Journal of Applied Pharmacognosy and Phytochemistry
Volume 3, Issue 1, Year of Publication 2023, Page 07 – 13

Review Article

JOURNAL OF APPLIED PHARMACOGNOSY AND PHYTOCHEMISTRY | JOAPP
www.joapponline.com

SYSTEMATIC REVIEW ON PLANTS OF NORTHEAST INDIA WITH POTENT ANTIDIABETIC ACTIVITY: A COMPREHENSIVE ANALYSIS

Dhiraj Baishya, Himangshu Deka, Ananta Choudhury*, Paramartha Bhuyan, Bhardwaj Bhaskar Das, Nasir Hussain, Jintu Deka, Amlanjyoti Puzari, Himangshu Choudhury

Article Information
Received: 12th October 2022
Revised: 28th January 2023
Accepted: 22nd February 2023
Published: 31st March 2023

Keywords
Diabetes mellitus, antidiabetic activity, medicinal plants, Northeast India, systematic review

ABSTRACT

Background: Diabetes mellitus is a global health concern with increasing prevalence. Medicinal plants have been traditionally used for diabetes management, and Northeast India is known for its rich biodiversity and traditional knowledge. This systematic review aims to comprehensively analyze the plants in Northeast India with potent antidiabetic activity. **Methods:** A systematic search of electronic databases was conducted to identify relevant studies published between 2000 and 2019. Studies investigating the antidiabetic potential of plants from Northeast India were included. Data extraction and synthesis were performed, focusing on plant species, traditional medicinal uses, mechanisms of action, and bioactive compounds. **Results:** A total of 47 studies meet the inclusion criteria and were included in the review. The commonly studied plants with potent antidiabetic activity in Northeast India included Bitter gourd (Momordica charantia), Jamun (Syzygium cumini), Gurmar (Gymnema sylvestre), Turmeric (Curcuma longa), Bael (Aegle marmelos), and Amla (Phyllanthus emblica). These plants exhibited various mechanisms of action, such as enhanced insulin secretion, improved glucose uptake, and protection of pancreatic beta cells. Additionally, several other plant species, including Clerodendrum colebrookianum, Ficus racemosa, Ziziphus jujuba, Alpinia galanga, and Justicia adhatoda, demonstrated promising antidiabetic properties. **Conclusion:** This systematic review provides a comprehensive analysis of plants in Northeast India with potent antidiabetic activity. The findings highlight the potential of commonly studied plants like Bitter gourd, Jamun, Gurmar, Turmeric, Bael, and Amla, while also identifying lesser-known plant species with promising antidiabetic properties. Further research, including phytochemical analysis and clinical trials, is needed to validate the efficacy, safety, and optimal usage of these plants in diabetes management.

*Faculty of Pharmaceutical Science, Assam down town University, Panikhaiti, Guwahati, Assam, 781026

***For Correspondence:** **ananta.choudhury@adtu.in**

INTRODUCTION

Diabetes mellitus, a chronic metabolic disorder characterized by elevated blood glucose levels, is a significant global health concern affecting millions of individuals worldwide [1]. The management of diabetes often involves the use of synthetic drugs; however, natural products derived from medicinal plants have gained attention as potential alternative or adjunctive treatments [2]. Northeast India, a region known for its rich biodiversity, offers a vast array of plant species that have been traditionally used for various medicinal purposes. The exploration of plants from this region for their antidiabetic potential holds great promise in the search for novel therapeutic interventions [3,4].

The present systematic review aims to comprehensively analyze the plants found in Northeast India that exhibit potent antidiabetic activity. Through a meticulous review of the available scientific literature, this study seeks to identify the plant species native to this region that have demonstrated promising antidiabetic properties and evaluate their potential as natural remedies for diabetes management

MATERIAL AND METHODS

A systematic literature search was conducted across scientific databases, including PubMed, Scopus, and Web of Science. The search terms included "Northeast India," "antidiabetic," "hypoglycemic," "plants," and related variations. Studies published between 2000-2019 were considered. Relevant studies were identified, and data extraction was performed on the selected studies.

The Northeast region of India, known for its unique biodiversity, is home to a diverse range of plant species with potential antidiabetic properties. Traditional knowledge and practices have been instrumental in identifying and utilizing these plants for managing various ailments, including diabetes. Here is some detailed information about a few notable plants from Northeast India that have shown promise in terms of their antidiabetic potential:

***Momordica Charantia* (Bitter gourd):** *Momordica Charantia* commonly known as bitter gourd or karela, is a tropical vine widely recognized for its potential antidiabetic properties. The plant belongs to the Cucurbitaceae family and is native to Asia, Africa, and the Caribbean [5]. Bitter gourd extracts have demonstrated hypoglycemic effects by increasing insulin secretion and improving glucose uptake [6]. Bitter gourd contains several bioactive compounds, including charantin, vicine, and polypeptide-p, which are believed to contribute to its hypoglycemic effects [8]. These compounds have been shown to stimulate insulin secretion, increase glucose uptake by cells, and improve glucose metabolism, resulting in reduced blood glucose levels [9]. Apart from that, it has been reported to possess insulin-like properties, acting as an insulin-mimetic agent [10]. It can enhance the binding of insulin to its receptors and stimulate glucose uptake in cells, similar to the action of endogenous insulin [11].

Further, Bitter gourd exhibits effective anti-inflammatory and antioxidant properties, which can help reduce inflammation and oxidative damage in diabetes. Studies have demonstrated that bitter gourd supplementation can improve glycemic control by reducing fasting blood glucose levels and glycated hemoglobin (HbA1c) [12]. It may also contribute to the normalization of lipid profiles by decreasing total cholesterol, triglycerides, and low-density lipoprotein (LDL) cholesterol while increasing high-density lipoprotein (HDL) cholesterol [13].

***Syzygium Cumini* (Jamun):** Syzygium cumini, commonly known as Jamun or Indian Blackberry, is a fruit-bearing tree native to the Indian subcontinent. The fruit of Syzygium cumini has been traditionally used in Ayurvedic and folk medicine for its various health benefits, including its potential antidiabetic properties [14]. Syzygium cumini has been reported to contains bioactive compounds such as jamboline, ellagic acid, and anthocyanins, which are believed to enhance insulin secretion from pancreatic beta cells and improve glucose uptake by peripheral tissues, leading to a decrease in blood glucose levels [15,16]. Further, research suggests that Syzygium cumini may have insulin-sensitizing effects, improving insulin sensitivity and glucose utilization by cells. It also improves binding of insulin to its receptors and promote the translocation of glucose transporters (GLUT4) to the cell membrane, facilitating glucose uptake. Moreover, it possesses potent antioxidant activity and also play significant role in modulation of carbohydrate metabolism by inhibiting carbohydrate-digesting enzymes such as α-amylase and α-glucosidase [17,18]. Lastly Syzygium cumini has shown potential in improving lipid profiles by reducing total cholesterol, triglycerides, and low-density lipoprotein (LDL) cholesterol, while increasing high-density lipoprotein (HDL) cholesterol levels [19,20].

***Gymnema Sylvestre* (Gurmar):** Gymnema Sylvestre, commonly known as Gurmar, is a medicinal plant that has been traditionally used in Ayurvedic medicine for its antidiabetic properties. Several studies have investigated the potential benefits of Gymnema Sylvestre in the management of diabetes [21]. The active compounds found in Gymnema Sylvestre, such as gymnemic acids, have been shown to possess antidiabetic effects. These compounds are believed to work through multiple mechanisms, including increased insulin secretion, enhanced glucose uptake, and improved insulin sensitivity [22,23]. Research has indicated that Gymnema sylvestre may help regulate blood sugar levels by reducing intestinal glucose absorption and suppressing the sensation of sweetness, thereby curbing sugar cravings [24]. Additionally, it has demonstrated the ability to regenerate pancreatic beta cells, which are responsible for insulin production [25].

***Curcuma longa* (Turmeric):** Curcuma longa, commonly known as Turmeric, is a spice widely used in culinary and traditional medicine. It contains a bioactive compound called curcumin, which has been studied for its potential antidiabetic effects [26,27]. Curcumin has shown promise in managing diabetes through various mechanisms. It possesses antioxidant and anti-inflammatory properties, which can help reduce oxidative stress and inflammation often associated with diabetes. Additionally, curcumin has been found to enhance insulin sensitivity, promote glucose uptake by cells, and improve pancreatic beta-cell function [28,29]. Research study conducted by Chuengsamarn et al. (2012) investigated the effects of curcumin supplementation in patients with type 2 diabetes. The results showed that curcumin supplementation significantly reduced fasting blood glucose levels, HbA1c levels, and markers of insulin resistance compared to the control group [27].

***Aegle Marmelos* (Bael):** Bael, also known as wood apple, is widely cultivated in Northeast India. It possesses antidiabetic activity through mechanisms such as enhancing insulin secretion, improving glucose uptake, and reducing oxidative stress [30]. Active compounds like marmelosin and umbelliferone contribute to its therapeutic potential [31]. Additionally, *Aegle marmelos* exhibits antioxidant and anti-inflammatory properties, which can protect pancreatic beta cells from oxidative stress and inflammation often associated with diabetes. It also aids in the regeneration of beta cells, contributing to improved insulin production [32,33].

***Phyllanthus Emblica* (Indian gooseberry or Amla):** Amla is a rich source of vitamin C and exhibits antioxidant and antidiabetic properties [34]. It helps in maintaining glucose homeostasis, improving insulin sensitivity, and protecting pancreatic beta cells. Active compounds such as emblicanin A and ellagic acid contribute to its antidiabetic effects [35].

***Clerodendrum Colebrookianum* (Colebrooke's Glorybower):** *Clerodendrum colebrookianum* locally known as "Sonaru" or "Norang," Clerodendrum colebrookianum is a flowering plant used in traditional medicine [36]. Clerodendrum colebrookianum contains a rich array of bioactive compounds such as alkaloids, flavonoids, tannins, terpenoids, and phenolic compounds [37]. These constituents are believed to contribute to the plant's therapeutic effects, including its anti-diabetic properties. Studies have shown its hypoglycemic effects by improving glucose metabolism, enhancing insulin sensitivity, and protecting pancreatic beta cells. Active compounds like colebroside and clerodane diterpenoids contribute to its antidiabetic activity [38].

***Ficus Racemosa* (Cluster fig):** *Ficus Racemosa*, commonly known as "Dumar" or "Gular," is a medicinal plant found in Northeast India. It exhibits antidiabetic effects by reducing blood glucose levels, enhancing insulin secretion, and improving insulin sensitivity [39]. Bioactive components like flavonoids, phenolic compounds, and triterpenoids are responsible for its antidiabetic properties [40].

***Ziziphus Jujuba* (Indian jujube):** Indian jujube, also known as "Bor" or "Baer," is a fruit-bearing tree widely cultivated in Northeast India [41]. It shows potential as an antidiabetic agent by reducing fasting blood glucose levels, improving insulin sensitivity, and protecting pancreatic beta cells [42]. Active constituents like flavonoids, triterpenoids, and polysaccharides contribute to its antidiabetic activity [43].

***Alpinia Galanga* (Greater galangal):** *Alpinia Galanga*, locally called "Mitha owa," is a rhizomatous plant used in traditional medicine. It exhibits hypoglycemic effects by enhancing insulin secretion, improving glucose uptake, and reducing insulin resistance [44]. Active compounds such as flavonoids, phenolic acids, and terpenoids contribute to its antidiabetic properties [45].

***Justicia Adhatoda* (Malabar nut):** Malabar nut, known as "Vasaka" in Northeast India, is a medicinal plant with potential antidiabetic activity [46]. It shows hypoglycemic effects by improving insulin sensitivity, reducing glucose production in the liver, and enhancing glucose uptake in peripheral tissues. Active constituents like alkaloids, flavonoids, and phenolic compounds contribute to its antidiabetic activity [47].

It is important to note that while these plants have shown potential in preclinical and clinical studies, further research is required to validate their efficacy, determine optimal dosage, and understand their mechanisms of action. Additionally, consultation with healthcare professionals is recommended before using any plant-based remedies for diabetes management.

RESULTS

The systematic review aimed to analyze the plants in Northeast India with potent antidiabetic activity, providing a comprehensive analysis of the available literature. A thorough search of electronic databases resulted in a total of 47 relevant studies that met the inclusion criteria. The studies included in the review were conducted between 2000 and 2019, covering a wide range of plant species and their antidiabetic potential.

Among the plant species investigated, Bitter gourd (*Momordica charantia*), Jamun (*Syzygium cumini*), Gurmar (*Gymnema sylvestre*), Turmeric (*Curcuma longa*), Bael (*Aegle marmelos*), and Amla (*Phyllanthus emblica*) were the most commonly studied plants. These plants have been extensively researched for their antidiabetic properties, and a significant body of evidence supports their potential therapeutic benefits.

The studies revealed that these plants exhibited various mechanisms of action in managing diabetes. Bitter gourd extracts were found to enhance insulin secretion, improve glucose uptake, and regulate carbohydrate metabolism. Jamun demonstrated hypoglycemic effects by reducing blood glucose levels, enhancing insulin sensitivity, and protecting pancreatic beta cells. Gurmar was shown to stimulate insulin secretion, enhance glucose uptake, and reduce sweet taste sensation, contributing to its antidiabetic activity. Turmeric exhibited anti-inflammatory properties, improved insulin sensitivity, and protected pancreatic beta cells. Bael demonstrated hypoglycemic effects by enhancing insulin secretion, improving glucose uptake, and reducing oxidative stress. Amla exhibited antioxidant activity, improved insulin sensitivity, and protected pancreatic beta cells.

In addition to these commonly studied plants, the review also identified several other plant species with potential antidiabetic activity. Clerodendrum colebrookianum, Ficus racemosa, Ziziphus jujuba, Alpinia galanga, and Justicia adhatoda were among the plants that demonstrated promising antidiabetic properties, as reported in the selected studies. These plants exhibited various mechanisms of action, including enhancing insulin secretion, improving glucose metabolism, reducing insulin resistance, and protecting pancreatic beta cells.

Overall, the systematic review provides comprehensive evidence supporting the antidiabetic potential of plants in Northeast India. The findings highlight the diversity of plant species in the region and their traditional medicinal uses in managing diabetes. While the commonly studied plants such as Bitter gourd, Jamun, Gurmar, Turmeric, Bael, and Amla have been extensively researched, the review also suggests the need for further investigation into less studied plant species for their antidiabetic properties.

DISCUSSION

The systematic review conducted on plants in Northeast India with potent antidiabetic activity provides valuable insights into the diverse flora of the region and their traditional medicinal uses. The findings of this comprehensive analysis contribute to the growing body of knowledge on medicinal plants with antidiabetic potential and highlight the significance of exploring the rich biodiversity of Northeast India for the development of novel therapeutic interventions.

The review identified several plant species that have shown promising antidiabetic properties in scientific studies. These plants have been traditionally used by local communities in Northeast India for managing diabetes and related conditions. Some of the notable plants include Bitter gourd (Momordica charantia), Jamun (Syzygium cumini), Gurmar (Gymnema sylvestre), Turmeric (Curcuma longa), Bael (Aegle marmelos), Amla (Phyllanthus emblica), *Clerodendrum Colebrookianum* (Colebrooke's Glorybower), Cluster fig *(Ficus Racemosa*), Indian jujube *(Ziziphus Jujuba)*, Greater galangal (*Alpinia Galanga*), and Malabar nut *(Justicia Adhatoda*). These plants have been extensively investigated, and their bioactive

constituents have demonstrated significant hypoglycemic effects, including enhancing insulin secretion, improving glucose uptake, modulating glucose metabolism, and inhibiting carbohydrate-digesting enzymes.

The observed antidiabetic activity of these plants can be attributed to the presence of various bioactive compounds such as alkaloids, flavonoids, terpenoids, phenolic compounds, and polysaccharides. These compounds act through multiple mechanisms to regulate glucose homeostasis and alleviate the symptoms associated with diabetes. For example, some plants stimulate insulin secretion from pancreatic beta cells, while others improve insulin sensitivity in target tissues. Additionally, the antioxidant and anti-inflammatory properties exhibited by many of these plants contribute to their potential therapeutic effects in diabetes management by reducing oxidative stress and inflammation, which are known to be associated with the pathogenesis of diabetes.

Although the review highlights the potential of these plants for antidiabetic interventions, it is important to note that further research is necessary to validate their efficacy, determine the optimal dosage and formulation, and assess their safety and potential interactions with other medications. While preclinical studies and some clinical trials have shown promising results, more rigorous clinical trials involving larger sample sizes and longer durations are needed to establish their effectiveness and safety profiles in human subjects.

Moreover, the review also underscores the importance of preserving traditional knowledge and integrating it with scientific research. Traditional medicinal practices have long recognized the therapeutic potential of these plants, and their use in managing diabetes has been passed down through generations. By combining traditional wisdom with modern scientific approaches, there is an opportunity to identify new drug candidates, develop standardized formulations, and optimize therapeutic strategies for diabetes management.

CONCLUSION

The systematic review highlights the significant potential of plant species in Northeast India for their antidiabetic activity. These findings contribute to the existing knowledge on natural products with antidiabetic properties and underscore the importance of exploring indigenous medicinal plants as potential sources of alternative or adjunctive treatments for diabetes. Further research, including phytochemical analysis, mechanistic studies, and clinical trials, is warranted to validate the antidiabetic efficacy, safety, and therapeutic potential of these plants in the management of diabetes mellitus.

FINANCIAL ASSISTANCE

Nil

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Verma M, Jain D, Ashok Mysore J. Potentials of medicinal plants as therapeutic agents for diabetic nephropathy: a review. *Indian Journal of Pharmacology* **52(4)**, 354-361 (2020)

[2] Topno RK, Ali SM, Srivastava SK, Mustapha MN, Paswan S, Ali R. A review on medicinal plants with antidiabetic activity. *Asian Pacific Journal of Tropical Disease* **7(5)**, 341-348 (2017)

[3] Gaonkar AK, Sharma A, Walia T, Sharma, RC, Kaur K, Shriniwas. Potential of medicinal plants from Northeast India: A review. *Avicenna Journal of Phytomedicine* **4(1)**, 1-20 (2014)

[4] Arya AK, Durgapal M, Bachheti A, Joshi KK, Gonfa YH, Bachheti RK, Husen A. Ethnomedicinal use, phytochemistry, and other potential application of aquatic and semiaquatic medicinal plants. *Evidence-Based Complementary and Alternative Medicine* 4931556 (2022).

[5] Joseph B, Jini D. Antidiabetic effects of *Momordica charantia* (bitter melon) and its medicinal potency. *Asian Pacific Journal* of *Tropical Disease* **3(2)**, 93–102 (2013).

[6] Elangovan A, Subramanian A, Durairaj S, Ramachandran J, Lakshmanan DK, Ravichandran G, Nambirajan G, Thilagar S. Antidiabetic and hypolipidemic efficacy of skin and seed extracts of Momordica cymbalaria on alloxan induced diabetic model in rats. *Journal of ethnopharmacology* **241**, 111989 (2019).

[7] Ahmad S, Anwar F, Rasheed S. Medicinal value of *Momordica charantia*: A review. *Critical Reviews in Food Science and Nutrition* **52(7)**, 559–577 (2012).

[8] Ayyanar M, Subash-Babu P, Ignacimuthu S. *Syzygium cumini* (L.) Skeels., a novel therapeutic agent for diabetes: folk medicinal and pharmacological evidences. *Complementary Therapies in Medicine* **21(3)**,

232-243 (2013)

[9] Lin X, Sui X, Han J, Gao H, Guo L. Bitter Melon (*Momordica charantia*): A review of its traditional uses, phytochemistry and pharmacology. *Frontiers in Pharmacology* **8**, 468 (2017)

[10] Bai J, Zhu Y, Dong Y. Response of gut microbiota and inflammatory status to bitter melon (*Momordica charantia* L.) in high fat diet induced obese rats. *Journal of Ethnopharmacology* **194**, 717-726 (2016).

[11] Gholap S, Kar A. *Momordica Charantia*: Pharmacological Effects and Medicinal Uses. *International Journal of Applied Biology and Pharmaceutical Technology* **4**, 63–76 (2013).

[12] Joseph B, Jini D. Antidiabetic effects of *Momordica charantia* (bitter melon) and its medicinal potency. *Asian pacific journal of tropical disease* **3(2)**, 93-102 (2013).

[13] Wang JL, Shiao MS, Wu CC, Tsai TH. Ameliorative effects of *Momordica charantia* on lipid metabolism in hypercholesterolemic rats. *The Canadian Journal of Physiology and Pharmacology* **88**, 817–824 (2010).

[14] Ayyanar M, Subash-Babu P. *Syzygium cumini (L.)* Skeels: A review of its phytochemical constituents and traditional uses. *Asian Pacific journal of tropical biomedicine* **2(3)**, 240-246 (2012).

[15] Hasini R, Chandan BJ, Perumal P, Rajan S. Phytochemistry and Pharmacology of Myrtaceae Plants: A Review. *Pharmacognosy Reviews* **10(20)**, 76-83 (2016).

[16] Sharma P, Yadav AP. A review on medicinal properties of *Syzygium cumini (L.)* Skeels. *Journal of Medicinal Plants Studies* **1(1)**, 11-16 (2009).

[17] Sindhu G, Sreenivasa B, Pushpa KI, Kadalmani B. Studies on the Hypoglycemic and Anti-Diabetic Activities of Ethanolic Extract of *Syzygium cumini (L.)* Skeels in Alloxan Induced Diabetic Rats. *Indian J. Pharm. Sci*. **70(5)**, 645-649 (2008).

[18] Yadav D, Koti BS, Chandrashekar HS, Bhat DS, Udupa N. Anti-hyperlipidemic properties of polyphenolic extract of black plum (*Syzygium cumini*) fruit. *International Journal of Nutrition and Food Sciences* **3(3)**, 394–398 (2014).

[19] Chatterjee TA, Bhargava R, Yadav A. In vivo anti-cholesterolemic activity of ethanolic extract of *Syzygium cumini* seeds. *Indian Journal of Applied Research* **4(4)**, 128–130 (2014).

[20] Yadav D, Koti BS, Chandrashekar HS, Udupa N. Effect of Black Plum (S*yzygium cumini*) on lipid profile in an animal model of hyperlipidemia. *Asia Pacific Journal of Tropical Biomedicine* **3(5)**, 352–355 (2013).

[21] Kumar VH, Nayak IN, Huilgol SV, Yendigeri SM, Narendar K. Antidiabetic and hypolipidemic activity of *Gymnema sylvestre* in dexamethasone induced insulin resistance in Albino rats. *International Journal* of *Medical* and *Health Sciences Research* **4(3)**, 639–645 (2015).

[22] Veerashree V, Anuradha CM, Kumar V. Elicitor-enhanced production of gymnemic acid in cell suspension cultures of *Gymnema sylvestre* R.Br. *Plant Cell, Tissue and Organ Culture* **108(1)**, 27–35 (2012).

[23] Kaushik M, Kaushik A, Arya R, Singh G, Malik P. Anti-obesity property of hexane extract from the leaves of *Gymnema sylvestre* in high fed cafeteria diet induced obesity rats. *International Research Journal of Pharmacy* **2**, 112–116 (2011).

[24] Kashima H, Eguchi K, Miyamoto K, Fujimoto M, Endo MY, Aso-Someya N, Kobayashi T, Hayashi N, Fukuba Y. Suppression of Oral Sweet Taste Sensation with *Gymnema sylvestre* affects postprandial gastrointestinal blood flow and gastric emptying in humans. *Chem Senses* **42(4)**, 295-302 (2017).

[25] Thakur MB, Kaul A, Lama P. *Gymnema sylvestre*: an ayurvedic herb with sweet remedial properties. *Indian Journal of Drug Discovery and Development* **4(1)**, 11-17 (2018).

[26] Kaur A, Chauhan N. Turmeric (*Curcuma longa*): A potential herb for medicinal and therapeutic applications. *Journal of Pharmacognosy and Phytochemistry* **7(1)**, 1754-1761 (2018).

[27] Chuengsamarn S, Rattanamongkolgul S, Luechapudiporn R, Phisalaphong C, Jirawatnotai S. Curcumin extract for prevention of type 2 diabetes. *Diabetes Care* **35(11)**, 2121-2127 (2012).

[28] Gupta SC, Patchva S, Aggarwal BB. Therapeutic roles of curcumin: lessons learned from clinical trials. *The AAPS Journal* **15(1)**, 195-218 (2013).

[29] Chuengsamarn S, Rattanamongkolgul S, Phonrat B, Tungtrongchitr R, Jirawatnotai S. Reduction of atherogenic risk in patients with type 2 diabetes by curcuminoid extract: a randomized controlled trial. *The Journal of Nutritional Biochemistry* **25(2)**, 144-150 (2014).

[30] Acharya SR, Pal S, Ghosh R. Preliminary evaluation of antidiabetic activity of methanol extract of *Aegle marmelos (Linn.)* leaf in streptozotocin-induced diabetic rats.

International Journal of Green Pharmacy **6(2)**, 142-146 (2012).

[31] Deb L, Saha S, Das S, Debnath PK. Evaluation of antidiabetic activity of *Aegle marmelos (Linn.)* Corr. bark extracts in streptozotocin-induced diabetic rats. *Asian Pacific Journal of Tropical Biomedicine* **3(7)**, 550-556 (2013).

[32] Gholamnezhad Z, Havakhah S, Boskabady MH. Preclinical and clinical effects of *Aegle marmelos* (Bael) on cardiovascular diseases: A review. *Journal of Ethnopharmacology* **194**, 830-856 (2016).

[33] Kumar GP, Arulselvan P, Kumar DS, Subramanian SP, Kandaswamy M. Studies on the antioxidant activities of *Aegle marmelos* leaves in diabetic rats. *Biological and Pharmaceutical Bulletin* **31(5)**, 796-801 (2008).

[34] Manjunatha JR, Bettadaiah BK. Amelioration of streptozotocin-induced diabetes mellitus, oxidative stress, and dyslipidemia in rats by Amla (*Emblica officinalis*) powder. *Journal of Medicinal Food* **20(9)**, 830-837 (2017).

[35] Akhtar MS, Ramzan A. Efficacy of Amla (E*mblica officinalis Gaertn.*) for the prevention of hyperglycemia and oxidative stress in streptozotocin-induced diabetic rats. *Indian Journal of Physiology and Pharmacology* **54(3)**, 248-254 (2010).

[36] Patil AD, Patil SA, Mehta AA. Antihyperglycemic activity and inhibition of advanced glycation end product formation by *C. colebrookianum* in streptozotocin induced diabetic rats. *Indian Journal of Pharmacology* **44(2)**, 179-183 (2012).

[37] Prakash A, Chaturvedi AK, Saxena A. Therapeutic potential of *Clerodendrum colebrookianum*: A review on its ethnobotany, phytochemistry, and pharmacological profile. *Journal of Ethnopharmacology* **214**, 210-229 (2018).

[38] Dhakad AK, Pandey VB. Comparative pharmacognostic evaluation of three Clerodendron species used as Sonaru. *Pharmacognosy Journal* **11(6)**, 1239-1244 (2019).

[39] Kumar V, Shah KA, Patel NR. Preliminary screening of *Ficus racemosa Linn.* for antidiabetic activity. *Indian Journal of Pharmaceutical Sciences* **73(3)**, 332-335 (2011).

[40] Singh S, Kumar S, Laloo D, Hemalatha S, Gauthaman K. Anti-hyperglycemic effect of *Ficus racemosa Linn.* leaves on glucose tolerance test in normal and diabetic rats. *Indian Journal of Pharmacology* **41(2)**, 75-78 (2009).

[41] Rahman MS, Rashid MA, Rahman MM, Islam MA. Evaluation of *in vitro* antioxidant and antimicrobial activities of the leaves of *Ziziphus mauritiana Lam*. *Oriental Pharmacy and Experimental Medicine* **11(3)**, 189-195 (2011)

[42] Al Ghasham A, Al Muzaini M, Qureshi KA, Elhassan GO, Khan RA, Farhana SA, Hashmi S, El-Agamy E, Abdallah, WE. Phytochemical screening, antioxidant and antimicrobial activities of methanolic extract of *Ziziphus mauritiana Lam.* leaves collected from Unaizah, Saudi Arabia. *International Journal of Pharmaceutical Research & Allied Sciences* **6(3)**, 33 – 46 (2017).

[43] Mandal S, De R. *Ziziphus mauritiana Lam.*: A multipurpose fruit tree. *International Journal of Pharmaceutical Sciences Review and Research* **7(1)**, 119-122 (2011).

[44] Lobo R, Saldanha LL, Nayak SU. Hypoglycemic activity of *Alpinia galanga (L.)* rhizome is partly mediated by inhibition of carbohydrate digestion and absorption, and enhancement of insulin secretion. *Indian Journal of Pharmacology* **44(2)**, 256-260 (2012).

[45] Venkatesh S, Reddy GD. Antidiabetic effect of methanolic extract of *Alpinia galanga (L.)* rhizomes in alloxan-induced diabetic rats. *Pharmacognosy Research* **6(1)**, 24-29 (2014).

[46] Arya RK, Singh K, Tripathi JS. Antidiabetic evaluation of alkaloids of *Adhatoda vasica* in alloxan diabetic rats. *Der Pharmacia Lettre* **4(4)**, 1294-1301 (2012).

[47] Kumar V, Chauhan NS. Insulin mimetic and anti-diabetic effect of vanadium in rats treated with trivalent vanadium compound bis-(2-ethyl-2-hydroxy butanedioato) oxovanadium (IV) along with Adhatoda vasica extract. *Journal of Trace Elements in Medicine and Biology* **25(3)**, 176-182 (2011).