Plant Archives Volume 20 No. 1, 2020 pp. 2543-2550 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

POTENTIAL MEDICINAL PLANTS USED AGAINST *DIABETES MELLITUS* : A REVIEW

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Abstract

The rapid increase in incidence of *Diabetes mellitus* is becoming a serious threat to the people all over the world. It is considered as one of the most common non-communicable diseases globally. Till recent times the treatment of the disease by allopathic or synthetic drugs either has undesired side effects or are not cost effective to the population. Hence, the present paper reviews on the herbal formulations of plants with their mechanism of action and pharmacological test results. A total of 50 plants belonging to 40 genera under 29 families are found useful against Diabetes. The majority of the medicinal plants under review in the present article belongs to the family Menispermaceae and Verbenaceae followed by Combretaceae and Moraceae. It is said that the herbal approach of management of disease may have late response but it corrects the related metabolic abnormalities. Therefore, now-a-days much attention is drawn towards identification of plants and their pharmacological evaluation for herbal formulations before recommended to prove their efficacy in human system.

Key words : Medicinal plants, *Diabetes mellitus*, Herbal formulations, Physiological effects.

Introduction

Diabetes (Madhumeha) was known to Indian 'Ayurveda' since about 3000 years affecting the populace of both developed and developing countries since time immemorial. It was "Sushruta", the great Indian physician who diagnosed diabetes during 1000 B.C. Based on different medicinal systems such as 'Ayurveda', 'Unani' and 'Siddha' the knowledge of medicinal plants has been accumulated since many centuries. Diabetes is either genetically inherited or is caused by the deficiency in production of insulin by the pancreas or by the defect in production of insulin. One of the common manifestations of the metabolic disorder of *Diabetes mellitus* is hyperglycemia (WHO, 1980). Chronic hyperglycemia can cause damage to eyes, heart, nerves, kidneys and blood vessels (Mayfield, 1998). Though there are many synthetic drugs developed for patients suffering from diabetes, none of them proved to be effective and had undesirable side effects (Li *et al.*, 2004). Therefore, there was a need to acquire knowledge about the different indigenous plants and herbal formulations to cure diabetes (Satyanarayana *et al.*, 2006). Many folklore indigenous Indian medicinal plants have been found to be effective in management of diabetes. It is advantageous to use herbal drugs as they are easily available and have very low side effects. The ethno-botanical survey reports about 800 plants that possess anti-diabetic potential (Alarcon *et al.*, 1998; Nanda and Satapathy, 2001; Satapathy *et al.*, 2001 & 2003; Satapathy and Chand, 2010). This study reviews some important traditional herbs having anti-diabetic activity which can help researchers and physicians to make more success in the field of herbal medications. Plants have been an exemplary source of many currently available herbal drugs whose adequate herbal formulations form the modern day cure for *Diabetes mellitus*. The anti-diabetic or anti-hyperglycemic effects of these plants is dedicated to the ability of these plants to facilitate the metabolites in insulin dependent processes or to restore the function of the pancreatic tissue by increasing the insulin output. Hence, the treatment of *Diabetes mellitus* with herbal

Table 1: List of Medicinal plants with anti-diabetic properties.

Medicinal plants & Family	Plant part(s) used	Extract type	Experimental animal	Physiologic effects	References
Aegle marmelos (L.) Correa (Rutaceae)	Fruit/ leaf	Aqueous extract	Rats	Lower blood sugar level by lowering insulin resistance.	Mudi *et al.* (2017), Ansari *et al.* (2017), Panaskar *et al.* (2013).
Allium cepa L. (Amaryllidaceae)	Bulb	Aqueous extract (300 mg/kg)	Rats	Reduce blood glucose levels, serum cholesterol and serum lipids.	Ozougwu (2011).
Alpinia galanga (L.) Willd. (Zingiberaceae)	Rhizome	Alcoholic extract	Rats	Control blood sugar level, reduce urine albumin.	Kaushik *et al.* (2013).
Anacardium occidentale L. (Anacardiaceae)	Leaf	Raw	Rats	Hypoglycemic.	Sokeng *et al.* (2001).
Annona squamosa L. (Annonaceae)	Leaf	Aqueous extract	Unknown	Hypoglycemic, anti-diabetic.	Teonard *et al.* (2015), Gupta *et al.* (2005).
Aristolochia indica L. (Aristolochiaceae)	Aerial part	Chloroform extract	Swiss albino mice	Hypoglycemic, anti-diabetic.	Karan *et al.* (2012).
Artocarpus hetero-phyllus Lam. (Moraceae)	Stem	Ethanolic extract	Rats	Revert loss of weight, increased urea and creatinine.	Ajiboye *et al.* (2018).
Asparagus racemosus Willd. (Asparagaceae)	Root	Ethanolic extract	Rats	Stimulates secretion of islet cells and clonal β-cells.	Somania *et al.* (2012), Hannan *et al.* (2007).
Azadirachta indica A. Juss (Meliaceae)	Leaf	Aqueous extract	Rats	Reduce blood glucose level, lipid peroxidation.	Kazeem *et al.* (2013), Perez Gutierrez & de Jesus Martinez Ortiz (2013), Gupta *et al.* (2016).
Boerhaavia diffusa L. (Nyctaginaceae)	Leaf	Aqueous extract	Rats	Acts by increasing insulin, sensitivity and reducing blood glucose level.	Pari and Satheesh (2004), Chopra *et al.* (1958), Kirtikar & Basu (1933).
Bougainvillea spectabilis L. (Nyctaginaceae)	Leaf	Ethanolic extract	Unknown	Antihyperglycemic activity due to insulin sensitivity.	Purohit & Sharma (2006).
Brassica juncea (L.) Czern. (Brassicaceae)	Seed	Aqueous extract	Rats	Hypoglycemic activity.	Thirumalai *et al.* (2011).
Bryophyllum pinnatum (Lam.) Oken (Crassulaceae)	Leaf	Aqueous extract	Rats	Hypoglycemic effect.	Ojewole (2005).
Canavalia ensiformis DC. (Fabaceae)	Seed	Aqueous extract	Unknown	Hypoglycemic effect.	Asolkar *et al.* (1992).
Calotropis gigantea (L.) R.Br. ex Schult. (Apocynaceae)	Leaf/ flower	Aqueous extract	Rats	Lower serum glucose level.	Rathod *et al.* (2011), Choudhary *et al.* (2012).
Carica papaya L.	Fruit	Aqueous extract	Rats	Lower blood sugar level.	Oke (1998).
Casearia esculenta Roxb. (Flacourticeae)	Root	Aqueous extract	Rats	Hypoglycemic and antihyperglycemic effect.	Yoganarasimhan (2000), Prakasam (2004).
Catharanthus roseus (L.) G.Don (Apocynaceae)	Leaf	Methanolic extract	Rats	Hypoglycemic effect.	Ohadoma & Michael (2011).
Clerodendrum inerme (L.) Gaertn. (Verbenaceae)	Aerial part	Methanol extract	Wistar albino rats	Antidiabetic activity, Reduction in blood sugar.	Panigrahi *et al.* (2015)
Clerodendrum philippinum Schauer. (Verbenaceae)	Leaf	Methanol extract	Wistar albino rats	Antidiabetic activity.	Kar *et al.* (2015)

Table 1 contd....

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Medicinal plants & Family	Plant part(s) used	Extract type	Experimental animal	Physiologic effects	References
Clerodendrum serratum L. (Verbenaceae)	Leaf	Methanol extract	Wistar albino rats	Antidiabetic activity.	Kar *et al.* (2014)
Clerodendrum viscosum Vent. (Verbenaceae)	Leaf	Methanol extract	Wistar albino rats	Decrease hyperglycemia, Antidiabetic activity.	Panigrahi *et al.* (2015)
Cocculus indica Wight. & Arn. (Menispermaceae)	Fruit	Alcoholic extract	Unknown	Hypoglycemic, restores β-cells.	Kumar *et al.* (1993)
Cocculus hirsutus (L.) Diels (Menispermaceae)	Leaf	Aqueous extract	Rats	Antihyperglycemic effect.	Badole *et al.* (2006).
Coscinium fenestratum Goetgh. (Menispermaceae)	Stem	Alcoholic extract	Rats	Regulates glucose homeostasis.	Punitha *et al.* (2005).
Emilia sonchifolia (L.) DC. ex Wight. (Asteraceae)	Whole plant	Crude extract	Rats	Hypoglycemic effect.	Monago & Ugbomeh (2004).
Ficus benghalensis L. (Moraceae)	Bark	Aqueous extract	Unknown	Antihypoglycemic effect.	Bramachari *et al.* (1961), Geetha *et al.* (1994), Cherian *et al.* (1993).
Ficus religiosa L. (Moraceae)	Bark	Aqueous extract	Rats	Antidiabetic activity.	Pandit *et al.* (2010), Kirana *et al.* (2009), Kirana *et al.* (2011).
Momordica charantia L. (Cucurbitaceae)	Fruit	Juice	Rats	Antidiabectic & antioxidant activity.	Mahmoud *et al.* (2017), Ma *et al.* (2017).
Murraya koenigii (L.) Spreng. (Rutaceae)	Leaf	Aqueous extract	Rats	Hypoglycemic effect.	Narayana *et al.* (1975), Yadav *et al.* (2002), Kesari *et al.* (2005).
Naringi crenulata (Roxb.) Nicolson (Rutaceae)	Leaf	Methanol extract	Wistar albino rats	Antidiabetic activity.	Mekap *et al.* (2016)
Nelumbo nucifera Gaertn. (Nelumbonaceae)	Rhizome	Ethanolic extract	Rats	Hypoglycemic effect.	Kato *et al.* (2015), Mukherjee et *al.* (1997).
Nyctanthus arbori-tristis L. (Oleaceae)	Flower	Aqueous extract	Mice	Decrease blood sugar levels.	Rangika *et al.* (2015).
Oxalis corniculata L. (Oxalidaceae)	Whole Plant	Methanol extract	Wistar albino rats	Antidiabetic activity.	Mekap *et al.* (2016).
Phyllanthus emblica L. (Euphorbiaceae)	Fruit	Aqueous extract	Unknown	Antidiabetic, antioxidant, free-radical scavenging property.	Nampoothiri *et al.* (2011).
Piper longum L. (Piperaceae)	Dry fruit	Crude extract	Rats	Antihyperglycemic and antilipidic peroxidative effect.	D'souza *et al.* (2014).
Polyalthia longifolia var. Pendula (Annonaceae)	Root bark	Methanol extract	Wistar albino rats	Antihyperglycemic, Antidiabetic activity.	Ghosh *et al.* (2011).
Polyalthia longifolia var. Pendula (Annonaceae)	Stem bark	Methanol extract	Wistar albino rats	Antidiabetic activity.	Ghosh *et al.* (2009).
Polyalthia longifolia var. Angustifolia (Annonaceae)	Stem bark	Methanol extract	Wistar albino rats	Antidiabetic activity.	Ghosh *et al.* (2010).

Table 1 contd....

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Medicinal plants & Family	Plant part(s) used	Extract type	Experimental animal	Physiologic effects	References
Polyalthia longifolia var. Angustifolia (Annonaceae)	Stem bark	Chloroform extract	Wistar albino rats	Antidiabetic activity.	Ghosh *et al*. (2008).
Sida rhombifolia L. (Malvaceae)	Aerial part	Methanol extract	Wistar albino rats	Antidiabetic activity.	Ghosh *et al*. (2011).
Sida rhombifolia L. (Malvaceae)	Root	Methanol & aqueous extract	Wistar albino rats	Antidiabetic activity.	Ghosh *et al*. (2009).
Sida acuta L. (Malvaceae)	Root	Aqueous extract	Wistar albino rats	Antidiabetic activity.	Jena *et al*. (2011).
Streblus asper Lour. (Moraceae)	Stem bark	Petroleum ether extract & the isolated compound, α-amyrin acetate.	Albino rats	Antidiabetic activity.	Karan *et al*. (2013).
Streblus asper Lour. (Moraceae)	Root	Petroleum ether extract	Swiss albino mice	Antidiabetic activity.	Karan *et al*. (2012).
Syzyguim cumini (L.) Skeels (Myrtaceae)	Leaf, seed, fruit, bark	Crude extract	Unknown	Antihyperglycemic effect.	Bramachari *et al*. (1961), Rahman *et al*. (1989).
Terminalia bellirica (Gaertn.) Roxb. (Combretaceae)	Fruit	Methanolic extract	Unknown	α-amylase and β-amylase inhibitor activity.	Latha & Daisy (2013).
Terminalia chebula Retz. (Combretaceae)	Seed	Chloroform extract	Rats	Anti diabetic and reno-protective.	Rao *et al*. (2004).
Terminalia catappa L. (Combretaceae)	Fruit	Petroleum ether, methanol & aqueous extract	Rats	Antidiabetic effect.	Nagappa *et al*. (2003).
Tinospora cordifolia (Willd.) Hook.f. & Thoms. (Menisperm-aceae)	Stem	Methanolic extract	Wistar rats	Reduce blood sugar level, HBA1c level.	Sangeta *et al*. (2013), Rajalakshmi & Anita (2016).
Toddalia asiatica (L.) Lam. (Rutaceae)	Leaf	Methanol extract	Wistar albino rats	Reduction in blood glucose level.	Mekap *et al*. (2016).
Trigonella foenum-graecum L. (Fabaceae)	Seed	Dry powder	Rats	Improves blood sugar level and anti oxidant activity.	Sankar *et al*. (2012), Pradeep & Srinivasan (2018).
Vetiveria zizanioides (L.) Nash (Poaceae)	Root	Ethanol extract	Wistar albino rats	Antidiabetic activity	Karan *et al*. (2012).
Zingiber officinale Roscoe. (Zingiberaceae)	Fruit	Aqueous extract	Rats	Reduce blood glucose level, total serum lipids, total serum cholesterol.	Ozougwu & Eyo (2011).

formulations/drugs aims on protecting β-cells and maintaining the glucose levels. Plants contain many secondary metabolites like glycosides, alkaloids, terpenoids, flavonoids, carotenoids etc. that frequently implies having anti-diabetic effect.

A detailed and comprehensive literature review was made by searching various websites as well as relevant research papers published besides the study materials available at different educational and research institutes including Centurion University of Technology and Management, Odisha, India. Various proceedings, scientific journal articles on medicinal plants, herbal

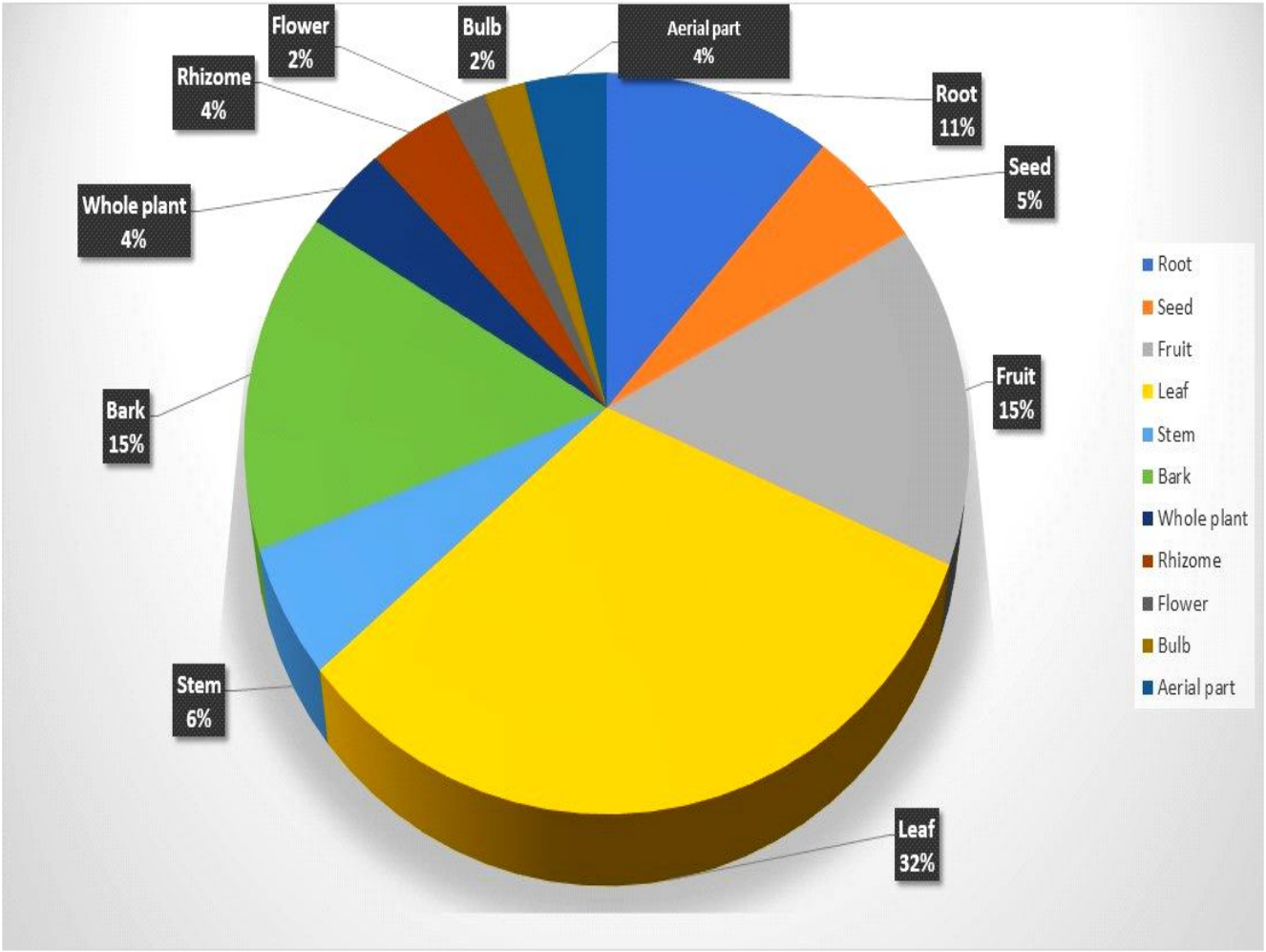

Fig. 1: Percentage of the various plant parts used as medication.

practices and formulations and recommendations and communiqués of World Health Organisation documents were referred with regards to the medicinal plants having anti-diabetic properties. The search keywords such as medicinal plants, *diabetes mellitus*, herbal formulations, anti-diabetic drug plants, physiological effects etc. were used for finding out related research articles for the preparation of updated review article.

The results of the review study revealed the reports on the use and evaluation of fifty potential medicinal plants with anti-diabetic properties and compiled in details of their folklore claims and experimental status (Table 1). The present review article enumerates the updated information and documentation of the indigenous medicinal plants used for the treatment of *Diabetes mellitus*. The results of the present exhaustive literature survey indicated that the data on 50 plants belonging to 40 genera under 29 families involved in treating the disease. It was also found that majority of the plant species used against diabetes belonged to the angiospermic family Menispermaceae and Verbenaceae followed by Combretaceae and Moraceae. Analysis of the data indicated that all the parts of the plants have been used for the treatment of the disease; however leaf is more frequently used (32%) followed by fruit and bark (15% each), root (11%), stem (6%), seed (5%), whole plant, rhizome, and aerial part (4% each), flower and bulb (2%) (Fig. 1).

Conclusion

Traditional system of treatments are now-a-days accepted all over the world as they are considered to be less toxic and free from side effects than the synthetic drugs (Dhanabal *et al.*, 2004). The medicinal plants have played a pivotal role for multinational drug industries and research institutes for the discovery biologically active compounds used as potential drugs. The information concised in the present revised article may be of immense help to drug manufacturers for further extensive scientific evaluation leading to novel herbal approach for management and control of *diabetes mellitus* in future.

References

Ajiboye, B.O., O.O. Adeleke, O. Adeyonu, O. Imiere and O.B. Emmanuel (2018). Ameliorative Activity of ethanolic extract of *Artocarpus heterophyllus* stem bark on alloxan-induced diabetic rats. *Adv. Pharm. Bull.*, **8(1):** 141-147.

Alarcon, A.F.J., R.R. Roman, G.S. Perez, C.A. Aguilar, W.C.C. Contreras and S.J.L. Flores (1998). Study of the anti-hyperglycaemic effect of plants used as antidiuretics. *J. Ethanopharm*., **61:** 101-110.

Ansari, P., N. Afroz, S. Jalil, S.B. Azad and M.G. Mustakim (2017). Anti- hyperglycemic activity of *Aegle marmelos* (L.) Corr. is partly mediated by increased insulin secretion, á-amylase inhibition, and retardation of glucose absorption. *J. Pediatr. Endocrinol. Metab*., **30(1):** 37-47.

Asolkar, L.V., K.K. Kakkar and O.J. Chatre (1992). Glossary of Indian medicinal plants with active principles (Part I) A-K series, p. 176. Publication and Information Directorate, CSIR, New Delhi.

Badole, S., N. Patel, S. Bodhankar, B. Jain and S. Bhardwaj (2006). Anti-hyperglycemic activity of aqueous extract of leaves of *Cocculus hirsutus* (L.) Diels in alloxan-induced diabetic mice. *Indian Journal Pharmacology,* **38(1):** 49.

Brahmachari, H.D. and K.T. Augusti (1961). Hypoglycaemic agents from Indian indigenous plants. *J. Pharm. (London),* **13 (6):** 381.

Cherian, S. and K.T. Augusti (1993). Antidiabetic effects of a glycoside of leucopelargonidin isolated from *Ficus bengalensis* Linn. *Indian J. Exp. Biol*., **31:** 26-9.

Chopra, R., I. Chopra, K. Handa and L. Kapur (1958). Indigenous Drugs of India, UN Dhar and Sons. Calcutta, India, Edition 2nd: 426.

Choudhary, N.K., S. Sharma, A.K. Jha, M.S. Karchuli and J. Dwivedi (2012). Antioxidant potential and protection of pancreatic â-cells by *Calotropis gigantea* in streptozocin induced diabetic rats. *J. Complement Integr*. Med., **9**.

D'souza, J.J., P.P. D'souza, F. Fazal, A. Kumar and H.P. Bhat (2014). Anti-diabetic effects of the Indian indigenous fruit *Emblica officinalis* Gaertn: active constituents and modes of action. *Food Funct*., **5(4):** 635-644.

Geetha, B.S., B.C. Mathew and K.T. Augusti (1994). Hypoglycemic effects of leucodelphinidin derivative isolated from *Ficus bengalensis*. *Indian J. Physiol. Pharmacol.*, **38:** 220-222.

Ghosh, G., P.K. Sahu, D. Mishra and S.K. Mishra (2008). Antidiabetic Activity of Chloroform Extract of Stem Bark of *Polyalthia longifolia* var. Angustifolia on Normal and Alloxan Induced Diabetic Rats. *Advanced Pharmacology and Toxicology,* **9(3):** 51-54.

Ghosh, G., P.K. Sahu, S.C. Si, B.B. Barik and S.K. Mishra (2009). Antidiabetic Activity of Methanolic Extract of Stem Bark of *Polyalthia longifolia* var. Pendula. *Indian Drugs,* **46 (12):** 43-46.

Ghosh, G., P.K. Sahu, P.S. Kuma and S.K. Mishra (2009). Antihyperglycaemic Activity of *Sida rhombifolia* Root Extract in Alloxan Induced Diabetic Rats and Euglycaemic Rats. *Int. J. Pharmacol. Biol. Sci.,* **3(2):** 45-49.

Ghosh, G., D.M. Kar, B.B. Subudhi and S.K. Mishra (2010). Anti-hyperglycemic and Antioxidant Activity of Stem Bark of *Polyalthia longifolia* var. Angustifolia. *Der Pharmacia. Lettre.*, **2(2):** 206 -216.

Ghosh, G., B.B. Subudhi and S.K. Mishra (2011). Antihyperglycemic Activity of Root Bark of *Polyalthia longifolia* var. Pendula and Aerial Parts of *Sida rhombifolia* Linn. and its Relationship with Antioxidant Property. *Asian Journal of Chemistry,* **23(1):** 141-144.

Gupta, N.K., N. Srivastva, P. Bubber and S. Puri (2016). The Antioxidant Potential of *Azadirachta indica* ameliorates cardioprotection following *Diabetic mellitus*- Induced Microangiopathy. *Pharmacogn. Mag*., **12(2):** 371- 378.

Gupta, R.K., A.N. Kesari and G. Watal (2005). Hypoglycaemic and anti-diabetic effect of aqueous extract of leaves of *Annona squamosa* L. in an experimental animal. *Current Science,* **88(8):**1244 -1254.

Hannan, J.M., L. Marenah, L. Ali, B. Rokeya and P.R. Flatt (2007). Insulin secretory actions of extracts of *Asparagus racemosus* root in perfused pancreas, isolated islets and clonal pancreatic beta-cells. *J. Endocrinol.,* **192(1):** 159-168.

Jena, S., S.K. Mishra, G. Ghosh and P.K. Chand (2011). Antidiabetic Activity of Root of *Sida acuta* Linn. in Normoglycemic and Alloxan Induced Diabetic Rats. *Indian Drugs,* **48 (3):** 27- 33.

Kar, M.K., T.R. Swain and S.K. Mishra (2015). Antidiabetic activity of *Clerodendrum philippinum* Schauer leaves in Streptozotocin induced diabetic rats. *International Journal of Pharmacy and Pharmaceutical Sciences,* **7 (9):** 386-389.

Kar, M.K., T.R. Swain and S.K. Mishra (2014). Antidiabetic activity of *Clerodendrum serratum* (L.) Moon leaves in Streptozotocin-induced diabetic rats. *Asian J. Pharm. Clin. Res.*, **7(6):** 260-263.

Karan, S.K., S.K. Mishra, D. Pal and A. Mondal (2012). Isolation of â -Sitosterol and Evaluation of Antidiabetic Activity of *Aristolochia indica* in Alloxan-induced Diabetic Mice with a reference to *in-vitro* Antioxidant Activity. *Journal of Medicinal Plants Research*, **6(7):** 1219-1223.

Karan, S.K., S.K. Mishra, D.K. Pal, R.K. Singh and G. Raj (2012). Antidiabetic Effect of the Roots of *Streblus asper* in Alloxan-induced Diabetes Mellitus. *Asian Journal of Chemistry,* **24(1):** 422-424.

Karan, S.K., A. Mondal, S.K. Mishra, D. Pal and K.K. Rout (1913). Antidiabetic effect of *Streblus asper* in streptozotocin-induced diabetic rats. *Pharmaceutical Biology,* **51(3):** 369-375.

Karan, S.K., S.K. Mishra and D.K. Pal (2012). Antihyperglycemic Effect of *Vetiveria zizanioides* (L.) Nash Root extract in Alloxan induced Diabetic Rats. *Journal Pharmaceutical and Scientific Innovation,* **1(6):** 35-38.

Kato, E., Y. Inagaki and J. Kawabata (2015). Higenamine 4'-O-â-d-glucoside in the lotus plumule induces glucose uptake of L6 cells through â2-adrenergic receptor. *Bioorg. Med.*

Chem., **23(13):** 3317-3321.

Kaushik, P., D. Kaushik, J. Yadav and P. Pahwa (2013). Protective effect of *Alpinia galanga* in STZ-induced diabetic nephropathy. *Pak. J. Biol. Sci.*, **16(16):** 804-811.

Kazeem, M.I., T.V. Dansu and S.A. Adeola (2013). Inhibitory effect of *Azadirachta indica* A. Juss leaf extract on the activities of alpha-amylase and alpha-glucosidase. *Pak. J. Biol. Sci.*, **16 (21):** 1358-1362.

Kesari, A.N., R.K. Gupta and G. Watal (2005). Hypoglycemic effects of *Murraya koenigii* on normal and alloxan-diabetic rabbits. *Journal Ethnopharmacology*, **97(2):** 247-251.

Kirana, H., S.S. Agrawal and B.P. Srinivasan (2009). Aqueous extract of *Ficus religiosa* Linn. reduces oxidative stress in experimentally induced Type 2 diabetic rats. *Indian J. Exp. Biol.*, **47(10):** 822-826.

Kirana, H., M.V. Jali and B.P. Srinivasan (2011). The study of aqueous extract of *Ficus religiosa* Linn. on cytokine TNF-á in type 2 diabetic rats. *Pharmacogn. Res.*, **3(1):** 30-34.

Kirtikar, K.R. and B.D. Basu (1933). Indian Medicinal Plants, **2**nd ed., pp. 1052-1054, Lalit Mohan Basu Publications, Allahabad.

Kumar, G.P., S. Sudheesh and N. Vijayalakshmi (1993). Hypoglycaemic effect of *Coccinia indica*: mechanism of action. *Planta. Medica.*, **59(04):** 330-332.

Latha, R.C. and P. Daisy (2013). Therapeutic potential of octyl gallate isolated from fruits of *Terminalia bellerica* in streptozotocin-induced diabetic rats. *Pharm. Biol.*, **51(6):** 798-805.

Li, W., H. Zheng, J. Bukuru and N. De Kimpe (2004). Natural medicines used in the traditional Chinese medical system for therapy of diabetes mellitus. *Journal Ethnopharmacology*, **92(1):** 1-21.

Ma, C., H. Yu, Y. Xiao and H. Wang (2017). *Momordica charantia* extracts ameliorate insulin resistance by regulating the expression of SOCS-3 and JNK in type 2 diabetes mellitus rats. *Pharm. Biol.*, **55(1):** 2170-2177.

Mahmoud, M.F., F.E. El Ashry, N.N. El Maraghy and A. Fahmy (2017). Studies on the antidiabetic activities of *Momordica charantia* fruit juice in streptozotocin- induced diabetic rats. *Pharm. Biol.*, **55(1):** 758-765.

Mayfield, J. (1998). New classification and diagnostic criteria for diabetes mellitus *Am. Fam. Physician*, **58:** 1355-70.

Mekap, S.K., S. Sahoo, K.B. Satapathy and S.K. Mishra (2016). Evaluation of Antidiabetic Activity of *Oxalis corniculata* Linn. Whole Plant. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, **7(2):** 2142- 2152.

Mekap, S.K., S. Sahoo, K.B. Satapathy and S.K. Mishra (2016). Antidiabetic Evaluation of Leaf Extracts of *Naringi crenulata* (Roxb.)Nicolson. *International Journal for Pharmaceutical Research Scholars*, **5(2):** 218-232.

Mekap, S.K., S. Sahoo, K.B. Satapathy and S.K. Mishra (2016). Evaluation of *Toddalia asiatica* (L.) Lam. leaf extracts for antidiabetic activity. *Pharmaceutical and Biological Evaluations*, **3(1):** 115-125.

Mellitus, D. Report of a WHO study group (1985). W*orld Health Organ Tech. Rep. Ser.*, **727:** 1-113.

Monago, C.C. and P.A. Ugbomeh (2004). Anti-diabetic effects of *Emilia sonchifolia* in dithizone diabetic rats. *Global Journal Pure & Applied Sciences*, **10(1):**183–187.

Mudi, S.R., M. Akhter, S.K. Biswas, M.A. Muttalib and S. Choudhury (2017). Effect of aqueous extract of *Aegle marmelos* fruit and leaf on glycemic, insulinemic and lipidemic status of type-2 diabetic model rats. *J. Complement Integr. Med*., **14(2)**.

Mukherjee, P.K., K. Saha, M. Pal and B.P. Saha (1997). Effect of *Nelumbo nucifera* rhizome extract on blood sugar level in rats. *J. Ethnopharmacol*., **58(3):** 207-213.

Nagappa, A., P. Thakurdesai, N. Venkat Rao and J. Singh (2003). Effective protection of *Terminalia catappa* L. leaves from damage induced by carbon tetrachloride in liver mitochondria. *J. Ethnopharmacol*., **88(1):** 45-50.

Nampoothiri, S.V., A. Prathapan, O.L. Cherian, K.G. Raghu and V.V. Venugopalan (2011). *In vitro* antioxidant and inhibitory potential of *Terminalia bellerica* and *Emblica officinalis* fruits against LDL oxidation and key enzymes linked to type 2 diabetes. *Food Chem. Toxicol*., **49(1):**125-131.

Nanda, G.C. and K.B. Satapathy (2001). Common Plants for Diabetes (A Comprehensive compilation based on Folklore & Trials). Central Research Institute for Ayurveda (CCRAS, Dept. of ISM & H, Ministry of Health & Family Welfare, Govt. of India, Bhubaneswar - 751009, 34 p.

Narayan, K. and K.N.V. Sastry (1975). The hypoglycemic effect of *Murraya koenigii* in normal and alloxan diabetic dogs. *Mysore J. Agric. Sci*., **9:** 132-136.

Ohadoma, S.C. and H.U. Michael (2011). Effects of Co-Administration of Methanol Leaf Extract of *Catharanthus roseus* on the Hypoglycemic Activity of Metformin and Glibenclamide in Rats. *Asian Pacific Journal of Tropical Medicine*, **4(6):** 475-477.

Ojewole, J.A. (2005). Antinociceptive, anti-inflammatory and antidiabetic effects of *Bryophyllum pinnatum* (Crassulaceae) leaf aqueous extract, *J. Ethnopharmacol*, **99(1):** 13-19.

Oke, J.M. (1998). Antidiabetic potency of pawpaw. *African Journal of Biomedical Research*, **1:** 31-34.

Ozougwu, J.C. (2011). Anti-diabetic effects of *Allium cepa* (Onions) aqueous extracts on alloxan-induced diabetic Rattus novergicus. *Journal of Medicinal Plants Research*, **5(7):** 1134-1139.

Ozougwu, J.C. and J.E. Eyo (2011). Evaluation of the activity of *Zingiber officinale* (ginger) aqueous extracts on alloxan-induced diabetic rats. *Pharmacology*,**1:** 258-269.

Panaskar, S.N., M.M. Joglekar, S.S. Taklikar, V.S. Haldavnekar and A.U. Arvindekar (2013). *Aegle marmelos* Correa leaf extract prevents secondary complications in streptozotocin-induced diabetic rats and demonstration of limonene as a potent antiglycating agent. *J. Pharm. Pharmacol.*, **65(6):** 884-894.

Pandit, R., A. Phadke and A. Jagtap (2010). Antidiabetic effect of *Ficus religiosa* extract in streptozotocin-induced

diabetic rats. *J. Ethnopharmacol*., **128(2):** 462-466.

Panigrahi, B.K., S.K. Mishra and S.K. Sahu (2015). Antidiabetic effects of *Clerodendrum inerme* (L.) Gaertn. *International Journal of Pharmacy & Pharmaceutical Research*, **4(2):** 248-256.

Panigrahi, B.K., S.K. Mishra and S.K. Sahu (2015). Antidiabetic effects of *Clerodendrum viscosum* Vent. *World Journal Pharmaceutical Sciences*, **3(9):** 1944-1948.

Pari, L. and M.A. Satheesh (2004). Anti-diabetic activity of *Boerhaavia diffusa* effect on hepatic key enzymes in experimental diabetes. *J. Ethnopharmacol*., **91(1):**109-113.

Perez Gutierrez, R.M. and M. de Jesus Martinez Ortiz (2013). Beneficial effect of *Azadirachta indica* on advanced glycation end-product in streptozotocin- diabetic rat. *Pharm. Biol.,* **52(11):** 1435-1444.

Pradeep, S.R. and K. Srinivasan (2018). Alleviation of oxidative stress-mediated nephropathy by dietary fenugreek (*Trigonella foenum-graecum*) seeds and onion (*Allium cepa*) in streptozotocin-induced diabetic rats. *Food Funct*., **9(1):**134-148.

Prakasam, A., S. Sethupathy and K.V. Pugalendi (2004). Influence of *Casearia esculenta* root extract on protein metabolism and marker enzymes in streptozotocin-induced diabetic rats. *Pol. J. Pharmacol*., **56:** 587-593.

Punitha, I., K. Rajendran and A. Shirwaikar (2005). Alcoholic stem extract of *Coscinium fenestratum* regulates carbohydrate metabolism and improves antioxidant status in streptozotocin-nicotinamide-induced diabetic rats. *Evidence- Based Complementary and Alternative Medicine,* **2(3):** 375-381.

Purohit, A. and A. Sharma (2006). Blood glucose lowering potential of *Bougainvillea spectabilis* Willd. leaf extract in streptozotocin-induced type-I diabetic Albino Rats. *Indian Drugs-Bombay,* **43(7):** 538.

Rahman, A.U. and K. Zaman (1989). Medicinal plants with hypoglycaemic activity. *J. Ethnopharmacol*., **26:** 155.

Rajalakshmi, M. and R. Anita (2016). â-cell regenerative efficacy of a polysaccharide isolated from methanolic extract of *Tinospora cordifolia* stem on streptozotocin- induced diabetic Wistar rats. *Chem. Biol. Interact*., **243:** 45-53.

Rangika, B.S., P.D. Dayananda and D.C. Peiris (2015). Hypoglycemic and hypolipidemic activities of aqueous extract of flowers from *Nycantes arbor-tristis* L. in male mice. *BMC Complement Altern. Med.,* **15:** 289.

Rao, K.N., M.B. Krishna and N. Srinivas (2004). Effect of chronic administration of *Boerhaavia diffusa* Linn. leaf extract on experimental diabetes in rats. *Trop. J. Pharma. Res*., **3:** 305-309.

Rathod, N.R., H.R. Chitme, R. Irchhaiya and R. Chandra (2011). Hypoglycemic Effect of *Calotropis gigantea* Linn. leaves and flowers in Streptozotocin-induced diabetic rats. *Oman Med. J*., **26(2):**104-108.

Sangetha, M.K., C.D. Mohana Priya and H.R. Vasanthi (2013). Anti-diabetic property of *Tinospora cordifolia* and its active compound is mediated through the expression of Glut-4 in L myotubes. *Phytomedicine*, **20(3-4):** 246-248.

Sankar, P., S. Subhashree and S. Sudharani (2012). Effect of *Trigonella foenum-graecum* seed powder on the antioxidant levels of high fat diet and low dose streptozotocin induced type II diabetic rats. *Eur. Rev. Med. Pharmacol. Sci.,* **3:** 10-17.

Satapathy, K.B., G.C. Nanda and P.K. Chand (2001). Some promising anti-diabetic plants of Orissa. In: Conservation and Utilization of medicinal plants (Ed. S. Sahoo *et al.*) Allied Publishers Limited, New Delhi, 358-369.

Satapathy, K.B., G.C. Nanda and P.K. Chand (2003). Plants for diabetics. Divya Prakashani, Plot No. 58/60, Divya Vihar, Samantarapur, Bhubaneswar, Orissa, 128 p.

Satapathy, K.B. and P.K. Chand (2010). Herbal Cure of Diabetes. LAP LAMBERT Academic Publishing AG & Co. KG Saarbrücken Dudweiler Landstraße 99, 66123 Saarbrücken Germany, 217 p.

Satyanarayana, T., B. Katyayani, H.E. Latha, A.A. Mathews and E.M. Chinna (2006). Hypoglycemic and anti-hyperglycemic effect of alcoholic extract of *Euphorbia leucophylla* and its fractions in normal and in alloxan induced diabetic rats. *Pharmacognosy Magazine*, **2(8):** 244.

Sokeng, S.D., P. Kamtchouing, P. Watcho, B.H. Jatsa, F.P. Moundipa, D. Lontsi and M. Bopelet (2001). Hypoglycemic activity of *Anarcardium occidentale* L. aqueous extract in normal and streptozotocin-induced diabetic rats. *Diabetes Research*, **36:** 1-9.

Somania, R., A.K. Singhai, P. Shivgunde and D. Jain (2012). *Asparagus racemosus* Willd. (Liliaceae) ameliorates early diabetic nephropathy in STZ induced diabetic rats. *Indian J. Exp. Biol*., **50(7):** 469-475.

Thirumalai,T., S.V. Therasa, E.K. Elumalai and E. David (2011). Hypoglycemic effect of *Brassica juncea* (seeds) on streptozotocin induced diabetic male albino rat. *Asian Pac. J. Trop. Biomed*., **1(4):** 323-325.

Teonard, L., T. Dimo and D. Paul (2015). Comprehensive notes on anti diabetic potential of medicinal plants and polyherbal formulation. *Afr. J. Tradit. Complement Altern. Med.,* **3:** 57-64.

WHO Expert Committee on Diabetes Mellitus: Second Report (1980). World Health Organization, Geneva, 7-80.

Yadav, S., V. Vats, Y. Dhunnoo and J.K. Grover (2002). Hypoglycemic and antihyperglycemic activity of *Murraya koenigii* leaves in diabetic rats. *Journal of Ethnopharmacology,* **82:**111-116.

Yoganarasimhan, S.N. (2000). Medical plants of India. **2**:109-110, Tamilnadu, International Book Publishers., Print Cyber Media., Bangalore.