World Journal of Pharmaceutical and Life Sciences
WJPLS
www.wjpls.org
SJIF Impact Factor: 4.223

# UNSCATHED HERBAL REMEDIES FOR DIABETES: SIMPLE DIETETIC TRICKS CAN DEPART THE NEGATIVES

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**Article Received on 21/04/2017** **Article Revised on 10/05/2017** **Article Accepted on 01/06/2017**

## ABSTRACT

Diabetes mellitus is a public health problem which leads to serious complications over time and is identified as one of the main threats to human health in the 21st century. Diabetes is one of four priority non-communicable diseases (NCDs) targeted for action by world leaders. Diabetes Mellitus (DM) is a fifth fastest growing disorder and entailing a huge financial burden and multiple medical policy issues. The management of diabetes is still a major challenge. All the existing therapies of diabetes have limited efficacy, confined tolerability and/or significant mechanism based side effects. Thus there is great demand for research on natural products with anti-diabetic properties. Numerous studies have confirmed that the plant drugs and formulations are considered to be less hazardous and free from side effects than the synthetic ones. The World Health Organization (WHO) has listed 21,000 plants, which are used for medicinal purposes around the world. Medicinal plants and phyto-constituents play an important role in the management of diabetes mellitus especially in developing countries where resources are meagre. Additionally, lifestyle and particularly dietary habits play an important role in the development of diabetes. On the other hand, specific individual food groups and diet components such as monounsaturated fatty acids, fruits, vegetables, whole grain cereals, dietary fiber, fish, magnesium and nuts may protect against the development of diabetes, possibly through the amelioration of insulin sensitivity and its anti-inflammatory actions, while consumption of red and processed meats and saturated fat may increase the risk of type 2 diabetes. A comprehensive review was conducted to pile up information about medicinal plants used for the treatment of diabetes along with plant parts used and its active chemical constituents. In this review article, emphasis is also given on the role of diet and life style in the management of diabetes.

**KEYWORDS:** Diabetes, herbal remedies, dietetic tricks, life style, complications.

## INTRODUCTION

Diabetes is a chronic disorder of metabolism of carbohydrates, proteins and fat due to absolute or relative deficiency of insulin secretion and with varying degree of insulin resistance which can be characterized by hyperglycaemia, glycosuria, hyperlipidaemia, and negative nitrogen balance. The World Health Organization (WHO) estimates that globally, high blood glucose is the third highest risk factor for premature mortality, after high blood pressure and tobacco use.[1] Diabetes was one of the first diseases described, with an Egyptian manuscript from c. 1500 BCE mentioning ‘’too great empting of the urine’’. Indian physicians around the same time identified the disease and classified it as *madhumeha* or ‘’honey urine’’, nothing the urine would attract ants. Type 1 and type 2 diabetes were identified as separate conditions for the first time by the Indian physicians Sushruta and Charaka in 400-500 CE with type 1 associated with youth and type 2 with being overweight.[2]

**Type 1** diabetes (previously known as insulin-dependent, juvenile or childhood-onset diabetes) is characterized by deficient insulin production in the body. People with type 1 diabetes require daily administration of insulin to regulate the amount of glucose in their blood. If they do not have access to insulin, they cannot survive. The cause of type 1 diabetes is not known and it is currently not preventable. Symptoms include excessive urination and thirst, constant hunger, weight loss, vision changes and fatigue.

**Type 2** diabetes (formerly called non-insulin-dependent or adult onset diabetes) results from the body’s ineffective use of insulin. Type 2 diabetes accounts for the vast majority of people with diabetes around the world. Symptoms may be similar to those of type 1

diabetes, but are often less marked or absent. As a result, the disease may go undiagnosed for several years, until complications have already arisen. For many years type 2 diabetes was seen only in adults but it has begun to occur in children.

**Gestational diabetes (GDM)** is a temporary condition that occurs in pregnancy and carries long term risk of type 2 diabetes. The condition is present when blood glucose values are above normal but still below those diagnostic of diabetes. Women with gestational diabetes are at increased risk of some complications during pregnancy and delivery, as are their infants. Gestational diabetes is diagnosed through prenatal screening, rather than reported symptoms.[3]

Plants are still important sources of medicines, especially in developing countries that still use plant based traditional medicine for their healthcare.[4] Herbal medicine, also called botanical medicine or phyto medicine, refers to the use of any plant's seeds, berries, roots, leaves, bark, or flowers for medicinal purposes. Long practiced outside of conventional medicine, herbalism is becoming more main stream as up-to-date analysis and research show their value in the treatment and prevention of disease.[5] Interests in ethno-botanical explorations have been increased in recently at the national and international level. A perusal of the literature reveals that there is still a huge gap in knowledge of ethno-medicine and its scientific validation in this part of the world. Traditional use of plants and plant-parts has been a deep rooted practical knowledge in the culture and livelihood of the people living in the remote parts of the world and has been using different medicinal plants in their daily healthcare practices.

According to the World Health Organization (WHO) about 65-80% of the world's population in developing countries depends essentially on plants and plant derived compounds for their primary health care.[6] Ayurveda and other traditional medicinal system for the treatment of diabetes describe a number of plants used as herbal drugs. They play an important role as alternative medicine due to less side effects and low cost. Ayurvedic plants provide the best option for search of desired safe and effective medications. Since ancient times, plants have been an exemplary source of medicine. Various Ayurvedic plants have been found to possess significant anti-diabetic property after their preclinical and clinical evaluation. Use of these plants may delay the development of diabetic complications and can correct the metabolic abnormalities through variety of mechanisms. Moreover, during the past few years many experimental studies were carried using aqueous and alcoholic extracts of anti-diabetic plants which explore the new ways of treatment of diabetes mellitus.[7]

## METHODOLOGY

This review article has been prepared from secondary study materials such as published journal articles, review papers, conference papers & reports, technical & theoretical notes, books, & relevant information found from various online sources.

### Ethno-botanical Study

Hyperglycemia can be reversed by a variety of measures. Administration of exogenous insulin is the treatment for all type 1 diabetic patients and for some type 2 patients who do not achieve adequate blood glucose control with oral hypoglycemic drugs. Insulin therapy has several drawbacks like insulin resistance, anorexia, brain atrophy and fatty liver in chronic treatment.[2] Herbal and natural products of folk medicine have been used for centuries in every culture throughout the world. Scientists and medical professionals have shown increased interest in this field as they recognize the true health benefits of these remedies. "Let food be your medicine and let medicine be your food" was advised by the father of medicine, Hippocrates, over two million ago.[8] There is a new trend in the world to turn back to natural substances to avoid the side effects associated with the synthetic drugs. Many plant species have been used to treat life-threatening diseases like diabetes. A World Health Organization (WHO) study shows that 80% of the world population solely relies on the medicinal plants for their primary health care needs.[9] In this review article, an attempt has been made to compile the reported hypoglycemic plants available in different scientific journals and may be useful to the health professionals, scientists and scholars working in the field of pharmacology and therapeutics to develop evidence based alternative medicine to cure different kinds of diabetes in man and animals. This review shows the importance and the interest placed on medicinal plants in the drive to demonstrate their anti-diabetic effects and the responsible bioactive agents. This review also covers the common name of a plant, the parts that are commonly used as a remedy sources and extracts.

**Analysis of remedies obtained from different plant parts for Diabetes Mellitus.**

| Family | Scientific name | Common name/ English name | Parts used | Extract types | Active chemical compound | References |
|---|---|---|---|---|---|---|
| Febaceae | *Abrus precatorius* | Ratti, Kundumani | Seed, Root, Leaf | Aqueous | - | [10,11] |
| Febaceae | *Acacia Arabica* | Indian gum arsbic | Seed, Bark | - | Polyphenol, Tannin | [10,12,13,14,15, 16,17] |
| Rutaceae | *Aegle marmelose* | Bael, Golden apple | Seed, Fruit, Leaf | Ethanolic, Aqueous | Aegelin 2, Coumarin, Flavonoid, Alkaloid | [5,12,18,19] |
| Liliaceae | *Allium cepa* | Pyaj, Onion | Bulb | Ethyl ether extracts | S-methyl cysteine sulphoxide, Allyl propyl disulphide | [5,10,12,20,21, 22,23] |
| Liliaceae | *Allium sativum* | Lahsun, Garlic | Bulb | Ethanolic | S-allyl cysteine sulfoxide/allicin, | [5,10,12,20,21, 23,24,25] |
| Aloceae | *Aloe vera* | Aloe vera | Leaf | Leaf pulp extract | Glucomannan | [10,12,19,20,21,25, 26,27,28] |
| Asphadlaceae | *Aloe barbadensis* | Barbados aloe | Leaf | - | Lophenol,24-methyyl lophenol, 24-ethyle lophenol cycloartenol, 24-methylene cycloartenol | [21] |
| Amaranthaceae | Amaranthus esculentus | - | Whole plant | Oil fraction | - | [12,22] |
| Acanthaceae | *Andrographis paniculata* | Kalomegh | Leaves | | Trapenids & steroids | [5,18,19,29] |
| Annonaceae | *Annona squamosal* | Ata | Leaf and fruit | Ethanolic and aqueous | - | [12,22] |
| Moraceae | *Artocarpus heterophyllus* | Jack fruit | Fruit | Aqueous | Sapogenin | [12,30] |
| Liliaceae | *Asparagus racemosus* | - | Root | Ethanol, Chloroform, Hexane | - | [22] |
| Meliaceae | *Azadirachta indica* | Neem | leaf, seed and fruits | Raw leaf extracts | Azadirachtin, Meliacin, Salanin, Nimbin, Valassin Nimbidin,β-sitosterol | [5,10,12,18,19,20,21, 24,25,31,32,33,34] |
| Chenopodiaceae | *Beta vulgaris* | Beetroot | Entire plant | - | Pectin, Polydextrose | [12,14,21] |
| Brassicaceae | *Brassica juncea* | Mustard | Seed, Leaf | Aqueous | Isorhamnetin diglcoside | [12,13,14] |
| Brassicaceae | *Brassica nigra* | - | Seed | Aqueous | - | [22,35] |
| Solanaceae | *Capsicum frutescens* | Chilli | - | - | Capsaicin | [12,13,14,22,36] |
| Cariaceae | *Carica papaya* | papaya | fruit | Aqueous extract | Saponin, Tannin, alkaloid, Flavonoid, Anthraquinone, Glycoside | [12,13,18,37,38] |
| Leguminoceae | *Cajanus cajan* | Pigeon pea | Seed, Leaf | Ethanolic | 7-phenol-octahydroquinolisin-2-one | [12,14,19,21,39] |
| Apocynaceae | *Catharanthus roseus* | Red periwinkle / Nayantara | Whole plant | - | Vinculin, Alkaloid | [12,31] |
| Apiaceae | *Centella asiatica* | Thankuni | Leaf/whole plant | Ethanolic leaf extract | Alkaloids, Phenols, Flavonoids, Quinones, Triterpenoids | [12,19,40,41] |
| Lauraceae | *Cinnamonum zeylanicum* | Cinnamon | Leaf, Bark | - | Cinnamaldehyde | [12,13,14] |
| Apiaceae | *Coriandrum sativum* | Coriander | Leaf, Seed, Fruit | Aqueous | Alanine | [12,42,43,44] |
| Cucurbitaceae | *Coccinia indica* | Ivy-gourd | Fruit, Leaf | Alcoholic | B-amyrin, Lupeol, Cucurbitacin B | [12,19,45,46] |
| Zingiberaceae | *Curcuma longa* | Haldi, Turmeric | Raw turmeric/ | Aqueous extract | Curcuminoid | [5,7,12,18,21,31,37] |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | root | | | |
| Apiaceae | *Cuminum cyminum* | Cumin seed | Seed | - | Aldehyde | [12,14,21] |
| Ebenaceae | *Diospyros lotus* | Date plum | Fruit | Aqueous | Phenolic | [12,13] |
| Moraceae | *Ficus racemosa* | Jogadumur | Ripe fruits/ Bark | | α-amyrin acetate | [18,31,37] |
| Moraceae | *Ficus bengalensis* | Banyan tree | Bark | - | Leucopelargonidin | [12] |
| Moraceae | *Ficus carica* | Anjir | Leaf, Fruit | - | Invert sugar | [12] |
| Ascelpiadaceae | *Gymnema sylvestre* | Gurmur, Destroyer of sugar | Leaf | Aqueous, Methanolic | Gymnemic acid, Gymnema saponin | [20,37,47,48,49] |
| Febaceae | *Glycine max* | Soya bean | Seed | - | 3-O-methyl-D-chiro-inositol | [12,13,14] |
| Malvaceae | *Hibiscus rosa sinensis* | - | Flower | Ethanolic | | [12,19,50,51,52,56] |
| Poaceae | *Hordeum vulgare* | Barley | Seed | - | Beta-glucan | [12] |
| Crassulaceae | *Kalanchoe pinnata* | Patharkuchi | Leaf | - | - | [31] |
| Nymphaeaceae | Nelumbo nucifera | Sacred lotus | Flower | - | Tolbutamide | [12,14,79] |
| Anacardiaceae | *Mangifera indica* | Mango tree | Stem, Bark, Fruit, Leaf | Aqueous, Alcoholic | Mangiferin, Phenolics, Flavonoid | [12,18,37] |
| Lamiaceae | *Mentha piperita* | Peppermint | Leaf | - | Essential oil, Terpen, Flavonoid. Vanadium, Zinc, Chromium, Copper, Iron, Potassium, Sodium, Nickel | [12,14] |
| Cucurbitaceae | *Momordica charantia* | Karela/ Bitter melon | Fruit | Methanolic, Aqueous, Chlorophormic | Charantin, β- sitosterol, cucurbitacin | [10,12,18,28,37,38, 56,65] |
| Rutaceae | *Murraya koenigii* | Curry leaf tree | Leaf, Fruit | Fruit juice | Carbazole, alkaloid | [12,13,14] |
| Musaceae | *Musa paradisiaca* | Banana | Mature, green fruit | Methanolic extract | Dietary fibre, pectin | [12,18] |
| Musaceae | *Musa sapientum* | Sweet banana | Flower | - | Flavonoids, Steroid, Glycosides | [12,13,14,21] |
| Lamiaceae | *Ocimum sanctum* | Tulsi/ Holy basil | Leaf | Aqueous, Ethanolic | Eugenol (1-hydroxy-2-methoxy-4- allylbenzene) | [5,10,12,19,21,37,53, 54,55,56,57] |
| Lauraceae | *Persea americana* | Avocado | Fruit | Aqueous | Fat, Protein, Vitamin, Mineral | [12,13,14] |
| Phyllanthaceae | *Phyllanthus emblica* | Amla/ Amloki | Fruit | Ethanolic extract | Tannoid | [12,18,31] |
| Piperaceae | *Piper betle* | Pan | Leaf | Aqueous | - | [12,22,58,59] |
| Myrtaceae | *Psidium guajava* | Guava | Leaf, Fruit | Aqueous, Ethanolic | Terpen, Flavonoid, Strictinin, Polysaccharide, Isostrictinin, Pedunculagin | [12,13,18,22,37,51, 60,61,62] |
| Amaranthaceae | *Spinacea oleracea* | Palongshak | Whole plant | - | - | [31,63,64,65] |
| Meliaceae | *Swietenia macrophylla king* | Mehogony | Seed | Aqueous, Ethanolic | Triterpenoids, Fatty acid, Methyl esters, Aldehydes, Fucosterol, Phytosterols and β-sitosterol | [66,67,68,69,70,71, 72,73,74] |
| Myrtaceae | *Syzigium cumini* | Jamun/ Blackberry | Fruit, leaf, seed, bark | Ethanolic extract | Jambosine, Jamboline or Antimellin | [5,18,20,24,37,55] |
| Febaceae | *Tamarindus indica* | Tatul tree | Seed, Fruit | Methanolic extract | Flavonoid, Steroid | [12] |

| | | | | | | |
|---|---|---|---|---|---|---|
| Combretaceae | *Terminalia catappa* | Indian almond | Fruit | Petroleum ether, Methanolic, Aqueous | Phenolics | [12] |
| Papilionaceae | *Trigonella foenum graceum* | Methi | seed | Alcoholic, Ethanolic | - | [5,76] |
| Poaceae | *Triticum vulgare* | Wheat | Whole plant | - | Albumin | [12,14] |
| Febaceae | *Xanthocercis zambesiaca* | Nyala tree | Leaf | - | Fagomine, 4-O-beta-D-glucopyranosylfagomine, Castanosperamine | [12,13,14] |
| Zingiberaceae | *Zingiber officinale* | Ginger | Bulb | - | Gingerol, Ethanol | [12,37,77] |

**PRESENT SITUATION**

Diabetes is one of the most challenging public health problems of the 21st century. Each year more and more people live with this condition, which can result in life-changing complications. According to IDF (2015), the Global prevalence of diabetes was 8.8% (7.2-11.4%) in 2015 and it will become 10.4% (8.5-13.5%) in 2040. One in eleven adults in 2015 was affected with diabetes and it will be one in ten adults in 2040. One in two adults with diabetes is undiagnosed. The IDF estimated that, one in seven births is affected by gestational diabetes, 542,000 children have type 1 diabetes and 12% of global health expenditure is spent on diabetes. The 10 top countries in numbers of people suffering from diabetes are India, USA, China, Japan, Indonesia, Egypt, Brazil, Russia, Mexico and Bangladesh.[1]

One critical feature about the 7th edition of the IDF Diabetes Atlas is that the data shows a continued increase in the prevalence of diabetes. Today, we know that 415 million people (one out of eleven adults) have diabetes and every six seconds a person dies with diabetes. Moreover, every two seconds a new case of diabetes is diagnosed somewhere in the world. This is most alarming and the whole world needs to know about it and take action. If the current trends in diabetes prevalence continue, by 2040 some 642 million people will have diabetes. Given that 75% of all people with diabetes live in low- and middle-income countries.[3]

**FUTURE PROSPECTS**

Traditional herbal medicine has been used since ancient time in many parts of the world. The many side effects of insulin therapy and other oral hypoglycemic agents necessitate the use of more effective and safer anti-diabetic drugs. For example, long-term use of Metformin causes diarrhoea, nausea, gas, weakness, indigestion, abdominal discomfort and headache.[78] Diabetes is still not completely curable by the present anti-diabetic medicines. All the existing therapies however have limited efficacy, confined tolerability and/or significant mechanism based side effects.[2] Plant based drug are considered to be less toxic and free from side effects than synthetic one. Hence, they play an important role as alternative medicine. Diabetes has been treated with plant medicine since antiquity. Recent scientific investigation has confirmed the efficacy of many anti-diabetic plant preparations some of which are very effective and relatively non-toxic.[9] Although many plant species have been validated for their anti-diabetic properties and related complications, there is a need for modern research in the identification of phytochemical compound(s), their target(s) and their modes of action and combination therapy of plant products with synthetic drugs.[20]

Treatment employing two or more herbs in combination is known as ‘’polyherbal therapy’’. Polyherbal therapy is said to be a better choice in the treatment of diabetes mellitus having the advantage of producing maximum therapeutic efficacy with minimal side effects. This may provide synergistic and potentiative pharmacological properties within themselves because of presence of vast range of phyto-bioactive constituents. Polyherbal therapy also gives an opportunity to reduce the dose of herbs used for glycemic control in order to avoid the burden of herbal over dose.[2] To make the therapy cost effective, extensive clinical studies for long-term side effects are a must. A large-scale production of quality plant material and innovative procedures to easily consume these medicinal plant species have to be further validated.[20]

**COMPLICATIONS IN DIABETES MELLITUS**

Diabetes is a group of chronic diseases characterized by hyperglycaemia. Chronic hyperglycaemia injures the human body in many different ways. Modern medical care therefore uses a vast array of lifestyle and pharmaceutical interventions aimed at preventing and controlling hyperglycaemia.

One of the chief injuries arising from hyperglycaemia is injury to vasculature, which is classified as either small vascular injury (microvascular disease) or injury to the large blood vessels of the body (macrovascular disease). As medical science advances increasingly toward prevention of complications of diabetes, it is important for clinicians to be familiar with the relationship between diabetes control and vascular injury.[79] Diabetes involves chronic levels of abnormally high glucose (hyperglycaemia). Many patients, especially those with type 2 diabetes; also have elevated blood pressure (hypertension), chronic high levels of insulin

(hyperinsulinemia) and unhealthy levels of cholesterol and other blood fats (hyperlipidaemia). All of these factors contribute to the long-term complications of diabetes.[80] Such as:

| Complication types | Diseases |
|---|---|
| Microvascular complications | Eye diseases (diabetic retinopathy, glaucoma, cataracts), diabetic nephropathy, diabetic neuropathy |
| Macrovascular complications | Cardiovascular disease, cerebrovascular disease, peripheral arterial disease |
| Micro and macrovascular complications | Diabetic foot ulcer |
| Acute metabolic complications | Diabetic ketoacidosis, hypoglycaemia, Hyperosmolar hyperglycaemic non-ketotic state |
| Miscellaneous complications | Impaired thinking, cancer, musculoskeletal disorders, pregnancy complications, insulin shock, emotional difficulties |

### *1. Microvascular Complications of Diabetes*

**Eye diseases**

These include diabetic retinopathy, glaucoma and cataracts. Diabetes is a leading cause of visual impairment and blindness.[80] Diabetic retinopathy may be the most common microvascular complication of diabetes. It is responsible for ~ 10,000 new cases of blindness every year in the United States alone.[81] The risk of developing diabetic retinopathy or other microvascular complications of diabetes depends on both the duration and the severity of hyperglycaemia. Development of diabetic retinopathy in patients with type 2 diabetes was found to be related to both the severity of hyperglycaemia and the presence of hypertension in the U.K.[79] Diabetic retinopathy is the most frequent cause of new cases of blindness among adults aged 20-74 years. Diabetic retinopathy can progress from mild non proliferative abnormalities, to moderate and severe non proliferative diabetic retinopathy, and finally, to proliferative diabetic retinopathy.[81]

**Diabetic nephropathy**

Diabetic nephropathy is the leading cause of renal failure in the United States. It is defined by proteinuria of > 500 mg in 24 hours in the setting of diabetes, but this is preceded by lower degrees of proteinuria, called "micro albuminuria." Micro albuminuria is defined as albumin excretion of 30–299 mg/24 hours. Without intervention, diabetic patients with micro albuminuria typically progress to proteinuria and overt diabetic nephropathy. This progression occurs in both type 1 and type 2 diabetes. As many as 7% of patients with type 2 diabetes may already have micro albuminuria at the time they are diagnosed with diabetes. In the European Diabetes Prospective Complications Study, the cumulative incidence of micro albuminuria in patients with type 1 diabetes was ~ 12% during a period of 7 years. In the UKPDS, the incidence of micro albuminuria was 2% per year in patients with type 2 diabetes, and the 10-year prevalence after diagnosis was 25%.[79]

**Diabetic neuropathy**

Diabetic neuropathy is recognized by the American Diabetes Association (ADA) as "the presence of symptoms and/or signs of peripheral nerve dysfunction in people with diabetes after the exclusion of other causes."[15] As with other microvascular complications, the risk of developing diabetic neuropathy is proportional to both the magnitude and duration of hyperglycaemia, and some individuals may possess genetic attributes that affect their predisposition to developing such complications.[79] Diabetic peripheral neuropathy (DPN) is one of the most prevalent and complicated conditions to manage among diabetic patients. About 60% to 70% of people with diabetes have mild to severe forms of nervous system damage; resulting in impaired sensation or pain in the feet or hands, slowed digestion of food in the stomach, carpal tunnel syndrome, precursor for foot ulcers, and other nerve problems. Diabetes is the major contributing reason for non-traumatic lower extremity amputations (more than 60% of cases). The most common form of DPN involves the somatic nervous system; the autonomic nervous system may be affected in some patients.

### *2. Macrovascular complications of diabetes*

Diabetes exerts a heavy toll on the vascular system. The hallmark of diabetic macrovascular disease is accelerated by atherosclerosis involving the aorta and large and medium-sized arteries. Macrovascular disease causes accelerated atherosclerosis among diabetics, resulting in increased risk of myocardial infarction, stroke, and lower-extremity gangrene. Macrovascular complications associated with diabetes include cardiovascular, cerebrovascular, and peripheral arterial diseases.

**Cardiovascular disease (CVD)**

People with diabetes are 2 to 4 times more likely to develop cardiovascular disease (CVD) than those without diabetes. Diabetes increases the risk that an individual will develop cardiovascular disease (CVD). Although the precise mechanisms through which diabetes increases the likelihood of atherosclerotic plaque formation are not completely defined, the association between the two is profound. CVD is the primary cause of death in people with either type 1 or type 2 diabetes.[82] In fact, CVD accounts for the greatest component of health care expenditures in people with diabetes.[79]

**Cerebrovascular disease**

Cerebrovascular disease is a term encompassing many disorders that affect the blood vessels of the central nervous system. These disorders result from either inadequate blood flow to the brain (i.e., cerebral

ischemia) or from haemorrhages into the parenchyma or subarachnoid space of the central nervous system (CNS). Diabetes is also a strong independent predictor of risk of stroke as in coronary artery disease. Patients with type 2 diabetes have a much higher risk of stroke, with an increased risk of 150–400%. Risk of stroke-related dementia and recurrence, as well as stroke-related mortality, is elevated in patients with diabetes.[79]

**Peripheral Arterial Disease**

Peripheral arterial disease (PAD) is an atherosclerotic occlusive disease. It is the major risk factor for lower extremity amputations. The abnormal metabolic state accompanying diabetes results in changes in the state of arterial structure and function predisposing people to PAD. The risk of development of PAD increases threefold to fourfold in patients with diabetes mellitus.

***3. Diabetic foot ulcers***

Diabetic foot ulcers and infections are responsible for >30% of the hospitalisations related to diabetes mellitus. 25% of people with diabetes mellitus are estimated to develop a foot ulcer during their lifetime. Diabetic foot ulceration is also an expensive complication of diabetes mellitus, owing to both medical care and on account of time lost from work and loss of income and financial independence [83],[84].

***4. Acute metabolic complications***

**Diabetic ketoacidosis**

A lack of insulin can force the body to burn fats instead of glucose for energy. The result is a toxic byproduct called ketones, along with severe hyperglycaemia.[80]

**Hyperosmolar hyperglycaemic nonketotic state**

This involves severe hyperglycaemia and dehydration.[80]

**Hypoglycaemia**

Hypoglycaemia is common in insulin-treated diabetic patients and also occurs occasionally in patients treated with the oral hypoglycaemic sulfonylurea agents. Hypoglycaemia may range from very mild lowering of glycaemia (60-70 mg/dl) with minimal or no symptoms, to severe hypoglycaemia with very low ant levels of glucose (<40 mg/dl) and neurologic impairment.[80]

***5. Miscellaneous complication***

**Impaired thinking**

Many studies have linked diabetes to increased risk of memory loss, dementia, Alzheimer's disease and other cognitive deficits. Recently some researchers have suggested that Alzheimer's disease might be "type 3 diabetes," involving insulin resistance in the brain.[80]

**Cancer**

Diabetes increases the risk of malignant tumors in the colon, pancreas, liver and several other organs.[80]

**Musculoskeletal disorders**

Conditions ranging from gout to osteoporosis to restless legs syndrome to myofascial pain syndrome are more common in diabetic patients than non-diabetics.[80]

**Pregnancy complications**

Diabetes increases the risk of preeclampsia, miscarriage, stillbirth and birth defects.[80]

**Emotional difficulties**

Many but not all of the studies exploring connections between diabetes and mental illness have found increased rates of depression, anxiety and other psychological disorders in diabetic patients. In addition to chronic hyperglycaemia, diabetic patients can experience acute episodes of hyperglycaemia as well as hypoglycaemia (low glucose). Severe cases can cause seizures, brain damage and a potentially fatal diabetic coma.[80]

**Insulin shock**

This advanced stage of hypoglycaemia is typically due to excessive amounts of insulin medication or certain anti diabetic agents.[80]

## ROLE OF DIET AND LIFE STYLE MANAGEMENT IN DIABETES

Lifestyle management is a fundamental aspect of diabetes care and includes diabetes self-management education (DSME), diabetes self-management support (DSMS), nutrition therapy, physical activity, smoking cessation counselling, and psychosocial care. Patients and care providers should focus together on how to optimize lifestyle from the time of the initial comprehensive medical evaluation, throughout all subsequent evaluations and follow-up, and during the assessment of complications and management of comorbid conditions in order to enhance diabetes care.[85]

**1. Diabetes self-management education and support:**

In accordance with the national standards for diabetes self-management education and support, all people with diabetes should participate in diabetes self-management education to facilitate the knowledge, skills, and ability necessary for diabetes self-care and in diabetes self-management support to assist with implementing and sustaining skills and behaviours needed for on-going self-management, both at diagnosis and as needed thereafter. Diabetes self-management education and support should be patient centered, respectful, and responsive to individual patient preferences, needs, and values and should help guide clinical decisions. DSME focuses on supporting patient empowerment by providing people with diabetes the tools to make informed self-management decisions.[85,86] Diabetes care has shifted to an approach that is more patient centered and places the person with diabetes and his or her family at the centre of the care model, working in collaboration with health care professionals. Patient-centered care is respectful of and responsive to individual patient

preferences, needs, and values. It ensures that patient values guide all decision making.[85]

**2. Nutrition therapy:** For many individuals with diabetes, the most challenging part of the treatment plan is determining what to eat and following a food plan. There is not a one-size-fits-all eating pattern for individuals with diabetes. Nutrition therapy has an integral role in overall diabetes management, and each person with diabetes should be actively engaged in education, self-management, and treatment planning with his or her health care team, including the collaborative development of an individualized eating plan.[85]

**Component of a Diabetic Diet**
(2006 Position Statement of the American Diabetes Association).

| | **% of Total Daily Calories Intake** | **Remarks** |
|---|---|---|
| Carbohydrate | 45 –65 % (55%) | -Type and amount of CHO are both important<br>-Greatest impact on blood sugar |
| Protein | 12 –20 % (15%) | -Patients with nephropathy should limit protein to <10% |
| Fat | 25 –35% (30%) | -Monounsaturated & Omega-3 fatty acids are the best types<br>-Limit Saturated fat to < 7%<br>-Minimize trans-fatty acids |

**3. Carbohydrates:** The optimal and normal carbohydrate to lipid ratio in diet is a major challenge considering its role to prevent chronic diseases such as type 2 diabetes. In a study conducted by Richard et al. it was observed that reduced dietary fat intake and increased intake of carbohydrates prevent the incidence of chronic diseases. Some studies demonstrated that increased intake of carbohydrates reduced the incidence of diabetes.[88] However, several studies reported that increased carbohydrate intake would decrease HDL levels and increase fasting plasma TG concentrations. These data suggested that increased carbohydrate intake increases the secretion of insulin to maintain insulin homeostasis, and a high carbohydrate intake, leading to insulin secretion, is associated with receiving energy that causes higher levels of insulin after a meal. Insulin secretion with high output may be associated with age-related decline in insulin secretion, resulting in a more rapid development of diabetes. It was reported that dietary fibre, particularly soluble fibre, improves the postprandial glycaemic response and insulin concentration through slowing down the digestion and absorption of food and creating a gel-like substance in the stomach by several metabolic hormones. Several studies have shown that glycaemic control is improved and LDL cholesterol decreases with relatively high carbohydrate, low fat diets including naturally occurring fibre-rich foods compared with relatively low carbohydrate, higher fat diets. Clinical studies on glycaemic index and glycaemic load also showed that the form and content of carbohydrate and fat intake may be effective in short-term glycaemic response. WHO/FAO recommended to get at least 55% of energy intake form carbohydrate in normal people. Hence, there are no specific carbohydrate guidelines to prevent diabetes.[87]

By choosing appropriate portions of carbohydrate containing foods and selecting ones that have more fibre and a **lower glycaemic index**, will help to improve blood glucose control. Glycaemic index is a scale (0-100) ranking how quickly a carbohydrate containing food will digest into glucose in our blood. **High GI foods** breakdown quickly whereas **low GI foods** break down slowly. With low GI foods one will feel full longer and body's insulin has more time to perform its job and remove glucose from the blood.[89]

**GI=glycaemic index**

| **Low GI foods (55 Or Less) Choose most often** | **Medium GI foods (56-69)** | **High GI foods (70+) Choose less often** |
|---|---|---|
| Whole grain | bread Couscous | White bread |
| Pumpernickel bread | Rye bread | Instant mashed potatoes |
| Oatmeal | Instant Oatmeal | Rice Krispies |
| All-Bran cereal | Shredded Wheat | Refined, sweetened cereals |
| Converted rice | Cream of Wheat | Instant rice |
| Brown & Basmati rice | Whole grain crackers | Bagels |
| Bulgur, Barley, Quinoa | Pita bread | Waffles/pancakes – made with white flour |
| Beans, peas, lentils | Apricot, banana | French fries |
| Apples, peaches, pears | Cantaloupe | Dried dates/figs |
| Firm cooked pasta | Long grain white rice | Soda crackers |
| Grapefruit, oranges | Pineapple, raisins | Sweetened fruit juice |
| Berries, cherries, grapes | Canned fruit in juice | Parsnips, pumpkin |
| Kiwi, Mango, Plum | Cranberry juice | Rutabaga, turnip |
| Avocado | New potatoes | Broad beans |
| Sweet Potato | Beets | Refried beans |
| Carrots, broccoli | Sweetened condensed milk | Ice cream |
| Cauliflower, corn | | Soft drinks |
| Leafy vegetables | | Glucose |
| Low fat milk, soymilk, yogurt and cottage cheese | *Adapted from "The GI Diet" Rick Gallop | |

**4. Fat:** Quality and quantity of dietary fat affect glucose tolerance and insulin sensitivity. A high fat diet may cause glucose intolerance through several mechanisms, including lowering insulin binding to its receptors, degradation of glucose transport, reducing TG synthesis, and accumulation of stored triglycerides in skeletal muscles. The fatty acids composition may be related to insulin function through its effect on composition of membrane's phospholipids, which in turn affect membrane fluidity and insulin signalling.[87]

A high fat diet is a good predictor of developing IGT in healthy people as well as IGT development to type 2 diabetes. High intake of total fat is associated with increased fasting insulin concentration and decreased insulin sensitivity index.[87]

Intake of saturated fatty acids, monounsaturated and polyunsaturated fatty acids except for the n-3 fatty acids, led to insulin resistance when consuming a high-fat diet. Epidemiological studies suggested that high intake of saturated fat is associated with the risk of IGT and increased fasting glucose and insulin levels. The higher proportion of saturated fatty acids in serum lipids or phospholipids in muscles associated with higher fasting insulin levels would reduce insulin sensitivity and increase the risk of type 2 diabetes. Higher intake of vegetable fat and PUFA reduces the risk of type 2 diabetes as well as decreased fasting plasma glucose concentration and the two-hour glucose concentration.[87] In general, trans fats should be avoided.[85]

**5. Protein:** There is no evidence that adjusting the daily level of protein ingestion (typically 1–1.5 g/kg body weight/day or 15–20% total calories) will improve health in individuals with diabetic kidney disease, and research is inconclusive regarding the ideal amount of dietary protein to optimize either glycaemic control or CVD risk. Therefore, protein intake goals should be individualized based on current eating patterns. Some research has found successful management of type 2 diabetes with meal plans including slightly higher levels of protein (20–30%), which may contribute to increased satiety. For those with diabetic kidney disease (with albuminuria and/or reduced estimated glomerular filtration rate), dietary protein should be maintained at the recommended daily allowance of 0.8 g/kg body weight/day.[85]

**6. Mediterranean Diet and Diabetes:** Mediterranean diet was introduced for the first time in 1960s by Ancel Keys through observing food habits of Mediterranean populations. The Mediterranean dietary pattern emphasizes a consumption of fat primarily from foods high in monounsaturated fatty acids and mainly olive oil and encourages daily consumption of fruits, vegetables, low fat dairy products and whole grains, weekly consumption of fish, poultry, tree nuts, legumes, monthly consumption of red meat, as well as a moderate consumption of alcohol, high ingestion of dietary fibre, antioxidants, polyphenols and magnesium.[87,90] In addition, it normally contains meals, but the proportions of macronutrients may vary. There is no single Mediterranean diet, although the dietary patterns in the Mediterranean region have many common characteristics. The Mediterranean diet is one of the best-known food patterns for the human health. The Mediterranean diet has beneficial effects for the prevention of type 2 diabetes. These effects include reduced oxidative stress and insulin resistance. Mediterranean diet can act as an anti-inflammatory dietary pattern able to maintain or treat chronic diseases, such as type 2 diabetes.[87]

**7. Obesity management:** There is strong and consistent evidence that obesity management can delay the progression from prediabetes to type 2 diabetes and may be beneficial in the treatment of type2 diabetes. In overweight and obese patients with type2 diabetes, modest and sustained weight loss has been shown to improve glycaemic control and to reduce the need for glucose-lowering medications. Small studies have demonstrated that in obese patients with type 2 diabetes more extreme dietary energy restriction with very low-calorie diets can reduce A1C to,6.5% (48 mmol/mol) and fasting glucose to, 126mg/dL (7.0mmol/L) in the absence of pharmacological therapy or on-going procedures. Body weight management is important for overweight and obese people with type 1 and type 2 diabetes. Lifestyle intervention programs should be intensive and have frequent follow-up to achieve significant reductions in excess body weight and improve clinical indicators. There is strong and consistent evidence that modest persistent weight loss can delay the progression from prediabetes to type 2 diabetes and is beneficial to the management of type 2 diabetes.[85]

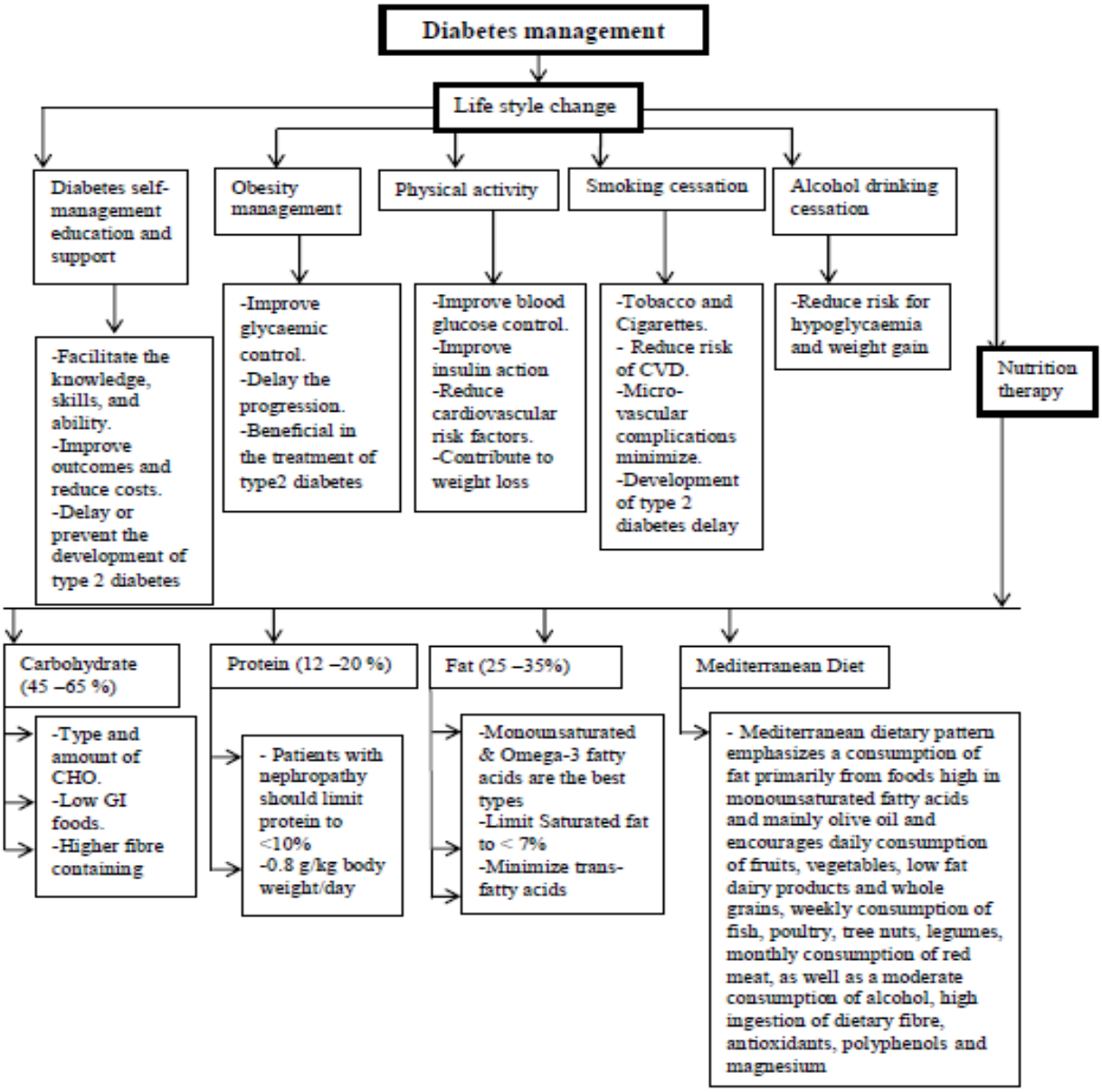
**8. Physical activity:** Physical activity is a general term that includes all movement that increases energy use and is an important part of the diabetes management plan. Exercise is a more specific form of physical activity that is structured and designed to improve physical fitness. Both physical activity and exercise are important. Exercise has been shown to improve blood glucose control, reduce cardiovascular risk factors, contribute to weight loss, and improve well-being. Physical activity is as important for those with type 1 diabetes as it is for the general population, but its specific role in the prevention of diabetes complications and the management of blood glucose is not as clear as it is for those with type 2 diabetes.[85]

Numerous studies have shown an association between physical inactivity and the incidence of type 2 diabetes. Exercise has a significant role in the regulation of blood glucose, metabolism of proteins and fats, improvement of insulin action, prevention of complications of diabetes, improvement of muscle flexibility and strength, beneficial effects on the cardiovascular system activity is beneficial for the mental state of individual, because it increases the energy of the human body, improves self-

esteem and decreases depression. The basis of a useful exercise is its intensity, duration and frequency. The duration of the exercise should be 30 minutes in the beginning, starting with 5-10 minutes of warm-up and ending always with recovery exercises. The lower frequency recommended is 3 times/wk. Usually low intensity and long-duration exercise programs are considered as the most appropriate and safe patterns for patients with diabetes.[87]

**9. Smoking cessation: Tobacco And Cigarettes:** Results from epidemiological, case-control, and cohort studies provide convincing evidence to support the causal link between cigarette smoking and health risks. Recent data show tobacco use is higher among adults with chronic conditions. Other studies of individuals with diabetes consistently demonstrate that smokers (and people exposed to second hand smoke) have a heightened risk of CVD, premature death, and micro-vascular complications. Smoking may have a role in the development of type 2 diabetes. One study in smokers with newly diagnosed type 2 diabetes found that smoking cessation was associated with amelioration of metabolic parameters and reduced blood pressure and albuminuria at 1 year.[85]

**10. Psychosocial issues-** Emotional well-being is an important part of diabetes care and self-management. Psychological and social problems can impair the individual's or family's ability to carry out diabetes care tasks and therefore potentially compromise health status.[85]



**Diet chart for dietetic patient (Thin person)**

| Time | Diet content |
|---|---|
| 7.00-8.00 am | Wheat flour bread- 90 gm (3 small sized)<br>Egg- 1 or lentils- 15 gm<br>vegetable- Spinage, cauliflower, capsicums, cucumber, papaya, tomato, radish, chilli, gourd (any one from this) |
| 11.00 am | Parched rice (1 cup), biscuit etc- 30 gm<br>Fruits- coconut water, emblica, hog plum, lemon, rose apple, grape fruit, star fruit, melon etc (any one from this) |
| 1.00-2.00 pm | plain rice 3oo gm (2.5 cup)<br>Meat or fish- 60 gm (2 pieces)<br>Lentils- 20 gm (1 medium sized cup)<br>Vegetables-spinach, capsicum, cauliflower, chilli, gourds, cucumber, papaya, turnip, tomato, pumpkin, drumstick (any one from this)<br>or potato, sweet pumpkin, edible root, beetroot, kidney bin, cowpea (any one from this) |
| 5.00-6.00 pm | Parched rice (1 cup), biscuit etc- 30 gm |
| 8.00-9.00 pm | Wheat flour bread-120 gm (4 small sized) or plain rice- 2 cup<br>Meat or fish- 60 gm (2 pieces)<br>Lentils- 20 gm (1 medium sized cup)<br>vegetable- Spinage, cauliflower, capsicums, cucumber, papaya, tomato, radish, chilli, gourd (any one from this) |

***Note***- Calory-1800 (Carbohydrate-280 gm ;Protein- 70 gm ; Fat- 46 gm)

**Diet chart for dietetic patient (Obese person)**

| Time | Diet content |
|---|---|
| Breakfast | Wheat flour bread- 2 small sized<br>Egg- 1(without egg yolk) or lentils |
| Lunch | Parched rice (1 cup)<br>Meat (2 pieces) or fish (1 piece) or lentil or vegetable |
| Supper | Wheat flour bread- 3 small sized<br>Lentils or vegetables or fish or meat (1 pece) |
| Fruits | Banana (1) or mango (1 piece) or jackfruit (3/4 pieces) or small apple (1) or orange (1) |
| Milk | 1 glass (without milk cream) |

## CONCLUSIONS

The present study reveals that traditional ethno-botany practices still play a very important role. Ethno-botany practices not only play an important role of primary health care but also play a vital role of conservation of phytodiversity and cultural diversity. Based on the observations, it is expected that the results of this study will lead to phytochemical and pharmacological investigations. The result could also serve as a base to develop phytomedicine in combating diseases. However, many other active agents obtained from plants have not been well characterized. More investigations must be carried out to evaluate the mechanism of action of medicinal plants with anti-diabetic effect.

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