



Received on 19 June 2016; received in revised form, 19 July 2016; accepted, 28 July 2016; published 31 July 2016

## AZADIRACHTA INDICA AND ITS ANTIDIABETIC POTENTIAL – A REVIEW

Sk. Ershadul Haque\* and M Sreenivasulu

Narayana Pharmacy College, Chintha Reddy Palem, Nellore - 524002, Andhra Pradesh, India.

### Keywords:

Neem, *Azadirachta indica*, Diabetes, Nimbi

### Correspondence to Author:

Sk. Ershadul Haque

Narayana Pharmacy College,  
Chintha Reddy Palem, Nellore -  
524002, Andhra Pradesh, India.

E-mail: skershadulhq@gmail.com

**ABSTRACT:** Diabetes mellitus (DM) is a serious metabolic disease which has several complications including diabetic nephropathy, coronary heart disease, and hypertension. It has been estimated that by the year 2010, the prevalence of DM worldwide will reach approximately 240 million. Despite considerable progress in the management of diabetes mellitus by synthetic drugs, the search for indigenous and diabetic agents continues. Natural product based compounds and their analogs thereof from various medicinal plants have provided numerous clinically useful drugs. In this review article, we mainly focused on neem (*Azadirachta indica*), the most useful traditional plant in India that has been explored towards an antidiabetic application.

**INTRODUCTION:** The phytochemicals identified from traditional medicinal plants are presenting an exciting opportunity for the development of new types of therapeutics<sup>1</sup>. Many indigenous Indian medicinal plants have been reported by various researchers' growth towards anti-diabetic applications<sup>1</sup>. Many such oral hypoglycaemic agents are not very effective in lowering glucose in diabetic patients<sup>2</sup>. Therefore, the search for effective drugs for the treatment of diabetes mellitus continues. Many ethnobotanical surveys on medicinal plants used by the local population have been performed in different parts of the world including Morocco, Saudi Arabia, Taiwan, Trinidad, and Tobago<sup>3-8</sup>. Only a few reviews on plants have been screened for hypoglycemic activity in India<sup>9-19</sup>. Anti-diabetic medicinal plants are in general known to exert their beneficial effects on diabetes *via* various modes and mechanisms.

Intervention with various plant extracts have shown evidence that the hitherto destroyed beta cells can be regenerated and in most cases, the partly non-destroyed cells protected from further degeneration by the activity of the extracts. For instance, a naturally occurring flavonoid-epicatechin<sup>20</sup>, chard – *Beta vulgaris* L. var *varcida*<sup>21</sup>, silymarin<sup>22</sup>, *Terminalia catappa* leaves<sup>23</sup>, walnut leaves – *Julgaris regia* L.<sup>24</sup> and *Gymnema sylvestre*<sup>25, 26</sup> used as traditional diabetes management and exert their antidiabetic action by regeneration of previously necrosed pancreatic beta cells, hence re-establishing insulin production. De Jussieu stated that the neem tree had been described as *Azadirachta indica* as early as 1830 and its taxonomic position are as follows:

Order: Rutales  
Suborder: Rutinae  
Family: Meliaceae (mahogany family)  
Subfamily: Melioideae  
Tribe: Melieae  
Genus: *Azadirachta*  
Species: *indica*



Each part of the neem tree has some medicinal property and is thus commercially exploitable. Trees have been used as traditional medicine for a household remedy against various human ailments, from antiquity<sup>27-32</sup>. During the last five decades, apart from the chemistry of the neem compounds, considerable progress has been achieved regarding the biological activity and medicinal applications of neem. It is now considered as a valuable source of unique natural products for the development of medicines against various diseases and also for the development of industrial products<sup>33</sup>.

It has been extensively used in Ayurveda, Unani and homeopathic medicine and has become a cynosure of modern medicine. The importance of the neem tree has been recognized by the US National Academy of Sciences, which published a report in 1992 entitled "Neem – a tree for solving global problems." The advancement of neem research has earlier been documented<sup>34, 35</sup>.

Neem oil, bark and leaf extracts have been therapeutically used as folk medicine to control diseases like leprosy, intestinal helminthiasis, respiratory disorders, constipation, and skin infections<sup>33</sup>. However, apart from these uses, there are several reports on the biological activities and pharmacological actions based on modern scientific investigations, such as antiviral<sup>36</sup>, antibacterial<sup>37</sup>, antifungal<sup>38</sup>, anti-inflammatory and antipyretic<sup>39</sup>, antiseptic, anti paralytic<sup>40</sup>, antioxidant<sup>41, 42</sup>, etc. According to Bnouham *et al.*, plant products exploiting beta cell regenerative mechanism which is useful in the management of both type I and type II diabetes mellitus<sup>26</sup>.

### Common Name of *Azadirachta indica*:

**TABLE 1: DIFFERENT NAMES OF AZADIRACHTA INDICA**

Botanical name	<i>Azadirachta indica</i>
Latin name	Melia azaderach
English name	Margosa tree
Sanskrit name	Nimbah
Hindi name	Neem
Marathi name	Nimbi
Tamil name	Vempu, veppai
Telgu name	Kondavepa
Kannada name	Bevu
Indian name	Neem, nim, Indian lilac, nimmi, limbo, limda

**TABLE 2: AYURVEDIC USES OF AZADIRACHTA INDICA**

Part	Medicinal use
Leaf	Leprosy, eye problem, epistaxis, intestinal worms, anorexia, biliousness, skin ulcers.
Bark	Analgesic, alternative and curative of fever
Flower	Bile suppression, elimination of intestinal worms and phlegm.
Fruit	Piles, intestinal worms, urinary disorder, epistaxis, phlegm, eye problem, diabetes, wounds, and leprosy
Twig	Cough, asthma, piles, phantom tumor, intestinal worms, spermatorrhoea, obstinate urinary disorder, diabetes
Gum	Scabies, wounds, ulcer, and skin diseases
Seed	Leprosy, and intestinal diseases
Oil	Leprosy and intestinal worms
Root	Refrigerant, diuretic

**MATERIALS AND METHODS:** Different methods for obtaining the extract from different parts of the neem.

**Extract from Neem Leaves:** Matured leaves *Azadirachta indica* (*A. indica*) were procured from the local market leaves were rinsed severally with clean tap water to remove dust particles and debris and thereafter allowed to drain completely and were dried in the shade. The plant materials of *A. indica* were chopped with a knife and one kilogram (1kg) with an electric blender in 1.95 liters of 80% (v/v) ethanol respectively. The mixtures were then allowed for 48 h in an oven at 40 °C for thorough extraction of the plant's active components. These were then filtered with cheesecloth and later with "Whatman no. 1" filter paper to obtain a homogenous filtrate. The filtrates were after that concentrated in vacuum at low temperature (37- 40 °C) to about one-tenth the original volume using a rotary evaporator. The concentrates were further allowed openly in a water bath (40°C) for complete dryness yielding 34.71g (3.471%) of brown oily substances for *A. indica*. The extracts were then refrigerated at 2- 8 °C until use<sup>43</sup>.

The coarsely powdered leaf drug of *Azadirachta indica* about 200 gm was extracted with water (aqueous extraction) by continuous extraction method using Soxhlet apparatus. The aqueous extract was filtered and concentrated to a dry mass by using the oven. A greenish black color residue was obtained<sup>44</sup>. Fresh leaves of *A. indica* obtained from the local market were washed in tap water and then left to dry at room temperature for 2-3 days.

The dried leaves were then ground to fine powder in a mixer. The dried leaf powder was then extracted with 95% ethanol using a Soxhlet apparatus for 15 h after filtration through cotton wool the filtrate was concentrated at 650 °C by a rotavapor. The concentrate was then freeze-dried to yield dried powder and was designated as *A. indica* leaf ethanol extract<sup>41</sup>. Fresh matured leaves of *A. indica* were collected. Air-dried powder (1 kg) of *A. indica* leaves was extracted by percolation at room temperature with 70% ethanol. Leaf extract of *A. indica* was concentrated under reduced pressure (bath temperature 50 °C) and, finally, dried in a vacuum desiccator. The residue was dissolved in distilled water and filtered. The filtrate was evaporated to dryness. The dried mass was suitably diluted with normal saline and used in the experiments<sup>44</sup>.

**Extraction from Neem Bark:** Air dried bark from full-grown Neem tree; devoid of external hardwood was used. It was cut into small pieces (2cm X 2cm) and 100 gm was soaked in 1 liter distilled water for 24 h at room temperature with occasional shaking. The brown-red extract, after filtration was lyophilized to yield 6g of dry powder. A measured amount of the powder was dissolved in distilled water at a suitable concentration before the experiment and centrifuged, if necessary<sup>45</sup>.

**Standardization of the Neem Bark Extract – Qualitative and Quantitative Aspects:** An aliquot of an aqueous solution of the lyophilized powder of the neem bark extract after clarification was subjected to high-pressure liquid chromatography (HPLC). The major bioactive principle has been characterized to be phenolic glycoside in nature<sup>46</sup>; qualitative and quantitative analyses of the bark extract were carried out concerning phenolics and carbohydrate content. Presence of phenolic compounds was identified by the blue color developed according to the method of Lowry *et al.*,<sup>47</sup> and the quantity were determined using tyrosine as standard. Glycoside as carbohydrate was detected qualitatively by positive Molisch's test<sup>48</sup> and quantities by a phenol-sulphuric acid method using glucose as standard<sup>49</sup>.

**Extraction from Seeds:** Seeds of neem were procured from the local market and were dried in the shade. From the seeds, husks, and kernel were

separated. Petroleum ether extracts (60-80 °C) were obtained using Soxhlet apparatus<sup>44</sup>.

**Antidiabetic Effect of Various Parts of *Azadirachta indica*:** Item Justin Atangwho *et al.*, in the year of 2010 reported that histological effect of combined extracts of *Vernonia amygdalina* (VA) and *Azadirachta indica* on normal and diabetic rats demonstrate a possible synergy in pancreatic islets cells regeneration as one of its anti-diabetic mechanisms, far and above single extracts of VA and *A. indica* and also protect against diabetes-induced liver damage. VA extracts could only cause a partial recovery in treated diabetic rats and even in non-diabetic rats caused features of mild injury, but not the case with *A. indica* extracts. This may imply that at certain concentrations and duration of treatment VA extracts might become toxic to the hepatocytes<sup>50</sup>.

Junwani and Bhilai in the year of 2010 reported on a comparative study of Aloe, Kundru, and Neem as an antidiabetic agent. In this journal, it is mentioned that aqueous extracts of neem plant showed antihyperglycemic activity in streptozotocin-induced rats and this effect is because of the increase in glucose uptake and glycogen deposition in isolated rat hemidiaphragm<sup>43</sup>.

In 1986, V.P. Dixit *et al.*, studied the effect of neem seed oil on the blood glucose concentration of normal and alloxan diabetes rats. They concluded that in normal glycemic animals, the oil produced a significant lowering of blood glucose at both 3 h and 6 h. Seed oil administration in the alloxan-treated rats also produced a substantial lowering of blood glucose levels at 3h and 6h. The results of the study showed that the seed oil of neem possesses active constituents capable of lowering blood glucose in both normal and hyperglycemic animals<sup>51</sup>.

Item Justin Atangwho *et al.*, 2009 reported the effects of co-administration of extracts of *Vernonia amygdalina* and *Azadirachta indica* on serum electrolyte profile of diabetic and non diabetic rats. They discussed that *A. indica* extract caused no significant change in serum electrolyte profile of diabetic and non diabetic rats. Dilutional hyponatremia and hypophosphatemia which are

features of diabetic complications, with the former amplified by VA treatment but not by *A. indica* treatment, has been observed in this study. Combined administration of VA and *A. indica* reversed the dilutional hyponatremia but sustained hypophosphatemia<sup>52</sup>.

Shraddha Bisht and S.S. Sisodia in the year of 2010 reported that the anti-hyperglycemic and anti-dyslipidemic potential of *Azadirachta indica* leaf extract in STZ- induced diabetes mellitus. In this, they mention a group who received an ethanolic extract of *A.indica* leaves showed a significant and continuous decrease in blood sugar level till the 90 min. When it was observed after 120 min, it was reached near about normal level. Evaluation of the ethanolic extract of *A. indica* leaves in normal glycemic and STZ-hyperglycemic rats indicated that the extract possessed hypoglycemic and antihyperglycemic activities<sup>53</sup>.

S. Gupta *et al.*, reported that Protective role of extracts of neem seeds in diabetes caused by streptozotocin in rats. STZ is a commonly employed compound for induction of type-1 diabetes. STZ causes diabetes by rapid depletion of  $\beta$ -cells which leads to a reduction in insulin release. Hyperglycemia causes oxidative damage by generation of ROS and the development of diabetic complications. Further, the STZ diabetic animals may exhibit most of the diabetic complications, namely, myocardial cardiovascular, gastro-

intestinal, nervous, vas deferens, kidney, and urinary bladder dysfunctions. They concluded the results that petroleum ether extract of neem seed kernel (NSK) and neem seed husk (NSH) showed significant protection against the oxidative damage induced by STZ in heart and erythrocytes of rats. NSK and NSH may act as cardioprotective and free radical scavenger agent<sup>54</sup>.

In the year of 1996, R. R. Chattopadhyay reported an article on the possible mechanism of anti-hyperglycemic effect of *Azadirachta indica* leaf extract. In this article, he concluded that *A. indica* leaf extract, itself, did not affect peripheral utilization of glucose both in normal and diabetic rabbits. Epinephrine decreased the peripheral utilization of glucose significantly both in normal and diabetic animals. Pre-treatment with *A. indica* leaf extract, however, almost completely blocked the depressive effect of epinephrine in diabetic rabbits and, to a certain extent, in normal ones. In *in-vitro* trials, it was observed that epinephrine decreased the hepatic glycogen significantly in normal and diabetic rabbits. *A. indica* leaf extract, in itself, failed to alter the hepatic glycogen, but it partially blocked epinephrine action on hepatic glycogen both in normal and diabetic rabbits.

*A. indica* leaf extract blocked the peripheral depressant and  $\beta$ -adrenergic stimulation<sup>44</sup>. **Fig. 1** shows the *A. indica* plant, bark, leaf and seed.



FIG. 1: (A) PLANT, (B) BARK (C) LEAVES AND SEEDS

**Chemical compounds in *Azadirachta indica*:** The chemical compounds that have been identified in **Table 3**, scientists feel that there are many more compounds yet to be identified in neem<sup>55</sup>. Other

then sodium, potassium, salts, it contains chlorophyll, calcium, phosphorus, iron, thiamine, riboflavin, nicotinic acid, vitamin C, carotene, and oxalic acid. The chemicals classified are:

**TABLE 3: CHEMICAL COMPOUNDS, SOURCE AND ACTIVITY OF AZADIRACHTA INDICA**

Compound	Source	Activity
Azadirachtin	Seed oil	Insect repellent
Nimbidin	Seed oil	Antiviral
Nimbin	Seed oil	Antiviral
Azadirachtin	Leaves	Insect repellent
Meliantriol	Leaves	Antifeedant
Salanin	Leaves	Antifeedant
Nimbosterol	Flowers	Insecticidal
Myricitin	Flowers	Insecticidal
Kaempferol	Flowers	Insecticidal
Deacetyl azadirachtinol	Fruits	Paralyzes insects swallowing mechanisms
Nimbin	Bark	Antiviral
Nimbinin	Bark	Antiviral
Nimbidin	Bark	Antiviral
Margolone	Bark	Antibacterial
Margolonone	Bark	Antibacterial
Isomargolone	Stem bark	Antibacterial

**Treatment for Several Diseases:**

- **Heart Disease:** Including high blood pressure, blood clots, cholesterol, and Arrhythmia/rapid heartbeat.
- **Blood Disorders:** Including poor circulation, blood poisoning, and kidney problems.
- **Digestive Disorders:** Including heartburn/indigestion, peptic / duodenal ulcers, gastritis, and hemorrhoids.
- **Nervous Disorders:** Including anxiety, epilepsy, and hives.
- **Sexually Transmitted Diseases:** Including gonorrhea, syphilis, Chlamydia, genital herpes, genital/vaginal warts, candidacies, and urinary tract infections. As far as AIDS is concerned the immune modulatory properties of neem appear to enhance the cell-mediated immune response in people who are HIV positive but who do not have full-blown AIDS.
- **Jaundice and Hepatitis:** Drink the diluted juice of the tender neem leaves with a teaspoon of honey to flush out toxins in liver disorders. Neem is antipruritic, thermogenic and tonic, stomachic and abdominal movement controller. 2 teaspoon of neem leaves juice with honey is indicated to accelerate the process of cure.
- **Birth Control:** Works for Men and Women. It is said that neem might be the solution for birth control in men as experiments have shown it can make sperm infertile without affecting sex drive or impeding the sperm count.
- **Respiratory Disorder:** Decoction of neem bark is used as anti-tussive in dry cough. Dried neem leaves powder given daily in 1 gm dose twice a day with honey suppresses cough. Neem oil 5-10 drops given with 2 tablespoons of sugar once a day for 15 days helps in tropical eosinophilia. The expectorant, depurative and antiseptic properties of neem attribute to cure cough.
- **Diabetes:** Neem being bitter, stomachic, antipruritic, and revitalize works wonders in this disease. One tablespoon of neem leaves juice approximately 5 ml taken early in the morning on an empty stomach for 3 months is helpful in diabetes. Neem leaves chewed or powder took daily in the morning also controls diabetes.
- **Cancer:** Neem being depurative purifies the blood and is an astringent decreases the body heat. Chewing of 10 to 20 neem leaves early morning with warm water is helpful.
- **Leprosy and Leucoderma:** 10 drops of neem oil mixed with 1 teaspoon sugar twice a day acts as a supportive part of treatment. The anti-leprotic action of neem works.
- **Allergy:** 8 to 10 fresh neem leaves are to be eaten early morning on an empty stomach. This helps in purifying blood and controls the allergic condition. It is also used in Tuberculosis, Bronchitis, Conjunctivitis, Allergies, Bad Breath, Hangover, Stress, Insomnia, Smoking.
- **Treatment for AIDS:** The National Institutes of Health reported positive results from a 1993 study using neem to kill the AIDS virus in a lab. The suggested pathway is via neem immune modulating polysaccharide compounds that may cause increased antibody production. Further research is underway.
- **Diabetes:** Neem has been shown to reduce insulin in the blood. The Indian Government allows the sale of neem for this purpose. Dosage as small as one tablespoon a day can reduce insulin levels by 50%.

- **Neem Gum:** Use of Neem Gum in Industries.
- **Cosmetic Industry:** Used in facial masks, lotions, face powder, protective creams.
- **Paper Industry:** Used as an adhesive and strengthening the paper.
- **Pharmaceutical Industry:** Used in antiseptic creams, tablet binder, and coater.
- **Textile Industry:** Used in dyeing and printing of fabrics.
- **Personal Hygiene Industry:** Used in soaps, toothpaste, tooth powders.
- **Food Industry:** Used as a stabilizing agent, gels and thickening agent.

**CONCLUSION:** We conclude this review with some facts that neem *i.e. Azadirachta indica* have anti-diabetic activity with various possibilities of mechanisms. Neem leaves, bark, seed and seed husk, have shown very significant hypoglycemic activity. We can say that neem works as an anti-diabetic agent by lowering blood glucose level, by utilizing glucose peripherally or it may increase the release of insulin and also may inhibit proximal tubular reabsorption mechanism for glucose in the kidney. Neem is not only useful in treating diabetes, but also it shows good activity against diabetic complications. NSK and NSH may act as cardioprotective and free radical scavenger agent in case of a diabetic complication. Therefore, we should formulate neem leaf or seed powdered extracts as dosage forms to treat the diabetic patient. It will contribute a lot to the pharmaceutical field.

**ACKNOWLEDGEMENT:** Nil

**CONFLICT OF INTEREST:** Nil

## REFERENCES:

1. Tiwari Ashok K and Madhusudana R: Diabetes mellitus and multiple therapeutic approaches of phytochemicals: present status and prospects. J Current Science 2002; 83 (1): 30-38.
2. Subramoniam A, Pushpangadan P, Rajasekharan S, Evans DA, Latha PG and Valsaraj R: Effects of *Artemisia pallens* Wall on blood glucose levels in normal and alloxan-induced diabetic rats. J Ethnopharmacol 1996; 50: 13-17.
3. Atta-Ur R and Khurshid Z: Medicinal plants with hypoglycemic activity. J. Ethnopharmacol 1989; 26(2): 1-55.
4. Lin CC: Crude drugs used for the treatment of diabetes mellitus in Taiwan. Am J Clin Med 1992; 20: 269-279.
5. Mahabir D and Gulliford MC: Use of medicinal plants for diabetes in Trinidad and Tobago. Rev Panam Salud Publica 1997; 1: 174-179.
6. Ziyat A, Legssyer A and Mekhfi H: Phytotherapy of hypertension and Diabetes in oriental Morocco. J Ethnopharmacol 1997; 58: 45-54.
7. Al-Rowais NA: Herbal medicine in the treatment of diabetes mellitus. Saudi Med J 2002; 23: 1327-1331.
8. Bnouham M, Mekhfi H, Legssyer A and Ziyat A: Medicinal plants used in treatment of diabetes in Morocco. Int J Diab Metab 2002; 10: 33-50.
9. Mukherjee SK and Mukherjee S: Therapeutic advances in diabetes mellitus through ages. J Rev Ind Med 1966; 1: 9.
10. Chaudhary RR, Udupa KN, Chaturvedi GN, Tripathi SN and Vohora SB: Plants with possible hypoglycemic activity in advance. Sin. Research in Indian Medicine, Banaras Hindu University, Varanasi (India); 1970; 57.
11. Karnick CR: Some aspects of crude Indian drugs plants used in Ayurvedic system of medicine (Madhumeha). Acta Phytother Amst 1972; 19: 141-149.
12. Satavati GV, Raina MK and Sharma M: Medicinal Plants of India, (Indian Council of Medical Research) 1976; 48: 2.
13. Satyavati GV, Gupta AK and Tandon N: Medicinal Plants of (Indian Council of Medical Research, New Delhi), 1987; 2.
14. Satyavati GV: Pharmacology of medicinal plants and other natural products in current research in Pharmacology in India Pharmacognosy Reviews 2008; 12(4): 284-301.
15. Mukherjee SK: Indigenous drugs in diabetes mellitus. J Diabetic Asso India (Suppl) 1981; 21: 97-106.
16. Mehta KC: Indian herbal drugs in the treatment of diabetes. Current Med Pract 1982; 26(10): 305-308.
17. Nagarajan S, Jain HC and Aulakh GS: Indigenous plants used in the Control of Diabetes in Cultivation and Utilization of Medicinal Plants. Regional Research Laboratory Jammu (India) 1982; 584-604.
18. Patnaik GK and Dhawan BN: Pharmacological studies on Indian medicinal plants in current research on medicinal plants in India. Indian National Academy, New Delhi, 1986; 45-47.
19. Das PK, Dasgupta G and Mishra AK: Clinical studies on medicinal plants of India. Current Research of Medicinal Plants in India 1986; 72-86.
20. Chakravarthy BK, Gupta S and Gode KD: Functional beta cell regeneration in the islets of the pancreas in alloxan-induced diabetic rats by epicatechin. Life Science 1982; 31(24): 2693-2697.6.
21. Bolkent RA and Yanarda O: Tabakolu-ouz andozsoy-sacan effect of chard (*Beta vulgaris*. var. cida) extract on pancreatic  $\beta$  cells in streptozotocin-diabetic rats: a morphological and Biochem. J. Ethnopharmacology 2000; 73: 251-259.
22. Soto C, Mena R, Luna J, Cerbon M, Larrieta E, Vital P, Uria E, Sanchez M, Recoba R, Barron H, Favari L and Lara A: Salymarín induces recovery of pancreatic function after alloxan damage in rats. Life Science 2004; 75(18): 216-2180.
23. Ahmed SM, Vrushabendra SBM, Gopkumar P, Dhanapal R and Chandrashekara: Anti-diabetic activity of *Terminalia catappa* Linn. leaf extracts in alloxan-induced diabetic rats. Iranian J Pharm Therap 2005; 4(1): 38-39.
24. Jelodar G, Mohsen M and Shahram S: Effect of walnut leaf, coriander and pomegranate on blood glucose and histopathology of pancreas of alloxan-induced diabetic rats. African J Traditional Complementary and Alternative Med 2007; 4(3): 299-305.

25. Yeh GY, Eisenberg DM, Kaptuk TJ and Philips RS: A system review of herbs and dietary supplements for glycemic control in diabetes. *Diabetes Care* 2003; 26(4): 1277-1294.
26. Bnouham M, Ziyat A, Mekhfi H, Tahri A and Legssyer A: Medicinal plants with potential anti-diabetic activity – A review of ten years of herbal medicine research (1990-2000). *Int J Diabetes Metabolism* 2006; 14: 1-25.
27. Chopra RN, Nayer SL and Chopra IC: *Glossary of Indian Medicinal Plants*. CSIR, New Delhi, Health & Fitness, 1956; 329.
28. Chopra RN, Chopra IC, Handa KL and Kapur LD: *Indigenous Drugs of India*. U.N. Dhur and Sons, Kolkata, 1958; 551–595.
29. Kirtikar KR and Basu BD: *In Medicinal Plants*. Vivek Vihar, New Delhi, 1975; 536.
30. Thakur RS, Singh SB and Goswami A: *Azadirachta indica* A. Juss. – A review. *Curr Res Med Aromat Plants* 1981; 3: 135-140.
31. Koul O, Isman MB and Ketkar CM: Properties and uses of neem *Azadirachta indica*. *Can J Bot* 1990; 68: 1-11.
32. Chatterjee A and Pakrashi S: *The Treatise on Indian Medicinal Plants*, 1994; 2(30): 59-70.
33. Biswas KI, Chattopadhyay R, Banerjee K and Bandyopadhyay U: Biological activities and medicinal properties of Neem (*Azadirachta indica*). *Curr Sci* 2002; 82(11): 1336-1345.
34. Schmutterer H: *The Neem Tree Source of Unique Natural Products for Integrated Pest Management Medicine, Industry and Other Purposes*, VCH, Weinheim, Germany, 1995; 1-696.
35. Singh RP, Chari MS, Raheja AK and Kraus W: *Neem and Environment*, Oxford & IBH Publishing, New Delhi, 1996; I and II; 1–1198.
36. Gogati SS and Marathe AD: Anti-viral effect of neem leaf (*Azadirachta indica*) extracts on chinkugunga and measles viruses. *J Res Edu Ind Med* 1989; 8: 1-5.
37. Singh N and Sastry MS: Antimicrobial activity of neem oil. *Ind J Pharmacol* 1997; 13: 102-106.
38. Kher A and Chaurasia SC: Antifungal activity of essential oils of three medical plants. *Ind Drug* 1997; 15: 41-42.
39. Okpanyi SN and Ezeukwu GC: Anti-inflammatory and antipyretic activities of *Azadirachta indica*. *Planta Media* 1981; 4(1): 34-39.
40. Allan EJ, Stuchbury T and Mordue AJ: *Azadirachta indica* A. Juss. (Neem tree): *In-vitro* culture, micropropagation and the production of azadirachtin and other secondary metabolites. *Biotechnology in agriculture and forestry science series*, Springer, 1991; 43: 11-41.
41. Bandyopadhyay U, Biswas K, Chatterjee R, Bandyopadhyay D, Chattopadhyay I and Ganguly CK: Gastroprotective effect of neem (*Azadirachta indica*) bark extract: possible involvement of H<sup>+</sup>-K<sup>+</sup>-ATPase inhibition and scavenging of hydroxyl radical. *Life Sci* 2002; 71: 2845-2865.
42. Atangwho IJ, Ebong PE, Egbung GE, Akpaso MI and Edem E: Asuquo histological effect of combined extracts of *Vernonia amygdalina* and *Azadirachta indica* on normal and diabetic rats: the pancreas and liver. *Res J Agri Bio Sci* 2010; 6(4): 514-521.
43. Gunjan M, Jana GK and Jha AK: A comparative study of aloe, kundru and neem as an antidiabetic agent. *Drug Invention Today* 2010; 2(1): 22-24.
44. Chattopadhyay RR: Possible mechanism of anti-hyperglycemic effect of *Azadirachta indica* leaf extract. Part IV. *Gen Pharmac* 1996; 27: 431–434.
45. Bandyopadhyay U, Chatterjee R and Bandyopadhyay RK: Process for the isolation of an active principle from *Azadirachta indica* useful for controlling gastric hyperacidity and gastric ulceration. US patent No. 5730986 of 1998.
46. Lowry OH, Rosebrough NJ, Far AL and Randall RJ: Protein measurement with the folin phenol reagent. *J Biol Chem* 1951; 193: 265-75.
47. Vogel AI: *Textbook of practical organic chemistry*, Revised by Furniss BS, Hannaford AJ, Smith PWG, Tatchell AR. Longman Group, UK, 1989.
48. Dubois M, Gilles KA, Hamilton JK, Rebers PA and Smith F: Colorimetric method for determination of sugars and related substances. *Anal Chem* 1956; 28: 350-356.
49. Gupta S, Kataria M, Gupta PK, Murganandan S and Yashroy RC: Protective role of extracts of neem seeds in diabetes caused by streptozotocin in rats. *Journal of Ethnopharmacology* 2004; 90: 185-189.
50. Atangwho IJ, Ebong PE, Egbung GE, Akpaso MI and Asuquo EE: Histological effect of combined extracts of *Vernonia amygdalina* and *Azadirachta indica* on normal and diabetic rats: the pancreas and liver. *J Agri Bio Sci* 2010; 6(4): 514-521.
51. Dixit VP, Sinha R and Tank R: Effect of neem seed oil on the blood glucose concentration of normal and alloxan diabetic rats. *J. Ethnopharmacology* 1986; 17: 95-98.
52. Atangwho IJ, Ebong PE, Egbung GE and Ani IF: Effects of co-administration of extracts of *Vernonia amygdalina* and *Azadirachta indica* on serum electrolyte profile and nondiabetic rats. *Australian J Basic and App Sci* 2009; 3(3): 2974-2978.
53. Bisht S and Sisodia SS: Anti-hyperglycemic and anti-dyslipidemic of *Azadirachta indica* leaf extraction STZ-induced diabetes mellitus. *J Pharm Sci & Res* 2010; 2(10): 622-627.
54. Gupta S, Kataria M, Gupta PK, Murganandan S and Yashroy RC: Protective role of extracts of neem seeds in diabetes caused by streptozotocin in rats. *Journal Ethnopharmacology*, 2004; 90: 185-189.
55. Sultana B, Anwar F and Przybylski R: Antioxidant activity of phenolic components present in barks of *Azadirachta indica*, *Terminalia arjuna*, *Acacianilotica*, and *Eugenia jambolana* Lam trees. *J Food Chem* 2007; 104: 1106-1114.

**How to cite this article:**

Haque SE and Sreenivasulu M: *Azadirachta indica* and its antidiabetic potential – a review. *Int J Pharmacognosy* 2016; 3(7): 288-94. doi link: [http://dx.doi.org/10.13040/IJPSR.0975-8232.IJP.3\(7\).288-94](http://dx.doi.org/10.13040/IJPSR.0975-8232.IJP.3(7).288-94).

This Journal licensed under a Creative Commons Attribution-Non-commercial-Share Alike 3.0 Unported License.

This article can be downloaded to **ANDROID OS** based mobile. Scan QR Code using Code/Bar Scanner from your mobile. (Scanners are available on Google Playstore)