



**FLAVONOIDS CONTAINING MEDICINAL PLANTS WITH ANTI-DIABETIC  
ACTIVITY: A REVIEW**

**Shyam Prakash G.\*, Gayathiri K, Sangeetha M, Sharanya VK, Gopi Sudheerkumar J, Vimalavathini R,  
Dr. Kavimani S**

Department of Pharmacology, Mother Theresa Post Graduate and Research Institute of Health Sciences, Indira Nagar,  
Gorimedu, Puducherry-605006, India.

**\*Author for Correspondence: Shyam Prakash G.**

Department of Pharmacology, Mother Theresa Post Graduate and Research Institute of Health Sciences, Indira Nagar, Gorimedu, Puducherry-605006, India.

Article Received on 26/11/2015

Article Revised on 17/12/2015

Article Accepted on 08/01/2016

**ABSTRACT**

Diabetes mellitus is a chronic metabolic disorder characterized by elevated blood sugar. Diabetes mellitus is not a single disease but a heterogeneous group of disease all of which leads to elevation of glucose in blood (hyperglycaemia) and loss of glucose in the urine. Diabetes mellitus may be due to diminished insulin as in type 1 or impaired insulin action as in type 2 diabetes mellitus. The disease occurs worldwide and its incidence is increasing rapidly in the most of the world. The need of natural and non-toxic anti-diabetic drugs is very much essential for diabetic therapy as the continuous use of synthetic anti-diabetic drugs causes side effects and also toxicity. Certain plants play a major role in the development of therapy and hence this paper reviewed on the medicinal plants with flavonoids as their active constituents which are responsible for the hypoglycaemic activity.

**KEYWORDS:** Diabetes mellitus, medicinal plants, anti-diabetic activity, flavonoids, STZ induced diabetes.

**INTRODUCTION**

Diabetes mellitus is one of the common and widespread disease affecting the people of both developed and developing countries. It has been estimated that about 25% of the world's population is affected by this disease. The main cause of Diabetes mellitus is the abnormal carbohydrate metabolism which is associated to low blood insulin level or insensitivity of the target organs to insulin.<sup>[1]</sup>

The Disease is a result of either due to the improper response of the target cells to insulin, due to inadequate secretion of insulin or combination of both. Changes in the life style is very much essential along with the medical diagnosis and treatment, as the disease is associated with the reduced quality of life and high risk of mortality and morbidity. Because of the side effects associated with the oral hypoglycaemic agents, there is growing interest in the herbal remedies. Hence the traditional herbal medicines which are obtained from the plants play a vital role in the management of Diabetes mellitus.<sup>[2]</sup>

**Types of Diabetes**

**Type 1 Diabetes** which was previously known as insulin dependent diabetes mellitus (IDDM) is an immune mediated or juvenile-onset diabetes mellitus. It is due to an auto-immune reaction in which the body's immune system attacks the insulin producing cells. This type of Diabetes mellitus can affect the people of any age but

most often in children or young adults, who are in need of insulin injections every day as a part of management of the disease and also to maintain the level of glucose in blood.<sup>[3]</sup>

**Type 2 Diabetes** is a condition where there is a diminish of both synthesis and secretion of insulin by the islets of langerhans is found or there is increased insulin whereby glucose does not move into the cells. It may not be detected in the early stages as the onset tends to be slow. Obesity and lack of physical activity are the most common cause of insulin resistance in the cells. The age of onset for the disease is more common in those over 50 years of age.<sup>[4]</sup>

**Gestational Diabetes Mellitus (GDM)** is another type of Diabetes mellitus and is state of glucose intolerance with the onset or the first recognition occurring during pregnancy. The most common metabolic complications of pregnancy, fetal mortality and morbidity is seen in gestational diabetes mellitus.<sup>[5,6]</sup> Hence the early diagnosis is essential in order to reduce the maternal and fetal morbidity and to prevent or delay the onset of Type 2 diabetes mellitus.<sup>[7]</sup>

**Adverse effects of current treatment for Diabetes mellitus**

Presently Insulin and Oral hypoglycaemic agents are used in the management of Diabetes mellitus (Type 1 and Type 2). The major undesirable effect of Insulin is

Hypoglycaemia which can cause brain damage. Some patient's can develop short-lived dependent oedema (due to Na<sup>+</sup> retention) at the start of insulin therapy. The most common unwanted effect of Metformin is gastrointestinal disturbances, abdominal pain and metallic taste. The commonest adverse effect of sulfonylureas is hypoglycaemia which can be severe and prolonged. Thiozolidinediones causes serious hepatotoxicity, weight gain and gastrointestinal disturbances.<sup>[8]</sup>

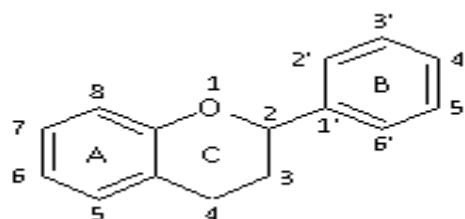
Hence in order to overcome these problems it is necessary to search and investigate the new classes of compounds. Several medicinal plants are used for the treatment of Diabetes mellitus in different societies of Asia, Africa and in North America. Therefore medicinal plants are of great importance for health of individuals and also for the communities. The medicinal value of such plants depends up on the kind of chemical substance that possess which produce a specific physiological action.<sup>[9]</sup>

Wide ranges of plants were demonstrated along with their chemical compounds as active constituents and are being used in the treatment of Diabetes mellitus. Among them flavonoids, alkaloids, glycosides, peptidoglycans, steroids, carbohydrates, terpenoids, amino acids, and inorganic ions are some of the common examples. Thus plants proved to be a potential source of anti-diabetic drugs and for other diseases also. Among the several medicinal plants used in the management of diabetes mellitus, some of the medicinal plants with flavonoids as their active constituents are reviewed in this study.<sup>[10,13]</sup>

### Chemistry and types of Flavonoids

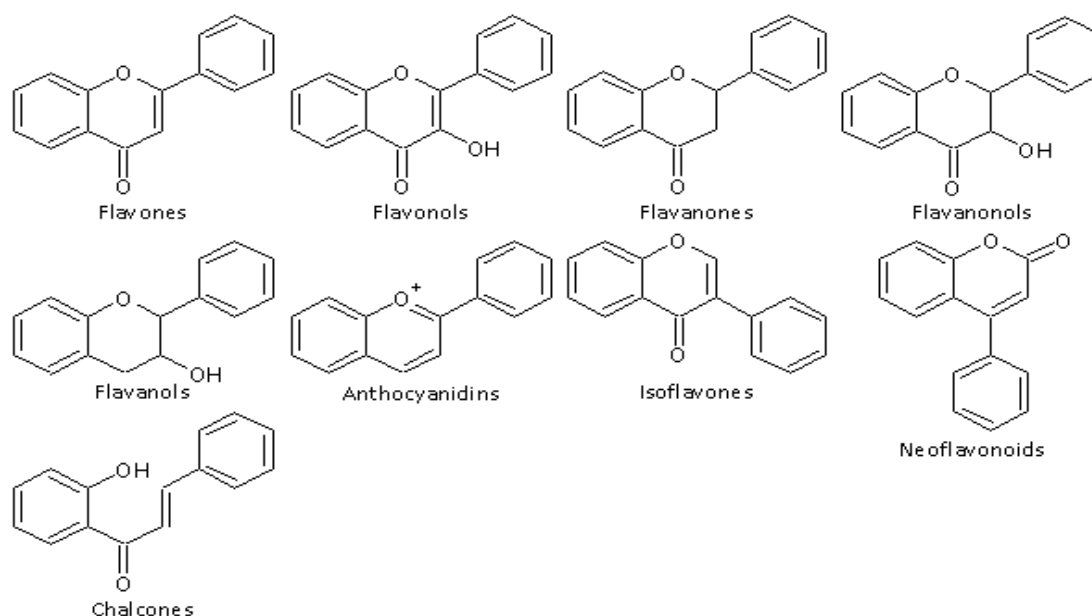
Flavonoids are the group of plant metabolites which consists of large group of polyphenolic compounds with a benzo-pyrone structure. These are synthesized by

phenyl-propanoid pathway and the secondary metabolite of phenolic structure exhibit wide range of pharmacological activities including anti-diabetic activity.<sup>[14, 15]</sup> The activities of flavonoids are dependent on their respective chemical structures and the chemical nature of them depends on the structural class, conjugation, degree of polymerization and also degree of hydrolyzation. Flavonoids are based on a C<sub>15</sub> (C<sub>6</sub>C<sub>3</sub>C<sub>6</sub>) framework which possesses a chroman ring (C-ring) with a second aromatic ring at the positions C-2, C-3 or C-4. A five-membered ring (ex: aurones) or acyclic form (chalcones) is sometimes replaced in place of heterocyclic six-membered C-ring. The different classes of flavonoids can be categorized on the basis of oxidation state of the C-ring.<sup>[16]</sup>



General structure of Flavonoid

Flavonoids can be divided into classes such as flavones (ex: flavone, apigenin & luteolin), flavonols (ex: quercetin, kaempferol, myricetin & fisetin), flavanones (ex: flavanone, hesperetin & naringenin) and others. The pattern of substitution of the C-ring and the level of oxidation differs the various classes of flavanoids from one another.<sup>[17]</sup> Some of the important subgroups of flavonoids along with chemical structure are listed below.



**Anti-diabetic plants with flavonoids*****Acacia Arabica (A.arabica)***

*Acacia Arabica* which is commonly known as Indian gum belongs to the family Fabaceae, most often found in India particularly in Punjab, Rajasthan and southern states of India. The seeds and the bark of *Acacia arabica* have shown a significant hypoglycaemic property. The main chemical constituents of *Acacia arabica* is gallic acid, m-digallic acid, chlorogenic acid, gallolyated flavan-3, 4-diol, robidandiol (7,3,4,5-tetrahydroxyflavan-3-4-diol), androstene steroid, D-pinitol carbohydrate, and catechin-5-galloyl ester.<sup>[18]</sup>

Bhandari M et al., demonstrated that *Acacia arabica* seeds contained a substance which is responsible for the depression of the blood glucose in normoglycemic rabbits but not in alloxan-induced rabbits. It suggests that the mechanism of action involves the release of insulin from beta cells of pancreas. Even the bark in the form of decoction (20mg/kg) as well as standard drug Tolbutamide produced a significant reduction in the blood glucose levels in mild alloxonised diabetic rabbits fasted for 18 hours.<sup>[19]</sup> Yasir et al., evaluated an aqueous and hydro alcoholic extracts of *A.arabica* for its hypoglycaemic activity and found that both extracts has significant hypoglycaemic property at 400 mg/kg.<sup>[20]</sup>

***Agrimonia eupatoria (A.eupatoria)***

*Agrimonia eupatoria* is a species of agrimony that is often referred to as common agrimony, church steeples or sticklewort, the plant belongs to the family Rosaceae. The chemical constituents of *Agrimonia eupatoria* includes volatile oils, flavanoids, apigenin, luteolin, quercetin, kaempferol, tiliroside, triterpene glycoside, including euscaptic acid and tormentic acid, phenolic acids and 3-21% of Tannins.<sup>[21]</sup>

Zhang and Cheng, isolated nine compounds viz. Apigenin-7-O-3-D-glucopyranoside, catechin, quercetin, rutin, kampferol-3-O-alpha-L-rhamnoside, kampferol-3-O-beta-D-glucopyranoside, lutcolin - 7 - O - beta - D-glucopyranoside, 19alpha, 24-dihydroxy ursolic acid, 3,3'- di - O - methyl ellagic acid 4 - O - beta - D-glucopyranoside from *A.eupatoria* was found to be responsible in reducing the blood glucose level.<sup>[22]</sup>

***Bougainvillea spectabilis Linn(B.spectabilis)***

*Bougainvillea* is a genus of flowering plants belongs to the family Nyctaginaceae. It is native to South America from Brazil west to Peru and south to southern Argentina and is familiar ornamental plant commonly grown in Indian gardens.

The results of the phytochemical analysis revealed the presence of alkaloid flavanoids, glycosides, phlobotannins, saponins, steroids, tannins and terpenoids, in distilled water, acetone chloroform and ethanol and methanol extracts of stem flowers and leaves extracts of *B. spectabilis*.<sup>[23]</sup> The plant posses the anti-diabetic activity and the blood glucose lowering potential of

*Bougainvillea spectabilis* leaf extract in streptozotocin-induced type I diabetic albino rats was reported. The ethanolic extract of the leaves has anti-hyperglycaemic activity and the probable mechanism of action is increased uptake of glucose by enhanced glycogenesis in the liver and also due to increase in insulin sensitivity.<sup>[24]</sup>

***Beta vulgaris(B.vulgaris)***

*Beta vulgaris* is a plant in the Amaranthaceae family. There are number of cultivated varieties but beet root or garden beet is well known which is a root vegetable.

Preliminary phytochemical analysis for the presence of saponins, tannins, alkaloids and flavonoids were conducted. The results confirm the presence of tannins, alkaloids, and flavanoids as the phytochemicals.<sup>[25]</sup> Rahmatulla et al., evaluated the anti-diabetic potential of *Beta vulgaris* in which the administration of methanol extracts of roots led to a dose-dependent and significant decrease in the blood glucose level in Glucose-loaded mice.<sup>[26]</sup> Betavulgarosides II- IV, isolated from the root of *Beta vulgaris L.* has significantly reduced the rise in blood glucose levels in an oral glucose tolerance test in rats.<sup>[27]</sup>

***Bauhinia purpurea (B.purpurea)***

*Bauhinia purpurea* is a species of flowering plant belongs to the family Fabaceae. It is native to south china and south East Asia. Itconstitutes a wide range of chemical constituents such as petroleum ether extracts contains phytosterols, fixed oils and fats. Ethyl acetate extracts containing alkaloids, carbohydrates, glycosides, phenolic compounds &tannins, coumarin, protein & amino acid compounds. Methanolic extracts found to be containing alkaloids, carbohydrates, glycosides, phenolic compounds, saponins, tannins, coumarin, protein, amino acid and also flavonoids.<sup>[28]</sup>

Prasanna shama K & Shastry CS evaluated the anti-diabetic activity of ethanol extract of *B.purpurea* in STZ-induced diabetic rats & confirmed the activity at as dose of 200, 400 mg/kg of body weight orally. The triterpenoids,its esters & flavanoids which are the bioactive anti-diabetic principles were found to be responsible for hypoglycaemic activity, which have the property of increased insulin secretion.<sup>[29]</sup>

***Morus alba (M.alba)***

*Morus alba* plant is also known as Mulberry belongs to the family Moraceae has a significant role in the sericulture industry as it a primary food for a monophagus insect Bombyx. The biochemical compounds found in the mulberry plant are Moran (glycopeptides), hydrophilic flavonoids (flavones & flavonone), 2-Arylbenzofuran & ethanolic extract, flavonoids, ploy phenols, carotenoids, vitamin A, C E, Ethyl acetate, which plays a vital role in the hypoglycaemic activity.<sup>[30]</sup> Laddha G P et al., evaluated a hypoglycaemic effect of *Morus alba* on rabbit as an animal model. The oral administration of the petroleum

leaf extracts (50, 100mg/kg b.w) showed a significant decrease in the blood glucose level in the model of alloxan induced Diabetes in New Zealand rabbit.<sup>[31]</sup> The oral administration of (600 mg/kg/day) alcohol extract of root bark for 10 days significantly reduced blood glucose by increasing the insulin level in STZ-induced diabetes in rats.<sup>[32]</sup>

#### ***Lawsonia inermis (L.inermis)***

*Lawsonia inermis* is a tall shrub or a small tree belonging to the family Lythraceae. It is a native of North Africa & south west Asia, widely cultivated as ornamental & dye plant through India.<sup>[33]</sup> The plant reported to contain carbohydrates, proteins, flavonoids, tannins & phenolic compounds, alkaloids, terpenoids, quinines, coumarin, xanthones & fatty acids.<sup>[34]</sup> Ethanol (70 %) extract of *L. inermis* showed significant hypoglycaemic and hypolipidaemic activities in alloxan induced diabetic mice after oral administration.<sup>[35]</sup> Arati chikaraddy et al., evaluated the hypoglycaemic activity of *L.inermis* Linn in alloxan induced diabetes in albino rats in which diabetes was induced by the administration of alloxan monohydrate (180 mg/kg b.w) intra peritoneally and certain groups of animals were treated with ethanolic extracts of leaves of *L.inermis* (150, 200 and 400 mg/kg b.w). The results showed a highly significant fall in blood glucose at a dose of 400 mg/kg b.w, even though there was a significant hypoglycaemic activity in all the remaining doses. (150, 200 mg/kg b.w).<sup>[36]</sup>

#### ***Hibiscus rosa-sinensis (H.rosa-sinensis)***

*Hibiscus rosa-sinensis* is an ornamental plant often known as a fence plant which belongs to the family Malvaceae. Even though it is found in India and Philippines the plant is native to china with wide variety of coloured flowers in it. Different extract of *Hibiscus rosa-sinensis* plant was investigated for the presence of alkaloids, glycosides, fatty materials, reducing sugars, resin, sterols and the lack of tannins and saponins. Isolation of  $\beta$ -sitosterol, taraxeryl acetate and four uncharacterized compounds which included an alkaloid and three sterols has been reported in the leaves.<sup>[37]</sup> Flowers found to contain vitamins, flavonoids, ascorbic acid, niacin, riboflavin, thiamine and cyaniding diglucoside. Quercetin-3-diglucoside, cyanidin-3-sophoroside-5-glycosides, 3, 7- diglucoside, cyanidin-3, 5-diglucoside have been isolated from deep yellow flowers.<sup>[38]</sup> Mishra et al., evaluated the crude extract of *Hibiscus rosa-sinensis* for the hypoglycaemic activity in alloxan induced diabetes in mice and found a significant decrease in the glucose level.<sup>[39]</sup> The Hibiscus mucilage which is rich in flavonol bioside was found to be responsible for the hypoglycaemic activity.<sup>[40]</sup>

#### ***Syzygium cumini (S.cumini)***

*Syzygium cumini* (Family: Myrtaceae) is an important medicinal plant in various traditional system of medicine. It also known as *Syzygium jambolanum* and *Eugenia cumini*. Other common names include Jambul, Black Plum, Java Plum, Indian Blackberry, Jamblang,

Jamun etc. Today these trees are found growing throughout the Asian subcontinent, Eastern Africa, South America.<sup>[41]</sup> Fruits contain many different kinds of anti-oxidant compounds, including flavonoids, phenolics, carotenoids and vitamins, which are all considered beneficial to human health, for decreasing the risk of degenerative diseases by reduction of oxidative stress, and for the inhibition of macromolecular oxidation.<sup>[42]</sup>

A compound, mycaminose which was isolated from the SC seed extract, ethyl acetate and methanol extracted compounds from the seed were evaluated for the anti-diabetic activity against STZ induced diabetic rats at as dose of 50 mg/kg, 200 and 400 mg/kg respectively. The compound 'Mycaminose', ethyl and methyl extract produced a significant reduction in the blood glucose level by stimulating the increase in the insulin release from pancreatic islets. The study also showed no mortality up to the dose of 2,000 mg/kg body weight and hence the extracts were considered safe for long term administration.<sup>[43]</sup>

#### ***Trigonella foenumgraceum (T.foenumgraceum)***

*Trigonella foenumgraceum* (Fenugreek) is an annual leguminous bean and belong to the family Fabaceae. Its seeds and green leaves used as food posses medicinal applications, and is an old practice of human history.<sup>[44]</sup> Among the bioactive compounds found in fenugreek, the major chemical constituents, Polyphenolic compounds, galactomannan (fiber), diosgenin (saponin), quercetin (flavonoid), trigonelline (alkaloid) and 4-hydroxyisoleucine (unusual amino acid) have, by far superseded the rest due to their numerous health promoting activities especially their hypoglycaemic nature.<sup>[45, 46, 47]</sup>

Eidia et al., reported that oral administration of ethanolic extracts of fenugreek (0.1, 0.25 and 0.5 g/kg for 14 days shows anti-diabetic effect in STZ- induced diabetic rats by normalizing the levels of serum glucose, total cholesterol, triacylglycerol, urea, uric acid, creatinine, aspartate amino-transferase and alanine amino-transferase.<sup>[48]</sup> Fenugreek contains an amino acid, 4-hydroxyisoleucine, demonstrated to have insulinotropic and anti-diabetic properties in streptozotocin induced diabetic rats by altering the levels of glucose or liver damage markers significantly.<sup>[49]</sup> Oral administration of 4-hydroxyisoleucine an amino acid isolated from fenugreek seeds (50mg/kg) to db/db mice ameliorates the blood glucose level and lipid parameters by enhancing the insulin sensitivity and glucose uptake in peripheral tissues.<sup>[50]</sup>

#### **CONCLUSION**

Diabetes mellitus is a serious metabolic disorder in which the difference in social structure, stress, obesity, hormonal imbalance and heredity are vital factors in the progression and widespread all over the world. At present the treatment involves the use of biguanides, thiozolidonediones, sulfonylureas, D-phenylalanine derivatives, meglitinides and insulin. However because

of their side effects there is a definite need of new compounds from the plant source for the treatment of Diabetes mellitus<sup>[51, 52]</sup>. In this review an attempt has been made to investigate the flavanoid containing medicinal plants which were already evaluated. The mechanism of action of flavonoids varies depending up on the type of flavonoid the plant possesses. But the potent antioxidant activity may be their important function<sup>[53]</sup>. Many flavonoids have been reported to effectively counter Diabetes by their direct action on insulin receptor, by modulating insulin signalling and also by inhibiting glucose transport<sup>[54]</sup>. Hence flavonoids which are the an important polyphenolic molecules of various plants thought to provide health benefits and finds much useful in the management of Diabetes mellitus.

## REFERENCES

- Maiti R, Jana D, Das UK, Ghosh D. Anti-diabetic effect of aqueous extract of seed of *Tamarindusindica* streptozotocin induced diabetic rats. *J Ethnopharmacol.*, 2004; 92: 85-91.
- Patel, K. and K. Srinivasan. Plant foods in the management of diabetes mellitus: vegetables as potential hypoglycaemic agents. *Nahrung.*, 1997; 41: 68-74.
- B. Jayaprasad, D. Thamayandhi. Traditionally using medicinal plants in Tamil nadu, *International journal of Research in Pharmaceutical and Biosciences.*, 2012; 2(1): 1-8.
- Muralitharannair. Diabetes mellitus, part 1: Physiology and complications, *British Journal of Nursing*, 2007; 16(3).
- Metzger BE, Buchanan TA, Coustan DR, de Leiva A, Dunger DB, Hadden DR, et al. Summary and recommendations of the fifth international workshopconference on gestational diabetes mellitus. *Diabetes Care.*, 2007; 30: S 251.
- Jovanovich L, Pettit DJ. Gestational diabetes mellitus. *JAMA.*, 2001; 286: 2516-2518.
- Kim C, Newton KM, Knopp RH. Gestational diabetes and the incidence of type 2 diabetes. *Diabetes Care.*, 2002; 25: 1862.
- Rajupatil et.al, Current status of Indian medicinal plants with anti-diabetic potential: a Review, *Asian Pacific Journal of Tropical Biomedicine.*, 2011; S291-S298.
- Riserus U, Willett WC, Hu FB. Dietary fats and prevention of type 2 diabetes. *Prog Lipid Res.*, 2009; 48(1): 44-51.
- Edeoga HO, Okwu DE, Mbaebie BO. Phytochemical constituents of some Nigerian medicinal plants. *Afr J Biotechnol.*, 2005; 4(7): 685-688.
- Olasode OA. Why vitiligo in diabetes. *Egypt Dermatol Online J.*, 2005; 1(2): 1-6.
- Etuk EU, Bello SO, Isezuo SA, Mohammed BJ. Ethno botanical survey of medicinal plants used for the treatment of diabetes mellitus in the north western region of Nigeria. *Asian J Exp Biol Sci.*, 2010; 1(1): 55-59.
- Cooke DW, Plotnick L. Type 1 diabetes mellitus in pediatrics. *Pediatr Rev.*, 2008; 29(11): 374-384.
- M. F. Mahomoodally, A. Gurib-Fakim, and A. H. Subratty, "Antimicrobial activities and phytochemical profiles of endemic medicinal plants of Mauritius," *Pharmaceutical Biology*, 2005; 43(3): 237-242.
- K. Pandey, "Anti-staphylococcal activity of a pan-tropical aggressive and obnoxious weed *Parihenium hysterophorus*: an *in vitro* study," *National Academy Science Letters*, 2007; 30: 11-12, 383-386.
- Haslam, E. *Chemistry and Pharmacology of Natural Products. Plant Polyphenols: Vegetable Tannins Revisited*; Cambridge University Press: Sydney, Australia, 1989; 8.
- E. J. Middleton, "Effect of plant flavonoids on immune and inflammatory cell function," *Advances in Experimental Medicine and Biology*, 1998; 439: 175-182.
- Raj, J., CCRH (Central Council for Research in Homoeopathy) Quarterly Bulletin, 2000; 22(1-2).
- Bhandari M.M.: *Flora of the Indian Desert*, M.P.S. Jodhpur, India., 1978; 132-134.
- Yasir M, Jain P, Debajyoti, Kharya MD. Hypoglycaemic and anti-hyperglycaemic effect of different extracts of *Acacia arabicalamk* bark in normal and alloxan induced diabetic rats. *Int. J Phytomed.*, 2010; 2: 133-138.
- Frances Watkins, Barbara Pendry, Alberto Sanchez-Medina, Olivia Corcoran (2012). "Antimicrobial assays of three native British plants used in Anglo-Saxon medicine for wound healing formulations in 10th century England Original Research Article Pages 408-415". *Journal of Ethno pharmacology.*, 2012; 144(2): 225-456.
- Zhang JH, Cheng YS. Studies on the lowering blood sugar substances from agrimony. *Zhong Yao Cai.*, 2009; 32(10): 1537-1539.
- Nadia Sharif et al, Phytochemical analysis and inhibitory activity of Ornamental Plant (*Bougainvillea spectabilis*), *Asian Journal of Plant Science and Research*, 2013; 3(2): 1-5.
- Purohit, A, Sharma A. Blood glucose lowering potential of *Bougainvillea spectabilis* leaf extract in streptozotocin induced type 1 diabetic albino rats. *Indian Drugs.*, 2006; 43(7): 538-542.
- Kumar C, Kumar R, Nehar S. Phytochemical properties, total antioxidant status of acetone and methanol extract of *Terminalia arjuna* Roxb. Bark and its hypoglycaemic effect on Type-II diabetic albino rats. *J Pharmacogn Phytochem*, 2013; 2: 199-208.
- Rahmatullah et al., Anti-hyperglycaemic and anti-nociceptive activity tests with *Beta vulgaris* L. ssp. *Vulgaris* roots: a preliminary report, *World Journal of Pharmaceutical Research*, 3(9): 109-118.
- Bolkent S, Yanardağ R, Tabakoğlu-Oğuz A, Özsoy-Saçan O. Effects of chard (*Beta vulgaris* L. var. *cicla*) extract on pancreatic B cells in streptozotocin-diabetic rats: A morphological and biochemical study. *Ethnopharmacol.*, 2000; 73(1-2): 251-259.

28. CD. Shaji Selvin et al., Isolation of Active Constituents Derived from Whole Plant of *Bauhinia purpurea*, International journal of pharmaceutical and chemical sciences., 2012; 1(2).
29. Prasanna shama K and Shastry CS. Evaluation of Anti-diabetic Activity of *Bauhinia purpurea* Linn in Streptozotocin Induced Diabetic Rats, International journal of advances in pharmacy, biology and chemistry, IJAPBC., 2012; 1(4): 2277 – 4688.
30. SaurabhBajpai, History and active pharmacokinetic principles of mulberry: A review, IOSR Journal of Pharmacy (IOSRPHR., 2(4): 13-16.
31. Laddha G P et al., Anti-diabetic effect of *Morus alba* on Rabbit as an animal model, IRJP., 2012; 3(4).
32. Singab AN, El-Beshbishy HA, Yonekawa M, Nomura T, Fukai T., Hypoglycaemic effect of Egyptian *Morus alba* root bark extract: effect on diabetes and lipid peroxidation of streptozotocin-induced diabetic rats. J Ehanopharmacol., 2005; 100: 333-338
33. Santosh Yadav et al., Essential Perspectives of *Lawsonia inermis*, International journal of pharmaceutical and chemical sciences., 2013; 2(2).
34. Gagandeep Chaudhary, *Lawsonia inermis* Linnaeus: A Phytopharmacological Review, International Journal of Pharmaceutical Sciences and Drug Research., 2010; 2(2): 91-98.
35. Patel P, Harde P, Pillai J, Darji N, and Patel B. Anti-diabetic herbal drugs A Review. Pharmacophore., 2012; 3(1): 18-29.
36. Arati chikaraddy et al., Hypoglycaemic activity of ethanolic extract of *Lawsonia inermis* linn. (henna) in alloxan induced diabetic albino rats, IJPBS., 2012; 2(4): 287-292.
37. Pekamwar et al., *Hibiscus rosa-sinensis*: a review on ornamental plant, World journal of pharmacy and pharmaceutical sciences., 2(6): 4719-4727.
38. Srivastava DN, Bhatt SK, Udupa KN. Gas chromatographic identification of fatty acids, fatty alcohols and hydrocarbons of *Hibiscus rosa-sinensis* leaves. J. Amer. Oil Chem Soc, 1976; 53: 607.
39. Mishra et al., Evaluation of Medicinal Properties of *Hibiscus rosa-sinensis* in Male Swiss Albino Mice, IJPCR., 2009; 1(3): 106-111.
40. Sachdewa, Nigam, Khemani. Hypoglycaemic effects of *Hibiscus rosa-sinensis* L. leaf extract in glucose and streptozotocin induced diabetes in rats. Indian J Exp Biol., 2001; 39: 284-286.
41. Shrikant Baslingappa Swami et al., Jamun (*Syzygium cumini*): A Review of Its Food and Medicinal Uses, Food and Nutrition Sciences, 2012; 3: 1100-1117.
42. J. Kubola, S. Siriamornpun and N. Meeso, "Phytochemicals, Vitamin C and Sugar Content of Thai Wild Fruits," Food Chemistry., 2011; 126 (3): 972-981.
43. Kumar et al., Anti-diabetic activity of *Syzygium cumini* and its isolated compound against streptozotocin- induced diabetic rats, Journal of Medicinal Plants Research., 2008; 2(9): 246-249.
44. Thomas JE, Bandara M, Lee E , Driedger D, Acharya S. Biochemical monitoring in fenugreek to develop functional food and medicinal plant variants. N Biotechnology., 2011; 110–117.
45. Mehrafarin A, Qaderi A, Rezazadeh Sh, Naghdi-Badi H, Noormohammadi Gh, and Zand E. Bioengineering of important secondary metabolites and metabolic pathways in fenugreek (*Trigonella foenum-graecum* L.). J Med Plants., 2010; 9(35): 1 – 18.
46. Rizvi SI, Mishra N. Traditional Indian medicines used for the management of diabetes mellitus. J Diabetes Res., 2013; 1-11.
47. R. Dharmalingam and P. Nazni, Phytochemical Evaluation of coriandrum L Flowers, International Journal of Food And Nutritional Sciences, 2013; 2(4): 35-39.
48. Eidia A, Eidib M, Sokhtehe M. Effect of fenugreek (*Trigonella foenum-graecum* L.) seeds on serum parameters in normal and streptozotocin-induced diabetic rats. Nutr Res., 2007; 27: 728-733.
49. Haeri MR, Izaddoost M, Ardekani MR, Nobar MR, White KN. The effect of fenugreek 4-hydroxyisoleucine on liver function biomarkers and glucose in diabetic and fructose fed-rats. Phytother Res., 2009; 23(1): 61-64.
50. Singh A, Singh K, Saxena A. Hypoglycaemic activity of different extract of various plants. Int J Res Ayu Pharm 2010; 1(1): 212-224.
51. U.K. Prospective Diabetes Study Group. Perspectives in Diabetes. U.K. Prospective Diabetes study 16. Overview of 6 years' therapy of type 2 diabetes: a progressive disease. Diabetes., 1995; 44: 1249-1258.
52. Moller DE. New drug targets for type 2 diabetes and the metabolic syndrome. Nature., 2001; 414: 821-827.
53. A. Lukačínová et al., Preventive Effects of Flavonoids on Alloxan-Induced Diabetes Mellitus in Rats, ACTA VET. BRNO., 2008; 77: 175-182;
54. Wang, Victor C X, Handbook on research on advancing health education through technology, 13: 294-295.