IJBPAS, October, 2024, 13(10): 5209-5225

ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

INDIAN MEDICINAL PLANTS UTILIZED IN TRADITIONAL MEDICINE FOR THE MANAGEMENT OF DIABETES

GOEL N., TIWARI U., SINGH S., GUPTA M. AND GUPTA S.P.*

Rajiv Gandhi Institute of Pharmacy, Faculty of Pharmaceutical Science & Technology, AKS University, Satna (MP)-India-485001

***Corresponding Author: Dr. Surya Prakash Gupta: E Mail: suryatony@yahoo.co.in**

Received 24th Sept. 2023; Revised 25th Oct. 2023; Accepted 16th Jan. 2024; Available online 1st Oct. 2024

https://doi.org/10.31032/IJBPAS/2024/13.10.9085

ABSTRACT

Globally, diabetes mellitus is a very prevalent and dangerous metabolic disease. This terrible illness is present everywhere in the globe and is rapidly endangering human health. Diabetes mellitus is a collective term for a series of metabolic illnesses that are characterized by high blood glucose levels that are caused by anomalies in the synthesis, function, or interaction of both insulin and glucose. Diabetes mellitus has been treated using traditional herbal medicines all throughout the world. Although a variety of medications and poly-herbal plants are used in medicine, many herbs are recognized to successfully treat and manage diabetes, and they also have no unfavorable side effects. Synthetic oral hypoglycemic medications, such as insulin, are the standard therapy for diabetes and are successful in reducing hyperglycemia. However, they have a lot of negative side effects and don't really slow down the development of diabetes problems. This is the primary cause of the growing number of individuals searching for substitute drugs that may have less side effects or none at all. An overview of various documented anti-diabetic medicinal plants and commercialized plant-based poly-herbal herbal preparations is provided in this article.

Keywords: Diabetes mellitus, Insulin, Hyperglycemia, Anti-diabetic medicinal plants

INTRODUCTION

Changes in the metabolism of proteins, lipids and carbohydrates are hallmarks of diabetes mellitus, a complex metabolic illness **[1]**. It is thought that managing diabetes mellitus is a worldwide issue for which there is now no effective cure. As

long as they are taken consistently, current medications like insulin and oral hypoglycemic medicines regulate blood sugar levels, but they also have a variety of negative side effects **[2, 3]**. Numerous indigenous plant species and poly-herbal treatments have been attempted to treat diabetes mellitus **[2, 4, 5]**. Traditional medicinal systems have traditionally suggested herbal therapy as a cure for diabetes. Numerous Indian plants have been studied for their potential benefits in treating various forms of diabetes; these studies have been reported in a wide range of scientific publications **[6]**. Around 600 plants that are thought to have anti-diabetic effects are mentioned by the Ayurvedic medicinal system in the ancient Indian scriptures of Charak, Samhita, Mahdhav Nidan, and Astang Sanghra **[7]**. Several phytochemicals derived from a broad range of plants have shown a hypoglycemic impact on several occasions, indicating that they could be beneficial for treating diabetic mellitus. Several phytochemicals derived from a broad range of plants have shown a hypoglycemic impact on several occasions, they may be useful in the treatment of diabetes mellitus, according to preliminary research. *Allium sativum, Allium cepa Aloevera, Coccinia indica, Cajanus cajan, Caesalpinia bonducella* is a species of Caesalpinia. *Ficus bengalenesis* is a species of *Ficus*. *Gymnema sylvestre* (*Gymnema sylvestre*) *charantia momordica*, Holy water, *marsupium pterocarpus, Trigonella foenum, Swertia chirayita, Syzigium cumini, Tinospora cordifolia*, graecum are the herbs from India that have been shown to be the most successful and often researched when it comes to diabetes and its consequences **[8, 9]**.

Herbal Drugs with Anti-Diabetic Properties

Numerous Indian plants have been studied for their potential benefits in treating various forms of diabetes; these studies have been reported in a wide range of scientific publications **[6]**. Around 600 plants that are thought to have antidiabetic effects are mentioned by the Ayurvedic medicinal system in the ancient Indian scriptures of Charak, Samhita, Mahdhav Nidan, and Astang Sanghra **[7]**. A hypoglycemic impact has been frequently shown by several phytochemicals derived from a broad range of plants, demonstrating how they may be used to treat type 2 diabetes. The most effective and often researched Indian herbs for diabetes and its complications are the ones listed below:

***Wattakaka volubilis* (L.f.) Stapf. (Asclepiadaceae)**

Local Name: Perun-kurinjan

It's a big, meaty climber that spreads over the plains. Its leaves are papery. Cow's milk is consumed orally together with leaf powder. Quantity: For 90 days, consume

50–75 millilitre of the combination twice daily, after meals **[10]**.

***Trigonella foenum graecum*: (fenugreek)**

Fenugreek seeds are widely available in India and are frequently used as a major ingredient in Indian spices. Extracted from fenugreek seeds, 4-hydroxyleucine is a new amino acid that enhanced the release of insulin when glucose was stimulated in isolated islet cells in rats and humans. 4-hydroxyleucine, when glucose was stimulated, a new amino acid obtained from fenugreek seeds boosted the quantity of Human and rat islet cells on their own produce insulin. It has been shown that feeding fenugreek seeds to diabetic rats enhanced their glucose metabolism and brought their liver, heart, and skeletal muscle back to normal levels of creatinine kinase activity. Additionally, it decreased the functioning of the kidney and liver glucose-6-phosphatase as well as fructose-1, 6-biphosphatase. This plant has antioxidant properties as well **[11]**.

***Abrus precatorius L.* (Fabaceae)**

Local Name: Kundumani

It grows across India's plains, is a climber that is also referred to as wild liquorice. This plant's leaves are mixed with the seeds of *Syzygium cumini, Gymnema sylvestre*, and *Andrographis paniculata*. The combination is given orally with cow's milk after being shade dried and pounded into a powder. Quantity: For 120 days, consume around 50 cc of the combination two times a day, before meals **[12]**.

Aloe vera* and *Aloe barbadensis

Common houseplant aloe is used as a versatile home medicine for a long time. The two primary components taken from the plant are gel and latex. The leaf is composed of aloe vera gel. The Phytopharmacological Journal Aloe latex or "aloe juice" is a bitter-yellow substance that emerges from the pericyclic tubules just under the leaf's outer layer. It is also known as pulp or mucilage. Rat's glucose tolerance is effectively increased by aloe gum extracts in both normal and diabetic settings. Hypoglycemic effects were seen in alloxanized diabetic rats administered leaf exudates from Aloe barbadensis over an extended period of time as compared to a single treatment. In diabetic rats, both acute and long-term administrations of the plant's bitter component demonstrated a hypoglycemic impact. The bitter component of aloe vera acts by inducing the production and/affects the pancreatic beta cell's secretion of insulin. This plant exhibits dose-dependent counter-inflammatory effects and also helps diabetic mice repair their wounds **[13]**.

***Tinospora cordifolia*: (Guduchi)**

This big climbing deciduous shrub belongs to the Menispermaceae family. It has a lustrous texture. It is sometimes referred to as Guduchi and is extensively available across India. Following six weeks of oral

Tinospora cordifolia (*T. cordifolia*) injection of root extract to diabetic rats given alloxan, the rat's serum and tissue lipid levels, as well as their blood and urine glucose levels, all dramatically dropped. Additionally, the extract stopped the body weight from dropping. In Indian ayurvedic medicine, *T. cordifolia* is often used to treat diabetes mellitus **[14]**.

***Acacia arabica*: (Babool)**

It is mostly found in its natural environment, which is all throughout India. The plant extract has anti-diabetic effects because of its secretory influence on insulin secretion. It causes hypoglycemia in rats that are not alloxanized, but it does in control rats. When powdered Acacia arabica seeds were given to healthy rabbits at doses of 2 g/kg, 3 g/kg, and 4 g/kg body weight, they had an effect on hypoglycemia. This was achieved by initiating the release of insulin from the pancreatic beta cells **[15]**.

***Allium sativum*: (garlic)**

Perennial plants like this are planted all throughout India. The root of its strong odor is allicin, a sulfur-containing chemical that also exhibits strong hypoglycemic effects. It is believed that the impact shown in the rabbits is brought about by either the insulin sparing effect, elevated release of insulin from pancreatic beta cells, or improved hepatic metabolism. The quantity of hepatic glycogen and free amino acids in the blood increased significantly in rabbits given sugar during a two-month period, in addition to a drop in cholesterol and values of blood glucose during fasting compared to controls on sucrose. This was accomplished by giving a 10-milliliter/kg/day aqueous homogenate of garlic orally **[16]**.

***Momordica charantia*: (bitter gourd) Cucurbitaceae).**

Local Name: Kaattu pagar-kai.

This plant, which appears in many varieties, is well known by the moniker "bitter guard" *Momordica charantia* is a widely used drug for diabetes and hyperglycemia in India and other Asian countries. It has been shown in a number of animal models that fruit pulp, seed, leaf, and entire plant extracts have hypoglycemic effects. Polypeptide P dramatically lowered blood sugar levels when it was administered subcutaneously to humans and langurs. Polypeptide p was extracted from *M. charantia* fruit, seeds and tissues. In rats with normal blood sugar and STZ diabetes, extracts of *M. charantia* (200 mg/kg) combined with ethanol demonstrated antihyperglycemic and hypoglycemic effects. Suppression of glucose-6-phosphatase and promotion of hepatic glucose-6-phosphate dehydrogenase activity are potential explanations of this, together with liver fructose-1, 6-biphosphatase **[4]**. This is a common climbing shrub found all throughout India. Oral consumption of unripe fruits occurs at mealtimes. Dosage: Eat two to three fresh,

unripe fruits as needed throughout the day for three months **[17]**.

MECHANISM OF ACTION OF HERBAL ANTI-DIABETICS

Herb's ability to lower blood sugar is mediated by a number of methods.

The modalities of action of herbal antidiabetic drugs may be divided into the following groups: **[18, 19, 20, 21, 22]**.

- Blockage of the potassium channel in pancreatic beta cells, cAMP (2nd messenger) activation, and adrenometicism.
- Reduction of renal glucose reabsorption inhibition.
- Stopping the processes that break down insulin or encouraging islet beta cells to produce insulin decrease in the resistance to insulin.
- Providing the minerals—calcium, zinc, magnesium, manganese, and copper—that the beta-cells require pancreatic beta cell regeneration and/or repair
- Expanding the size and quantity of Langerhans cell islets boosting the synthesis of insulin.
- Induction hepatic glycolysis and glycogenesis.
- Preventive action against beta cell degeneration.
- Better digestion accompanied with lower urea and blood sugar levels.
- Preventing the abnormal conversion of glucose from starch.
- Blocking of α-glucocidase and β-galactocidase.
- Activities that reduce cortisol.
- Blocking of alpha-amylase6.

PHARMACOLOGICAL MANAGEMENT OF DIABETES MELLITUS

The cornerstone for individuals with type I diabetes is insulin replacement treatment. Insulin is also crucial for those with type II diabetes when oral medicines, diet, exercise, and weight reduction are insufficient to regulate blood glucose levels **[23]**.

Insulin neutral and short-acting insulin (lispro, aspart, or glulisine) given once or twice day with food, together with long-acting insulin (glargine or insulin detemir), has been the most widely used treatment approach. Since the administration of detemir and glargine insulin is associated with a reduced incidence of severe and nocturnal hypoglycemia, it is often preferred over neutral protamine-hagedorn insulin **[24]**. There are new analogs of ultra-long-acting insulin in development. In contrast to glargine, insulin degludec produces equal glycemic control with less nocturnal hypoglycemia and delivers almost 40 hours of basal insulin coverage **[25]**.

Biguanides are a kind of oral hypoglycemic medication that lowers the quantity of

glucose the liver produces, sulphonylureas, which increase insulin secretion from β-cells, GLP-1 receptor agonists and a-glucosidase inhibitors that target the Glucagon-Like Peptide-1 axis were discovered, which prevent the stomach from absorbing carbs, thiazolidinediones, which enhance insulin action, sodium-glucose cotransporter inhibitors, bile acid sequestrants and dopamine agonists **[26, 27]**. Clinical research also connected common antidiabetic drugs to unfavorable side effects, exorbitant prices, and apparent treatment failures. Therefore, it's necessary to create a pressing demand and desire for alternative remedies **[28]**.

ANALYSIS OF BIOCHEMICAL PARAMETERS

Kidney Function Test

Serum Creatinine

Serum creatinine levels were measured by Tausky using the alkaline picrate technique. Three milliliters of distilled water were mixed with one milliliter of serum After adding two milliliters of 10% sodium tungstate and two milliliters of 2/3 N H_2SO_4, the liquid was aggressively agitated for two minutes to extract the protein. Filtration was applied to the solution. Three milliliters of the protein-free filtrate were pipetted off, and then one milliliter of picric acid and sodium hydroxide were added. 15 minutes later, at 470 nm, the color intensity was determined. The formula was used to calculate the creatinine content of the serum. The test OD was multiplied by the calculation factor and divided by the standard OD to obtain the results in milligrams per millilitre **[47, 48]**.

Serum Urea

The urea was calculated using the Natelson technique. The following were added: 0.3 millilitre 10% sodium tungstate, 0.1 millilitre serum, 0.3 millilitre 2/3N sulphuric acid, and 3.3 millilitre deionized water. The mixture was well combined before centrifugation. One milliliter of excess fluid, four milliliters of diacetylmonoxime, and sixteen milliliters of a combination of sulfuric acid and phosphoric acid were combined with the aforementioned amounts. The mixture was heated to a boil for thirty minutes, then allowed to cool before being run through spectrometry at 480 nm in comparison to a water blank. The concentration of urea was calculated using the formula **[47, 48]**.

Serum Uric acid

The Fossati *et al*., technique was used to quantify the concentration of uric acid in the serum. A four-hour re-extraction under a vertical condenser came next. 300 milliliters of distilled water were used to dissolve 40 grams of sodium tungstate and 32 milliliters of orthophosphoric acid were added. Once it has warmed up, add 300millilitre of pure water. Take 100 milliliters of distilled water and dissolve 32 grams of lithium sulfate

monohydrate to make a uric acid reagent, then mix 81 milliliters of sodium hydroxide (pH 2.5) with 100 milliliters of distilled water to get a standard solution that contains 10 milligrams of pure uric acid. 1.0 millilitre of uric acid agile and 0.02 millilitre of serum were allowed to come to room temperature for fifteen minutes. 520 nm was the measurement of the chroma. The procedure was used to calculate the uric acid concentration **[47, 48]**.

Blood Urea

Nitrous oxide using the Berthelot technique, blood urea nitrogen was determined. To make the test, ten liters of blood were combined with one milliliter of reagent I (urease solution comprising salicylate, hypochlorite, and Nitroprusside), standard, and blank, 10 liters of standard urea (40 mg/dl) and 10 liters of clean water. Every cuvette collected and kept at 37°C for five minutes. The enzyme urease is responsible for converting urea into CO_2 and ammonia. Indophenol is a blue-green chemical that is produced when salicylate, hypochlorite, and nitroprusside react with the resultant ammonia. The chroma generated is measured at 578 nm and is associated with the sample's urea level.

The blood urea was calculated using the following formula:

BUN (mg/dl) is calculated as test absorbance / standard absorbance x 40. **[47, 48]**.

PROTEIN ESTIMATION

Total Protein

The Lowry *et al*. technique, which required 0.9 millilitre of water, 4.5 millilitre of alkaline copper reagent, in addition to 0.1 milliliter of a sufficiently diluted material that will be stored for 10 minutes at room temperature, was used to calculate protein. Following the application of 0.5 cc of Folin's phenol, the chroma was measured at 640 nm after 20 minutes. A protein content of g/dl was provided **[49]**.

Serum Albumin

Albumin was calculated using the method developed by Basil T. After mixing 1.0 millilitre of BCG reagent and 0.1 millilitre of serum at room temperature, the mixture was incubated for one minute. At 600 nm, the intensity of a spectrophotometer is measured and compared to a blank. Milligrams per deciliter were used to quantify the albumin concentration **[49]**.

Nephroprotective Effects of Polyherbal Formulation:

A Pharmacological Evaluation:

The following formula was used to calculate the globulin content:

Concentration Globulin = Concentration Total proteins – Concentration Albumin

Determination of A/G Ratio

The following formula was used to compute the A/G Ratio:

A/G Ratio = Albumin Concentration / Globulin Concentration **[49]**.

ANALYSIS OF ELECTROLYTE LEVELS

Sodium

Serum sodium was determined using Marina & Trinder's colorimetric method. In order to conduct the test, 1 milliliter of aggregating reagent and 0.02 milliliter of reference reagent were well combined, five minutes of room temperature holding were followed by a two-minute, 2500 rpm centrifugation. The supernatant in each tube weighed around 0.05 milliliters. Three milliliters of filtered water were mixed with 0.2 milliliters of tinting agent. The blank is composed of 0.2 millilitre coloring reagent, 0.05 millilitre precipitating reagent, and 3 millilitre distilled water. After incubating for 5 minutes at 30°C, the absorbance was measured at 530 nm. Meq / L was used to express the results **[50]**.

Potassium

Using the Marina procedure, the blood's potassium level was ascertained. 0.1 millilitre of serum and 3 millilitre of boron reagent were combined. Three milliliters of boron solution and 0.1 milliliters of standard solution were used for the standard. After thoroughly mixing, the liquids were allowed to cool to room temperature for five minutes. At 620 nanometers, the final color was determined colorimetrically. The values were expressed in Meq / L **[50]**.

Phosphorus

Inorganic phosphorus was calculated using the method used by Fiske and Subbarrow. 0.8 millilitre of 0.2 milliliter centrifuging sample was mixed with liquid TCA while being constantly shaken. After the mixture was well combined, it was filtered and left for a little while. To 0.5 millilitre of filtrate, 0.5 millilitre of molybdate II solution was added. Subsequently, 0.2 milliliters of amino naptholsulphonic acid were used in the blend. After standing for five minutes, the spectrophotometry was recorded at 680 nm. Multiply 10 by the sample's absorbance to get the phosphorus concentration, then divide the resulting value by the absorbance of the reference **[50]**.

HEMATOLOGICAL PARAMETER

Haemoglobin

Hemoglobin was determined using the cyanmethaemoglobin procedure (Beacon Diagnostic Kit). Five milliliters of Drabkin's solution were added to a maximum of twenty liters of blood. After combining well, let rest for ten minutes. A blank of Drabkin's solution was used to test the absorbance at 540 nanometers. Analyze the absorbance of the standard in a similar way **[51]**.

To determine the globulin concentration, the formula was used:

Concentration of haemoglobin = (absorbance of test) / (absorbance of standard) x 16.31

Oxidative Parameters

Malondialdehyde (MDA/LPO) Estimation

Malondialdehyde was calculated using Beuge and Aust's thiobarbituric acid test

method. The blood sample and 2.0 milliliters of TCA-TBA-HCl reagent were well mixed. For fifteen minutes, the temperature was elevated in a bath of boiling water. Ten minutes were spent resuspending the flocculants at 1000 g. At 535 nm, the absorbance of the sample was measured without sampling against a blank. The concentration of malondialdehyde was calculated using the formula **[51]**.

MDA concentration = (test OD)/ (Standard OD) x (concentration of standard) / (sample taken)

ANALYSIS OF ENZYMATIC ANTIOXIDANT PARAMETERS

Superoxide Dismutase (Cu/Zn SOD)

The method developed by Kakkar *et al*., was used to test the superoxide dismutase activity. After adjusting 0.5 milliliter of blood serum to 1 milliliter with water, 2.5 milliliter of ethanol was added. Cooled 1.5 millilitre of chloroform. After mixing for a minute at 4°C, the mixture was centrifuged. Enzyme activity was the formula used to determine the amount of enzyme activity in the supernatant = (C-T)/(C/2) x 60/90 x 1/(volume of supernatant collected). The test mixture, which consists of 1.2 milliliters of sodium pyrophosphate buffer, initiates reactions by adding NADH, 0.2 milliliter NADH, 0.3 milliliter nitroblue tetrazolium, 0.01 milliliter phenazine methosulphate, water, Thirugnanasambantham *et al*., properly diluted, enzyme preparation, and 0.01 milliliter KCN. To halt the reaction, 1 milliliter of glacial acetic acid was added after 90 seconds of incubation at 30°C. Four milliliters of n-butanol were quickly stirred into the reaction mixture. At 560 nm, the chromogen intensity in the n-butanol layer was determined by comparing it to a blank. The control system was an enzyme-free mechanism. The measurement of enzyme activity included a 50% reduction in NBT/min/millilitre in the serum **[52]**.

Catalase

The quantity of catalase was measured using the method developed by Beers and Sizer. One milliliter of hydrogen peroxide reagent and 1.9 milliliters of water were added to the substrate. Five minutes were then spent incubating the mixture. The absorbance at 240 nanometre was determined after a 0.1 millilitre sample was added and left for two to three minutes. Enzyme activity was calculated using the formula. The amount of H_2O_2 ingested per minute in milliliters was used to express serum enzyme activity **[52]**.

Enzyme activity = (C-T)/SOD x (concentration of standard)/ (volume of sample taken)

Glutathione Peroxidase

To evaluate the effectiveness of mitochondrial glutathione peroxidase, Rotruck *et al*. Incubate the reaction mixture with H_2O_2 and 0.2 milliliters of EDTA and sodium azide at 37°C, 0.1 milliliter of material and 0.4 milliliter of phosphate

buffer, which may be stopped using 0.5 milliliter of TCA. After that, the tubes were centrifuged at 2000 rpm. The color was immediately visible at 420 nm when 4 milliliters of disodium hydrogen phosphate, 0.5 milliliters of DTNB, and 0.5 milliliters of supernatant were combined. The activity of GPX was calculated using the formula and given as a mole of GSH utilized minutes/milliliter in serum **[52]**.

Activity of GPx = (test OD)/ (Standard OD) X (concentration of standard)/(sample taken).

ANALYSIS OF NON-ENZYMATIC ANTIOXIDANT PARAMETER

Reduced Glutathione (GSH)

Reduced glutathione was computed using the Moron *et al*. technique. After 0.5 milliliter of the material was precipitated using 1 milliliter of 10% TCA, the precipitate was removed by centrifugation. Phosphate buffer was added to 1 milliliter of DTNB and 0.5 milliliter of leftovers to make 3 milliliters. We measured the absorbance at 412 nanometers **[53]**.

The GSH was computed using the formula. The expression for GSH was µg/milliliter. Acitivity of GSH = (Test OD) / (Standard OD) x (concentration of standard)/(sample taken)

Histopathological Studies

Following the rat's kidney paraffin-fixation, they were chilled in 10% buffered formalin, then sliced using a microtome into slices that were five millimeters thick. Standard methods were used for mounting components on glass slides. Prior to being captured on camera using a light microscope, the slices were examined under a microscope at 100 magnifications using Hematoxylin and Eosin stain **[53]**.

MEDICINAL PLANTS IN DIABETES MELLITUS MANAGEMENT

Eighty to eighty-five percent of diabetic individuals have utilized herbal medications to treat their diabetes mellitus **[29, 30]**. Diabetes mellitus has been treated with over 1200 medicinal herbs, according to ethnobotanical research **[31]**. The medications made from plants may rectify irregularities in metabolism and postpone the onset of problems related to diabetes **[32]**. Previous research has shown that novel bioactive medicines derived from plants that have hypoglycemic properties have more effective antidiabetic effects than traditional medications used to treat diabetes mellitus **[33, 34]**.

WHO recommended that more research be done on plant-based medications since they are often thought to be less harmful and to have fewer negative effects **[35]**. Numerous plant extracts have been utilized worldwide to treat diabetes mellitus; these extracts are thought to be less harmful, have less side effects and are reasonably affordable **[36]**. Plant extracts were used to isolate a large number of bioactive chemicals that might be used directly or as lead compounds **[37]**. For

example, Galega officinalis is used to make the oral hypoglycemic medication Metformin, which has long been used to treat diabetes mellitus **[37]**.

In Ethiopia, several sections of medicinal plants were employed in experiments to test their antidiabetic properties. The part of the medicinal plant that has been examined the most out of all of them is the leaves. Blood glucose levels have been demonstrated to be lowered by items derived from plants that are rich in phytoconstituents, including phenolic compounds, terpenoids, flavonoids, and coumarins, among other bioactive substances **[38]**.

Conventional drugs used to treat diabetic mellitus include *Justicia schimperiana* (Acanthaceae) and *Vernonia amygdalina* (Asteraceae) **[39, 40]**, *Croton macrostachys* (Euphorbiaceae) **[[39], [40], [41]]**, *Aloe vera* (Aloceae) **[40, 41]**, *Momordica charantia* Linn (Cucurbitaceae) **[42, 43]**, *moringa oleifera* (Moringacea) **[44]**, *Trigonella foenum*-Graecumillilitre (Fabaceae) **[40, 41, 45]**, *Euphorbia sp*. Gmel, (Euphorbiace) **[40, 46]**, and *Allium Sativum* (Amaryllidaceae) **[45]**.

CONCLUSION

In this current study, many of these traditional medicinal plants have been scientifically studied and validated for their anti-diabetic properties. These studies involve biochemical, pharmacological, and clinical investigations to understand the mechanisms of action and efficacy. Traditional medicinal plants offer a wide range of bio-active compounds with diverse mechanisms of action against diabetes. These mechanisms may include enhancing insulin secretion, improving insulin sensitivity, inhibiting carbohydrate absorption, and reducing oxidative stress. The discovery of potent anti-diabetic agents from traditional medicinal plants presents opportunities for the development of new pharmaceuticals or nutraceutical for diabetes management. These natural compounds may offer advantages such as fewer side effects and better tolerability compared to synthetic drugs. Future research should focus on addressing these challenges, exploring synergistic effects of plant combinations, and elucidating the long-term safety and efficacy of traditional medicinal plants for diabetes management. Overall, the review underscores the potential of Indian traditional medicinal plants as a valuable source of potent anti-diabetic agents, highlighting the need for further scientific exploration and integration into modern healthcare practices.

ACKNOWLEDGEMENT

The authors would like to thank AKS University, Satna, M.P. for motivation in publication of this work in a reputed journal.

REFERENCES

[1] Diagnosis and Classification of Diabetes, Mellitus, American

Diabetes Association, Position Statement, Diabetes Care, 2008; 31: Supplement 1.

[2] Wangnoo SK, Maji D, Das AK, Rao PV, Moses A, Sethi B, Unnikrishnan AG, Kalra S, Balaji V, Bantwal G, Kesavadev J, Jain SM, Dharmalingam M, Barriers and solutions to diabetes management:An Indian perspective, Mala, Indian Journal of Endocrinology and Metabolism, 2013;17 (4) 594-601.

[3] Davies MJ, Aroda VR, Collins BS, Gabbay RA, Green J, Maruthur NM, Rosas SE, Prato SD, Mathieu C, Mingrone G, Rossing P, Tankova T, Tsapas A, Buse JB, Management of Hyperglycemia in Type 2 Diabetes, 2022. A Consensus Report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD), Diabetes Care, 2022; 45(11): 2753–2786.

[4] Petchi RR, Vijaya C, Parasuraman S, Antidiabetic Activity of Polyherbal Formulation in Streptozotocin – Nicotinamide Induced Diabetic Wistar Rats, Journal of Traditional and Complementary Medicine, 2014; 4(2): 108-117.

[5] Gaonkar VP, Hullatti KK, Indian Traditional medicinal plants as a source of potent Anti-diabetic agents: A Review, Journal of Diabetes & Metabolic Disorders, 2020; 19: 1895–1908.

[6] Modak M, Dixit P, Londhe J, Ghaskadbi S, Devasagayam TPA, Indian Herbs and Herbal Drugs Used for the Treatment of Diabetes, J Clin Biochem Nutr, 2007; 40: 163–173.

[7] Gupta R, Bajpai KG, Johri S, Saxena AM, An Overview Of Indian Novel Traditional Medicinal Plants With Antidiabetic potentials, Afr J Trad CAM, 2008; 5(1): 1-17.

[8] Alam S, Sarker MMR, Sultana TN, Chowdhury MNR, Rashid MA, Chaity NI, Zhao C, Xiao J, Hafez EE, Khan SA, Mohamed IN, Antidiabetic Phytochemicals From Medicinal Plants: Prospective Candidates for New Drug Discoveryand Development, Frontiers in Endocrinology, 2022; 13: 1-35.

[9] Oyelere SF, Ajayi OH, Ayoade TE, Pereira GBS, Owoyemi BCD, Ilesanmi AO, Akinyemi OA, A detailed review on the phytochemical profiles and anti-diabetic mechanisms of

Momordica charantia, Heliyon, 2022; 8: 1-11.

[10] Shivani D, Srivani A, Mohan GK, A review on *Wattakaka volubilis* (L.f.) Stapf, Journal of Pharmacognosy and Phytochemistry, 2023; 12(2): 199-203.

[11] Kor NM, Didarshetaban MB, Pour HRS, Fenugreek (*Trigonella foenum-graecum L.*) As a Valuable Medicinal Plant, International journal of Advanced Biological and Biomedical Research, 2013; 1(8): 922-931.

[12] Okhale SE, Nwanosike EM, *Abrus precatorius* Linn (Fabaceae): phytochemistry, ethnomedicinal uses, ethnopharmacology and pharmacological activities, International Journal of Pharmaceutical Science and Research, 2016; 1(6): 37-43.

[13] Khan AH, Aloe Vera (Aloe barbadensis miller) and Its Natural Ingredients: A Mini Review, Phytopharmacology Research Journal (PRJ), 2021; 1(1): 49-55.

[14] Sinha K, Mishra NP, Singh J, Khanuja SPS, *Tinospora cordifolia* (Guduchi), a reservoir plant for therapeutic applications: A Review, Indian Journal of Traditional Knowledge, 2004; 3(3): 257-270.

[15] Kumar V, Saifi T, Gupta G, Kumar A, Giri M, Tyagi S, A Review on *Acacia arabica* (Babool): Biological, Morphological and Pharmacological Studies as well as Ethanobotanical, Unani and Traditional Uses, International Journal of Advances in Engineering and Management (IJAEM), 2022; 4(1): 1136-1144.

[16] Alam MK, Khorshed M, Hoq O, Uddin MS, Medicinal plant *Allium sativum* = A Review, Journal of Medicinal Plants Studies, 2016; 4(6): 72-79.

[17] Ahmad N, Hasan N, Ahmad Z, Zishan M, Zohrameena S, Momordica Charantia: For Traditional Uses And Pharmacological Actions, Journal of Drug Delivery & Therapeutics, 2016; 6(2): 1-5.

[18] Prabhakar PK, Doble M, A Target Based Therapeutic Approach Towards Diabetes Mellitus Using Medicinal Plants, Current Diabetes Reviews, 2008; 4(4): 291-308.

[19] Patel DK, Prasad SK, Kumar R, Hemalatha S, An overview on antidiabetic medicinal plants having insulin mimetic property,

Asian Pac J Trop Biomed, 2012; 2(4): 320-330.

[20] Sen DB, Balaraman RC, Sen AK, Zanwar AS, Greeshma KP, Maheshwari RA, Anti-Diabetic Activity of Herbal Remedies, Journal of Natural Remedies; 2023; 23(2): 373-381.

[21] Gupta RC, Chang D, Nammi S, Bensoussan A, Bilinski K, Roufogalis BD, Interactions between antidiabetic drugs and herbs: an overview of mechanisms of action and clinical implications, Diabetology & Metabolic Syndrome, 2017; 9(59): 1-12.

[22] Aba PE, Asuzu IU, Mechanisms of actions of some bioactive anti-diabetic principles from phytochemicals of medicinal plants: A review, Indian Journal of Natural Products and Resources, 2018; 9(2): 85-96.

[23] Asif M, The prevention and control the type-2 diabetes by changing lifestyle and dietary pattern, Journal of Education and Health Promotion, 2014; 3: 1-8.

[24] Özkum D, Ömrüm AK, Toklu HZ, Herbal medicine use among diabetes mellitus patients in Northern Cyprus, Journal of Medicinal Plants Research, 2013; 7(22): 1652-1664.

[25] Zhou W, Tao J, Zhou X, Chen H, Insulin Degludec, A Novel Ultra-Long-Acting Basal Insulin versus Insulin Glargine for the Management of Type 2 Diabetes: A Systematic Review and Meta-Analysis, Diabetes Ther, 2019; 10: 835–852.

[26] Lorenzati B, Zucco C, Miglietta S, Lamberti F, Bruno G, Oral Hypoglycemic Drugs: Pathophysiological Basis of Their Mechanism of Action, Pharmaceuticals, 2010; 3: 3005-3020.

[27] Verma S, Gupta M, Popli H, Aggarwal G, Diabetes Mellitus Treatment Using Herbal Drugs, International Journal of Phytomedicine, 2018; 10(1): 1-10.

[28] Chaudhury A, Duvoor C, Dendi VSR, Kraleti S, Chada A, Ravilla R, Marco A, Shekhawat NS, Montales MT, Kuriakose K, Sasapu A, Beebe A, Patil N, Musham CK, Lohani GP, Mirza W, Clinical Review of Antidiabetic Drugs : Implications for Type 2 Diabetes Mellitus Management, Frontiers in Endocrinology, 2017; 8: 1-12.

[29] Kifle ZD, Bayleyegn B, Tadesse TY, Woldeyohanins AE, Prevalence and associated factors

of herbal medicine use among adult diabetes mellitus patients at government hospital, Ethiopia: An institutional-based cross-sectional study, Metabolism Open, 2021; 11: 1-6.

[30] Ekor M, The grow in use of herbal medicines: issues relating to adversere actions and challenges in monitoring safety, Frontiers in Pharmacology, 2014; 4: 1-10.

[31] Ahmadi BB, Bahmani M, Tajeddini P, Naghdi N, Kopaei MR, An ethno-medicinal study of medicinal plants used for the treatment of diabetes, Journal of Nephropathology, 2016; 5(1): 44-50.

[32] Kooti W, Farokhipour M, Asadzadeh Z, Larky DA, Samani MA, The role of medicinal plants in the treatment of diabetes: a systematic review, Electronic Physician, 2016; 8(1): 1832-1842.

[33] Tran N, Pham B, Le L, Bioactive Compounds in Anti-Diabetic Plants: From Herbal Medicine to Modern Drug Discovery, Biology, 2020; 9(252): 1-31.

[34] Rahman MM, Dhar PS, Sumaia, Anika F, Ahmed L, Islam MR, Sultana NA, Cavalu S, Pop O, Rauf A, Exploring the plant-derived bioactive substances as antidiabetic agent: An extensive review, Biomedicine & Pharmacotherapy, 2022; 152: 1-20.

[35] WHO guidelines on safety monitoring of herbal medicines in pharmacovigilance systems, World Health Organization, Geneva, 2004.

[36] Kifle ZD, Abdelwuhab M, Melak AD, Genet M, Meseret T, Adugna M, Pharmacological evaluation of medicinal plants with antidiabetic activities in Ethiopia: A review, Metabolism Open, 13 2022; 13: 1-9.

[37] Sasidharan S, Chen Y, Saravanan D, Sundram KM, Latha LY. Extraction, Isolation And Characterization of Bioactive Compounds Fromplants' Extracts, Afr J Tradit Complement Altern Med, 2011; 8(1): 1-10.

[38] Kifle ZD, Abdelwuhab M, Melak AD, Genet M, Meseret T, Adugna M, Pharmacological evaluation of medicinal plants with antidiabetic activities in Ethiopia: A review, Metabolism Open, 13 2022; 13: 1-9.

[39] Meresa A, Gemechu W, Basha H, Fekadu N, Teka F, Ashebir R, Tadele A, Herbal Medicines for the Management of Diabetic Mellitus in Ethiopia and Eretria including

their Phytochemical Constituents, American Journal of Advanced Drug Delivery, 2017; 5(1): 040-058.

[40] Meresa A, Gemechu W, Basha H, Fekadu N, Teka F, Ashebir R, Tadele A, Herbal Medicines for the Management of Diabetic Mellitus in Ethiopia and Eretria including their Phytochemical Constituents, American Journal of Advanced Drug Delivery, 2017; 5(1): 040-058.

[41] Yikna BB, Yehualashet AS, Medicinal Plant Extracts Evaluated In Vitro and In Vivo for Antidiabetic Activities in Ethiopia: Bases for Future Clinical Trials and Related Investigations, Evidence-Based Complementary and Alternative Medicine, 2021; 1-24.

[42] Ahamad J, Amin S, Mir SR, *Momordica charantia* Linn. (Cucurbitaceae): Review on Phytochemistry and Pharmacology, Research Journal of Phytochemistry, 2017; 11(2): 53-65.

[43] Gupta M, Sharma S, Gautam AK, Bhadauria R, Momordica charantia linn. (karela): Nature's Silent Healer, International Journal of Pharmaceutical Sciences Review and Research, 2011; 11(1): 32-37.

[44] Fahey JW, Moringa oleifera: A Review of the Medical Evidence for Its Nutritional, Therapeutic, and Prophylactic Properties. Part 1, Trees for Life Journal, 2005; 1: 5.

[45] Nathiya S, Durga M, Devasena T, Therapeutic role of Trigonella foenum-graecum [Fenugreek] – A Review, Int J Pharm Sci Rev Res, 2014; 27(2): 74-80.

[46] Silva OLMD, Cordeiro I, Caruzo MBR, Synopsis of Euphorbia (Euphorbiaceae) in the state of São Paulo, Brazil, Phytotaxa, 2014; 181(4): 193–215.

[47] Okoro RN, Farate VT, The use of nephrotoxic drugs in patients with chronic kidney disease, Int J Clin Pharm, 2019; 41(3): 767-775.

[48] Kamianowska M, Szczepański M, Wasilewska A, Tubular and Glomerular Biomarkers of Acute Kidney Injury in Newborns, Curr Drug Metab, 2019; 20(5): 332-349.

[49] Alberghina D, Giannetto C, Vazzana I, Ferrantelli V, Piccione G, Reference intervals for total protein concentration, serum protein fractions, and albumin/globulin ratios in clinically healthy dairy cows, J Vet Diagn Invest, 2011; 23: 111–114.

[50] Poudel B, Mittal A, Yadav BK, Sharma P, Jha B, Raut KB, Estimation and Comparison of Serum Levels of Sodium, Potassium, Calcium and Phosphorus in Different Stages of Chronic Kidney Disease, Nepal Journal of Epidemiology, 2011; 1(5): 160-67.

[51] Berar AM, David DC, Lascu L, Matros L, Campian RS, Analysis of hematological and oxidative stress parameters in the evaluation of experimentally induced periapical lesions, Human & Veterinary Medicine, 2015; 7(3): 162-167.

[52] Gusti AMT, Qusti SY, Alshammari EM, Toraih EA, Fawzy MS, Antioxidants-Related Superoxide Dismutase (SOD), Catalase (CAT), Glutathione Peroxidase (GPX), Glutathione-S-Transferase (GST), and Nitric Oxide Synthase (NOS) Gene Variants Analysis in an Obese Population: A Preliminary Case-Control Study, Antioxidants, 2021; 10(595): 1-16.

[53] Khovarnagh N, Seyedalipour B, Antioxidant, histopathological and biochemical outcomes of short-term exposure to acetamiprid in liver and brain of rat: The protective role of N-acetylcysteine and S-methylcysteine, Saudi Pharmaceutical Journal, 2021; 29: 280–289.