"Fighting Diabetes: The Role of Herbs"

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# Abstract

Sixty percent of people worldwide utilize traditional medicines made from medicinal plants. Particularly in India, this article focuses on Indian herbal medications and plants used to treat diabetes. Diabetes is a serious human condition that affects people from all walks of life in many nations. In India, particularly in the cities, it is turning out to be a

serious health issue. Although there are several ways to lessen the negative effects of

diabetes and its secondary issues, herbal formulations are recommended because they are less expensive and have less side effects. The list includes herbal medications used to treat diabetes as well as medicinal plants with known antidiabetic and related therapeutic effects. Trigonella foenum graecum, Withania somnifera, Phyllanthus amarus, Pterocarpus marsupium, Tinospora cordifolia, Momordica charantia, Ocimum sanctum, Eugenia

jambolana, and Allium sativum are a few of them. Since free radical damage is one of the etiologic factors linked to the development of diabetes and its consequences, an

antidiabetic molecule with antioxidant qualities would be more advantageous.

Consequently, details regarding the antioxidant properties of these therapeutic herbs are also provided.[1,2,3,4]

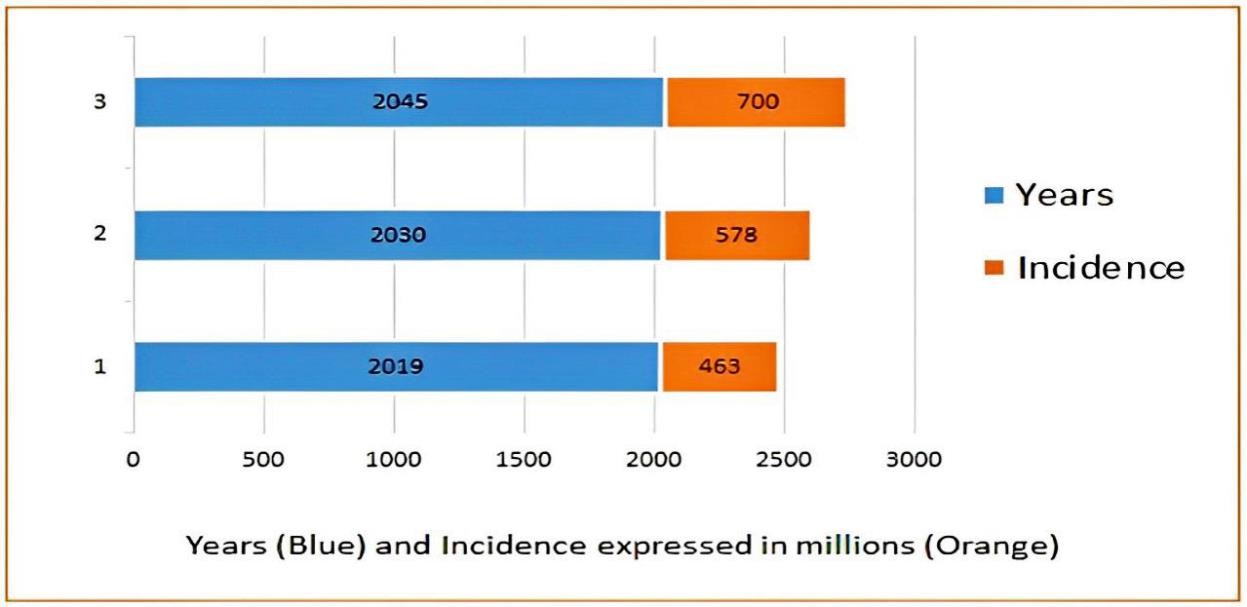
**Keywords:** medicinal plant, India, antidiabetic, antioxidant, diabetes

# Introduction

Defects in insulin secretion and/or activity may be part of the etiology of diabetes mellitus

(DM), a metabolic disease that causes chronic hyperglycemia. According to estimates, one in three Americans will get diabetes at some point in their lives. Type 2 diabetic mellitus (T2DM) is the most prevalent type of DM, accounting for over 90% of cases.[5,6] T2DM is

mostly caused by the body’s tissues not responding to insulin or producing enough of it. According to numerous scientific research, diabetes lowers human quality of life by increasing the risk of serious complications like stroke, amputation, renal failure, and blindness, which can result in high morbidity and early death. According to the International Diabetes Federation (IDF), there were about 463 million adults with diabetes in 2019, as shown in [[Figure 1](https://www.ncbi.nlm.nih.gov/core/lw/2.0/html/tileshop_pmc/tileshop_pmc_inline.html?title=Click%20on%20image%20to%20zoom&p=PMC3&id=10218826_ijms-24-09085-g001.jpg)]. By 2030, that number is expected to rise to 578 million, and by 2045, it will reach 700 million.[7,8,9]



# Projection of an increased incidence of diabetes patients worldwide[[Figure 1](https://www.ncbi.nlm.nih.gov/core/lw/2.0/html/tileshop_pmc/tileshop_pmc_inline.html?title=Click%20on%20image%20to%20zoom&p=PMC3&id=10218826_ijms-24-09085-g001.jpg)]

The last few decades have seen improvements in DM treatment methods. Anti-diabetic medications, however, can cause severe side effects such liver and renal problems and hypoglycemia coma. The use of medicinal plants in food products is advised by the World Health Organization (WHO) to treat diabetes mellitus.[10,11] In underdeveloped nations,

medicinal plants are used by at least four billion people to treat metabolic illnesses including diabetes mellitus. Thus, vitamins, medicinal herbs, and other vital components

with anti-hypoglycemic qualities continue to be crucial for diabetic treatment. Through pre- clinical and clinical trials, scientific publications demonstrated that important

components, vitamins, and medicinal plants have been successfully employed to lower blood sugar levels.[12,13,14]

Zinc intake, for instance, has been shown to control insulin receptors and increase insulin activity. Garlic has been shown in a study to protect adult albino rats from diabetic retinopathy. Based on variations in chemical structure, several phytochemicals with anti- diabetic qualities found in medicinal plants have been identified and categorized into

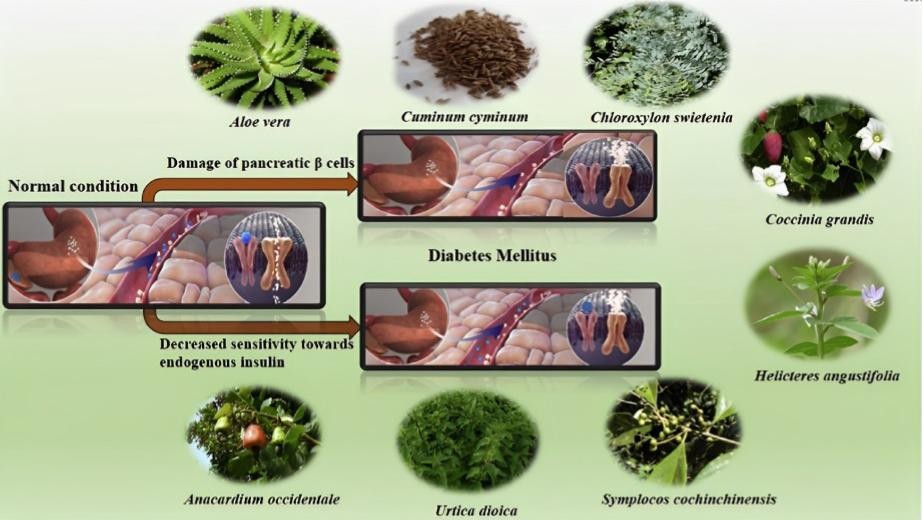
primary groups. Alkaloids, aromatic acids, carotenoids, coumarins, flavonoids, glycosides, organic acids, phenols and phenolics, phytosterols, protease inhibitors, saponins

steroids.[15,16,17]

# Clinical overview of diabetic mellitus:

Diabetes Mellitus Type I (T1DM) and Type II (T2DM) are the two forms of diabetes, which is a chronic illness marked by hyperglycemia. A reduced amount of insulin is supplied to the circulation in type 1 diabetes due to damage to the pancreatic b-cells. Patients will require the use of exogenous insulin in order to survive. Conversely, type 2 diabetes has been seen in 85% of diabetic individuals, which leads to peripheral insulin resistance and,

consequently, reduced insulin sensitivity to the liver, skeletal muscles, and adipose tissues. [[Fig 2][](https://ars.els-cdn.com/content/image/1-s2.0-S2225411017301049-fx1_lrg.jpg)19,20,21]



# Condition to develop diabetic mellitus disease and herbal approaches in the improvement of insulin secretion or improvement in insulin resistivity of the body cells.

Gestational diabetes mellitus is another type of diabetes that can occur in pregnant

women who have never been diagnosed with the disease. Age, obesity, physical inactivity, population expansion, and urbanization are some of the factors that can cause a constant rise in the number of diabetic patients. The prevalence of diabetes in adults globally was projected to be around 171 million in 2000, but by 2014, it has risen to 422 million, or

almost one in eleven individuals. The world's diabetes prevalence is predicted to double to around 366 million people by 2030 as a result of demographic shifts among those over 65 and, most significantly, the sedentary lifestyles adopted by those living in urban areas worldwide. Untreated diabetes can result in severe, life-threatening consequences such

diabetic ketoacidosis and coma because of the abnormally high blood glucose

levels.[22,23,24] Additional terrible effects of diabetes include vascular issues, which can lead to both macrovascular and microvascular illnesses because high glucose levels damage the vessels. Microvascular problems can result in blindness, neuropathy, and other

conditions, whereas macrovascular problems can cause cardiovascular problems. Lower limb amputations, depression, sexual dysfunction, and dementia are further

consequences of long-term diabetes.[25,26]

HERBS AS ANTIDIABETICS

Numerous medicinal plants have been recorded as being used to cure diabetes in Ayurveda and other ancient medical systems. Active ingredients originating from plants include a variety of chemical substances that have demonstrated a consistent level of activity and may be used to treat diabetes. According to Rao et al. (2010), these include triterpenes, terpenoides, steroids, gum, polysaccharides, peptidoglycans, hypoglycans, guanidine, alkaloids, glycosides, carbohydrates, glycopeptides, amino acids, and inorganic ions. Usually, a combination of bioactive components produces the intended biological reaction. Both within the same species and among various plant sections, the relative quantity of active components can change.[27] The active ingredients found in medicinal plants have been shown to have a variety of properties, including the ability to promote the release of insulin from beta cells, regenerate pancreatic beta cells, exhibit insulin-like effects, combat insulin resistance, and decrease glucose uptake, absorption, and utilization (Wadkar et al., 2008). The use of herbal medications as an antidiabetic remedy is growing in popularity because of its perceived efficacy, lower clinical side effects, and affordable price (Patel et and al., 2012). [28]

The active ingredients and mode of action of a few antidiabetic plants are listed in [[table](https://www.researchgate.net/publication/280611163_FIGHTING_DIABETES_WITH_HERBAL_TECHNOLOGICAL_DEVELOPMENTS) [no.1](https://www.researchgate.net/publication/280611163_FIGHTING_DIABETES_WITH_HERBAL_TECHNOLOGICAL_DEVELOPMENTS) ]

**List of some antidiabetic herbs and their mode of action:[** [**Table 1**](https://www.researchgate.net/publication/280611163_FIGHTING_DIABETES_WITH_HERBAL_TECHNOLOGICAL_DEVELOPMENTS) **]**[29,30]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sr.  No. | Botanical name and Family | Part of plant  Used | Active constitutions | Mode of action |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. | Acacia arabica (Indian Gum) Fabaceae | Seed and bark | Polyphenols, Tannis | Initiate insulin release from pancreatic beta cells (Patil et al., 2011 ji). |
| 2. | Aegle marmelos (Bel, Golden Apple) Rutaceae | Leaf | Again ,  marmelosin | Increases either the glucose utilization or  directly  stimulates insulin release from pancreatic beta cells (Arumugama, et al.,2008, Yaheya et al., 2009). |
| 3. | Allium cepa (onion) Alliaceae | Bulb | Allyl propyl disulphide, S- methyl cysteine sulphoxide | Stimulates insulin secretion and also increases HMG CoA  reductase activity and liver hexokinase activity (Thomson et al., 2007,  Tripathi et al.,  2012). |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
| 4. | Allium sativum (Garlic) Alliaceae | Bulb | Allyl propyl disulphide, allicin | Control the blood glucose and  lipids in serum as well as in tissues and altered the activities of liver hexokinase, glucose 6- phosphatase and HMG CoA  reductase (Ozougwu et al., 2011). |
| 5. | Aloe barbadensis (Aloe vera)  Liliaceae | Leaf | Alloin and barbaloin | Stimulates synthesis and/or release of insulin from the beta cells of the islets of Langerhans of pancreas and also the action of hepatic gluconeogenesis/ glucogenolysis ( Jafri et al.,  2011). |
| 6. | Andrographis paniculata  (Kalmegh) | Whole plant | Andrographolide, diterpenoid  lactone, | Prevents glucose absorption from  the gut wall |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Acanthaceae |  | and kalmeghin | (Nalamolu et al., 2006). |
| 7. | Annona squamosa (Custard apple, sugar apple) Annonaceae | Fruit | Liriodenine, moupinamide | Promotes the insulin release from the pancreatic beta cells, increases the consumption of glucose in the muscles and prevents the glucose output from  the liver (Kaleem et al., 2008). |
| 8 | Artemisia pallens Asteraceae | Leaf and  flower | Germacranolide | Increases the peripheral glucose utilization or inhibits the glucose  reabsorption in the proximal  tubule (Donga et al., 2011). |
| 9. | Azadirachta indica (Neem)  Meliaceae | Leaf flower | Azadirachtin and Nimbin | Regenerate the pancreas beta |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | and seed |  | cells (Khosla et al., 2000). |
| 10. | Bauhinia candicans Leguminosae | Leaf | Astragalin, kaempferitrin | Increases peripheral  metabolism of glucose  (Fuentes et al., 2004). |
| 11. | Beta vulgaris (Beet root)  Amaranthaceae | Root | Phenolics, Betacyanins | Decreases the nonenzymatic glycosylation of skin proteins and blood glucose (Yoshikawa et al., 1996). |
| 12. | Biophytum sensitivum (Sikerpud)  Oxalidaceae | Entire plant | Unknown | Stimulates the synthesis/release of insulin from  the beta cells |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  | (Ananda et al., 2012). |
| 13. | Boerhavia diffusa Nyctaginaceae | Whole plant | Punarnavine and ursolic acid | Improves the glucose tolerance (Patel et al, 2012). |
| 14. | Brassica nigra (Mustard) Brassicaceae | Whole Plant | Isorhamnetin diglucoside. Isothiocynate, Sinigrin | Increases the activity of glycogen synthetase,  decreases the glycogenolysis and gluconeogenesis by decreasing the activity of glycogen phosphorylase and gluconeogenic enzymes (Anand et al., 2009). |
| 15. | Bumelia storm | Root bark | Triterpenoids and  steroids | Shows insulin secretaguogue effect in pancreatic cells  (Naik et |

**Formulated Herbal Drugs with antidiabetic properties[31] :** [**Table**](https://pmc.ncbi.nlm.nih.gov/articles/PMC2275761/table/T2/)2

|  |  |  |
| --- | --- | --- |
| **Drug** | **Company** | **Ingredients** |
| Diabecon | Himalaya | Gymnema sylvestre, Pterocarpus marsupium, Glycyrrhiza glabra, Casearia esculenta, Syzygium  cumini, Asparagus racemosus, Boerhavia diffusa, Sphaeranthus indicus, Tinospora  cordifolia, Swertia chirata, Tribulus terrestris, Phyllanthus amarus,  Gmelina arborea,  Gossypium herbaceum,  Berberis aristata, Aloe vera, Triphala, Commiphora wightii, shilajeet,  Momordica charantia, Piper nigrum, Ocimum sanctum, Abutilon indicum, Curcuma  longa, Rumex maritimus |
| Diasulin |  | Officinalis, Gymnema sylvestre, Momordica charantia, Scoparia dulcis, Syzygium cumini, Tinospora cordifolia, Trigonella foenum graecum |
| Pancreatic tonic 180 cp | Ayurvedic herbal supplement | Pterocarpus marsupium, Gymnema sylvestre,  Momordica charantia, Syzygium cumini, Trigonella foenum graceum,  Azadirachta indica, Ficus racemosa, Aegle marmelos, Cinnamomum tamala |

|  |  |  |
| --- | --- | --- |
| Ayurveda alternative herbal formula to Diabetes: | Chakrapani Ayurveda | Gurmar (Gymnema sylvestre) Karela  (Momordica charantia) Pushkarmool (Inula racemosa) Jamun Gutli  (Syzygium cumini) Neem (Azadirachta indica)  Methika (Trigonella foenum gracecum) Guduchi  (Tinospora cordifolia) |
| Bitter gourd Powder | Garry and Sun natural Remedies | Bitter gourd (*Momordica charantia*) |
| Dia-care | Admark Herbals Limited | Sanjeevan Mool; Himej, Jambu beej, Kadu, Namejav, Neem chal. |
| Diabetes-Daily Care | Nature’s Health Supply | Alpha Lipoic Acid, Cinnamon 4% Extract, Chromax, Vanadium, Fenugreek 50% extract,  Gymnema sylvestre 25%  extract Momordica 7%  extract, Licorice Root 20% extract |
| Diabeta | Ayurvedic cure Ayurvedic Herbal Health Products | Gymnema sylvestre, Vinca rosea (Periwinkle), Curcuma longa (Turmeric), Azadirachta indica (Neem), Pterocarpus marsupium (Kino Tree), Momordica charantia (Bitter Gourd), Syzygiumcumini (Black Plum), Acacia arabica (Black Babhul), Tinospora cordifolia , Zingiber  officinale (Ginger) |
| Diabecure | Nature beaute sante | Juglans regia, Berberis vulgaris, Erytherea centaurium, Millefolium,  Taraxacum |

|  |  |  |
| --- | --- | --- |
| Epinsulin | Swastik Formulations | vijaysar (*Pterocarpus marsupium*) |
| Gurmar powder | Garry and Sun natural Remedies | Gurmar (Gymnema sylvestre) |

**Conclusion**

A vast array of botanicals have the ability to treat diabetes, according to Ayurveda. Many of them have not yet been investigated and validated by science, and just a small number have. The following plants have demonstrated varied degrees of hypoglycemic activity:

Momordica charantia, Eugenia jambolana, Trigonella foenum graecum, Pterocarpus marsupium, Ocimum sanctum, Gymnema sylvestre, Allium sativum, and Ficus religiosa.

According to reports, these plants may also help manage the difficulties associated with diabetes. Future research might focus on identifying, isolating, and purifying the bioactive substances found in these plants. Such studies’ findings could serve as a springboard for the creation of possible medications to treat diabetes. Diabetes management may benefit from this review.[41]

# Reference

1. Manisha Modak , Priyanjali Dixit ,Indian Herbs and Herbal Drugs Used for the Treatment of Diabetes ,J Clin Biochem Nutr. 2007 Apr 25;40(3):163–173. Doi: 10.3164/jcbn.40.163 [[Cross Ref](https://pmc.ncbi.nlm.nih.gov/articles/PMC2275761/) ]
2. Grover J.K., Yadav S., Vats V. Medicinal plants of India with antidiabetic potential.

J. Ethnopharmacol. 2002;81:81–100. Doi: 10.1016/s0378-8741(02)00059-4.

[[Cross Ref](https://www.sciencedirect.com/science/article/abs/pii/S0378874102000594) ]

1. Scartezzini P., Sproni E. Review on some plants of Indian traditional medicine with antioxidant activity. J. Ethnopharmacol. 2000;71:23–43. Doi: 10.1016/s0378- 8741(00)00213-0. [[Cross Ref](https://www.sciencedirect.com/science/article/abs/pii/S0378874100002130) ]
2. Seth S.D., Sharma B. Medicinal plants of India. Indian J. Med. Res. 2004;120:9–11.

[[Cross Ref](https://www.proquest.com/openview/b3e02f805783f62bb1ec3ad54db9cf64/1?pq-origsite=gscholar&cbl=37533) ]

1. Clement G Yedjou , Jameka Grigsby, The Management of Diabetes Mellitus Using Medicinal Plants and Vitamins Int J Mol Sci. 2023 May 22;24(10):9085.

Doi:10.3390/ijms24109085 [[Cross Ref ]](https://pmc.ncbi.nlm.nih.gov/articles/PMC10218826/)

1. Ozougwu J.C., Obimba K.C., Belonwu C.D., Unakalamba C.B. The pathogenesis and pathophysiology of type 1 and type 2 diabetes mellitus. J. Physiol. Pathophysiol. 2013;4:46–57. Doi: 10.5897/JPAP2013.0001. [[Cross Ref ]](https://scholar.google.com/scholar_lookup?journal=J.%20Physiol.%20Pathophysiol.&title=The%20pathogenesis%20and%20pathophysiology%20of%20type%201%20and%20type%202%20diabetes%20mellitus&author=J.C.%20Ozougwu&author=K.C.%20Obimba&author=C.D.%20Belonwu&author=C.B.%20Unakalamba&volume=4&publication_year=2013&pages=46-57&doi=10.5897/JPAP2013.0001)
2. Kim H.-G. Cognitive dysfunctions in individuals with diabetes mellitus. Yeungnam Univ. J. Med. 2019;36:183–191. Doi: 10.12701/yujm.2019.00255. [[Cross Ref ]](https://scholar.google.com/scholar_lookup?journal=Yeungnam%20Univ.%20J.%20Med.&title=Cognitive%20dysfunctions%20in%20individuals%20with%20diabetes%20mellitus&author=H.-G.%20Kim&volume=36&publication_year=2019&pages=183-191&pmid=31620632&doi=10.12701/yujm.2019.00255)
3. Cheng Y.J., Gregg E.W., Brinks R., Saydah S.H., Albright A.L., Imperatore G. 103-OR: Change in Lifetime Risk for Diabetes in the United States, 1997–2015. Diabetes. 2020;69:103-OR. Doi: 10.2337/db20-103-OR. [[Cross Ref ]](https://scholar.google.com/scholar_lookup?journal=Diabetes&title=103-OR%3A%20Change%20in%20Lifetime%20Risk%20for%20Diabetes%20in%20the%20United%20States%2C%201997%E2%80%932015&author=Y.J.%20Cheng&author=E.W.%20Gregg&author=R.%20Brinks&author=S.H.%20Saydah&author=A.L.%20Albright&volume=69&publication_year=2020&pages=103-OR&doi=10.2337/db20-103-OR)
4. Olokoba A.B., Obateru O.A., Olokoba L.B. Type 2 Diabetes Mellitus: A Review of Current Trends. Oman Med. J. 2012;27:269–273. Doi: 10.5001/omj.2012.68. [[Cross](https://scholar.google.com/scholar_lookup?journal=Oman%20Med.%20J.&title=Type%202%20Diabetes%20Mellitus%3A%20A%20Review%20of%20Current%20Trends&author=A.B.%20Olokoba&author=O.A.%20Obateru&author=L.B.%20Olokoba&volume=27&publication_year=2012&pages=269-273&pmid=23071876&doi=10.5001/omj.2012.68) [Ref ]](https://scholar.google.com/scholar_lookup?journal=Oman%20Med.%20J.&title=Type%202%20Diabetes%20Mellitus%3A%20A%20Review%20of%20Current%20Trends&author=A.B.%20Olokoba&author=O.A.%20Obateru&author=L.B.%20Olokoba&volume=27&publication_year=2012&pages=269-273&pmid=23071876&doi=10.5001/omj.2012.68)
5. Yun J.-S., Ko S.-H. Current trends in epidemiology of cardiovascular disease and cardiovascular risk management in type 2 diabetes. Metab. Clin. Exp. 2021;123:154838. Doi: 10.1016/j.metabol.2021.154838. [[Cross Ref ]](https://scholar.google.com/scholar_lookup?journal=Metab.%20Clin.%20Exp.&title=Current%20trends%20in%20epidemiology%20of%20cardiovascular%20disease%20and%20cardiovascular%20risk%20management%20in%20type%202%20diabetes&author=J.-S.%20Yun&author=S.-H.%20Ko&volume=123&publication_year=2021&pages=154838&pmid=34333002&doi=10.1016/j.metabol.2021.154838)
6. E Garcia D., Narvaez-Mendez M., Morgan S., Coronado-Malagon M., Arce-Salinas C.A., Barajas A., Arenas I., Svarch A. Biomarkers Through The Development, Progression and Chronic Complications of Diabetes Mellitus: A Mini-Review. J. Endocrinol. Diabetes. 2018;5:1–7. Doi: 10.15226/2374-6890/5/6/001121. [[Cross](https://scholar.google.com/scholar_lookup?journal=J.%20Endocrinol.%20Diabetes&title=Biomarkers%20Through%20The%20Development%2C%20Progression%20and%20Chronic%20Complications%20of%20Diabetes%20Mellitus%3A%20A%20Mini-Review&author=D.%20E%20Garcia&author=M.%20Narvaez-Mendez&author=S.%20Morgan&author=M.%20Coronado-Malagon&author=C.A.%20Arce-Salinas&volume=5&publication_year=2018&pages=1-7&doi=10.15226/2374-6890/5/6/001121) [Ref]](https://scholar.google.com/scholar_lookup?journal=J.%20Endocrinol.%20Diabetes&title=Biomarkers%20Through%20The%20Development%2C%20Progression%20and%20Chronic%20Complications%20of%20Diabetes%20Mellitus%3A%20A%20Mini-Review&author=D.%20E%20Garcia&author=M.%20Narvaez-Mendez&author=S.%20Morgan&author=M.%20Coronado-Malagon&author=C.A.%20Arce-Salinas&volume=5&publication_year=2018&pages=1-7&doi=10.15226/2374-6890/5/6/001121)
7. Lotfy M., Adeghate J., Kalasz H., Singh J., Adeghate E. Chronic complications of diabetes mellitus: A mini review. Curr. Diabetes Rev. 2016;13:3–10. Doi: 10.2174/1573399812666151016101622.
8. Ramtahal R., Khan C., Maharaj-Khan K., Nallamothu S., Hinds A., Dhanoo A., Yeh H.-C., Hill-Briggs F., Lazo M. Prevalence of self-reported sleep duration and sleep habits in type 2 diabetes patients in South Trinidad. J. Epidemiol. Glob. Health. 2015;5:S35–S43. Doi: 10.1016/j.jegh.2015.05.003.
9. Shidlovskaya T.A., Navalkivska N.Y. Distortion product otoacoustic emissions among the patients suffering diabetes mellitus type II with hearing impairment. Otorhinolaryngology. 2020:47–52. Doi: 10.37219/2528-8253-2019-4-47.
10. Chaudhury A., Duvoor C., Reddy Dendi V.S., Kraleti S., Chada A., Ravilla R., Marco A., Shekhawat N.S., Montales M.T., Kuriakose K., et al. Clinical Review of

Antidiabetic Drugs: Implications for Type 2 Diabetes Mellitus Management. Front. Endocrinol. 2017;8:6. Doi: 10.3389/fendo.2017.00006.

1. Roglic G. WHO Global report on diabetes: A summary. Int. J. Noncommunicable Dis. 2016;1:3. Doi: 10.4103/2468-8827.184853.
2. da Rocha Fernandes J., Ogurtsova K., Linnenkamp U., Guariguata L., Seuring T., Zhang P., Cavan D., Makaroff L.E. IDF Diabetes Atlas estimates of 2014 global health expenditures on diabetes. Diabetes Res. Clin. Pract. 2016;117:48–54. Doi: 10.1016/j.diabres.2016.04.016.
3. Ekor M. The growing use of herbal medicines: Issues relating to adverse reactions and challenges in monitoring safety. Front. Pharmacol. 2014;4:177. Doi: 10.3389/fphar.2013.00177.
4. Choudhury H., Pandey M., Hua C.K., Mun C.S., Jing J.K., Kong L., Ern L.Y., Ashraf N.A., Kit S.W., Yee T.S., et al. An update on natural compounds in the remedy of diabetes mellitus: A systematic review. J. Tradit. Complement. Med. 2018;8:361–

376. Doi: 10.1016/j.jtcme.2017.08.012.

1. Bharali S., Gupta O.P. Potential of plant medicine in the management of Type II diabetes mellitus. J. Ayurveda Integr. Med. 2013;4
2. Dineshkumar B., Analava M., Manjunatha M. Antidiabetic and hypolipidaemic effects of few common plants extract in type 2 diabetic patients at Bengal. Dubai Diabetes Endocrinol. J. 2010;18:59–65. Doi: 10.1159/000497694.
3. J.M. Forbes, M.E. Cooper ,Mechanisms of diabetic complications ,Physiol Rev, 93 (1) (2013)<http://physrev.physiology.org/content/93/1/137.short>(Accessed 24 May 2017)
4. Wild Sarah, Roglic Gojka, Green Anders, Sicree Richard, K. Hilary Global prevalence of diabetes: estimates for the year 2000 and projection for 2030 ,Diabetes Care, 27

(5) (2004), pp. 1047-1053, 10.2337/diacare.27.5.1047 [[Cross Ref ]](https://ct.prod.getft.io/c2NpZW5jZWRpcmVjdF9jb250ZW50aG9zdGluZyxBREEsaHR0cHM6Ly9jdC5wcm9kLmdldGZ0LmlvL2MyTnBaVzVqWldScGNtVmpkRjlqYjI1MFpXNTBhRzl6ZEdsdVp5eEJSRUVzYUhSMGNITTZMeTlrYVdGaVpYUmxjMnB2ZFhKdVlXeHpMbTl5Wnk5SFpYUkdkSEpEYjI1MFpXNTBMMGRsZEZCa1prSjVSRzlwUDJSdmFUMHhNQzR5TXpNM0pUSm1aR2xoWTJGeVpTNHlOeTQxTGpFd05EY21jbVZ6YjNWeVkyVjBlWEJsUFRRLm1QUnBQc01DQXJDVWJyTndoSkJ4NFJ6ZWQtYmZWNGxZN2dqOGgtOWpIYkE.-t_HVcZTZ1qX_13Vl84KqFPSx9dw8KrV80jySIoTnns)

1. W. Li, G. Yuan, Y. Pan, C. Wang, H. Chen Network pharmacology studies on the

bioactive compounds and action mechanisms of natural products for the treatment of diabetes mellitus: a review Front Pharmacol, 8 (2017), p. 74 [10.3389/fphar.2017.00074](https://doi.org/10.3389/fphar.2017.00074)

1. S.P.A.S. Senadheera, S. Ekanayake, C. Wanigatunge ,Anti-hyperglycaemic effects of herbal porridge made of Scoparia dulcis leaf extract in diabetics – a randomized crossover clinical trial BMC Complement Altern Med, 15 (1) (2015), p. 410, 10.1186/s12906-015-0935-6[[Cross Ref ]](https://ct.prod.getft.io/c2NpZW5jZWRpcmVjdF9jb250ZW50aG9zdGluZyxzcHJpbmdlcixodHRwOi8vbGluay5zcHJpbmdlci5jb20vMTAuMTE4Ni9zMTI5MDYtMDE1LTA5MzUtNj91dG1fc291cmNlPWdldGZ0ciZ1dG1fbWVkaXVtPWdldGZ0ciZ1dG1fY2FtcGFpZ249Z2V0ZnRyX3BpbG90.zmVMuqNb21tqf7a_WU4Os_8vhwv8WDvbwkxBgbdLO4I)
2. R.A. Anderson, Z. Zhan, R. Luo, et al.Cinnamon extract lowers glucose, insulin and cholesterol in people with elevated serum glucose ,J Tradit Complement Med, 6 (4) (2016), pp. 332-336[[Cross Ref ]](https://www.sciencedirect.com/science/article/pii/S2225411015000449/pdfft?md5=20c0e6666db1ba56246f19ebbdffddd0&pid=1-s2.0-S2225411015000449-main.pdf)
3. Seema Talreja, Chanchal Deep Kaur ,FIGHTING DIABETES WITH HERBAL TECHNOLOGICAL DEVELOPMENTS ,World Journal of Pharmaceutical research Volume 3, Issue 2, 2842-2867[[Cross Ref ]](https://www.researchgate.net/publication/280611163_FIGHTING_DIABETES_WITH_HERBAL_TECHNOLOGICAL_DEVELOPMENTS)
4. Ananthi J, Prakasam A, Pugalendi KV. Antihyperglycemic activity of Eclipta alba leaf on alloxan-induced diabetic rats. Yale Journal of Biology and Medicine 2003; 76: 97- 102.
5. Anturlikar SD, Gopumadhavan S, Chauhan BL. Et al. Effect of D-400, A Herbal Formulation, on Blood Sugar of Normal and Alloxan-induced Diabetic Rats. Indian Journal Physiology and Pharmacology 1995, 39 (2); 95-100. [[Cross Ref ]](https://www.researchgate.net/publication/280611163_FIGHTING_DIABETES_WITH_HERBAL_TECHNOLOGICAL_DEVELOPMENTS)
6. Aronoff SL, Berkowitz K, Shreiner B, et al. Glucose Metabolism and Regulation:

Beyond Insulin and Glucagon. Diabetes Spectrum 2004; 17(3): 183-190.[[Cross Ref](https://www.researchgate.net/publication/280611163_FIGHTING_DIABETES_WITH_HERBAL_TECHNOLOGICAL_DEVELOPMENTS)]

1. <https://pmc.ncbi.nlm.nih.gov/articles/PMC2275761/table/T2/>
2. Kaleem M., Asif M., Ahmed Q.U., Bano B. Antidiabetic and antioxidant activity of Annona squamosa extract in streptozotocin-induced diabetic rats. Singapore Med.

J. 2006;47:670–675.

1. Gupta R.K., Kesari A.N., Murthy P.S., Chandra R., Tandon V., Watal G. Hypoglycemic and antidiabetic effect of ethanolic extract of leaves of Annona squamosa L. in

experimental animals. J. Ethnopharmacol. 2005;99:75–81. Doi: 10.1016/j.jep.2005.01.048.

1. Gupta R.K., Kesari A.N., Watal G., Murthy P.S., Chandra R., Tandon V. Nutritional and hypoglycemic effect of fruit pulp of Annona squamosa in normal healthy and alloxan-induced diabetic rabbits. Ann. Nutr. Metab. 2005;49:407–413. Doi: 10.1159/000088987.
2. Subramonium A., Pushpangadan P., Rajasekharan A., Evans D.A., Latha P.G., Valsaraj R. Effects of Artemisia pallens Wall. On blood glucose levels in normal and alloxan-induced diabetic rats. J. Ethnopharmacol. 1996;50:13–17. Doi: 10.1016/0378-8741(95)01329-6.
3. Chempakam B. Hypoglycemic activity of arecoline in betel nut Areca catechu L. Ind.

J. Exp. Biol. 1993; 31:474–475.

1. Yoshikawa M., Murakami T., Kadoya M., Matsuda H., Muraoka O., Yamahara J., Murakami N. Medicinal foodstuff. III. Sugar beet. Hypoglycemic oleanolic acid oligoglycosides, betavulgarosides I, II, III and IV, from the root of Beta vulgaris L. Chemical and Pharmaceutical Bulletin. 1996;44:1212–1217. Doi: 10.1248/cpb.44.1212.
2. Pari L., Amarnath Satheesh M. Antidiabetic activity of Boerhavia diffusa L. effect on hepatic key enzymes in experimental diabetes. J. Ethnopharmacol. 2004;91:109–

113. Doi: 10.1016/j.jep.2003.12.013.

1. Satheesh M.A., Pari L. Antioxidant effect of Boerhavia diffusa L. in tissues of alloxan induced diabetic rats. Indian J. Exp. Biol. 2004;42:989–99