INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA):IJPS00]
Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Review Article

A Review On Anti-Diabetic Effect Of Neem (*Azadirachta Indica*) Leaves

Vishal Biswas, Yogita Dhuri*, Shamili Singh, Divyani Soni, Shruti Rathore

LCIT school of pharmacy Bilaspur

ARTICLE INFO

Received: 04 May 2024
Accepted: 08 May 2024
Published: 23 May 2024

Keywords:
Azadirachta indica, neem, neem leaf, diabetes mellitus, anti-diabetic properties, metabolic disorder

DOI:
10.5281/zenodo.11261407

ABSTRACT

Diabetes is a chronic disorder affecting the population on epidemic level. Diabetes results from abnormal metabolism of insulin wherein insulin action is impaired, or absolute insulin deficiency results in imbalance of glucose metabolism and leads to a syndrome called diabetes mellitus. Many oral antidiabetic drugs used today fail to give a long-term glycaemic control. The herbal extracts which are effective in lowering blood glucose level with minimal or no side effects are known to be used as antidiabetic remedies. More than 150 compounds have been isolated from different parts of neem and these have been divided into two major classes isoprenoids and non-isoprenoids, which are proteins and carbohydrates. Further, it consists of sulphurous compounds, polyphenolic compounds such as flavonoids and their glycosides, dihydrochalcone, coumarin, tannins and aliphatic compounds. Azadirachta indica is known to possess hypolipidemic, hypoglycemic, immunostimulant and hepatoprotective properties. While nimbocinone, nimolinone, kulactone, nimocinolides, isonimocinolide, nimbin, salanin, azadirachtin, flavonoids, myricetin, meldenindiol, vilasinin, margosinolide, isomargosinolide, desacetyldihydronimbic acid have been isolated from A. indica leaves having medicinal properties.

INTRODUCTION

Neem (Azadirachta indica; family: Meliaceae), a tropical evergreen tree, is widely distributed in Asia. Neem leaves and seeds are used in Ayurveda as a household remedy. The neem tree's Sanskrit name is 'Arishtha' which means 'Reliever of Sickness', also regarded as 'Sarba-roga-nibarini'. In India, the neem tree is still known as 'Village dispensary'. Different bioactive compounds have been isolated from neem leaves, such as nimbin, azadirachtin, nimbidiol, quercetin, nimbidin, etc. Many in vitro and in vivo studies have reported hypoglycemic activity of neem extracts, made with different solvents. Azadirachtin Nimbidiol and Gedunin and Azadiradione also showed anti-hyperglycemic activity, but toxicity is of concern with these bioactives. The bitterness of neem seed oil is created by Meliacin. Tignic acid (5-methyl-2-butanoic acid), extracted from neem seed is

***Corresponding Author:** Yogita Dhuri
Address: *LCIT school of pharmacy Bilaspur*
Email : yogitadhuri702@gmail.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

responsible for characteristics odour of the oil These compounds belong to the natural products called triterpenoids. During the most recent fifty years, extensive advancement has been accomplished with respect to the biological and therapeutic utilizations of neem. Presently it is considered to be an essential source of unique natural ingredients, both for the development of medicines against different diseases and also for the production of industrial goods. The therapeutic value of the medicinal plant is because of some biochemical substance that has a definite physiological activity on the human body.

Figure no 1: Neem tree

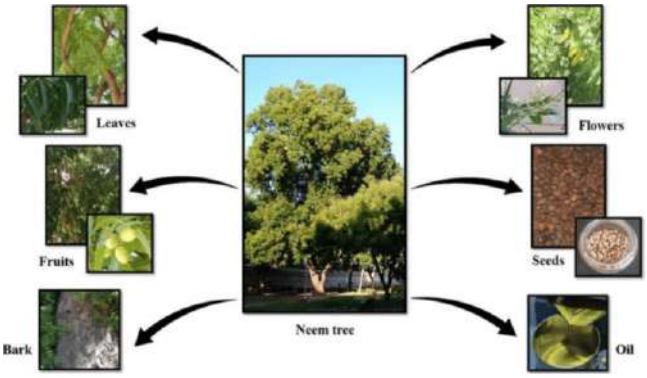
TAXONOMY OF NEEM PLANT

•**Order-** Rutales
•**Suborder**- Rutinae
•**Family-** Meliaceae (Mahogany family)
•**Subfamily-** Melioideae
•**Tribe-** Melieae
•**Genus-** Azadirachta
•**Species**- Indica

NEEM IN AYURVEDA

In Ayurvedic literature neem is well known for its medicinal properties viz., Neem bark is cool, bitter, astringent and acrid. In addition to this, it is used to cure tiredness, cough, fever, loss of appetite, worm infestation etc. It also heals wounds and vitiated conditions of kapha, vomiting, skin diseases, excessive thirst and diabetes. Along the bark, chemical compounds present in the leaves are reported to be valuable for eye disorders and insect poisons. It treats Vatik disorder and acts as anti-leprotic. It's fruits are bitter, purgative, anti-haemorrhoids and anthelminthic'. In the view of its immense utilities, this review summarizes the wide range of medicinal uses, pharmacological activities, biological activities of neem tree and its compounds and their chemistry.

NEEM MORPHOLOGY



As a huge tree, Azadirachta indica can grow to a height of 20 to 35 metres. Its leaf canopy makes it a useful shade tree. It is grown alongside roadsides and avenues in the towns and villages of India. The tree has small, bright green leaves and is tall and evergreen. It is one hundred feet high. As it blossoms in the spring, it produces tiny white flowers. It has a straight trunk. The bark is firm and rough, with fissures and sharp edges even on little trees. The colour of the bark is brownish-gray. The leaves are segmented into several leaflets that alternate and have sharp edges. The main draw is its small, white flowers. The fruit has thin skin and is oblong in shape. It is well known that neem has a variety of pharmacological qualities and medical applications due to its many sections. Using crude extracts and different fractions obtained from the leaves, bark, roots, seeds, and oil of neem, the biological activity of the plant is documented. The tree is flexible for a wide variety of climates and can flourish in sandy, stony shallow soils, as well as hard clay pan soils. Little water and plenty of daylight are needed for the tree. a wide range of (0 – 49°C) temperatures, it can grow well. The

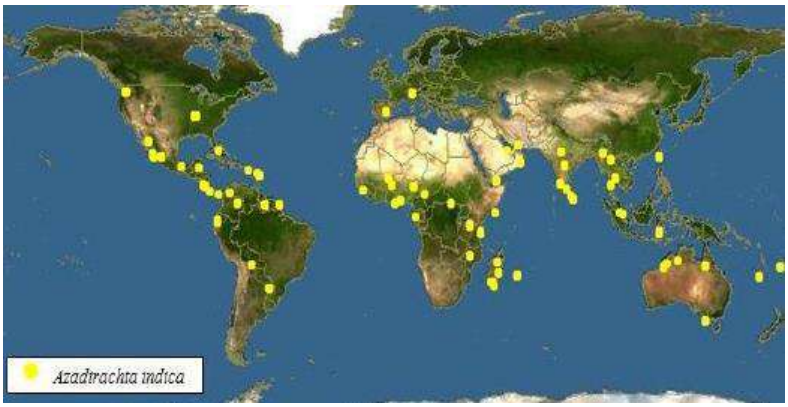
needed pH for neem tree growth is between 4 to 10 and it is also capable of neutralizing acidic soils through a specific calcium mining property.

PHARMACOGNOSTIC STUDIES OF NEEM (*AZADIRACHTA INDICA*) LEAF

Sr. No	Parameters	Observation
1.	Size & Shape	2-6 cm long, 1-3 cm width, Lanceolate
2.	Venation	Reticulate
3.	Apex	Acute
4.	Base	Oblique
5.	Margin	Serrate
6.	Color	Dark Green
7.	Oduor	Characteristic
8.	Taste	Bitter

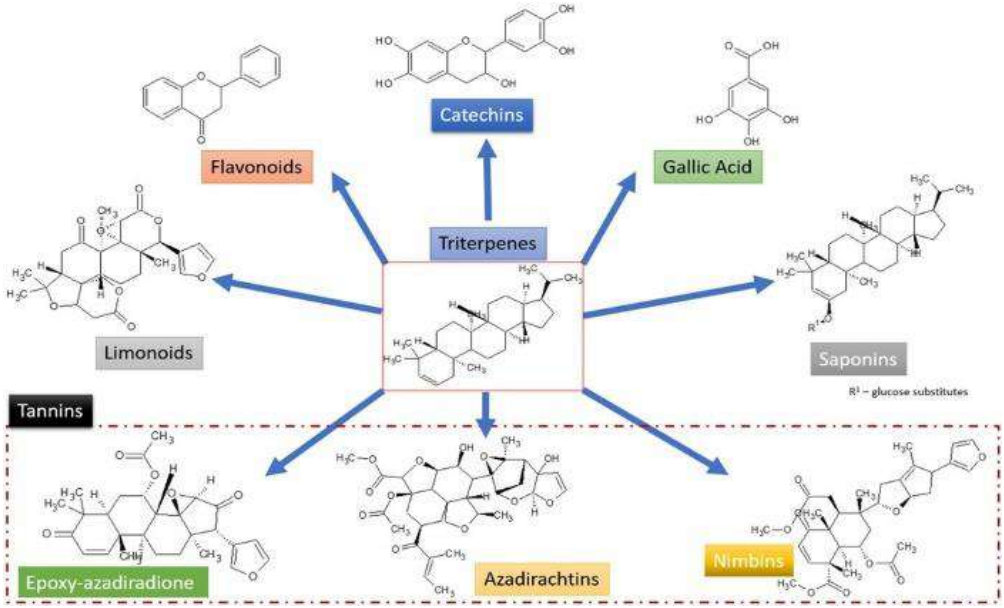
GEOGRAPHICAL SOURCE

The tree is most commonly used in India. It is grown from sea level to an elevation of about 700 metres, in tropical to subtropical climates, from the southern tip of Kerala to the Himalayan hills, and in semiarid to wet tropical climates. It is believed that Azadirachta indica is indigenous to the Indian subcontinent, Bangladesh, Cambodia, Laos, Myanmar, Thailand, and Vietnam in Indochina. It has been widely dispersed throughout tropical and subtropical areas, ranging from Indonesia to South America.



CHEMISTRY OF NEEM

Neem can be called as the “storehouse” of a number of phytochemicals. More than 300 phytochemicals were extracted from neem tree. The most two important classes of phytochemicals which have been isolated from various parts of neem are isoprenoids, and non-isoprenoids. The most widely recognized isoprenoids include diterpenoids, vilasinins, triterpenoids, limonoids, and C-secomeliacins while proteins, carbohydrates (polysaccharides), sulphur compounds, tannins, polyphenolics such as flavonoids and their glycosides, dihydrochalcone, coumarin and aliphatic compounds, phenolic acids come under non- isoprenoids. Nimbin is the first compound to be studied. Other phytochemicals derived from neem are nimbolide, azadirachtin, azadiradione, gedunin and azadirone. The complex structure of the phytochemicals has made a large diversity.



NEEM AS A MEDICINAL PLANT

Medicinal plants had become a part and parcel of human society to combat diseases from the starting of civilization. Over 2000 years, In India and its neighbouring nations, neem is one of the most versatile medicinal plants which have a wide range of biological activity. All parts of the neem tree viz. leaves, flowers, fruits, seeds, roots and bark have immense therapeutic value and traditionally been used for the treatment of fever, skin diseases, inflammations, infections and dental disorders. Some of the medicial values of the different part of neem tree are given below

1. Seeds:

Neem oil and cake are obtained from neem seeds. Neem oil is used as analgesic, antihelminthic, anticholinergic, antihistaminic, antipyretic, antiviral, antiprotozoal, insecticides bactericidal, insect repellents, fungicides and as veterinary medicines. Neem cake is used as animal feed, soil protectant, soil fertilizer and soil neutralizer.

2. **Leaves:**

Neem leaves have antiemetic, antifungal, anticlotting agent, anti-helminthic, antituberculosis, antitumor, antiseptic, antiviral, insecticides, nematicides, insect repellents activity.

3. **Twigs:**

Twigs are used as oral deodorant, tooth cleaners, toothache reliever.

4. **Bark:**

Neem ark has antidermatic, antiallergenic, antiprotozoal, antitumor and antifungal property.

5. **Flowers:**

Neem flowers have analgesic and stimulant property.

BIOACTIVE COMPOUNDS EXTRACTED FROM DIFFERENT PARTS OF NEEM TREE

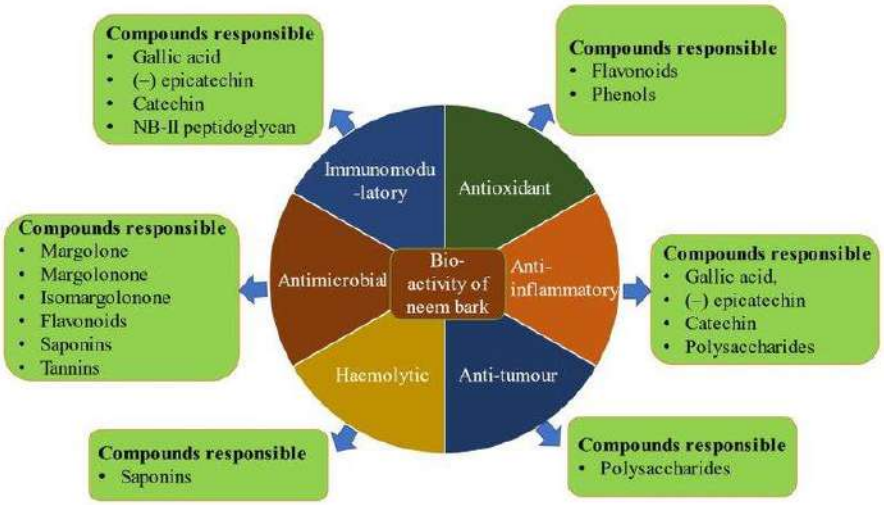
Neem compound	Source	Biological activity
Nimbidin	Seed oil	Anti-inflammatory, Antiarthritic, Hypoglycemic Antigastric, Antipyretic, ulcer, Antibacterial, Diuretic, Antifungal and Spermicidal
Nimbin	Seed oil	Spermicidal
Nimbolide	Seed oil	Antibacterial Antimalarial
Gedunin	Seed oil	Antifungal Antimalarial
Mahmoodin	Seed oil	Antibacterial
Azadirachtin	Seed	Antimalarial

Cyclic trisulphide and cyclic tetrasulphide	Leaf	Antifungal
Gallic acid, (–) epicatechin and catechin	Bark	Anti-inflammatory immunomodulatory
Margolone, margolonone and isomargolonone	Bark	Antibacterial
Polysaccharides GIa, GIb	Bark	Antitumor
Polysaccharides GIIa, GIIIa	Bark	Anti-inflammatory
NB-II peptidoglycan	Bark	Immunomodulatory

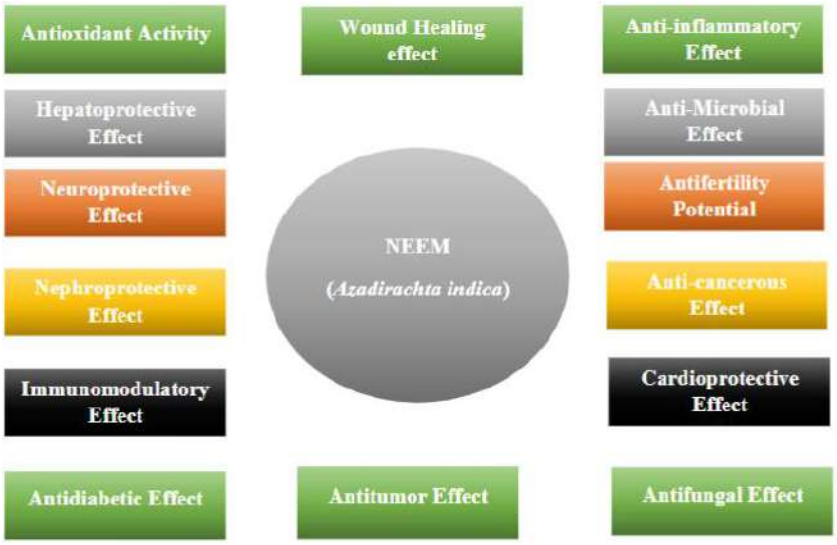
BIO- ACTIVITIES OF VARIOUS COMPOUNDS FROM NEEM LEAF

Azadirachtin	Antioxidant, anti-inflammatory
Chlorogenic acid	Antioxidant, anti-inflammatory
Quercetin	Antioxidant, anti-inflammatory
Kaempferol/derivatives	Antioxidant, anti-inflammatory
Myricetin	Antioxidant, anti-inflammatory
Nimbin	Antioxidant
Nimbolide	Antioxidant
Rutin	Antioxidant, antihyperglycemic
Scopoletin	Antioxidant
Sigmasterol/_-Sitosterol	Antioxidant

BIO- ACTIVITIES OF VARIOUS COMPOUNDS FROM NEEM BARK



MEDICINAL/PHARMACOLOGICAL ACTIVITIES OF NEEM



DIABETES MELLITUS

Diabetes mellitus is a metabolic disorder in which a person has high blood sugar level because either the pancreas does not produce enough insulin or cells do not respond to it. Diabetes mellitus (DM) is a disorder resulting from a defect in insulin secretion, insulin action, or both. Insulin deficiency in turn leads to chronic hyperglycaemia with disturbances of carbohydrate, fat and protein metabolism.

SYMPTOMS

Some of the symptoms of type 1 diabetes and type 2 diabetes are:

- Feeling more thirsty than usual.
- Urinating often.
- Losing weight without trying.
- Presence of ketones in the urine. Ketones are a byproduct of the breakdown of muscle and fat that happens when there's not enough available insulin.
- Feeling tired and weak.
- Feeling irritable or having other mood changes.
- Having blurry vision.
- Having slow-healing sores.
- Getting a lot of infections, such as gum, skin and vaginal infections.

CAUSES OF DIABETES MELLITUS

1. **Insulin resistance: -**

Type 2 diabetes mainly results from insulin resistance. Insulin resistance happens when cells in your muscles, fat and liver don't respond as they should to insulin. Several factors and conditions contribute to varying degrees of insulin resistance, including obesity, lack of physical activity, diet, hormonal imbalances, genetics and certain medications.

2. **Autoimmune disease:**

- Type 1 diabetes and LADA happen when your immune system attacks the insulin-producing cells in your pancreas.

3. **Hormonal imbalances: -**

During pregnancy, the placenta releases hormones that cause insulin resistance. You may develop gestational diabetes if your pancreas can't produce enough insulin to overcome the insulin resistance. Other hormone-related conditions like acromegaly and Cushing syndrome can also cause Type 2 diabetes.

4. **Pancreatic damage: -**

Physical damage to your pancreas from a condition, surgery or injury can impact its ability to make insulin, resulting in Type 3c diabetes.

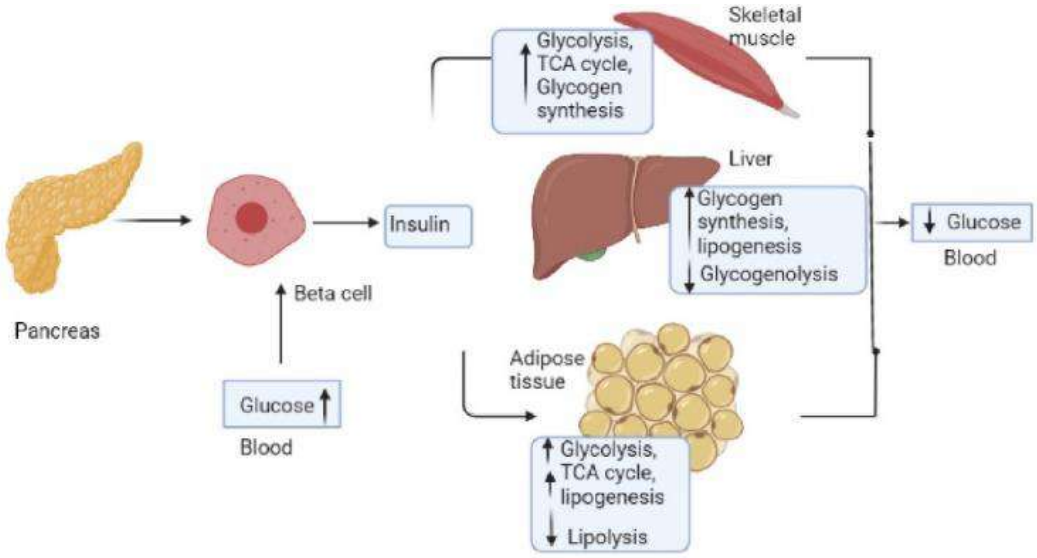
5. **Genetic mutations: -**

Certain genetic mutations can cause MODY and neonatal diabetes.

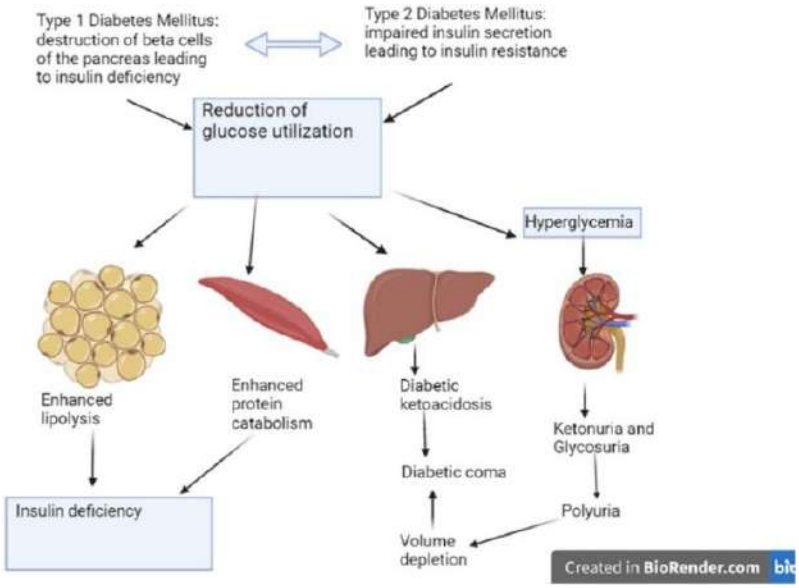
DIABETES IN INDIA

Based on current projections, 285 million adults globally (6.6%) in the 20–79 age range will have diabetes in 2010, and 438 million adults (7.8% of the adult population) will likely have the disease by 2030. India holds the dubious title of being the "diabetes capital of the world" as it has the highest percentage of diabetic patients worldwide. The International Diabetes Federation's Diabetes Atlas 2006 states that unless immediate preventive action is taken, India's current population of 40.9 million individuals with diabetes is predicted to increase to 69.9 million by 2025. With over 62 million people in India already diagnosed with the condition, diabetes is quickly becoming recognized as a possible epidemic. In 2000, India (31.7 million) topped the world with the highest number of people with diabetes mellitus followed by China (20.8 million) with the United States (17.7 million) in second and third place respectively.

HORMONAL REGULATION OF GLUCOSE METABOLISM



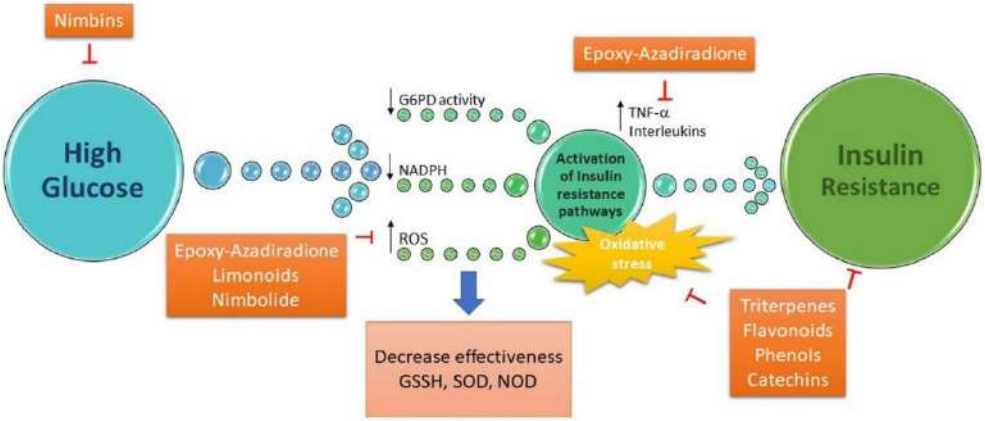
PATHOPHYSIOLOGY OF DIABETES



EFFECT OF NEEM LEAVES ON DIABETES

1. Now a days Diabetes is a major public health issue worldwide and that is approaching epidemic proportions globally. By the year 2020, the number of diabetic individuals was 170 million, and this figure is expected to ascend 366 million by 2030. Neem is one of the commonly used plants for the treatment of diabetes mellitus in conventional medicine.
2. Diabetes is a chronic- metabolic condition caused by elevated levels of blood glucose (or blood sugar) that can cause significant damage to the blood vessels, heart, kidneys and nerves. Oxidative stress, the difference between the development of reactive oxygen species (ROS) and the ability of enzymatic or non- enzymatic antioxidants may be the reasons for the pathophysiology involved in this condition. Such ROS can activate multiple harmful pathways that play an important role in diabetes disease development.
3. The mode of action results in insulin resistance or molecular mimicry. That, on the other hand, results in autoimmune destruction of Langerhans islet - cells and insulin deficiency or both. On peripheral tissues, the deficiency and improper action of insulin hampers the dietary carbohydrates, fats and proteins metabolism.
4. The explanation for the hypoglycaemic effect of neem leaf aqueous extract may be due to increased insulin release from islet pancreatic beta cells or increased peripheral glucose absorption and utilization Insulin released from remaining -cells and/or regenerated - cells improves the extract's antidiabetic impact, re-develop insulin sensitivity malabsorption in the small intestine of dietary carbohydrates or enhance the blood glucose uptake through peripheral tissues regulated by an insulin dependent glucose transporter named GLUT-4.
5. Several phytochemicals are found in plant extracts, such as flavonoids, free and bound anthraquinones, terpenoids, tannins, saponins, sterols and alkaloids, which have been related to the hypoglycaemic effect and ultimately serve to prevent diabetes. In addition, flavonoids in the adipocytes also increase the rate of lipogenesis and glucose transport activity which significantly reduces blood sugar.
6. The neem leaf extract contains alkaloids that are responsible for facilitating the restoration of insulin secretion through the regeneration of pancreas islets. Further, saponins and tannins were also found to have hypoglycemic activity. The terpenoids, found in the plants are very heart-friendly as they significantly minimize diastolic blood pressure and decrease the blood sugar levels. Anthraquinones are widely used to treat peripheral neuropathy, and has also been reported to reduce the level of blood glucose.
7. As per the study conducted by Arica et al., (2016), observed that the administration of different doses (25, 48.4, 93.5, 180.9 and 350 mg/kg) of aqueous neem leaf extract in different time interval, decreases blood glucose levels in diabetic mice (alloxan induced). The plant extract was comparable to standard drug (glibenclamide) in all doses and both routes.
8. The same type of effect of neem leaf extract was observed in alloxan induced diabetic rat, rabbit and dogs for the reduction of blood glucose level. It was also noted that in experimentally induced diabetes in rats and rabbits, oral administration of aqueous as well as alcoholic neem leaf extracts decreased blood glucose levels.

9. The anti-hyperglycemic effect is because of the antiserotonin function of neem leaf. Along with glucose, it was found that the neem leaf extract can reduce cholesterol (15%), lipids (15%), triglycerides (32%), creatinine (23%), and urea (13%) in rats (Dholi et al., 2011). This form of effect can be useful to avoid diabetic states because early intervention may avoid or postpone disease onset by an irregular glucose metabolism. Increased peripheral use of direct metabolism effects on tissues, especially on the liver, may lead to the hypoglycaemic effect of neem leaf. Among different compounds neem, rutin and quercetin have been found to have hypoglycemic/antihyperglycemic effects recently.
10. Neem leaves with chloroform as a solvent were collected and showed promising results for oral glucose tolerance testing and decreased significantly the activity of intestinal glucosidase. Meliacinolin, a new tetranortriterpinoid from chloroform extract also demonstrated in vivo anti-diabetic property against streptozotocin induced type 2 diabetes in mice. Alpha – glucosidase and alpha amylase activities have also been inhibited by meliacinolin, which may be an important technique to reduce the postprandial hyperglycemia levels.



FUTURE PROSPECTIVE

In developed diabetes mellitus, neem (A. indica) may have beneficial effects and even retard or avoid the onset of the disease. Less research was observed in the effect of neem leaves on obesity so it was hoped that, neem leaf extract might also find a place in the treatment of obesity in man and animals. Neem has hoped for a new generation of drugs, as information on how the new medicines target the specific physiological and cellular response remains unbroken. However, more studies with the various active principles on laboratory animals and people are required to determine its utility and effective mode of action in obesity and diabetes. A wide range of investigations into metabolism, tissue distribution, pharmacokinetics, toxicity and the chemical molecular mechanisms are required to develop modern neem leaf drugs.

CONCLUSION

Neem (Azadiracthta indica) is a very popular and traditional Indian tree and has been used in medicine since ancient times for many medicinal properties. The tree is known as “village Pharmacy” due to its versatile characteriatics and played an important role in the field of ayurvedic medicine and agriculture. The neem tree has medicinal value in all fields. Neem leaf extract is reported to possess diverse pharmacological activities like anti-inflammatory, hypolipidaemic, immunostimulant, hepatoprotective and hypoglycaemic effects. In this chapter we have summed up various bio- active components of neem leaf and their effect to prevent diabetes and

obesity. Many components have been identified by neem. Few have been studied extensively. Since in recent years the prevention and treatment of different diseases over the harmful side effect of chemical drugs has been increasingly being considered in medicinal plants and phytochemicals, this pharmacological study is a useful tool for the development of neem medicines.

ACKNOWLEDGMENT

With great pleasure and profound sense of gratitude, Miss. Shamili singh Assistant Professor of LCIT School of Pharmacy for his/her valuable guidance, keep interest, inspiration, unflinching encouragement and moral support throughout my major project report work. I especially indebted to my mentor Dr. (Mrs.) Shruti Rathore, Professor/ Principal, LCIT School of Pharmacy, Bilaspur (C.G.) who offered her continuous advice and encouragement throughout course of this thesis.

REFERENCES

1. Abdirahman, Y. A., Juma, K. K., Makori, W. A., Agyirifo, D. S., Ngugi, M. P., Gathumbi, P. K., ... & Njagi, E. N. M. (2015). Blood glucose lowering effect and safety of the aqueous leaf extracts of Zanha africana. Pharmaceutica Analytica Acta, 6(9), 1-9.
2. Adekunle, A. S., Adelusi, T. I., Jean-Paul, K., Ishmael, A., & Akintade, B. B. (2016). Insulinomimetic, Antihyperlipidemic and Antioxidative Properties of Azadirachta indica. Possible Mechanism of Action. Journal of Advances in Medicine and Medical Research, 1-11.
3. Akhila, A., & Rani, K. (1999). Chemistry of the neem tree (Azadirachta indica A. Juss.). In Fortschritte der Chemie organischer Naturstoffe/Progress in the Chemistry of Organic Natural Products (pp. 47-149). Springer, Vienna.
4. Alzohairy, M. A. (2016). Therapeutics role of Azadirachta indica (Neem) and their active constituents in diseases prevention and treatment. Evidence-Based Complementary and Alternative Medicine, 2016.
5. Amjad, L., & Shafighi, M. (2013). Evaluation of antioxidant activity, phenolic and flavonoid content in Punica granatum var. Isfahan Malas flowers. International Journal of Agriculture and Crop Sciences, 5(10), 1133.
6. Arika, W. M., Nyamai, D. W., Agyirifo, D. S., Ngugi, M. P., & Njagi, E. N. M. (2016). In vivo antidiabetic effect of aqueous leaf extract of Azardirachta indica, A. juss in alloxan induced diabetic mice. J Diabetic Complications Med, 1(2), 1-6.
7. Bedoya, F. J., Solano, F., & Lucas, M. (1996). N-monomethyl-arginine and nicotinamide prevent streptozotocin-induced double strand DNA break formation in pancreatic rat islets. Experientia, 52(4), 344-347.
8. Biswas, K., Chattopadhyay, I., Banerjee, R. K., & Bandyopadhyay, U. (2002). Biological activities and medicinal properties of neem (Azadirachta indica). Current Science-Bangalore-, 82(11), 1336-1345.
9. Brahmachari, G. (2004). Neem—an omnipotent plant: a retrospection. Chembiochem, 5(4), 408-421.
10. Broadhurst, C. L., Polansky, M. M., & Anderson, R. A. (2000). Insulin-like biological activity of culinary and medicinal plant aqueous extracts in vitro. Journal of Agricultural and Food Chemistry, 48(3), 849-852.
11. Christian, E. O., Onyeaghana, O. C., Ngozi, N. N., Olivia, O. O., Okwukwe, E. P., Ann, O. E., ... & Henrietta, O. C. (2020).
12. Evaluation of the effects of Azadirachta indica leaf on haematology, lipid profile, body weight and organ-system functions of streptozotocin-induced diabetic male rats. African Journal of Biochemistry Research, 14(3), 57-71.

13. Das, A. R., Mostofa, M., Hoque, M. E., Das, S., & Sarkar, A. K. (2010). Comparative efficacy of neem (Azadirachta Indica) and metformin hydrochloride (comet®) in streptozotocin induced diabetes melitus in rats. Bangladesh Journal of Veterinar Medicine, 8(1), 75-80.
14. Dash, S. P., Dixit, S., & Sahoo, S. (2017). Phytochemical and biochemical characterizations from leaf extracts from Azadirachta Indica: an important medicinal plant. Biochem Anal Biochem, 6(323), 2161-1009.
15. Dholi, S. K., Raparla, R., Mankala, S. K., & Nagappan, K. (2011). Invivo Antidiabetic evaluation of Neem leaf extract in alloxan induced rats. Journal of applied Pharmaceutical science, 1(4), 100-105.
16. Esmaeili, M. A., & Yazdanparast, R. (2004). Hypoglycaemic effect of Teucrium polium: studies with rat pancreatic islets. Journal of Ethnopharmacology, 95(1), 27-30.
17. Garza, A. L. D. L., Milagro-Yoldi, F. I., Boque, N., Campión-Zabalza, J., & Martinez, J. A. (2011). Natural inhibitors of pancreatic lipase as new players in obesity treatment.
18. Ghimeray, A. K., Jin, C. W., Ghimire, B. K., & Cho, D. H. (2009). Antioxidant activity and quantitative estimation of azadirachtin and nimbin in Azadirachta Indica A. Juss grown in foothills of Nepal. African Journal of Biotechnology, 8(13).
19. Girish, K., & Shankara, B. S. (2008). Neem–a green treasure. Electronic journal of Biology, 4(3), 102-111.
20. Gupta, S. C., Prasad, S., Tyagi, A. K., Kunnumakkara, A. B., & Aggarwal, B. B. (2017). Neem (Azadirachta indica): An indian traditional panacea with modern molecular basis. Phytomedicine, 34, 14-20
21. Hawkins, E. B., & Ehrlich, S. D. (2006). Gotu Kola. University of Maryland Medical Center. Baltimore. USA.
22. Hegde, N. G. (1995). Neem and small farmers-constraints at grass root level. Indian Forester, 121(11), 1040-1048.
23. Irfan, H. M., Asmawi, M. Z., Khan, N. A. K., & Sadikun, A. (2016). Effect of ethanolic extract of Moringa oleifera Lam. leaves on body weight and Hyperglycemia of diabetic rats. Pakistan journal of nutrition, 15(2), 112.
24. Jadge, D. R., Patil, S. V., & Purohit, R. (2008). Formulation of toothpaste from various forms and extracts of tender twigs of neem. J Pharm Res, 1(2), 148-152.
25. Jain, D. L., Baheti, A. M., Jain, S. R., & Khandelwal, K. R. (2010). Use of medicinal plants among tribes in Satpuda region of Dhule and Jalgaon districts of Maharashtra—an ethnobotanical survey.
26. Khosla, P., Bhanwra, S., Singh, J., Seth, S., & Srivastava, R. K. (2000). A study of hypoglycaemic effects of Azadirachta indica (Neem) in normal and alloxan diabetic rabbits. Indian Journal of Physiology and Pharmacology, 44(1), 69-74.
27. Koul, A., Goyal, R., & Bharati, S. (2014a). Protective effect of Azadirachta indica A. Juss against doxorubicin-induced cardiac toxicity in tumour bearing mice.
28. Koul, A., Mohan, V., & Bharati, S. (2014b). Azadirachta indica mitigates DMBA-induced hepatotoxicity: a biochemical and radiometric study.
29. Lale, N. E. S. (2002). Bio-activity and Limitation against wide spread use of neem products for the management of insect pests. Niger. J. Appl. Biol, 3, 115-125.
30. Maity, P., Biswas, K., Chattopadhyay, I., Banerjee, R. K., & Bandyopadhyay, U. (2009). The use of neem for controlling gastric hyperacidity and ulcer. Phytotherapy

Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives, 23(6), 747-755.

HOW TO CITE: Vishal Biswas, Yogita Dhuri, Shamili Singh, Divyani Soni, Shruti Rathore, A Review On Anti-Diabetic Effect Of Neem *(Azadirachta Indica*) Leaves, Int. J. of Pharm. Sci., 2024, Vol 2, Issue 5, 1224-1235. https://doi.org/10.5281/zenodo.11261407