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# Scientific alternative approach in Diabetes-An overview

## Munish Garg*[1] and Chanchal Garg[2]

[1]*Assistant Director, All India Council for Technical Education, East tower, NBCC Place, Lodhi Road, New Delhi-110003, India.*
[2]*Department of Pharmachemistry, Faculty of Pharmacy, Jamia Hamdard, New Delhi-110062, India.*
** Address for correspondence: 011-24369633 ; 09958659859 ; mgarg2006@gmail.com*

**Abstract**
Several attempts have been made in search of a suitable formulation for diabetes mellitus all over the world. Although, allopathic treatment helps to control the disease to an extent but regular medication and constant medical supervision always leads to non patient compliance and compels them to look for alternative measures. Out of them, herbal drugs seem to be promising, as scientific analysis of several plants reveal that they possess enormous therapeutic capabilities that modern medicines is searching for. Moreover, due to affordability especially in developing countries where resources are meager and where the coverage by health service is limited, more and more researchers are now working in this direction. This paper provides a general account of dietary management, physical activity with main focus on scope of herbal drugs and a comprehensive analysis of plants with proven antidiabetic activity that may provide insights for future study and development of herbal drugs in modern scientific perspective.
**Key words:** *diabetes, dietary management, physical activity, antidiabetic plants.*

**Introduction**
Diabetes mellitus is a global disease found in all nations of the world. There has been an explosive increase in the diabetics in the last two to three decades. Diabetes has become a major health concern worldwide with over 190 million suffering from disease now with a potential to have 324 million by 2025. Type 2 constitutes 90 % of the total diabetics in most countries with nearly 80% of the burden in developing countries (1). Particularly in India, there are currently 50 million people with diabetes, which is projected to increase by 90 million in the 2030. The fear of diabetic epidemic looms with statements in the press that read as "every fifth Indian and every fifth diabetic will be an Indian". The fact confirmed by reports from the World Health Organization (WHO) shows that India has the largest number of diabetic subjects in the world.
Diabetes mellitus is caused either by a lack of the hormone insulin (Type 1 diabetes) or the body's inability to use insulin (Type 2 diabetes). Type 2 diabetes is often triggered by obesity, stress and a sedentary life style. Since the drug therapy, whether using hypoglycemic agents or insulin, is costly, have side effects and keeps the diabetic individuals under constant medical supervision and the impression of being sick. These evidences have triggered the search for safe and effective alternatives. This paper reviews the alternative therapies adopted by people with main focus on history, use, scientific evidence, scope and future of herbal drugs in the management of diabetes.

**Dietary management in diabetes**
The diet therapy is the most natural, economical and more feasible. The proper intake of diet in diabetes improves the digestive power increases gastric secretions, gets easily digested in the body, and decreases the output of overall body fluids e.g. urine, sweat etc. Thus, the use of food items which are "madhu mehaghna" (antidote) is an important underlying principle of therapy for the diabetic patient. Aahar chiketsa (dietary management) is highly effective in early use of diseases and in case of non insulin dependent diabetes mellitus (NIDDM) which is directly related to diet. Diet high in simple carbohydrates and fat usually results in type-2 diabetes mellitus in the later stages of life. Also many patients with type-II diabetes mellitus can be controlled by diet alone without the use of hypoglycemic agents or insulin. Therefore, for proper management of diabetes individuals, the diet must be designed to supply adequate amount of nutrients namely carbohydrates, fats, proteins, vitamins and minerals (2).
High carbohydrate diet increases the sensitivity of peripheral tissues to both endogenous and exogenous insulin. Such diet improves glucose tolerance and lowers the level of serum insulin. In addition, the liberalization of carbohydrate might facilitate the reduction of saturated fatty acids and cholesterol in the diabetic diet (3). Diets that enhance glycemic controls are high in dietary fiber, low to moderate in dietary fat and moderate in high biological value proteins. Decreasing caloric intake for NIDDM patients results in weight reduction which is beneficial for diabetics (4). Very low energy diets produce greater improvement in glycemic control than more moderate diets in obese type-2 diabetes, even if weight losses are the same (5). Reduction in total and saturated fat and limited protein intake with replacement by complex carbohydrate and/or monosaturated fatty acids are the recommended diets for NIDDM. Such diets improve the metabolic control in diabetic individuals and reduce the risk of chronic complications (6). Decrease in energy and saturated fat intake help in NIDDM control. Diet that contains 60% carbohydrates and is rich in fiber improves blood sugar and lipid (7).
Thus, dietary manipulation is the first line of therapy for diabetic patients. Dietary strategies should aim to normalize the blood glucose and lipoprotein levels in order to reduce

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morbidity and mortality related to derangement of carbohydrates and lipoprotein metabolism in diabetes mellitus. To achieve these goals, quantity and quality of diets must be considered according to each individual and his clinical conditions.

**Role of physical activity in diabetes**

Regular physical activity is an essential component of management in persons with type-II diabetes. A careful assessment of an individual should be made by physician, while incorporating an exercise programme in the management. Exercise programme should be individualized according to individual capacity and disabilities. The person with diabetes must wear appropriate footwear.

The best form of exercise recommended to a diabetic is a stepwise increase of aerobic exercises. There are several benefits from a regular exercise schedule. These include improvement in insulin sensitivity, reduction of hypertension, reduction in weight, improvement in lipid profile (reduces serum triglycerides and increases HDL particularly HDL-2 cholesterol), improvement in cardiovascular function, increase in bone density, improvement in the sense of physical and mental well-being and improvement in the quality of life (8).

- Exercise must be done regularly.
- Brisk walk for 30-60 minutes or its equivalent physical activity.
- An exercise schedule should be one that the individual enjoys and which suits his/her needs.

The practice of yoga is traditional system, which is now gaining international acceptance of stress coping skills. Some of the aspects used in yoga are Asanas (involving postures), Pranayama (involving breath), Dhyana (involving meditation) and Bhavan (involving visualization which is also a part of dhyana). There are several studies done in our country, which have shown the role of yoga practices in the management of diabetes (9).

**Herbal treatment of diabetes**

In spite of the introduction of hypoglycemic agents, diabetes and its related complications continue to be a major medical problem since time immemorial. Patients with non-insulin dependent diabetes mellitus have been treated orally by folklore with a variety of plants extracts in the indigenous Indian system of medicine (Ayurveda). A mention was made on good number of plants for the cure of diabetes or madhumeha and some of them have been experimentally evaluated and the active principles were isolated in India (10-16). Such plants and remedies mentioned and used for the treatment of diabetes mellitus date back to the ancient authorities like Bhrigu, charaka, sushruta and vagbatta, the last three called vriddha-trayi of Ayurveda (17).

Medicinal plants play an important role in the management of diabetes mellitus especially in developing countries where resources are meager and where the coverage by health service is limited. The majority of the population when sick receive the treatment which is large by based on the use of medicinal plants or herbal drugs thus, the field of herbal medicines research has been gaining significant importance and the demand to use natural products in the treatment of diabetes in the increasing. So the pendulum is swinging back and the value of medicinal plants in the treatment is receiving attention.

A comprehensive approach was drawn by world health assembly. This was to include:

- A therapeutic classification of medicinal plants in different countries.
- Scientific criteria and methods for assessing the safety of medicinal plants products.
- International standards and specification for identity purity, strength and manufacturing practices.
- Methods for safe and effective use of medicinal plants products.
- Designation of research and training centre for the study of medicinal plants.

Plants based drugs can be used directly i.e. they may be collected, dried and used as therapeutic agents (crude drugs), or their constituents/active principles separated by various chemical processor which are employed as medicines. The phytochemicals identified from traditional medicinal plants are presenting an exciting opportunity for the development of new types of therapeutics (18). This has accelerated the global effort to harness and harvest those medicinal plants that bear a substantial amount of potential photochemical showing multiple beneficial effects in combating diabetes and diabetes-related complications.

Moreover, during the past few years some of the new bioactive drugs isolated from hypoglycemic plants showed antidiabetic activity with more efficacy than oral hypoglycemic agents used in clinical therapy. Many ethnobotanical surveys on medicinal plants used by the local population have been performed in different parts of the world including Morroco, Saudi Arabia, Taiwan, Trinidad and Tobago (19-24). A number of reviews have been published on plants screened for hypoglycemic activity in India (25-35). Two exhaustive reviews have been published based on global literature survey on 150 plants and 343 plants from different parts of the world (36, 19).

**Global market, regulations and acceptance of herbal drugs**

The global pharmaceutical market was worth US $550 billion in 2004 (37) and is expected to exceed US $1100 billion by the year 2010. The herbal industry shares about US $100 billion with good growth potential. The World Bank report trade in medicinal plants, botanical drugs products and raw materials is growing at annual growth rate of about 15% (WHO). Within the European community botanical medicine represents an import share of the pharmaceutical market (38). In 2001 US $ 17.8 Billion was spent in the united states on natural remedies (39). In India, the value of botanicals related trade is about US $10 billion per annum with annual export of US $1.1 billion (40) while china's annual herbal drug production is worth US $48 billion with export of US $3.1 billion (41). Presently, the United States is the largest market for Indian botanical products accounting for about 50% of the total exports. Out of this, only 40 per cent is value addition and 60 per cent is export of raw medicinal plant. Hence it is

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proposed that in future we should decrease exporting raw medicinal plant and export only value-added products to realise higher earnings. Japan, Hong Kong, Korea and Singapore are the major importer of Traditional Chinese medicine taking 66% share of China's botanical drugs export.

Globally, there have been concerted efforts to monitor quality and regulate the growing business of herbal drugs and traditional medicine. Health authorities and governments of various nations have taken an active interest in providing standardized botanical medication United States congress has fuelled rapid growth in the nutraceutical market with passage of the Dietary Supplement Health and Education Act in 1994. US Food and Drug Administration (FDA) has recently published the International Conference on Harmonization guidance Common Technical Document addressing concerns related to quality of medicines that also include herbals (42). The National Centre for Complementary and Alternative medicine has been inaugurated as the United States Federal Government's lead agency for scientific research in this area of medicine World Health Organization (WHO) is also been regarding traditional medicine and has been active in creating strategies, guidance and standards of botanical medicines (43, 44). Thus, the global scenario illustrates vividly both promise and challenges presented by the traditional medicines.

**Safety and quality of herbal drugs**

In India, about 9000 licensed units manufacture traditional medicines with or without proper standardization (45).

Most of the Indian manufactures do not follow WHO guidelines for quality control. Thus, adulteration of market samples remains a major problem in domestic and export market of Indian herbal products. Therefore, the government of India has promulgated GMP regulations for traditional systems of medicines to improve the quality and standards of Ayurvedic, Siddha and Unani drugs in Pharmacies. New rules regarding essential infrastructure manpower and quality control requirements came into force from 2000 and form part of the Drugs and cosmetic Act 1940 (46). Licensing of Ayurvedic medicine is also governed under Drug and Cosmetic Act 1940. Ayurvedic patent and proprietary medicine need to contain only the ingredients mentioned in the recommended books and specified in the Act. For any new herbal medicine, safety and efficacy data are mandatory. Depending on the nature of herbals and markets availability, different requirements exist for submission of clinical trial and safety data.

**Conclusion**

A comprehensive herbal drug therapeutic regimen thus offers time tested safe and effective support to conventional therapy in the management of diabetes. This is combination with adequate dietary management and physical activity would provide an integrated approach to the management of this deadly disease, particularly Type 2 diabetes. Additionally, due to unlimited potential of herbal drugs for innovative bioactive molecules, all efforts should be made to adopt a package of best practices encompassing conservation, cultivation, quality control, standardisation and research and development for medicinal plants and herbals.

***Table: List of Plants with Antidiabetic activity***

| Common Name | Botanical Name and Family | Parts Used | Active Constituents | Therapeutic Action | Ref |
|---|---|---|---|---|---|
| Bitter apple, Bitter cucumber, | *Citrullus colocynthis* Schard (Cucurbitaceae) | Rind of the plant | Glycosides and saponins | Decreases hyperglycemia. | 47 |
| Cabbage tree | *Anthocleista voglii* (Logoniaceae) | Root | ----- | Decreases blood glucose. | 48 |
| Gambol, Jamun, Black plum, berry, Jambul. | *Eugenia jambolana* Lam. / *Syzigium cumini* Skeels. (Myrtaceae) | Pulp/ seeds | Jamboline-a glucoside | Prevents pathological conversion of starch to glucose. Increases insulin secretion , inhibits insulinase activity from liver and kidney. | 49 - 51 |
| Banyan tree | *Ficus bengalensis* (Moraceae) | Bark infusion | Dimethoxy derivative of perlargonidin-3-o-α-L-rhamnoside, glucosides of leuco perlargonidin | Inhibits insulinase activity from liver and kidney and stimulates insulin secretion. | 52 - 55 |
| Bitter-kola, Malabar tamarind, false kola | *Garcinia kola* (Clusiaceae) Guttiferae | Seed | Kolaviron, a biflavonoid complex | Hypoglycaemic and hypolipidemic. | 56 |
| Mango | *Mangifera indica* (Anacardiaceae) | Extract of leaves | ----- | Hypoglycemic. Acts by reducing the intestinal absorption of glucose | 57 |

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| Holy basil | *Ocimum album* Roxb. (Lamiaceae) | Leaves | Volatile oil. | Decrease in fasting and postprandial glucose levels. | 58 |
| Barbados | *Aloe barbadensis* Mill. (Liliaceae) | Exudates of leaves | Bitter principles | Act by stimulating synthesis and/or release of insulin from β-cells of islets of langerhans. | 59, 60 |
| Devil's horsewh ip, Prickly chaff flower | *Achyranthes aspera* (amaranthaceae) | Whole plant | ---- | Hypoglyglycemic action by providing necessary elements like Ca, Zn, Mg, Mn, and Cu to the β-cells. | 61 |
| Banana | *Musa sapientum* Kuntze (Musaceae) | Fruits / flowers | Tannins. | Decreases hyperglycemic peak and area under the glucose tolerance curve, decreases blood glucose and glycosylated haemoglobin level and increases total haemoglobin. | 62, 63 |
| Olive leaf | *Olea europea* L. (Oleaceae) | Leaf | Oleuropeoside | Acts by potentiation of glucose induced insulin release and also by increased peripheral uptake of glucose | 64, 65 |
| ----- | *Bauhinia cheilandra* | Leaves | ----- | Hypoglycaemic. | 66 |
| White wormwood | *Artemisia herba-alba* (Compositae) | Aerial Parts | ----- | Decrease in Hyperglycaemia, prevention of elevated glycosylated haemoglobin levels and a hypolyposis effect. | 67 |
| Pigeon pea | *Cajanus cajan* Millsp. (Fabaceae) | Seed | ----- | Decrease in serum glucose level. | 68 |
| Delek air tree, Ironwood tree Anjan, Kaya | *Memecylon umbellatum* (Melastomaceae) | Leaves | ----- | Improves glucose tolerance | 69 |
| Ashvagandha, dunal, winter cherry | *Withania somnifera* (Solanaceae) | Roots | Withanolides | Decrease in blood glucose level. | 70 |
| Scouring Rush | *Equisetum myriochaetum* (Equisetaceae) | ----- | 3 kaempferol glucosides and one caffeoyl glucoside | Decreases glycaemia. | 71 |
| Saptrangi, Ponkoranti | *Salacia oblonga* Wall. (Hippcrateaceae) | Root bark | α- glucosidase inhibitor called kotalanol | Hypoglycemic. Inhibits α-glucosidase enzyme that digests starch in intestine. | 72 |
| Kirata | *Swertia chiraita* (Gentianaceae) | Bark | Xanthone named 1,8-dihydroxy-3,5-dimethoxy xanthone (swerchirin) | Decreases blood sugar. Acts by stimulating insulin release from the islets of langerhans. | 73, 74 |

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| Javanica | *Swertia japonica* (Gentianaceae) | Bark | 5- xanthones ,2-triterpenoids namely bellidifolin and thysanolactone respectively. | Hypoglycemic, decreases glucose concentration and blood triglyceride level, also stimulates glucose uptake. | 75, 76 |
| Spikenard | *Aralia cachemirica* Decne (Araliaceae) | Root | ----- | Hypoglycaemic | 77 |
| Nibima, kadze, and gangamau | *Cryptolepis sanguinolenta* (Asclepiadaceae) | Root | Cryptolepine- an indoloquinolone alkaloid | Decreases blood glucose concentration. | 78 |
| Honey grass, sweet plant, sugar leaf, Candyleaf, | *Stevia rebaudiana* Bertoni (Asteraceae) | Leaves | Stevioside, a glycoside | Antidiabetic. Increase insulin sensitivity in fructose rich chow-fed rats 67YU | 79 |
| Tulsi | *Ocimum sanctum* Linn. (Lamiaceae) | Leaves and leaf powder | Volatile oil. | Reduced glycemia. | 80, 81 |
| Vinca rosea | *Cantharanthus roseus* (apocynaceae) | Leaves | ----- | Marked lowering of glycaemia. | 82 |
| Neem, Indian liliac | *Azadirachta indica* (Meliaceae) | Leaf, bark, flowers, seed. | Bitter principles-nimbin, nimbinin, nimbidin 47 | The reduction in peripheral utilization of glucose and glycogenolytic effect due to epinephrine are blocked. Also blocks the inhibitory effect of serotonin on insulin secretion mediated by glucose. | 83, 84 |
| Folium mori, mulberry leaves | *Morus alba* L. (Moraceae) | ----- | ----- | Hypoglycemic. Acts by increase in glucose uptake. | 85 |
| ----- | *Rhodiola sachalinensis* (Crassulaceae) | Roots of the plant | ----- | Decrease in glycemia, liver glycogen, total blood lipids. | 86 |
| Loquat | *Eriobotrya japonica* Lindl. (Rosaceae) | | Sesquiterpene glycoside 3 and polyhydroxylated triterpenoids 5 and 6 | Decreases the area under the glucose tolerance curve and inhibition of glycosuria also decrease blood glucose level. | 87 |
| Velvet bean or cowhage | *Mucuna pruriens* (Fabaceae) | Seeds | D-chiro-inositol and its two galacto-derivatives | Antidiabetic. | 88 |
| Arugula, roquette | *Eruka sativa* (Brassicaceae) | Seed | ----- | Ameliorated hyperglycaemia, improved lipid profile. | 89 |
| ----- | *Strobilanthes crispus* (Acanthaceae) | Fermented and unfermented tea | Antioxidant and polyphenolic contents | Antihyperglycaemic and antilipidemic. | 90 |
| Dragon's blood, sacaca | *Croton cajucara* Benth | Bark | Trans- dehydrocrotonin (t-DCTN), a 19- nor clerodane | Hypoglycaemic. | 91 |

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| | (Euphorbiaceae) | | diterpene. | | |
| Jack fruit | *Atrocarpus heterophyllus* Lam. (Moraceae) | Leaves | ----- | Decrease in fasting blood glucose level and improves glucose tolerance. | 92 |
| Feathy bomboo | *Bambusa vulgaris* (Gramineae) | Whole plant | ----- | Decreases fasting glycaemia and improves glucose tolerance. | 92 |
| Kokilakchha | *Asteracantha longifolia* Nees. (Acanthaceae) | Whole plant | ----- | Improve glucose tolerance. | 93 |
| Indian Fig | *Opuntia ficus* (Cactaceae) | Stems | ----- | Decreases glycaemia. | 94 |
| Nopal | *Opuntia steptacantha* (Cactaceae) | Leaves and Stems | Fiber and pectin | Decreases blood glucose level, serum glucose and insulin concentration, decrease the area under the glucose tolerance curve. Enhances insulin sensitivity, pectin component may alter hepatic cholesterol metabolism | 95 |
| White orchid tree | *Bauhinia candicans* (Leguminosae) | Dried leaves | ----- | Shows in-vitro stimulatory effect of glucose uptake in isolated gastric glands of normal and alloxan diabetic rabbits. | 96 |
| Llareta | *Azorella compacta* Phil (Umbelliferae) | Whole plant | Diterpenoids- mulinolic acid, azorellanol and mulin-11,13-dien-20-oic acid | Acts on glucose utilization or production | 97 |
| Lantana, red sage, shrub verbena | *Lantana camara* (Verbenaceae) | Juice of leaves | ----- | Hypoglycemic. | 98 |
| Christ- thorn | *Zizyphus spina-christi* (Rhamnaceae) | Whole plant | A saponin glycoside – christinin A | Decreases the serum glucose level, liver phosphorylase and glucose -6- phosphatase activities, increases the serum pyruvate level and liver glycogen content. Also increases the glucose utilization and insulin and pancreatic cAMP levels. | 99 |
| Black tea | Camellia sinensis L. (Theaceae) | Leaves | Polyphenolic compounds. | Decreases blood glucose level. | 100 |
| Ginger, calamus, sweet ginger, ginger root, sonth(dried) | *Zingiber officinalis* (Zingiberaceae) | Fresh and dried root | ----- | Reduces body weight, glucose, insulin and lipid levels. | 101 |
| Agrimony | *Agrimony eupatoria* L. (Rosaceae) | Whole plant | ----- | Stimulated 2-deoxy glucose transport , glucose oxidation, incorporation of glucose into glycogen, and insulin secretion. | 102 |

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| Tasmanian Bleu gum | *Eucalyptus globulus* Labill. (Myrtaceae) | Leaves | ----- | Acts due to its pancreatic and extrapancreatic effects. | 103 |
| ____ | *Hintonia standleyana* | Stem bark | 4-phenylcoumarins and cucurbitacin glycosides | Antihyperglycemic. | 104 |
| Custard apple, sugar apple, sharifa | *Annona squamosa* (Annonaceae) | Fruit pulp | ----- | Improvement in glucose tolerance, decreased urine sugar, urine protein and glycohaemoglobin in diabetic rabbits. | 105 |
| Desert Indian wheat, Blond psyllium, Ispaghul Plantain | *Plantago ovata* (Plantaginaceae) | Aqueous extract of husks | Mucilage. | Reduces hyperglycemia in type 1 and 2 diabetes mellitus. Inhibits intestinal glucose absorption and enhancement of mobility. | 106 |
| Karela, Bitter gourd, balsam pear | *Momordica charantia* (Cucurbitaceae) | Fruits , leaves and roots | Momordicine –a bitter glucoside,charantin, vicine, and polypeptide-p | Decreases blood glucose levels. Acts like insulin or via insulin secretion from pancreas, increases glucose uptake. | 107, 108 |
| Ivy gourd, Tendli | *Coccinia indica* (Cucurbitaceae) | Fresh juice of leaves, fruits, stem or roots | Glucoside alkaloids, glucokenin | Acts by inhibiting glucose-6-phosphatase-key gluconeogenic enzyme, decrease in phosphorylase activity. | 109-111 |
| Chinese peony | *Paeonia lactiflora* Pall. (Ranunculaceae) | Dried roots | 8-dibenzoyl paeoniflorin and paeoniflorin | Decrease in blood sugar. Acts by increase in glucose utilization by paeoniflorin. | 112 |
| Moghat | *Glossostemon bruguieri* Desf. (sterculiaceae) | Root | ----- | Decrease in blood glucose level. | 113 |
| Gamazumi | *Viburnum dilatatum* Thumb. (Caprifoliaceae) | Fruit | Cyanidin 3- sambubioside (C3S) and 5-caffeol quinic acid (5-CAQ) | Antihyperglycaemic. Inhibits alpha-glucosidase activity. | 114 |
| Gulnar farsi | *Punica gratum* L. (Punicaceae) | Flowers | ----- | Antidiabetic. | 115 |
| Sandspurry | *Spergularia purpurea* (Caryophyllaceae) | Whole plant | ----- | Decreases glycaemia. | 116 |
| Native Armenian plant | *Bryonia alba* (Cucurbitaceae) | Root | Trihydroxyoctadecadienoic acid | Hypoglycemic along with restoration of disordered lipid metabolism. | 117 |
| Leaf Mustard | *Brassica juncea* (Brassicaceae) | ----- | ----- | Acts by decreasing the activity of glycogenphosphorylase and | 118 |

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| | | | | gluconeogenic enzymes. | |
| Cinnamon | *Cinnamomi cassiae* (Lauraceae) | Bark | ----- | Improves insulin sensitivity or slows the absorption pf carbohydrates in small intestine | 119 |
| Chamomile, manzanilla, lawn chamomile | *Chamaemelum nobile* (Compositae) | ----- | 3-hydroxy-3-methylglutaric acid(HMG) containing flavonoids, glucoside-chamaemeloside. | Hypoglycemic | 120 |
| Varnish tree, dhobi-nut, markingnut, oriental cashew, bhilarva | *Semecarpus anacardium* Linn. (Anacardiaceae) | Dried nuts | ----- | Lowered blood glucose level | 121 |
| Bhendu, Jonkaphal, Murdasing, Marorphali, East Indian screw tree, Murva | *Helicteres isora* (Sterculiaceae) | Bark | Triterpenoids, a-amyrin, ß-amyrin, lupeol and its acetate, friedelin, ß-sitosterol, epifriedelinol, bauerenol acetate, and taraxerone. | Decreases elevates blood glucose level. Increases hepatic hexokinase activity and significant decrease in hepatic glucose-6-phosphatase, serum acid phosphatase (ACP), alkaline phosphatase (ALP) and lactate dehydrogenase (LDH). | 122 |
| Onion | *Allium cepa* L. (Liliaceae) | Bulb | S-methyl cysteine sulphoxide | Improves the metabolic status in diabetese because of its hypocholesterolemic and hypoglycemic effect. | 123, 124 |
| Common sage, Broadleaf Sage, Dalmatian Sage, Garden Sage, Kitchen Sage | *Salvia officinalis* (Labiatae) | Sage tea | ----- | Prevents type 2 diabetes mellitus by lowering the plasma glucose levels. Effects fasting glucose levels and has metformin like effect on rats hepatocytes. | 125 |
| Anamu | *Petiveria alleaceae* L. (Phytolacaceae) | Leaves and stem powder | ----- | Decrease in blood glucose concentration. | 126 |
| Creosote bush | *Larrea tridentate* (Zygophyllaceae) | Whole plant | Masoprocol ( nordihydro guaiaretic acid, a lipoxygenase inhibitor) | Decreases plasma glucose concentration without any change in plasma insulin concentration, also improves oral glucose tolerance | 127 |
| Tree turmeric, Columbo Weed | *Coscinium fenestratum* (Menispermaceae) | Infusion / tincture | Berberines and saponins | Antidiabetic action. | 128 |
| Vijayasar | *Pterocarpus marsupium* (Leguminosea) | Heart wood | rich source of polyphenolic constituents namely marsupsin, pterosupin, pterostilbene and (-) epicatechin | Regeneration of pancreatic β-cells. Epicatechin reduces blood sugar and convert proinsulin to insulin β-cells. | 129-133 |
| Shweta musli, Sufed musli. | *Asparagus adscendens* (Asparagaceae) | Root | ----- | Stimulates insulin secretion, insulin action and inhibits starch digestion | 134 |

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| Little Club Moss | *Selaginella tamariscina* Beauv. (Lycopodiaceae) | Whole plant | ----- | Decreases blood glucose level and serum lipid peroxidase, increases concentration of serum insulin, it repairs the structure of pancreatic islet β-cells injured by alloxan. | 135 |
| ----- | *Embelia madagascariensis* (Myrsinaceae) | Leaves | ----- | Decrease in blod glucose level and suppresses epinephrine induced hyperglycaemia. | 136 |
| Wood nettle | *Laportea ovalifolia* (Urticaceae) | Whole plant | ----- | Reduction in fasting serum glucose concentration, serum concentration of total cholesterol, triglycerides,LDL cholesterol . | 137 |
| East Indian lotus | *Nelumbo nucifera* Gaerth (Nymphaeaceae) | Finely pulverized rhizomes | ----- | Decreases glycaemia and increases glucose tolerance and also potentiatesthe action of exogenously injected insulin. | 138, 139 |
| Queen carpe-myrtle,Banaba/Queen flower | *Lagerstroemia speciosa* Pers. (Lythraceae) | Leaves | Two terpenoides- colosolic acid and maslinic acid | Facilitates glucose transport into cells and reduces amount of triglycerides | 140, 141 |
| Asiatic sweetleaf sapphire-berry | *Symplocos paniculata* (Thumb.) Miq. (Symplocaceae) | Leaves and stems | Three ursane-type triterpenes, ursolic acid (1), corosolic acid(2) and 2 alpha, 3 alpha, 19 alpha, 23- tetrahydroxyurs-12-en-28-oic acid (3) | In type 2 diabetes and obesity. Inhibits protein tyrosine phosphatase 1B (PTP1B) 1 and 2 possessing only one or two hydroxyl groups can be potential PTP1B inhibitors. | 142 |
| ----- | *Cleome droserifolia* Delile (Capparidaceae) | Whole plant | ----- | Acts by potentiation of peripheral and hepatic insulin sensitivity, and diminished intestinal glucose absorption. | 143 |
| Nyala tree/Mashatu | *Xanthocercis zambesiaca* (Leguminosae) | Leaves and roots | 8 stucturally related nitrogen containing sugars, fagomine, 4-o-β-D-glucopyranosyl fagomine, 3-o-β-D-glucopyranosyl fagomine and 3-epifagomine. | Decreases blood glucose level. | 144 |
| Sapai, Faridbuti, Heart-Leaves Moonseed | *Tinospora crispa* (Menispermaceae) | Leaves | ----- | Hypoglycaemic. Acts by stimulating insulin release via modulation of $Ca^{+2}$ concentrationin pancreatic β-cells. | 145 |
| ----- | *Eriosema kraussianum* N.E.Br. (Fabaceae) | Roots | Two pyrano-isoflavone extractives | Vasodilatory and hypoglycaemic effects. | 146 |
| Sweet broomweed, licorice weed | *Scoparia dulcis* (Scrophulariaceae) | Whole plant | ----- | Significantly reduces blood glucose, serum and tissue | 147 |

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| | | | | cholesterol, triglycerides, free fatty acids, phospholipids, 3-hydroxy-3-methylglutaryl (HMG)-CoA reductase activity. | |
| Castor-leaved aralia | *Kalopanax pictus* Nakai (Araliaceae) | Stem bark | Kalopanax saponin A, hederagenin glycosides | Reduces hyperglycemia. Antidiabetic. | 148 |
| Marsh samphire, saltwort, crab grass | *Salicornia herbacea* L. (Chenopodiaceae) | Whole plant | ----- | Prevents onset of hyperglycaemia and hyperlipidemia induced by high fat diet in ICR mice. Stimulate cytokine production, nitric oxide release, and shows antioxidant effect. | 149 |
| Sand plantain | *Plantago psylium* L. (Plantaginaceae) | Husk. | Mucilage | Decrease the postprandial glucose, the area under the glucose tolerance curve and reduces the glycemic index of carbohydrate foods and help in diabetic control. | 150 |
| Toei- hom, screwpine | *Pandanus odorus* (Pandanaceae) | Roots | 4- hydroxy benzoic acid | Decreases plasma glucose level and increases serum glucose level and liver glycogen Increases the peripheral glucose consumption | 151-153 |
| Chaplu | *Piper sarmentosum* Roxb. (Piperaceae) | Whole plant | ----- | Decrease in plasma glucose levels | 154 |
| Corojo palm | *Acrocomia mexicana* (Leguminosea) | Roots | Tetrahydropyran | Hypoglycemic. | 155 |
| Fruit for Wolves,wolf-fruit,wolf-apple | *Solanum lycocarpum* St. Hill (Solanaceae) | Whole plant | ----- | Reduces glycaemia in alloxan induced diabetic rats, as antioxidant(reduced nitrate generation in diabetic animals) and restores haemoglobin and haematocrit to normal values in diabetic animals. | 156 |
| Brickellbush | *Brickellia veronicaefolia* A.Gray (Asteraceae) | Leaves | Flavone namely 5,7,3'-trihydroxy-3,6,4'-trimethoxy flavone. | Decreases blood glucose. | 157, 158 |
| ----- | *Gymnema montanum* | Leaf | Ascorbic acid (Vitamin C) and alpha-tocopherol (Vitamin E) responsible for the observed property. | Significant reduction in blood glucose and an increase in plasma insulin, the decrease in lipid peroxides and increase in reduced glutathione (GSH). | 159 |

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| ---- | *Allophylus cominia*(L.) (Sapindaceae) | Leaves | Free amine groups, free phenolics, tannins, leucoantocianidines, saponins, triterpens, and steroids | Causes increase hepatic hexokinase activity and significant decrease in hepatic glucose-6-phosphatase, serum acid phosphatase (ACP), alkaline phosphatase (ALP) and lactate dehydrogenase (LDH) | 160 |
| Jeera | *Cuminum cyminum* L. (Apiaceae) | Fruit | ----- | Decreases area under the glucose tolerance curve and hyperglycaemic peak | 161, 162 |
| Betel, Betel pepper, Betelvine, Betel vine Pan. | *Piper betle* (Piperaceae) | Leaf | Tannins | Antihyperglycemic. Influences glucose metabolism. | 163 |
| Bilwa, bael fruit, Bengal quince | *Aegle marmelose* (Rutaceae) | Leaf extract | Carbohydrates, Ascorbic acid. | Helps in restoration of blood glucose and body weight, decreases blood urea and serum cholesterol. | 164, 165 |
| Vairi, Pitika | *Salacia reticulate* Wright (Hippcrateaceae | Dried roots and stems | α- glucosidase inhibitor called kotalanol | Inhibits α- glucosidase enzyme that digests starch in intestine | 166 |
| Common fig | *Ficus carica* L. (Moraceae) | Leaves | ----- | Decreases postprandial glycaemia,hyperglycaemia, level of total cholesterol and reduction in total cholesterol / HDL cholesterol ratio. | 167, 168 |
| Gurmar, Small Indian ipecacuanha,Periploca of the woods | *Gymnema sylvestre* (Asclepiadaceae) | Leaves, stem | Gymnemoside a and beta-gymnemic acid V and a peptide Gurmarin. | Acts by enhancing endogenous insulin release, by regeneration /revitalization of residual β-cells. Also it neutralizes excess sugar | 169-171 |
| Fenugreek , Methi | *Trigonella foenum graecum* (Leguminosea) | Leaf and seeds | Soluble dietary fibers (SDF), steroid saponins extracted from seed – fenugreekine, an alkaloid – trigonelline | Antihyperglycaemic. Acts by delaying gastric emptying, slows carbohydrate absorption and inhibit glucose transport. | 172-177 |
| Garlic | *Allium sativum* L. (Liliaceae) | Bulb | A sulphur containing amino acid and a precursor of allicin and garlic oil –S-allyl cysteine sulphoxide, and ajoene. | Allicin restores blood levels of catalase and glutathione peroxidase. Ajoene decreases the activity of factors needed for lipid synthesis. It increases serum insulin and improves liver glycogen storage. | 178, 179 |
| Milk-Vetch Root | *Astragalus membranaceus* (Leguminosae) | Whole plant | Isoflavones-especially biochanin A | Regulates lipid metabolism. | 180 |
| ----- | Pueraria thomsonii | Whole plant | Isoflavones-especially biochanin A | Antidiabetic and regulates lipid metabolism. | 180 |
| Mature tea tree,avaram | *Cassia auriculata* | Seed , flower | Tannins | Antidiabetic action. | 181 |

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| | (Fabaceae) | buds. | | | |
| Palash, bastard-teak , flame-of-the-forest | *Butea monosperma* (fabaceae) | Flower | Phytochemical substances | Antidiabetic. | 181 |
| Coconut fiber | *Cocos nucifera* (Arecaceae) | | Neutral detergent fiber | Decreases glycaemia and serum insulin ,increases the faecal excretion of Cu,cr, mn, Mg, Zn, and Ca. | 182 |
| Bhui amla, Jaramla, Bhumiamalaki | *Phyllanthus amarus* (Euphorbiaceae) | Whole plant | Tannins, flvonoids | Decreases hyperglycemia. | 183, 184 |
| Bhui amla, Jaramla, Jangli amli | *Phyllanthus fraternus* (Euphorbiaceae) | Whole plant | Tannins, flvonoids | Decreases hyperglycemia. | 185 |
| Guduchi | *Tinospora cardifolia* (Menispermaceae) | Root extract | Bitter principles | Decrease in glycaemia and brain lipids. Enhances insulin secretion and improves glucose metabolism. | 186, 187 |
| Devil's root, touch-me-not | *Acanthopanax senticosus* (Araliaceae) | Leaves | Saponins - acanthopanaxosides A, B, C | Hypoglycemic. | 188 |
| Leaf beet ,Sugar beet | *Beta vulgaris* var. Cicla L. (Chenopodiaceae) | ----- | Betavulgarosides I,II,III.IV and oleanolic acid oligoglycosides | Inhibit the increase in non-enzymatic glycosylation of skin proteins and blood glucose. | 189 |
| Hairy beggarticks, cobbler's pegs, Spanish needle | *Bidens pilosa* (Asteraceae) | Aerial part | Polyacetylenic glucosides | Decreases elevated blood glucose level. | 190 |
| Milk thistle | *Silybum marianum* (Asteraceae) | Fruits, seeds and leaves | Silymarin which is composed of 3 main constituents -silybin, silychristine and silidianin | Antidiabetic.Lipoperoxidation and restoration of normal malondialdehyde concentration and has anti-oxidant action also. | 191 |
| Guava, apple guava Kuawa, Puawa,sand plum | *Psidium guajava* (Myrtaceae) | Leaves | Tannins. | Decrease the blood glucose level. | 192 |
| Spanish Moss | *Tillandsia usneoides* (Bromeliaceae) | ----- | 3-hydroxy-3-methyl glutaric acid ( HMG ) | Hypoglycemic. | 193 |
| Asiatic ginseng | *Panax ginseng* (Araliaceae) | Roots | Ginseng polypeptides and polysaccharides, Dammarane saponins: Protopanaxatriols, including ginsenosides RG1, RG2, Rf, Re) and protopanaxadiols (ginsenosides Rc, Rd, Rb1, Rb2). | Lowers blood glucose by decreasing the rate of carbohydrate absorption into the portal hepatic circulation and increasing glucose transport and uptake and modulation of insulin secretion. | 194, 195 |

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| Common Horse-chestnut | *Aesculus hippocastanum* L. (Hippocastanaceae) | Seeds | Five triterpene oligologlycosides named escins-I a, I b, II a, IIb, and IIIa | Hypoglycemic. | 196, 197 |
| Tonburi,Summer cypress(Japanese fruit), burning bush | *Kochia scoparia* (Chenopodiaceae) | Whole plant | Momordin $1_c$ and 2'-O-β-D-glucopyranoside with 3 saponins named scoparianosides A,B and C | Inhibit the increase in serum glucose, inhibit glucose and ethanol absorption. | 198 |
| Spanish sage | *Salvia lavandifolia* Vahl. (Lamiaceae) | Whole plant | ----- | Hypoglycemic. Acts by potentiation of insulin release induced by glucose, increased peripheral uptake of glucose, decreased intestinal absorption of glucose, hyperplasia of the pancreatic islets β-cells. | 199 |

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**Page 284-301**

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