fenugreek seeds improves glycemic control and decreases insulin resistance in mild type-2 diabetic patients. There is also a favourable effect on hypertriglyceridemia.

#### **2.44. *Tinospora cordifolia*: Amarta or Guduci (Hindi)**

*Tinospora cordifolia*, which is known by the common name Guduchi, is an herbaceous vine of the family Menispermaceae indigenous to the tropical areas of India, Myanmar and Sri Lanka.

The plant is a glabrous climbing shrub found throughout India, typically growing in deciduous and dry forests. The leaves are heart shaped. The succulent bark is creamy white to grey in color, with deep clefts spotted with lenticels. It puts out long, slender aerial roots, and is often grown on mango or neem trees. Flowers are yellow, growing in lax racemes from nodes on old wood. Fruits are drupes, turning red when ripe.

The oral administration of various extracts (hexane, ethyl acetate and methanol) of *Tinospora cordifolia* stem (TCS) were found to have potent antidiabetic activity that reduces blood sugar level in streptozotocin-(STZ) induced diabetic rats. In this study, the chronic (100 days) antihyperglycemic effect of the extracts at a dose of 250 mg/kg b.w.p.d of TCS were investigated. Insulin was used as a reference drug at a dose of 3 I.U/kg.b.w.p.d. Fasting blood glucose, glycosylated hemoglobin (HBA1C), serum insulin, C-peptide and liver enzymes levels were evaluated in normal, diabetic and treated rats. Supplementation of methanol extract significantly reduces the fasting blood glucose level when compared to other 2 extracts. Moreover this supplementation significantly decreases the glycosylated hemoglobin level as compare to diabetic control ( $p < 0.001$ ), reduced glucokinase and increased glucose-6-phosphatase activity were reversed significantly by the treatment of TCS methanol extract in respect to diabetic group. In the TCS treated groups, the insulin and C-peptide levels were improved which shows the regeneration of  $\beta$ -cell which secretes insulin, histopathological studies of pancreas of TCS methanol extract treated groups substantiate the regenerating capacity of extract.

#### **2.45. *Vinca rosea* (Catharanthus roseus): Sadabahar (Hindi) and Madagascar periwinkle (English)**

*Catharanthus roseus* (Madagascar Periwinkle) is a species of *Catharanthus* native and endemic to Madagascar. Synonyms include *Vinca rosea* (the basionym), *Ammocallis rosea*, and *Lochnera rosea*; other English names occasionally used include Cape Periwinkle, Rose Periwinkle, Rosy Periwinkle, and "Old-maid".

In the wild, it is an endangered plant; the main cause of decline is habitat destruction by slash and burn agriculture. It is also however

widely cultivated and is naturalised in subtropical and tropical areas of the world. It is an evergreen subshrub or herbaceous plant growing to 1 m tall. The leaves are oval to oblong, 2.5–9 cm long and 1–3.5 cm broad, glossy green, hairless, with a pale midrib and a short petiole 1–1.8 cm long; they are arranged in opposite pairs. The flowers are white to dark pink with a darker red centre, with a basal tube 2.5–3 cm long and a corolla 2–5 cm diameter with five petal-like lobes. The fruit is a pair of follicles 2–4 cm long and 3 mm broad.

The species has long been cultivated for herbal medicine and as an ornamental plant. In traditional Chinese medicine, extracts from it have been used to treat numerous diseases, including diabetes, malaria, and Hodgkin's disease. The substances vinblastine and vincristine extracted from the plant are used in the treatment of leukemia. The present study was carried out to evaluate the antidiabetic activity of *Vinca rosea* methanolic whole plant extracts in alloxan induced diabetic rats for 14 days. The methanolic whole plant extract at high dose (500 mg/kg) exhibited significant anti-hyperglycemic activity than whole plant extract at low dose (300 mg/kg) in diabetic rats. The methanolic extracts also showed improvement in parameters like body weight and lipid profile as well as regeneration of  $\beta$ -cells of pancreas in diabetic rats. Histopathological studies reinforce the healing of pancreas, by methanolic *Vinca rosea* extracts, as a possible mechanism of their antidiabetic activity.

## CONCLUSION

The area of medicinal plant research is fast developing. Both pre clinical and clinical testing are integral components of medicinal plant research. Preclinical testing of plants for medicinal properties is of vital importance, not only to provide a scientific basis for their usage but also validate their historical utilization by traditional healers and herbalists, and thus provides the society with sources of new, effective and safe drugs. With the opening of newer vistas in the field of medicine including the modern molecular biology tools, high output automated bioassays and newer technologies for rapid structure determination in the area of medicinal plant research, the field of pre-clinical testing seems to have a bright future. Despite the limitations, the various advantages the pre clinical testing offers, justify it as an essential prerequisite of a drug discovery process. It is possible that with the advancement of technology, current tests could prove successful where negative results may have been obtained 20 years ago (Prance, 1994). Thus preclinical testing can serve as an important link between a plant selection and its subsequent mass usage following proper clinical testing.

Diabetes and its attendant comorbidities pose a significant and ever-growing health problem for populations in the United States and internationally, with the potential of assuming a massive health-care crisis in the foreseeable future. Type 2 diabetes, obesity, the metabolic syndrome, and cardiovascular problems are closely related. It behooves us as clinicians to be well-informed and optimally equipped with the resources available to deal with the ramifications of this epidemic. This will require a two-pronged strategy: a concerted effort at lifestyle change at the community level to promote healthy behav-

iors and thus prevent or delay disease onset, and an aggressive, multifaceted treatment approach in the individual patient to minimize complications and disability. Research needs to be continued at the genetic and molecular level to better understand diabetes and discover new pharmacologic therapies. It is important to keep in mind, however, that the rural population and young people represent the new face of diabetes. The challenge before us is how best to allocate resources, provide grassroots education, and improve access to quality diabetes care for future generations. This commitment will require a sustained, collaborative endeavor on the part of governmental agencies, private organizations, and individual members of society to give priority to counteracting an emergent health care dilemma.

All the drugs discussed in this review have exhibited significant clinical & pharmacological activity. The potency of herbal drugs is significant & they have negligible side effects than the synthetic antidiabetic drugs. There is increasing demand by patients to use the natural products with antidiabetic activity. In recent times there has been renewed interest in the plant remedies. Plants hold definite promises in the management of Diabetes mellitus. Isolation & identification of active constituents from these plants, preparation of standardized dose & dosage regimen can play a significant role in improving the hypoglycaemic action.

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