



J Pharm Bioallied Sci. 2011 Oct-Dec; 3(4): 504–512.

PMCID: PMC3249697

doi: 10.4103/0975-7406.90103; 10.4103/0975-7406.90103

PMID: [22219583](https://pubmed.ncbi.nlm.nih.gov/22219583/)

Alternative therapies useful in the management of diabetes: A systematic review

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Received 2011 Feb 18; Revised 2011 Apr 26; Accepted 2011 Sep 14.

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Abstract

Diabetes mellitus is a metabolic disorder in the endocrine system. This dreadful disease is found in all parts of the world and becoming a serious threat of mankind health. There are lots of chemical agents available to control and to treat diabetic patients, but total recovery from diabetes has not been reported up to this date. In addition to adverse effects, drug treatments are not always satisfactory in maintaining euglycemia and avoiding late stage diabetic complications. Alternative to these synthetic agents, plants provided a potential source of hypoglycemic drugs and are widely used in several traditional systems of medicine to prevent diabetes. Several medicinal plants have been investigated for their beneficial effect in different type of diabetes. Other alternative therapies such as dietary supplements, acupuncture, hydrotherapy, and yoga therapies less likely to have the side effects of conventional approaches for diabetes.

KEY WORDS: Alternative therapy, diabetes, hydrotherapy, hypoglycemic, yoga

Diabetes mellitus is a metabolic disorder characterized by hyperglycemia, abnormal lipid, and protein metabolism along with specific long-term complication affecting the retina, kidney, and nervous system. [1] Diabetes mellitus has a significant impact on the health, quality of life and life expectancy of patients as well as on the health care system.

Diabetes mellitus has been recognized as a growing worldwide epidemic by many health's advocacy group including WHO.[2] The WHO has estimated that diabetes will be one of the world leading cause of death and disability with next quarter century. The statistics are alarming; 30 million people were diagnosed with diabetes worldwide in 1985, by 1995 the number had risen to 135 million, and at the current rate there will be some 300 million by the year 2025 as predicted by the WHO.[3] Currently, there are more than 17 million type 2 diabetic patients in the United States (or ~5.9% of the population), 11 million in Europe, and 6 million in Japan; which represents a potential primary therapeutic market of over \$6 billion. In the United States in 1997, the American Diabetes Association (ADA) reports that the total economic cost of

diabetes was estimated to be \$98 billion which includes \$44 billion in direct medical and treatment costs, and \$54 billion in indirect costs related to disability and mortality. The prevalence of all forms of diabetes is estimated to be 2%-3% of the world's population, with the number of diabetics increasing by 4%-5% per annum.

Pathophysiology and Complication

Diabetes is known to have a strong genetic component with contributing environmental determinants. Although the disease is heterogenous, there appear to be a fairly consistent phenotype once the disease is fully manifested. Whatever the pathogenic cause the early stage of diabetes is characterized by resistance insulin, targeting tissue mainly in liver, skeletal muscle, and adipocytes. Insulin resistance in the tissue is associated with excessive glucose production by the liver and impaired glucose utilization by peripheral tissue, especially muscle.[4-6]

Most of the food we eat is broken down into simply sugar called glucose. The glucose is the main source of fuel to get energy for the body. After digestion, the glucose reaches our blood stream, where it is available for body cells to utilize for energy, but insulin is needed for glucose to get into cells. Insulin is a hormone secreted by the pancreas to transport glucose from blood into different cells of the body. If the pancreas does not produce enough insulin or the produced insulin does not work properly, the glucose cannot enter the body cells. So glucose stay in blood cells which makes the blood sugar level high.[7,8]

Thus the body losses the main source of fuel for the energy even though the blood contain high amount of glucose. Since glucose is not metabolized, high amount of glucose circulate in blood, kidney remove extra sugar from blood and excrete it in the urine.[9] Since body does not utilize glucose, the body is under constant impression of hunger that's why in diabetes appetite increases and patient eat more frequently.

With increased insulin secretion to compensate for insulin resistance, base line blood glucose level can be maintained with in the normal range, but the patient may demonstrate impaired response to prandial carbohydrate loading and to oral glucose tolerance test. The chronic over stimulation of insulin secretion gradually diminishes and eventually exhausts the islets beta cells reserve.[10]

The quality of life of diabetic patient with chronic and severe hyperglycemia is adversely affected. Characteristic symptoms of tiredness and lethargy can become severe and lead to a decrease in work performance in adults and an increase of falls in the elderly.[11]

The most common acute complications are metabolic problems (hyperosmolar hyperglycemic non ketonic syndrome or HHNS) and infections. The long-term complications are macrovascular complication, microvascular complications, and diabetic foot.[11]

Conventional Therapy

The general consensus on treatment of type 2 diabetes is that life style management at the forefront of therapy options. In addition to exercise, weight control and medical nutrition therapy, oral glucose lowering drugs, and injections of insulin are the conventional therapies.

Pharmacological treatment is indicated when fasting glucose level exceeds 140 mg/dl the postprandial glucose level exceeds 160 mg/dl or HbA1c exceeds 8 %.[12]

Pharmacological Treatment and Limitations

Oral glucose lowering drugs: Five classes of oral agents are approved for the treatment of diabetes. Oral therapy is indicated in any patients in whom diet and exercise fail to achieve acceptable glycemic control. Although initial response may be good, oral hypoglycemic drugs may lose their effectiveness in a significant percentage of patients. The drug category includes sulfonylurea, biguanide, alpha-glucosidase

inhibitor, thiazolidinedione, and meglitinide. These drugs have various side effects such as sulfonylurea causes weight gain due to hyperinsulinemia[13,14] biguanide cause weakness, fatigue, lactic acidosis, alpha glucosidase inhibitor may cause diarrhea while thiazolidinediones may increase LDL-cholesterol level.

Insulin is usually added to an oral agent when glycemic control is suboptimal at maximal dose of oral medication. Weight gain and hypoglycemia are common side effect of insulin.[15–17] Vigorous insulin treatment may also carry an increase in atherogenesis.[16]

Need and Scope of Alternative Medicine

Regardless of the type of diabetes, patients are required to control their blood glucose with medication and/or by adhering to an exercise program and a dietary plan. Due to modernization of lifestyle type 2 diabetes mellitus is becoming a major health problem in developing countries. Patient with type 2 diabetes mellitus are usually placed on a restricted diet and are instructed to exercise the purpose of which primarily is weight control. If diet and exercise fail to control blood glucose at a desired level, pharmacological treatment is prescribed.[18] These treatments have their own drawbacks ranging from development of resistance and adverse effects to lack of responsiveness in a large segment of patient population. Moreover, none of the glucose lowering agents adequately control the hyperlipidemia that frequently met with the disease.[15]

The limitation of currently available oral antidiabetic agents either in terms of efficacy/safety coupled with the emergence of the disease into global epidemic have encouraged alternative therapy that can manage diabetes more efficiently and safely.

Alternative Approach

Complementary and alternative therapy is treatments that are neither widely taught in medical schools nor widely practiced in hospitals. The use of CAM in the worldwide is increasing. In 1997, 42% Americans had used an alternative medical therapy. Total visit to complementary *practitioners* (629 million) exceed total visit to US primary care physicians (386 million).[19] In Canada, a recent survey found that 75% people with diabetes used nonprescribed supplements (herbal, vitamin, mineral, or others) and alternative medications.[20] Overall research indicates that most people who use CAM therapies do so in addition to, rather than in place of conventional medical treatment[20,21] although some do not receive any concurrent conventional medical care.[22] CAM for diabetes have become increasingly popular the last several years. Alternative therapies with antidiabetic activity have been researched relatively, extensively, particularly in India. Ideal therapies should have a similar degree of efficacy without troublesome. Mechanism of Some complementary and alternative therapy used for lowering the blood glucose is summarized in [Table 1](#).

Physical Intervention

Yoga

Yoga is an old, traditional, Indian psychological, physical and spiritual exercise regimen that has been studied for several decades for its role in the management of several chronic disease including hypertension, asthma, obesity, and psychiatric illness.[23–25]

Additionally yoga has been studied for controlling both the symptom and complication associated with type 2 diabetes mellitus.[26–39] The results from these studies suggest a statistically significant role of yoga in diabetes. Furthermore, yoga practice showed a significant improvement for those diabetic patients with pre-existing complication.[40] Yoga practices have a role even in prevention of diabetes. Yoga helps

to regulate the body function and psychic processes, improve well-being and increase lovingly. There are several hypotheses for the biological mechanism that link the benefits of yoga to diabetes management. [30]

One hypothesis points to role of stress and relaxations[41–43] while others suggest that the noninvasive nature of yoga provides excellent support and few side effects to patient already taking medication for diabetes.

Massage therapy

Massage therapy could be incorporated into relaxation therapy, but it also serves another purpose that can be particularly useful for diabetes suffers. Massage has been recommended for diabetes for nearly 100 years.[44] Three published results[45–47] of two trials and one unpublished preliminary study have examined the positive effect of massage on normalizing blood glucose. One trial[48] also assess the improvement in 56% cases of diabetic neuropathy of the lower extremities by syncardial massage.

Several studies have documented the relaxing effect of massage. Massage has been demonstrated to reduce muscle tension in both subjective self-reports[49] an objective electromyographic testing.

Relaxation from massage has been demonstrated to be greater than that brought about from rest alone.[47] Massage can reduce heart rate and blood pressure, two features of the relaxation response.[50]

Additionally, patient massage has been shown to decrease anxiety in a variety of patient population including people with diabetes.[45–47] The extreme stress-reducing benefits of massage have raised the possibility that massage may be of benefits of to people with diabetes by including the relaxation response, thereby controlling the counter-regulatory stress hormones and permitting the body to use insulin more effectively. By skill fully the body's, massage can stimulate better blood movement around the body. Improve circulation can do wonders for diabetic neuropathy and other diabetic-related complications. Even then it is suggested that it is necessary to consult closely with health care team before using massage therapy as a diabetic even for relaxation purpose.

Acupuncture

Acupuncture therapy is a common approach to treating diabetes in China. Acupuncture is best known in the United States as an alternative therapy for chronic pain. However, it has been used for the treatment of diabetes and related complication during the past several decades. Acupuncture may be effective in treating not only diabetes, but also in preventing and managing complication of the disease.[51] A report in the 1994 Journal of traditional Chinese medicine serve as a model of effect of acupuncture on diabetic patients.[52]

The effect of acupuncture on diabetes have been observed experimentally and clinically.[53–56] Animal experiments have shown that acupuncture can activate glucose-6-phosphate and affect hypothalamus.[51] Acupuncture can act on the pancreas to enhance insulin synthesis, increase the number of receptors on target cells, and accelerate the utilization of glucose, resulting in lowering of blood sugar.[51] Data from other studies have shown the beneficial antiobesity effect of acupuncture.[51,57,58] It appears that the therapeutic effect of acupuncture on diabetes is not the result of its action on the single organ but on multiple system. Although acupuncture shown some effect in treating diabetes, its mechanism of action are still obscure.

Medicinal herbs

As per ancient literature, more than 800 plants are reported to have antidiabetic properties.[59] Ethanopharmacological surveys indicate that more than 1200 plants are used in traditional medicine for their allied hypoglycemic activity.[60] Indian Materia Medica has mentioned numerous dravyas have been

reported effective in Madhumeha.[61]

The indigenous diet may not be useful in lowering the blood sugar to the same extent as insulin and other hypoglycemic agent do, but it has some other influences, which may be useful for the management of the disease and its complications.[62] In diabetes, some herbal alternatives are proven to provide symptomatic relief and assist in the prevention of the secondary complication of the disease. Some herbs have also been proven to help in regeneration of β -cells and in overcoming resistance. In addition to maintaining normal blood sugar level, some herbs are also reported to possess antioxidant activity and cholesterol lowering action. The management of type 2 diabetes mellitus is possible with drug that can lower the blood sugar level in one hand and restore the liver glycogen level on the other hand. In modern system of medicine, there is no drug, which is reported to possess both of the properties.[63] However, the hypoglycemic effect of some herbal extracts have been confirmed in human and animal models of type 2 diabetes and conventional drugs have been derived from the active molecule of these medicinal plants. Metformin, a less toxic biguanide and potent oral glucose lowering agents, was developed from *Galega officinalis* and used to treat diabetes.[64–68]

To the date, over 400 traditional plant treatments for diabetes have been reported,[65] although only a small number of these have received scientific and medicinal evaluation to assess their efficacy. The following is a summary of several of the most studied and commonly used medicinal herbs.

Momordica charantia

Momordica charantia, also known as bitter melon, has been used extensively in folk medicine as a remedy for diabetes. The blood sugar lowering action of fresh juice or unripe fruit has been established in animal experimental models as well as human clinical trials.[69–74]

It is composed of several compounds with confirmed antidiabetic activity. Alcohol-extracted charantin and *M. charantia* consist of mixed steroids was found to be more potent than the oral hypoglycemic agent tolbutamide in an animal study.[75]

Trigonella foenum graecum

Commonly known as Fenugreek, popular for its pungent aromatic properties and is often used to add flavors in homes.

It has been used as a remedy for diabetes, particularly in India.[76] The active principle is in the defatted portion of the seed, which contains the alkaloid gonelline, nicotinic acid and coumarin. Several animal experimental studies confirmed the antidiabetic potential of *T. foenum graecum*. [15–18,77]

Human studies have confirmed the glucose and lipid-lowering test.[78] At least 50% of seeds is fiber and may constitute another potential mechanism of Fenugreek's beneficial effect in diabetic patients.[79]

In type 2 diabetes patients, the ingestion of 15 g of powder of Fenugreek seed soaked in water significantly reduced postprandial glucose levels during the glucose tolerance test.[79]

Gymnema sylvestre: Commonly known as Gurmar, has long been used as a treatment for diabetes. It appeared on the US market several years ago, known as a “Sugar blocker.” In a study of type 2 diabetes, 22 patients were given 400 mg *Gymnema sylvestre* extract daily along with their oral hypoglycemic drugs. All patients demonstrated improved blood sugar control. Twenty one of 22 were able to discontinue oral medication and maintain blood sugar control with the *Gymnema* extract alone.[80] It was postulated that *Gymnema sylvestre* enhance the production of endogenous insulin.[81]

Azadirachta indica: Commonly known as neem. It has been long used as a treatment for diabetes. Aqueous extract of neem leaves significantly decreases blood sugar level and prevents adrenaline as well as glucose-induced hyperglycaemia.[82] Aqueous leaf extract also reduces hyperglycaemia in

streptozotocin diabetes and the effect is possibly due to presence of a flavonoid, quercetin.[83] The plant blocks the action of epinephrine on glucose metabolism, thus increasing peripheral glucose utilization.[11] It also increased glucose uptake and glycogen deposition in isolated rat hemi diaphragm.[12]

Other plants which are most effective and the most commonly used in treatment of diabetes are summarized in [Table 2](#). All plants have shown varying degree of hypoglycemic and anti-hyperglycemic activity.[84]

Dietary Supplement

Vitamins and minerals are micronutrients that our body requires in small quantities for specific function. They most commonly function as essential co enzyme and co factor for metabolic reaction and thus help supports basic cellular reactions. Micronutrients have been investigated as potential preventive and treatment agents for both type 1 and type 2 diabetes and for common complication of diabetes.[85,86]

Chromium

trace element trivalent chromium (Cr^{3+}) for is an essential micronutrient for human. It is required for the maintenance of normal glucose metabolism.[87] Effects of chromium on glycemic control, dislipidemia, weight loss, body composition, and bone density have all been studied.[88] Considerable experimental and epidemiological evidence now indicates that chromium level are a major determinant of insulin sensitivity, as it functions as a cofactor in all insulin regulating activities.[89] Chromium facilitate insulin binding and subsequent uptake of glucose into the cell. Supplemental chromium has been shown to decrease fasting glucose level, improve glucose tolerance, lower insulin levels, and decrease total cholesterol and triglycerides while increases HDL cholesterol in normal, elderly, and type 2 diabetic subjects.[90] Without chromium insulin action is blocked and glucose level is elevated.[86] Although low recommended daily allowance has been established for chromium over 200 mg/day appears necessary for optimal blood sugar regulation. A good supply of chromium is assured by supplemental chromium[91] because chromium appears to increase the activity of insulin receptor, it is logical to expect that adequate level of insulin must also be present. Patient using chromium supplement should be cautioned about the potential for hypoglycemia, and monitoring renal function is prudent.

Vanadium

The trace element vanadium has not been established as an essential nutrients and human deficiency has not been documented.[88,92] Vanadium exist in natural valence state with vanadate(+4) and vanadyl (+5) forms most common in biological system.

Several small trials[93–96] have evaluated the use of oral vanadium supplements in diabetes most focus on type-2 diabetes[93] although animal study suggests that vanadium has also potential benefits in type 1 diabetes.[97] In subject with type 2 diabetes, vanadium increased insulin sensitivity as assessed by euglycemic hyperinsulinimic clamp studies in some[93–95] but not all[96] trials. Two small studies have confirmed the effectiveness of vanadyl sulphate at a dose of 100 mg/day in improving insulin sensitivity.[94,95]

Magnesium

The mineral magnesium functions as an essential cofactor for more than 300 enzymes. Magnesium is one of the more common micronutrient deficiency in diabetes.[85,86,98,99] Low dietary magnesium intake has been associated with increased incidence of type 2 diabetes in some[100] but not in all[101] studies. Magnesium deficiency has been associated with complication of diabetes, retinopathy in particular. One study found patients with the most severe retinopathy were also lowest in magnesium.[102]

Nicotinamide

(Vitamin B3) occurs in two forms, nicotinic acid and nicotinamide. The active coenzyme forms (nicotinamide adenine dinucleotide NAD and NAD phosphate) are essential for the functions of hundreds of enzymes and normal carbohydrate, lipid and protein metabolism.[103] The effects of nicotinamide supplementation have been studied in several trials focusing on the development[104–107] and progression[108–110] of type 1 diabetes a meta analysis[111] and one small trial in type 2 diabetes.[112]

Nicotinamide appears to be most effective in newly diagnosed diabetes and in subjects with positive islets cell antibodies but not diabetes. People who develops type 1 diabetes after puberty appear to be more responsive to nicotinamide treatment.[108–111] Study results have offered more support for the idea that nicotinamide help to preserve β -cell function[109] than for its possible role in diabetes prevention.[113]

Vitamin E

essential fat soluble vitamin functions primarily as an antioxidant.[114] low levels of vitamin E are associated with increased incidence of diabetes[115] and some research suggest that people with diabetes have decreased levels of antioxidants.[116] People with diabetes may also have greater antioxidant requirement because of increased free radical production with hyperglycemia.[117,118]

Increased levels of oxidative stress markers have been documented in people with diabetes.[119,120] Improvement in glycemic control decrease markers of oxidative stress as does vitamin supplementation. [117–122]

Clinical trials involving people with diabetes have investigated the effect of vitamin E on diabetes prevention[123] insulin sensitivity[124,125] glycemic control,[126–128] protein glycation,[129] microvascular complication of diabetes,[130,131] and cardiovascular disease and its risk factor. [121,122,132,133]

Miscellaneous approach

Aromatherapy

Aromatherapy has a long history of use;[134] clinical aromatherapy is the therapeutic use of essential oils, the efficacy of which is supported by research data. In aroma therapy, essential oils are inhaled or diluted and applied topically to the skin depending on the symptom. Essential oils are usually available in specialist and health shops and it is claimed that different oil impact on the mind and body in different ways. Oil may stimulate relax, sedate, sanitize and much more. All oils have a fragrance and a chemistry that can lead to a range of responses that affect the therapeutic effect.[135] Essential oils can be used to reduce the side effects of some complication (ulcer: loss of skin integrity) and to reduce that often take longer to resolve than in non diabetic patients.[136] Essential oil can also ameliorate the stress of the coping with a lifelong chronic condition such as diabetes.[137] To use aromatherapy for stress put 3-5 drops of an undiluted essential oil on a handkerchief or cotton ball and ask the patients to hold the handkerchief to his/her nose and breathe slowly for 5 min. This treatment can be repeated every four hour or more frequently when necessary. Some essential oil when mixed in correct measures may help some diabetics particularly when used in conjunction with massage therapy. These include Eucalyptus, Juniper and Geranium oil.

However, before any aromatherapy is used to help diabetic person, it is vital to consult with diabetic health care team.

Biofeedback

Management of type 2 diabetes requires continuous monitoring and multiple interventions to prevent long term complication.[138] One of the contributing factors in the etiology of glucose intolerance and poor glycemic control in individuals with diabetes is stress response.[139,140]

Stress management is a generic term that may encompass biofeed back, relaxation, cognitive behavioral therapy, and imagery. Biofeed back is a therapeutic technique involving an instrument that provides information about psychological activity such as skin temperature or muscle tension, with the objective of learning control over maladaptive response to stress.

Evaluation of stress management in diabetic patients showed the small but significant decrease in glycohemoglobin after 1 year.[141] In a controlled study of bio-feedback-assisted relaxation therapy in type 1 diabetes.[141–143] decrease in blood glucose were found in the treated group compared with a wait list control groups. The moderating effects of mood on glycemic control highlight the complex relationship between depression and diabetes.[141–144]

Use of biofeed back and relaxation for three months in diabetic patients were associated with significant decrease in average blood glucose in comparison to control.[145] The prevalence of mood and anxiety disorders is higher in individuals with type 2 diabetes in comparison to general population.[146] So further research is necessary to determine the long term effect of bio feedback on patient's response to treatment.

Hydrotherapy

Hydrotherapy is the treatment of illness and injury through the use of water both hot and cold. Hydrotherapy helps the body to get rid of toxins and relax muscle. It also relaxes body both mentally and physically.

Since hot-tub therapy can increase both flow to skeletal muscle, it has been recommended for the patients with type 2 diabetes who are unable to exercise.[147] A study reported that eight patients were asked to sit in a hot tub at an athletic facility with water up to their shoulders for 30 min for three weeks. During the study the patients weight, mean plasma glucose level and their mean Glycosylated hemoglobin decreased. [15] Caution should be taken that the water not to be too hot as neuropathy may prevent the patient from notifying they are burning themselves. Hot-tub therapy should be further evaluated as a therapy for patients with type 2 diabetes mellitus. The benefit could result from increased blood flow to skeletal muscle.[148]

Proper water sanitation and appropriate guidance should be considered when prescribing hot-tub therapy for diabetic patients.[149]

Chromotherapy

Chromotherapy involves therapeutic use of colors. According to this system, the cause of any disease can be treated by the lack of color harmony in the human system and this imbalance can be removed by the use of colored light to the body.

Color therapy uses sensitive to color to identify and correct any imbalance in body's internal energy pattern that might lead to physical ill health. Therapist believe that each organ and body system has its own characteristic vibrational energy and disorder can be healed by applying color of corresponding vibrational energy, either to whole body or to organs.

According to chromotherapy, diabetes is generally caused by a deficiency of orange and yellow colors in the body. There are two methods of treating disease by color, by application of light filtered through different colored glasses and by the external or internal use of color charged water.

Lemon yellow is the color the pancreas. It is a laxative and diuretic. It is a stimulant of brain, the liver and spleen. Green and orange are also helpful in controlling diabetes.[150]

Conclusion

Alternative therapies with antihyperglycemic effects are increasingly sought by patient with diabetes. This comes as no surprise since alternative treatments have been most widely used in chronic disease, which may be only partially alleviated by conventional treatment. Herbal medications are the most commonly used alternative therapy for blood sugar control. Scientific validation of several Indian plant species has provided the efficacy of the botanicals in reducing the sugar level. However, their safety and efficacy need to be further evaluated by well designed, controlled clinically because various non-standardized forms of the herbs have of been the testing material, the result have been difficult to replicates; therefore, preparations of standardized medicinal herbs is urgently needed in future studies and therapies several dietary supplements have been found to benefit people with diabetes, either because of potential or because of the beneficial effect on glucose metabolism. among the most important dietary supplements are chromium magnesium, vanadium, nicotinamide, and vitamin E. Other potential alternative treatments for diabetes include acupuncture, hydrotherapy, massage therapy, yoga and Chromotherapy, etc.

Footnotes

Source of Support: Nil

Conflict of Interest: None declared.

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Figures and Tables

Table 1

Complementary and alternative therapy with mechanism for lowering blood glucose

| CAT | Mechanism |
|----------------------------------|--|
| Yoga | Improve in insulin sensitivity and decline in insulin resistance ^[30] |
| Massage | At an injection site increase serum insulin, thereby decrease blood glucose ^[151] |
| Acupuncture | Act on pancreas to enhance insulin synthesis, accelerate the utilization glucose, resulting in blood sugar ^[51] |
| Aromatherapy | Ameliorate the stress of coping with a lifelong chronic condition such as diabetes ^[137] |
| <i>Momordica charantia</i> | Not known (In diabetic rabbit models it possesses a direct action similar to insulin) ^[152] |
| <i>Trigonella foenum graceum</i> | Hypoglycemic effect may be mediated through stimulating insulin synthesis and/or secretion from the beta pancreatic cells of Langerhans ^[153] |
| <i>Gymnema sylvestre</i> | This is attributed to the ability of gymnemic acids to delay the glucose absorption in the blood ^[154] |
| <i>Azadirachta indica</i> | Not known |
| L-Carnitine | Effect insulin sensitivity and enhance glucose uptake and storage ^[155] |
| Vanadium | Insulin mimetic with up gradation of insulin receptors ^[156] |
| Chromium | Facilitates insulin binding and subsequent uptake of glucose into cell ^[86] |
| Vitamin E | Potent lipophilic antioxidant activity with possible influences on protein glycation lipid oxidation and insulin sensitivity and secretion ^[156,86] |

Table 2

Herbs used for antihyperglycemic activity

| Herbs used for diabetes | Common name | Parts used |
|----------------------------------|----------------|------------|
| <i>Momordica charantia</i> | Bitter lemon | Fruit |
| <i>Trigonella foenum graceum</i> | Fenugreek | Seed |
| <i>Gymnema sylvestre</i> | Gurmar | Leaf |
| <i>Azadirachta indica</i> | Neem | Leaf |
| <i>Allium sepa</i> | Onion | Bulb |
| <i>Allium sativum</i> | Garlic | Bulb |
| <i>Aloe vera</i> | Ghikumari | Leaf |
| <i>Cajanus cajan</i> | Tuar | Seed |
| <i>Coccinia indica</i> | Kundru | Fruit |
| <i>Caesalpinia bonducella</i> | Kanderi | Bulb |
| <i>Ficus benghalensis</i> | Banyan Tree | Leaf |
| <i>Ocimum sanctum</i> | Tulsi | Leaf |
| <i>Pterocarpus marsupium</i> | Banda | Leaf |
| <i>Swetria chirayita</i> | Chirata | Leaf |
| <i>Syzigium cumini</i> | Jamun | Fruit |
| <i>Tinospora cordifolia</i> | Giloe | Leaf |
| <i>Eugenia jambolana</i> | Amrut | Fruit |
| <i>Mucuna pruriens</i> | Kiwanch | Leaf |
| <i>Murraya koeingii</i> | The curry tree | Leaf |
| <i>Brassica juncea</i> | Indian mustard | Leaf |

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