

**DIABETES MELLITUS AND ITS TRADITIONAL CURE IN INDIA****Rama Shankar and K.S. Dhiman\***

Regional Ayurveda Research Institute, Gwalior Road, Jhansi-284003.

\*Director General, Central Council for Research in Ayurvedic Sciences, Ministry of  
AYUSH, Government of India, New Delhi-110058.Article Received on  
13 Sept. 2016,Revised on 03 Oct. 2016,  
Accepted on 23 Oct. 2016

DOI: 10.20959/wjpr201611-7356

**\*Corresponding Author****K.S. Dhiman**Director General, Central  
Council for Research in  
Ayurvedic Sciences,  
Ministry of AYUSH,  
Government of India, New  
Delhi-110058.**ABSTRACT**

Diabetes a common physiological disorder widely affecting human health being in all over the world. It is caused due to less secretion of Insulin to absorb blood glucose or excessive deposition of glucose in blood cells. This is caused due to excessive strain, tension or life style. It is manageable by certain short of meditation, physical exercise or supplemented with medication. Herbal medicines or fresh drugs are managing the diabetes without any side effect on renal and heart like organs. In India number of medicinal plants is used in the management of diabetes without any side effect. Some of the important medicinal plants are *Aegle marmelos*, *Allium cepa*, *A. satuvum*, *Aloe barbadensis*, *Andrographis paniculata*, *Annona squamosa*, *Boerhaavia diffusa*, *Caesalpinia bonduc*, *Cathranthus roseus*, *Eugenia jambolana*, *Gentiana kurrooa*, *Momordica charantia*, *Swertia chirayita*, *Thallictrum foliolosum*, *Tinospora cordifolia*, *Vachelia nilotica*, *Withania somnifera* etc. Pharmacological investigation on rats and other similar animals have been worked out and the most of the plants expressed the hypoglycemic action. There is need of taking medicine and fixing doses in various modes of treatments on human being.

**KEYWORDS:** *Aegle marmelos*, *Allium cepa*, *A. satuvum*, *Aloe barbadensis*, *Andrographis paniculata*, *Annona squamosal*.**INTRODUCTION**

Diabetes is a common worldwide health disorder which cause increase in blood sugar level due to less secretion of insulin in pancreas to absorb the sugar taken as food. Generally it is caused due to less physical or unexpected life style like less sleep less exercise and changed

work style as well as food habit causing hyperglycemia. Once the disorder imbeds in the body it becomes incurable but it is manageable by change in life style, food habit with meditation as well as medication. For such types of management taking up taking up synthetic allopathic medicines for longer period is causing several side effects related with kidney and liver disorders. Accordingly, large number of work has been carried out and being continued in finding out herbal formulations either by the use of single drug plant of adding group of 2-5 ingredients. From Indian flora large number of tests has been performed on investigation anti diabetic and antioxidant activities of different plants whereas several have been proved to be anti diabetic due to presence of antidiabetic compounds in the drug plants. Most of the work on antidiabetic activities of medicinal plants on rats and other animal have been worked out and found effective in control of diabetes or hyper glycaemic symptoms.<sup>[1-106]</sup>

### Literature

Large number of work done on diabetes mellitus has been carried out in the form of simple reportings on medicinal plants in the management of diabetes, pharmacological studies, antioxidant and hypo and antihyperglycemic action of various plants in India and abroad (see Ahmad *et al.*, 1989; Acherekar *et al.*, 1991; Aderibigbe *et al.*, 1999; Adallu and Radhika, 2000; Ajabnoor, 1989; Alam and Gomes, 1998; Al-Awadi and Gumaa, 1987; Arai *et al.*, 1999; Augusti and Shella, 1994, 1996; Bever B.O., Zahnd, 1979; Bhattacharya, *et al.*, 1999; Biswas *et al.*, 2002; Chakravarty *et al.*, 1980; Chakrabarti *et al.*, 2003, 2005;. Chattopadhyay, 1999; Chattopadhyay *et al.*, 1987a,b; 1991; Chempakam, 1993; Davis and Maro, 1989; Dhaliwal, 1999; Devasagayam, *et al.*, 1995, 1996; Dhanabal *et al.*, 2005; Dixit *et al.*, 2005; Gomes *et al.*, 1995; Grover *et al.*, 2002; Gupta *et al.*, 1967, 1999, 2005a,b; Haranath *et al.*, 1958; Jafri *et al.*, 2000; Jahromi *et al.*, 1993; Joglekar, 1959; Kaleem *et al.*, 2006; Kamble *et al.*, 1998;. Karunanayake *et al.*, 1984; Khanna *et al.*, 1981; Khan *et al.*, 1995; Khosla *et al.*, 1995; Knott *et al.*, 1992; Kumari *et al.*, 1995; Kumar KCS, Muller, 1999; Kusano and Abe, 2000; Latha *et al.*, 2004; Mathew and Kuttan, 1997; Mathew and Augusti, 1975; Matteucci and Giampietro, 2000;. Maroo *et al.*, 2003; Noor and Ashcroft, 1998; Pari and Amarnath Satheesh, 2004a,b; Pari and Latha, 2006; Pari and Maheswari, 1999; Pari and, Umamaheswari, 2000; Pari and Venkateswaran, 2004; Preuss *et al.*, 1998; Price and Menon, 1999; Rai *et al.*, 1997; Ramachandran *et al.*, 2002; Ramya and Lakshmidhevi, 2015; Rao and Rao, 2001; Rao *et al.*, 1999; Raphael, 2002; Ravikumar and Anuradha, 1999; Roman-Ramos, *et al.*, 1995; Sabu and Kutta, 2002; Sachadeva and Khemani, 1999; Saleem *et al.*, 1999;. Satheesh and Pari, 2004; Sauvaire *et al.*, 1998; Saxena *et al.*, 1993; Scartezini and

Sproni, 2000;. Semwal et al., 2007; Seth and Sharma, 2002; Sharma et al., 1997; Shrivastava et al., 2012; Sheela and Augusti, 1992; Shibib et al., 1993; Somani et al., 2006; Stanely et al., 2001, 2003; Subramonium, 1996; Sutar et al., 2009; Tormo et al., 2004; Vats et al., 2002, 2004; Vijayvargia et al., 2000; Wadood et al., 1989; Yadav et al., 1997; Yoshikawa et al., 1996; 1998; Zacharias, 1980.).

Authors, during the course of studies on exploration of medicinal wealth as well as traditional healing practices in different parts of the Country specially in North East India and Uttar Pradesh found several traditional practitioners are using herbs for the management of diabetes either by recommending as food supplement or as medicine. Some of the common and specific are as follows:

***Aegle marmelos* Corr.: (Bilva)**

Tree belonging to family Rutaceae is wild in, districts Shrawasti, Bahraich, Balrampur, Gonda and adjoining part of Northern Uttar Pradesh and cultivated in most part of the Country as horticultural and medicinal plant. The leaves in combination with Basil leaf, and Neem leaves and black pepper is used in the management of diabetes.

***Allium cepa* L. (Onion, Palandu, Piyaj)**

Belonging to family Liliaceae, *Allium cepa* is cultivated in different part of India and the bulb juice is considered to be helpful in reducing blood sugar level (Kumari et al., 1995; Mathew and Augusti, 1975).

***Allium sativum* L. (Garlic, Lassun)**

This is a perennial herb cultivated throughout India. Allicin, a sulfur-containing compound is responsible for its pungent odour and it has been shown to have significant hypoglycemic activity.<sup>[16]</sup> This is effective probably due to increased hepatic metabolism, increased insulin release from pancreatic beta cells and/or insulin sparing effect (Zacharias, 1980). Aqueous homogenate of garlic (10 ml/kg/day) administered orally to sucrose fed rabbits (10 g/kg/day in water for two months) significantly increased hepatic glycogen and free amino acid content, decreased fasting blood glucose, and triglyceride levels in serum in comparison to sucrose controls.<sup>[19]</sup>

S-allyl cystein sulfoxide (SACS), the precursor of allicin and garlic oil, is a sulfur containing amino acid, which controlled lipid peroxidation better than glibenclamide and insulin. It also

improved diabetic conditions. SACS also stimulated *in vitro* insulin secretion from beta cells isolated from normal rats (Al-Awadi and Guma, 1987). Apart from this, *Allium sativum* exhibits antimicrobial, anticancer and cardio protective activities.

#### ***Aloe barbadensis* Mill. (Ghritakumari)**

*Aloe barbadensis* syn. *A. vera* a common domesticated medicinal plant whose pulp is use as medicine as well as skin caring for the removal of uneven spots developing on skin and making skin soft also a traditional medicine for the cure of jaundice skin diseases. Most of the cosmetics are prepared as *Aloe vera* based cream gel etc. The gel mucilaginous part of the leaf beneath the cuticle and epidermis is used orally as well as external applicant. Extracts of Aloe gel is found effective in managing diabetes. Action has been proved on rats (Davis and Maro, 1989). Similar is found in *Aloe barbadensis* also. Treatment of chronic but not single dose of exudates of *Aloe barbadensis* leaves showed hypoglycemic effect in induced diabetic rats. It also increase anti inflammatory effect as well as wound healing in diabetic mice.

#### ***Andrographis paniculata* Nees (Kalmegh)**

Belonging to family Acanthaceae it is distributed in tropical region of the Country. It is used in fever, jaundice, malaria and diabetes (Ramya and Lakshmidhevi, 2015).

#### ***Annona squamosa* L. (Sharifa)**

A cultivated small tree belonging to family Annonaceae is cultivated in India for nutritious fruits. Its pulp is used as atidiabetic and heavy nutritious horticultural plant. Fruit is useful in diabetes. Hypoglycemic and nutritious value of fruit pulp has been studied by Gupta et al., (2005a,b).

#### ***Areca catechu* L. (Areca nut, Shupari)**

Belonging to family Palmaceae is cultivated in most part of Assam and foot hills of other Northeastern states of India. Its nut is supposed to be useful in diabetes. Hypoglycemic studies were conducted by Chempakam (1993).

#### ***Azadirachta indica*: (Neem)**

Neem commonly cultivated tree in India for timber and medicinal purposes whose leaves are used as mosquito repellent as well as in fever, skin diseases and malarial fever even for the removal of lice and other insects from grain storage. The leaf is highly effective in increasing

the hypoglycemic antidiabetic activity either as single drug or combination of other ingredients like Tulasi, black pepper, bael etc.

Hydroalcoholic extracts of this plant showed anti-hyperglycemic activity in streptozotocin treated rats and this effect is because of increase in glucose uptake and glycogen deposition in isolated rat hemidiaphragm (Chattopadhyay *et al.*, 1987a,b; Biswas *et al.*, 2002). Apart from having anti-diabetic activity, this plant also has anti-bacterial, antimalarial, antifertility, hepatoprotective and antioxidant effects.

#### ***Berginia ciliata* (Pashan bheda)**

Commonly distributed in hills above 1600 masl in Western and Eastern Himalay, Sikkim, West Kameng and Lower Subansiri district of Arunachal Pradesh, Khasi hills of Meghalaya etc.

The traditional practional in Sherdukpens tribes of Arunachal Pradesh use leaves of this plants in the management of diabetes.

#### ***Boerhaavia diffusa* L. (Punarnava)**

Distributed in tropical part of India the plains of Assam, Uttar Pradesh, West Bengal, Madhya Pradesh, Kshattisgarh etc. is a highly demanded medicinal plant in the management of liver and kidney disorders and used in various ayurvedic formulations. The leaves and root are considered to be useful in the management of diabetes (Pari and Amarnath Satheesh, 2004a, b; Satheesh and Pari, 2004).

#### ***Bombax ceiba* L. (Shalmili, Semal)**

Tree, distributed in tropical part of India from assam, Arunachal Pradesh to Karnataka. The bark extract is used in diabetes. Hypoglycemic and toxic study of *Bombax ceiba* is known (Saleem *et al.*, 1999).

#### ***Caesalpinia bonduc* (L.) Roxb. (Latakaranj, Kuberaksh)**

*Caesalpinia bonduc* is widely distributed throughout the Country in tropical part from Assam to costal region passing through plains of West Bengal, Bihar, Uttar Pradesh and Madhya Pradesh and traditionally used for the control of blood sugar by the Indian tribes.

Both the aqueous and ethanolic extracts showed potent hypoglycemic activity in chronic type II diabetes along with increases liver glycogen content (Chakrabarti *et al.*, 2003). It also

increases secretion of insulin. Anti hyperglycemic and hypolipidemic activities action of *Caesalpinia bonduc* seeds in water and 50% Alcohol has been studied in streptozotocin - diabetic rats (Chakrabarti *et al.*, 2003; Sharma *et al.*, 1997).

#### ***Capparis deciduas* End. (Karir)**

This is found throughout India, in dry areas of Uttar Pradesh Rajasthan, Madhya Central and South India etc. Its fruits are used by traditional practioners as common domesticated herb.

Hypoglycemic effect was observed in alloxanized rats by feeding with with 30% extracts of *Capparis decidua* (*C. decidua*) fruit powder for a period of 3 weeks. This is also effective in reduced alloxan induced lipid peroxidation significantly in erythrocytes, kidney and heart. *C. decidua* was also found to alter superoxide dismutase and catalase enzyme levels to reduce oxidative stress (Khanna *et al.*, 1981). Its fruits also expressed hypolipidaemic activity by (Shibib *et al.*, 1993).

#### ***Cathranthus roseus* (Sadanpushpi)**

Cultivated as ornamental plant with the concept that flowers are anticancerous. Its leaf is used in the management of diabetes. Hypoglycemic and anti hyperglycemic effect was worked out.

#### ***Cinnamomum tamala* Nees (Tejpatra, Tamalapatra)**

Cultivated in tropical to temperate region of India from Western Himalaya to Assam and Arunachal Pradesh and in several part of Uttar Pradesh for the purpose of spices. Its leaves are useful in the management of diabetes.

Antidiabetic activity of leaf powder of *C. tamala* has been studied\*\*.

***Coccinia indica* W. & A. (Bimbi):** A climbing herb with white flowers, distributed in tropical India.

Dried extracts of *Coccinia indica* (*C. indica*) (500 mg/kg body weight) were administered to diabetic patients for 6 weeks. These extracts restored the activities of enzyme lipoprotein lipase (LPL) that was reduced and glucose-6-phosphatase and lactate dehydrogenase, which were raised in untreated diabetics by Kamble *et al.*, (1998). Oral administration of 500 mg/kg of *C. indica* leaves showed significant hypoglycemia in alloxanized diabetic dogs and increased glucose tolerance in normal and diabetic dogs (Shibib *et al.*, 1993).

***Coptis teeta* Wall. (Mishmi teeta)**

Belonging to family Ranunculaceae, Endemic to Mishmi hills of Dibang Valley district of Arunachal Pradesh is used in malarial fever, jaundice, hypertension and diabetes.

***Enicostemma litorale* Blume (Nagajivha, Chhota Chirayata)**

Belonging to family Gentianaceae a herb with white tubular flower is distributed plains of India and is useful in various disorders like fever, jaundice, malaria as well as diabetes.

***Eugenia jambolana* Lam. (Indian gooseberry, Jamun)**

Tree cultivated throughout India and in India decoction of kernels of *Eugenia jambolana* is used as home remedy for diabetes. This also forms a major constituent of many herbal formulations for diabetes. AYUSH 82 is one of them and combination of Karela fruit and Jamun seeds were tested on over 50 diabetic patients and given promising results in diabetes management. Combination of Jamun seeds and Karela fruit is also a combination of medicine being effective in diabetes management.

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 Acherekar *et al.*, (1991).

***Gentiana kurrooa* Royle (Karu, Renke)**

Belonging to family Gentianaceae distributed in Alpinr hills above 2500 masl, is used as multifarious tonic is widely used in tribal communities of Arunachal Pradesh for control of hypertension and diabetes.

***Gymnema sylvestre* R. Br. (Gudamar)**

Distributed in Central India and cultivated in tropical region of the Country. Leaf powder is used in managing diabetes. Used as one of the ingredient of AYUSH-82. However, no active principle was reported as responsible for hypoglycemic action.

***Mangifera indica* L. (Amra, Mango)**

Tree cultivated in India as horticultural plant for fruits which is digestive and rich source of sugar based Vitamin-C.

The leaves of this plant are used as an antidiabetic agent in Nigerian folk medicine, although when aqueous extract given orally did not alter blood glucose level in either normoglycemic or streptozotocin induced diabetic rats. However, antidiabetic activity was seen when the extract and glucose were administered simultaneously and also when the extract was given to the rats 60 min before the glucose. The results indicate that aqueous extract of *Mangifera indica* possess hypoglycemic activity. This may be due to an intestinal reduction of the absorption of glucose (Aderibigbe *et al.*, 1999; Khanna *et al.*, 1981).

#### ***Mimosa pudica* L. (Lajjalu)**

Prostrate herb belonging to family, Mimosaceae, having sensation to touch is a medicinal plant used in jaundice, uterine disorders and jaundice. The antidiabetic action of leaf extract is studied on rat by Sutar *et al.* (2009).

#### ***Momordica charantia*: (Karela, Bitter gourd)**

*Momordica charantia* is commonly used as an antidiabetic and antihyperglycemic agent in India as well as other Asian countries. Extracts of fruit pulp, seed, leaves and whole plant was shown to have hypoglycemic effect in various animals. Significant hypoglycemic action was observed by subcutaneous administration of fruits of *M. charantia* on langurs and humans by Shibib *et al.*, (1993).

#### ***Ocimum tenuiflorum*: (Tulasi, Holy basil)**

Belonging to family Lamiaceae cultivated as holy basil plant *Ocimumtenuiflorum* syn. *O. sanctum.*, (Tulsi) is known for its medicinal properties since ancient times. It is used as antiasthmatic, antistress, antibacterial, antifungal, antiviral, antitumor, gastric antiulcer activity, antioxidant, antimutagenic and immunostimulant activities. In combination of other drugs like Neem, Bael leaf and Black pepper fruits the plant is used as curative medicine of diabetes.

The aqueous extract of leaves of *O. sanctum* showed the significant reduction in blood sugar level in both normal and alloxan induced diabetic rats by (Vats *et al.*, 2002). Significant reduction in fasting blood glucose, uronic acid, total amino acid, total cholesterol, triglyceride and total lipid indicated the hypoglycemic and hypolipidemic effects of tulsi in diabetic rats by Rai *et al.*, (1997). Oral administration of plant extract was also observed by Vats *et al.*, (2004).

***Phyllanthus amarus* (Bhumyamlaki, Bhuiawala)**

Belonging to family Euphorbiaceae, herb with up to 60 cm height, commonly known as Bhuiamala is scattered throughout India beginning from North Eastern states up to Deccan and south Indian. Traditionally it is used for the cure of jaundice and Hepatitis- B is also used for the management of diabetes. The plant also shows anti-inflammatory, antimutagenic, anticarcinogenic, antidiarrhoeal activity.

Methanolic extract of *P. amarus* was found to have potent antioxidant activity. This extract also reduced the blood sugar in alloxanized diabetic rats by Raphael (2002).

***Piper nigrum* L. (Black pepper, Maricha)**

Climbing herb, belonging to family Piperaceae with fruits in spike are used for the cure of various diseases like fever, stimulant, cough, Alkaloids chavicine, piperine, piperidine and essential oil is responsible for all type of cures. Fruits are also used in diabetes in combination with other drugs like Neem, Tulasi and Bael leaves.

***Pterocarpus marsupium* Roxb. (Vijay sar)**

It is a deciduous moderate to large tree found in India mainly in hilly region. Pterostilbene, a constituent derived from wood of this plant caused hypoglycemia in dogs by Vats et al., (2002, Rai et al., 1997) showed the hypoglycemic activity of the extract because of presence of tannates. Flavonoid fraction from *Pterocarpus marsupium* has been shown to cause pancreatic beta cell regranulation by Gupta et al.(1999). Marsupin, pterosupin and liquiritigenin obtained from this plant showed antihyperlipidemic activity. (-) Epicatechin, its active principle, has been found to be insulinogenic, enhancing insulin release and conversion of proinsulin to insulin *in vitro*. Like insulin, (-) epicatechin stimulates oxygen uptake in fat cells and tissue slices of various organs, increases glycogen content of rat diaphragm in a dose-dependent manner Vats et al., (2004).

***Scoparia dulcis* L. (Mithi Patti)**

Distributed all over India, is a herb with white small flowers with sweet leaves. Its leaf is used in cure of diabetes besides being digestive. Ammelin is found as an antidiabetic compound. Anti diabetic effect of *S. dulcis* was observed, Noor and Ashcroft, 1998; Chattopadhyay et al., 1991.

***Swertia chirayita* (Chirayata)**

Found in Alpine hills of Western and Eastern Himalay is used as medicinal plant for the cure of jaundice, hepatitis- B, malaria, fever etc. It is also said to be used in the management of diabetes. Hypoglycemic action of Swerchirin-containing hexane fraction (SWI) of *Swertia chirayita* plant extract was observed.<sup>[101]</sup>

***Syzygium cumuni* (L.) Skeels (Jamun)**

Tree with violet fruits are cultivated all throughout India up to 500 msl. Seeds, kernel and fruit pulp is commonly used in management of diabetes.

Antihyperglycemic effect of aqueous and alcoholic extract as well as lyophilized powder shows reduction in blood glucose level by Acherekar et al. (1991).

***Trigonella foenum graecum* L. (Menthi, Fenugreek)**

It is cultivated all over India and the fenugreek seeds are usually used as one of the major constituents of Indian spices. 4-hydroxyleucine, a novel amino acid from fenugreek seeds increased glucose stimulated insulin release by isolated islet cells in both rats and humans by Vats et al. (2002). Oral administration of 2 and 8 g/kg of plant extract produced dose dependent decrease in the blood glucose levels in both normal as well as diabetic rats Administration of fenugreek seeds also improved glucose metabolism and normalized creatinine kinase activity in heart, skeletal muscle and liver of diabetic rats. It also reduced hepatic and renal glucose-6-phosphatase and fructose –1,6-biphosphatase activity. This plant also shows antioxidant activity.

***Thalictrum foliolosum* DC. (Pitamoolika)**

Belonging to family Ranunculaceae and distributed in temperate and Alpine Region of Himalaya from Arunachal Pradesh, Nagaland and Ranikhet, Masoorie areas is a plant having yellowish root is used for the cure of malaria, fever and occasionally in diabetes in Garhawal hills of Uttarakhand. Chemical constituent has been isolated and reported.

***Tinospora cordifolia* (Willd.) Miers (Amrita, Giloy, Guduchi)**

Large, smooth, deciduous climber belonging to the family Menispermaceae. It is widely distributed throughout India and used also in every part of India in most of the disorders. Oral administration of the extract of *Tinospora cordifolia* roots for 6 weeks resulted in a significant reduction in blood and urine glucose and in lipids in serum and tissues in alloxan

diabetic rats. The extract also prevented a decrease in body weight (Stanely et al., 2001, 2003). *T.cordifolia* is widely used in Indian ayurvedic medicine for treating diabetes mellitus (Price and Menon, 1999; Mathew and Kuttan, 1997). Oral administration of an aqueous *T. cordifolia* root extract to alloxan diabetic rats caused a significant reduction in blood glucose and brain lipids. Though the aqueous extract at a dose of 400 mg/kg could elicit significant anti-hyperglycemic effect in different animal models, its effect was equivalent to only one unit/kg of insulin (Gupta et al., 1967). It is reported that the daily administration of either alcoholic or aqueous extract of *T. cordifolia* decreases the blood glucose level and increases glucose tolerance in rodents by Noor and Ashcroft (1998).

#### ***Vachelia nilotica* (L.) P.J.H.Hurter & Mabb. (Babool)**

Belonging to family Mimosaceae a widely distributes in dry regions Uttar Pradesh, Madhya Pradesh and other parts of the Country including deserts of Rajasthan, is traditionally used in the management of diabetes besides other uses traditionally it is used in managing diabetes. Anti diabetic studies were made on rats by Wadood et al. (1989).

#### ***Withania somnifera* Dunal (Ashwagandha, Asagandh)**

Distributed in Central and dry regions of India with its minor cultivation in Assam and foothill Institutes of Arunachal Pradesh. Rat and leaf of *W. somnifera* is used in the management of diabetes.

### **DISCUSSION**

Diabetes mellitus is a lifelong disease caused due to non absorption of glucose by the body cells that deposited in the blood. Normally, insulin is required for break down and takes up of glucose but due to certain factors body stops secretion of insulin or non absorption of insulin to break down the glucose. Hormonal secretion of insulin needs to enhance and it is managed by:

1. Intake of insulin as supplement through injection.
2. Change of life style by adding exercise, walking and Yoga and Pranayams.
3. Change in food habit with the preference of taking those vegetable and herbs that regulates or enhances hypoglycemia.

There are many plants used in the management of diabetes either by stimulating insulin secretion or checking the absorption of glucose by the body cells. Even in traditional folk system also many plants are being used by the traditional practitioners with availability in

Nature or cultural cultivation. Large number of publications has come up on various hypoglycemic actions of different plants which have been identified as useful plants in diabetes as described in literature part of the paper.

### ACKNOWLEDGEMENT

Authors are thankful to the Ministry of AYUSH Government of India for encouragements and financial assistance.

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