A Review On

"Traditionally Used Anti-Diabetic Plants In South Asia"

A dissertation submitted to the Department of Pharmacy, Faculty of Allied Health Sciences, Daffodil International University for the partial fulfilment of the requirements for the degree of Bachelor of Pharmacy (B. Pharm.)

Submitted By

Kajima Rifat

ID: 191-29-1455

Department of Pharmacy

Daffodil International University

Date of Submission: May 2023

APPROVAL

This review article, "**Traditionally Used Anti-Diabetic Plants In South Asia**" has been recognized and approved by the Department of Pharmacy, Faculty of Allied Health Sciences, Daffodil International University, for partial completion of the criteria for the Bachelor of Pharmacy (B. Pharm.) degree in terms of style and quality.

BOARD OF EXAMINERS:

Dr. Muniruddin Ahamed
Professor and Head
Department of pharmacy
Faculty of Allied Health Science
Daffodil International University

Ms. Nazneen Ahmeda Sultana **Supervisor**
Assistant Professor
Department of Pharmacy
Faculty of Allied Health Science
Daffodil International University

Internal Examiner-1

Internal Examiner-2

External Examiner

DECLARATION

I hereby declare that, this project report "**Traditionally Used Anti-Diabetic Plants in South Asia**" is done by me Kajima Rifat, Id: 191-29-1455, Department of Pharmacy, Daffodil International University, to fulfil the partial requirement for the degree of Bachelor of Pharmacy. I am declaring that this project is my original work.

Supervised By:

Ms. Nazneen Ahmeda Sultana
Assistant Professor
Department of Pharmacy
Faculty of Allied Health Sciences
Daffodil International University

Submitted By:

Kajima Rifat

Kajima Rifat
ID: 191-29-1455
Department of Pharmacy
Faculty of Allied Health Sciences
Daffodil International University

ACKNOWLEDGEMENT

First of all, my gratitude is to the almighty Allah for keeping me in good health and giving me this opportunity to complete this project. Next I am grateful to my family members for their consistent support and encouragement without which it was not possible to complete this project.

I want to express my gratitude to my research mentor, **Ms. Nazneen Ahmeda Sultana**, Assistant Professor, Department of Pharmacy, Daffodil International University, who oversaw my study.

I also want to extend my heartfelt gratitude to **Professor Dr. Muniruddin Ahamed**, Head, Department of Pharmacy, Daffodil International University, for providing me with all the resources I need for this study.

I would also like to express my gratitude to **Professor Dr. Abu Naser Zafar Ullah**, Dean, Faculty of Allied Health Sciences at Daffodil International University, for his ongoing support.

I would like to thank every teacher in the department for their assistance and encouragement and to everyone who has contributed to this project in some way, whether directly or indirectly.

Kajima Rifat

Kajima Rifat

Author

ABSTRACT

Around the world, people have traditionally employed plants to treat a variety of illnesses. Due to its wealth of diverse sources of ethno medicine, South Asia's health industry relies heavily on traditionally utilized medicinal herbs. Rural residents of poor nations rely heavily on conventional medical sources. Since recent years, the number of cases of diabetes mellitus has increased. According to WHO, diabetics will be seventh leading cause of death in 2030. Therefore, numerous studies are being conducted to find better medications to treat this illness. For the treatment of diabetes mellitus, the use of medicinal plant extracts and their extracted bioactive components has significantly grown in recent years. These folk medicines are proved to be more effective, cheaper and have less side effects. Traditional medicines have been in use for a while and are crucial as alternative treatments. In addition, over the past few years, certain newly discovered bioactive medicines derived from plants displayed more efficiency against diabetes than oral hypoglycemic medications utilized in clinical therapy. Traditional medicine has a promising future in the treatment of diabetes mellitus and has a solid track record in clinical practice. Medicinal plants are importance source of biological compounds have been derived directly from them. This review has been discussed about some traditionally used plants available in South Asia which have anti-diabetic effects. *Andrographis paniculata*, *Swertia Chirayita, Terminalia arjuna, Azadirachta indica, Zingiber officinale, Aegle marmelos, Allium cepa*, *Allium sativum*, *Aloe vera, Momordica charantia, Panax ginseng* C.A Meyer, *Ocimum sanctum* L, *Eugenia jambolana, Trigonella foenum-graecum, Centella asiatica* were mostly available anti-diabetic medicinal plants in South Asia. The activity were contained the different parts of this plant like as bark, leaf, seeds, fruit flower and other parts.

TABLE OF CONTENTS

Chapter 1 - Introduction

Chapter 2 - Methodology

Chapter 3 - Results & Discussion

Chapter 4 - References

Serial No	Topic	Page No
4.1	References	31-40

Chapter-1: Introduction

1.1. General Introduction:

Diabetes is a long-term (chronic) illness that affects how your body converts food into energy. The majority of the food you eat is converted by your body into sugar (glucose), which is then released into your bloodstream. When blood sugar levels rise, the pancreas is notified to produce insulin. In order for blood sugar to enter your body's cells and be used as energy, insulin functions like a key. When you have diabetes, your body can't use insulin properly or doesn't produce enough of it. Too much blood sugar remains in the circulatory system when there is insufficient insulin or when cells cease reacting to insulin. That can eventually lead to major health issues like renal disease, eyesight loss, and heart disease.

1.2. Types of Diabetes

There are mainly 3 types of diabetes. These are –

1. Type 1 Diabetes
2. Type 2 Diabetes
3. Gestational Diabetes

1.2.1. Type 1 Diabetes:

It is believed that type 1 diabetes is brought on by an unintentional autoimmune reaction. Our body's production of insulin is stopped by this mechanism. Type 1 diabetes affects 5–10% of adults with diabetes. Type 1 diabetes symptoms frequently appear suddenly. Typically, it occurs in kids, teenagers, and young adults. One must take insulin every day to stay alive if he/she has type 1 diabetes. There is at present no cure for type 1 diabetes.

1.2.2. Type 2 Diabetes:

When you have type 2 diabetes, your body struggles to properly utilize insulin and maintain appropriate blood sugar levels. The majority of diabetics (90–95%) are type 2. It takes many years to develop, and adults are typically diagnosed with it (but more and more kids, teenagers, and young adults are as well).

1.2.3. Gestational Diabetes:

Pregnant women who have never had diabetes can acquire gestational diabetes. If someone have gestational diabetes, your unborn child may be more susceptible to health issues. After your baby is born, gestational diabetes typically disappears. However, it raises the chance of developing type 2 diabetes in later life. The child has a higher chance of being obese as a youngster or adolescent and going on to acquire type 2 diabetes [1].

1.3. Symptoms of Diabetes:

1.3.1. Type 1 Diabetes-

- Increased thirst and urination.
- Increased hunger
- Blurred vision
- Extreme fatigue
- If not treated with insulin, patient can undergo life threatening coma

1.3.2. Type 2 Diabetes:

- Fatigue
- Increased urination especially at night
- Unusual thirst
- Blurred vision
- Frequent infection
- Slow healing wounds [2]

1.4. Complications of Diabetes

Diabetes can have an impact on a variety of human organ systems and, over time, can result in serious consequences. Diabetes problems can be divided into macrovascular and microvascular subtypes. Damage to the nervous system (neuropathy), the kidneys (nephropathy), and the eyes (retinopathy) are all examples of complications of microvascular damage [3]. Cardiovascular disease, stroke, and peripheral vascular disease are examples of macrovascular consequences. Peripheral vascular diseases are the wounds that do not heal, cause gangrene and ultimately

amputation. Other issues include dental problems, decreased susceptibility to illnesses like the flu and pneumonia and other birth issues in diabetic pregnant women [4].

1.5. Causes of Diabetes

It is uncertain what causes the majority of diabetes types. Sugar builds up in the bloodstream in every situation. This is as a result of inadequate insulin production by the pancreas. Diabetes of either type can result from a mix of hereditary and environmental causes. What those factors might be is unknown [5].

1.6. Objectives

The goals of this project are –

- To understand effectiveness of different medicinal plants for managing Diabetes Mellitus in South Asia.
- To treat diabetic patients avoiding the side effects of conventional medicines.
- To reduce the treatment cost of Diabetes Mellitus.
- To treat the pre diabetic patients without the conventional medicines

Chapter 2: Methodology

2. Methodology & Data Collection:

I wanted to perform this review article to fulfill the requirements for the Bachelor of Pharmacy degree (B. Pharm.). That's why I started writing this literature. Like the majority of academic papers, a review article must have at least three fundamental components: an introduction or background data part, the review's body (which discusses the sources) and lastly, a conclusion to finish up the study. As you can see, this work is divided into three sections: the introductory part, the methodology part and the result and discussion part.

In this literature review data was collected on on-line source such as google scholar, PubMed, book shelf, CAS, international diabetes federation etc. Additionally, manual searches were carried out in book and journals. For this review, all the info has been consistently compiled following the rigorous assortment of knowledge from the on the market source.

In addition to that, I used a few more regular tools and programs. As- Microsoft Word, Sci-hub, Quillbot, Grammarly, resoomer, Turnitin.

a. **Microsoft Word:** It is used to create a better bibliography and serve as a basic text editor.
b. **Sci-hub:** In essence, Sci-Hub offers free access to more than 50 million publications, and researchers may easily do searches using a paper's headline or DOI to receive quick, free access, making it a convenient search engine for discovering academic papers.
c. **Quillbot:** Its main function is to paraphrase any text using artificial intelligence in a variety of distinct ways.
d. **Grammarly:** It ensures that everything we write is not only clear, captivating, and simple to read but also adheres to proper spelling, punctuation, and grammar.
e. **Resoomer:** It summarizes a passage so that important information can be taken.
f. **Turnitin:** It is a tool that students and researchers used to spot possible plagiarism.

Chapter-3: Result & Discussion

3.1. Anti-diabetic plants traditionally used in South Asia:

3.1.1. Result

Table 1: South Asian plants having anti-diabetic effects

Plant Name	Family	Local Name	Parts Used	References
Andrographis paniculata	Acanthaceae	Kalomegh	Whole Plant	
Swertia Chirayita	Gentianaceae	Chirata	Root	
Terminalia arjuna	Combretaceae	Arjun	Bark	
Azadirachta indica	Meliaceae	Neem	Leaf	[6]
Zingiber officinale	Zingiberaceae	Ginger	Root	[7]
Aegle marmelos	Rutaceae	Bel/Bilva	Leaf	
Allium cepa	Amaryllidaceae	Onion	Bulb	
Allium sativum	Amaryllidaceae	Garlic	Bulb	
Aloe vera	Asphodelaceae	Ghrit Kumari	Leaf	[8]
Momordica charantia	Cucurbitaceae	Bitter Melon	Fruits, Seeds & Callus	
Panax ginseng C.A Meyer	Araliaceae	Man Root	Root	
Ocimum sanctum L	Lamiaceae	Holy Basil	Leaf	[9]
Eugenia jambolana	Myrtaceae	Black plum/Jamun	Seeds, Leaves, Fruits	
Trigonella foenum-graecum	Fabaceae	Fenugreek/ Methi	Seed & Leaf	
Centella asiatica	Apiaceae	Thankuni	Leaf	[10]

3.1.2. Discussion

3.1.2.1. Andrographis paniculata:

The local name of *Andrographis paniculata* is “Kalomegh”. It belongs to Acanthaceae family. Typically, the entire plant is employed as a medication to treat diabetes. It is avaible in China, India and other south-east Asian countries [11]. The active constituents of this plant are dehydroandrographolide, neoandrographolide and andrographolide. Aqueous *A. paniculata* extract may have the ability to prevent glucose-induced hyperglycemia in normal rabbits, but it has no effect on epinephrine-induced hyperglycemia. Continuous treatment for six weeks had no discernible effects on blood glucose levels when people are fasting [12]. However, according to Subramanian et al. in a different study, *A. paniculata* and andrographolide can have hypoglycemic impacts by blocking the enzymes alpha-amylase and alpha-glucosidase [13]. In alloxan-induced rats with diabetes, a strong anti-diabetic efficacy was seen by resuming the impaired estrous cycle . In alloxan-induced rats with diabetes, a strong anti-diabetic efficacy was seen by resuming the impaired estrous cycle [14].

Figure 01: *Andrographis paniculata* [15]

3.1.2.2. Swertia Chirayita

The local name of *Swertia Chirayita* is “Chirota”. It belongs to Gentianaceae family. It is widely cultivated in Southern and Southeastern Asia. Diabetes is treated using chirata root and a honey concoction. This plant is rich source of flavonoids, xanthones, terpenoids, irridoid and alkaloids. A 250 mg/kg S. chirata ethanolic plant extract effectively decreased blood glucose levels in tolbutamide-pretreated, glucose-fed, and fasting experimental models when administered [16]. A further investigation showed that administration of hexane plant extract to albino rats enhanced glycogen content and insulin release, lowering blood sugar levels [17]. According to Saxena et al., Sweechin, a substance from S. chirata, increased the discharge of insulin from islet cells under isolated environment in a concentration-dependent way [18].

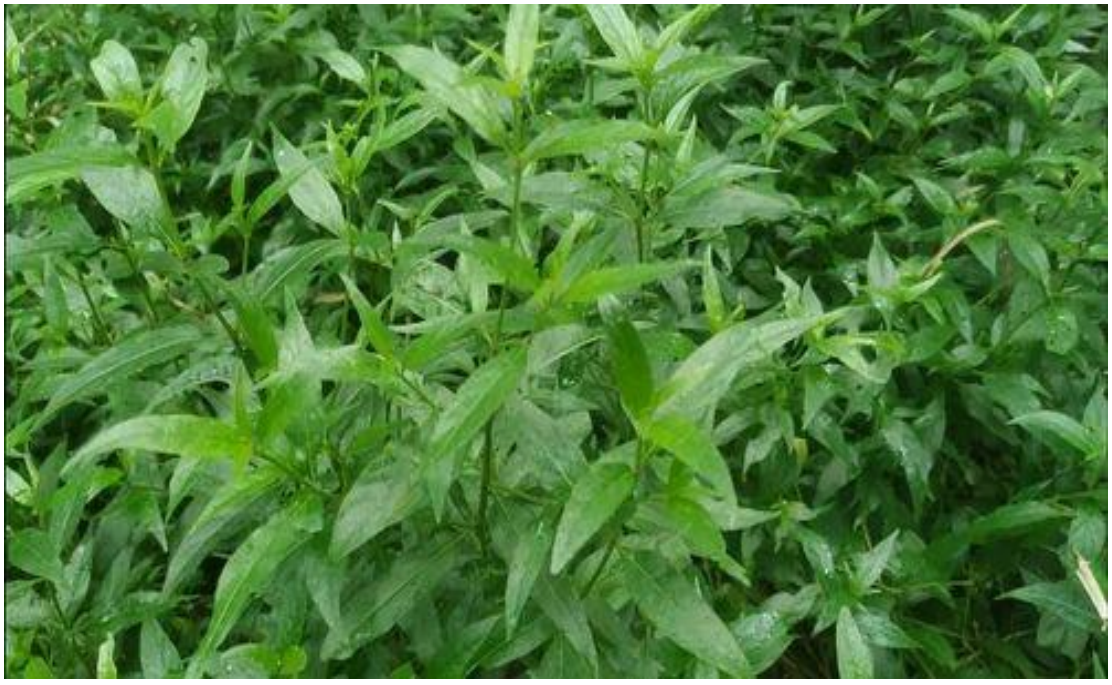

Figure 02: *Swertia Chirayita* [19]

3.1.2.3. Terminalia arjuna

The local name of *Terminalia arjuna is "Arjun".* It belongs to Combretaceae family. It's bark in powder or macerated form is used to treat diabetes. distributed in India, Burma, Mauritius and Sri Lanka. The plant contains tannins, flavonoids, phenols, saponins, alkaloids and phytosterols. *T. arjuna's* dried bark has a lot of anti-oxidant chemicals that reduced oxidative stress in rat hearts combined with damaged ischemic hearts [20]. According to Ram et al., ethanolic plant extract can lower total cholesterol levels and low density lipoprotein cholesterol levels at doses of 100 mg/kg and 500 mg/kg, respectively [21].

Figure 03: *Terminalia arjuna* [22]

3.1.2.4. Azadirachta indica

The local name for *Azadirachta indica* is “Neem”. It belongs to Meliaceae family. The paste of leaf extract is taken for managing diabetes. It is available in Indian subcontinent and some dry areas of South Asia. This plant has terpenes, steroids, saponins, glycosides, tannins, flavonoids and alkaloids. After receiving oral nimbidin therapy, fasting rabbits showed a noticeable hypoglycemic impact [23]. In a mouse model, chloroform extracts of A. indica may decrease oral glucose tolerance with intestinal glucosidase activity [24]. According to a different study, neem leaf extract has considerable anti-diabetic properties and may be used to treat Type 2 diabetes [25]. A. indica leaf extract shown considerable hypoglycemic action against an alloxan-induced diabetic experimentals, according to a study by Kar et al [26].

Figure 04: *Azadirachta indica* [29]

3.1.2.5. *Zingiber officinale*

The local name of *Zingiber officinale* is “Ginger”. It belongs to Zingiberaceae family. These are distributed in tropical and sub-tropical regions of South Asia. Its root has anti diabetic effects. Numerous studies demonstrated that ginger improves insulin sensitivity, which is helpful in the management of DM [28]. It has the phenolic chemical constituents such as gingerol, shogaols, vanilloids, paradol and zingerone According to a study, ginger's solution (100 ml of distilled water with 10 grams of peeled ginger) exhibits powerful glucosidase and amylase inhibitory effects [29]. The boiled rice (5 g in 25 mL of distilled water) treated with α -glucosidase (50 mg in 27 mL of distilled water) and an extract of ginger (2 mL) showed a 10% substantial decline in glucose concentration. The delivery of extracts of ginger plus cooked rice resulted in a significant 15% drop in glucose levels [30].

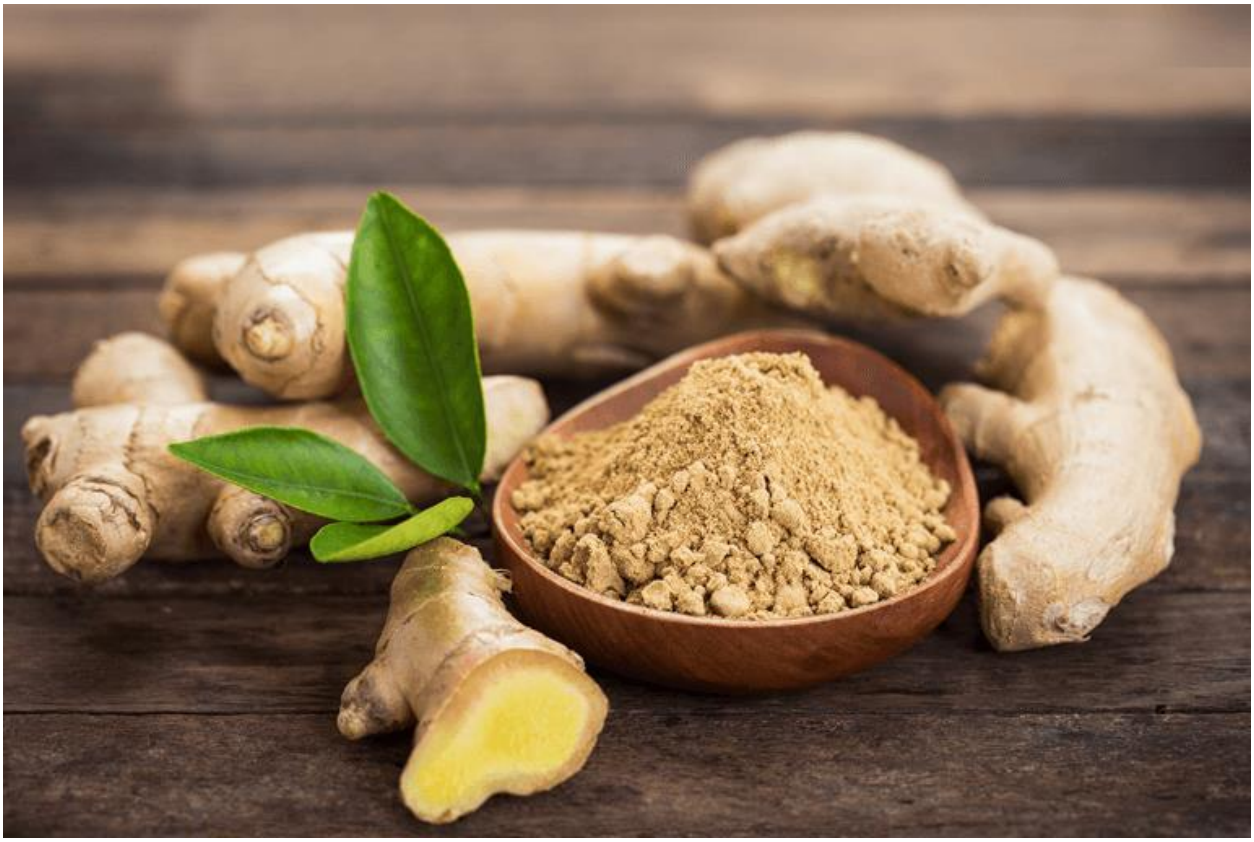

Figure 05: *Zingiber officinale* [31]

3.1.2.6. Aegle marmelos

The local name for *Aegle marmelos* is “Bel/Bilva” It is a member of Rutaceae family. It is available in Indian subcontinent and Southeast Asia like the countries India, Thailand, Sri Lanka and Malaysia. Its leaf has anti diabetic effects. It contains some active phytochemicals such as xanthotoxol, aegeline, coumarin, marmeline and imperatorin. Comparing alloxanized rats to controls, administration of aqueous extract of leaves improves digestion and lowers urea, serum cholesterol and blood sugar. This extract not only showed hypoglycemic action but also reduced the maximum rise in blood sugar at one hour in an oral glucose tolerance test [32].

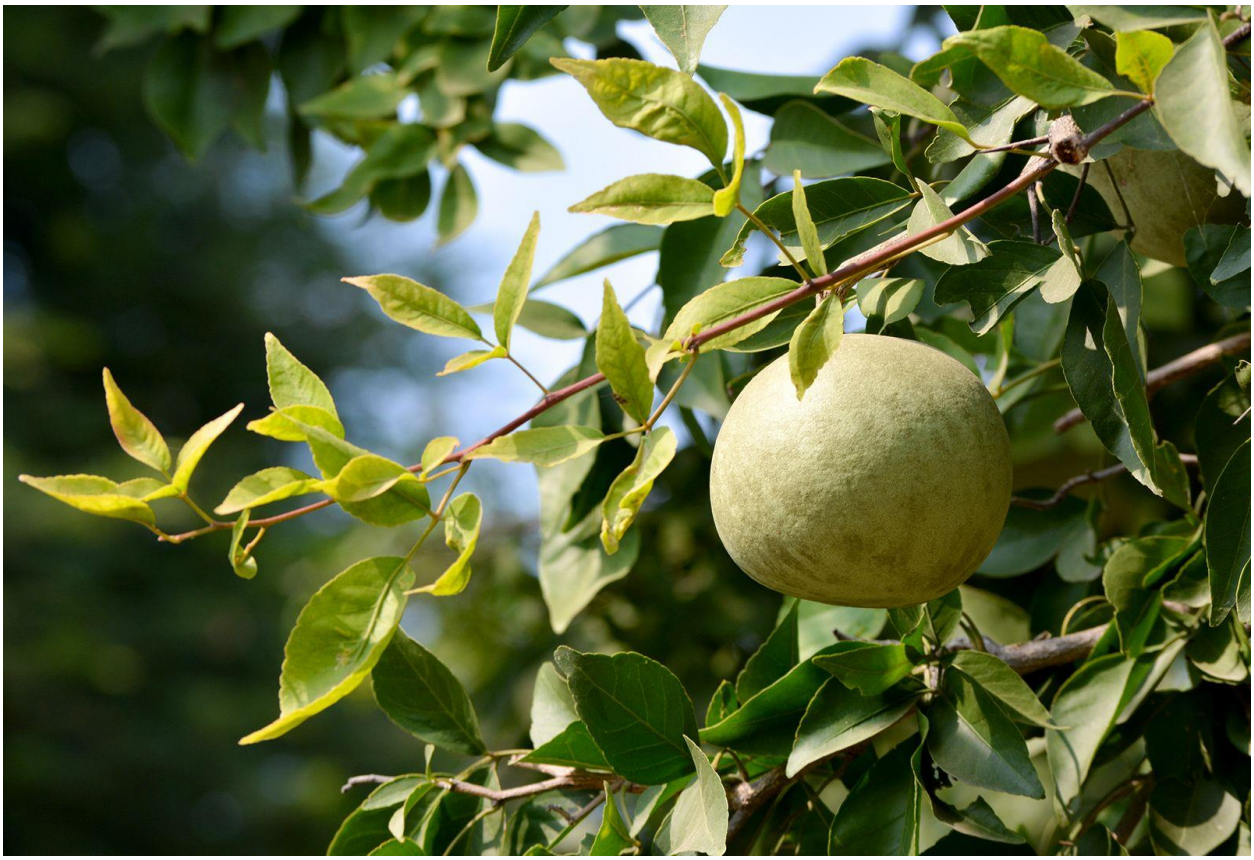

Figure 06: *Aegle marmelos* [33]

3.1.2.7. Allium cepa

The local name for *Allium cepa* is “Onion”.It is a member of Amaryllidaceae family. Its bulb has anti diabetic effects. It is available in south Asian countries. Bio active compounds of this plant are polyphenols including fructooligosaccharides and flavonoids. Different ether soluble portions of dried onion powder, in addition to its insoluble parts, exhibit anti-hyperglycemic effect in diabetic rabbits. S-methyl cysteine sulphoxide (SMCS), an amino acid with sulfur from the Allium cepa plant, was given to rats with alloxan-induced diabetes for 45 days. This treatment greatly lowered blood sugar levels, lipid levels in serum and tissues, and liver hexokinase, glucose 6-phosphatase, and HMG Co A reductase activity [34] [35]. One 50 g dosage of onion juice administered orally to diabetic patients dramatically reduced post-meal glucose levels [36].

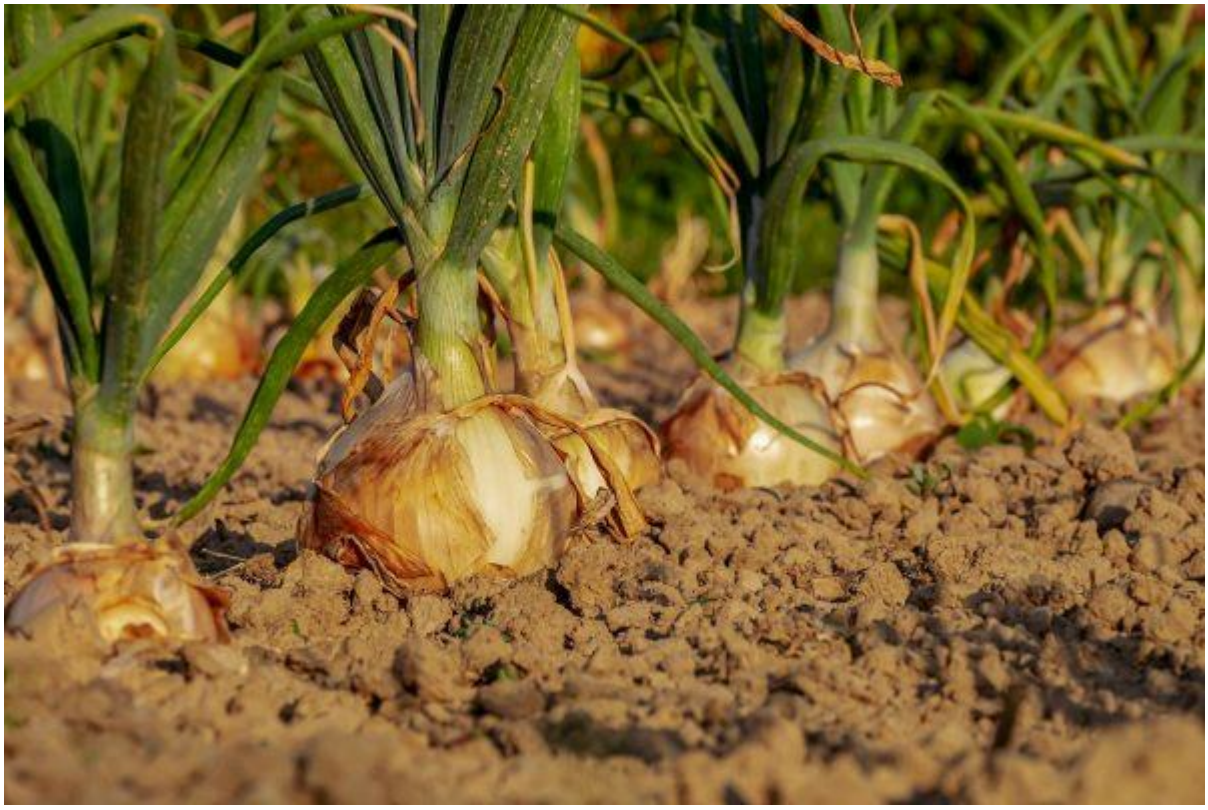

Figure 07: *Allium cepa* [37]

3.1.2.8. Allium sativum

The local name for *Allium sativum* is “Garlic”. It is a member of Amaryllidaceae family. It is mostly available and cultivated in South Asian countries. Its bulb has anti diabetic effects. Increased hepatic metabolism, increased insulin release from pancreatic beta cells, and/or an insulin conserving action are suggested to be the causes of this impact [38]. It contains S-methylcysteine sulfoxide and allyl propyldisulfide which reduce blood sugar. Orally giving sucrose-fed rabbits (10 g/kg/day in water for two months) an aqueous homogenate of garlic (10 ml/kg/day) Substantially higher hepatic glycogen and free amino acid content, lower serum triglyceride and fasting blood glucose levels when compared to sucrose controls [39]

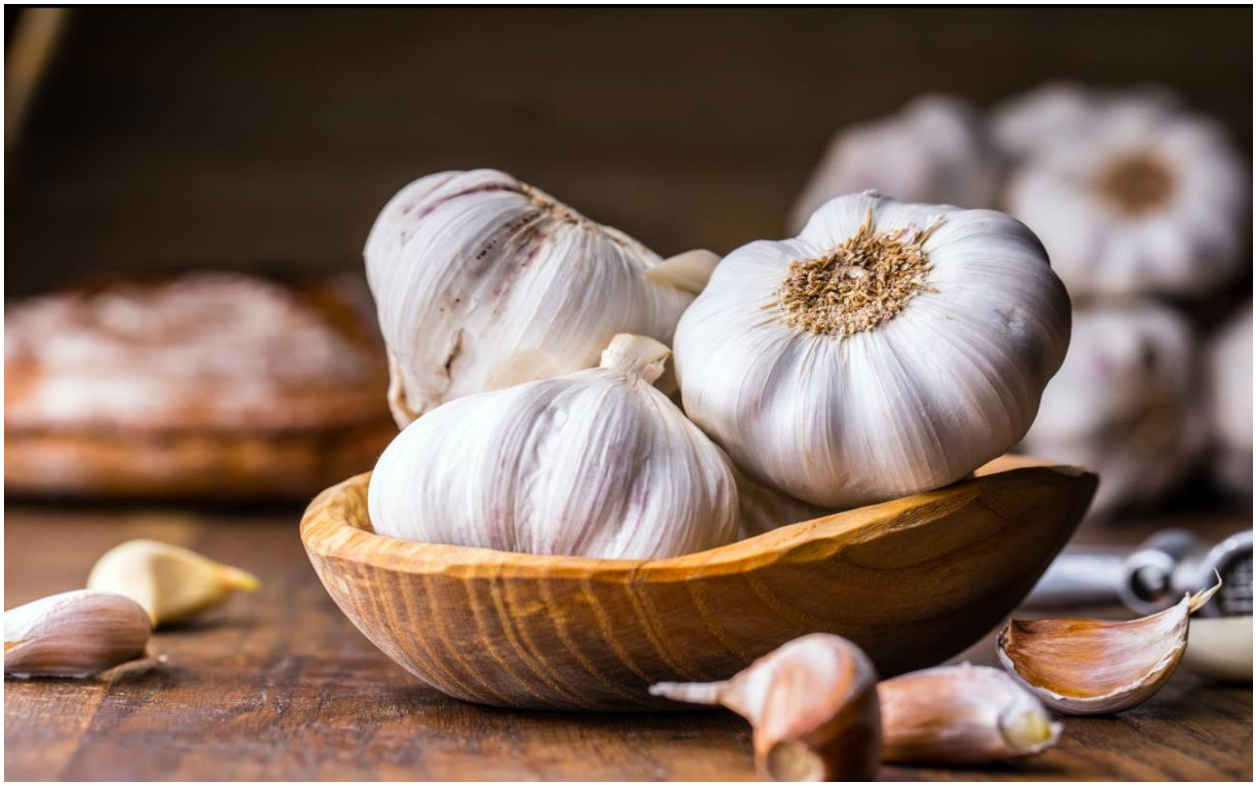

Figure 08: *Allium sativum* [40]

3.1.2.9. Aloe vera

The local name for *Aloe vera* is “Ghrit Kumari”. It is a member of Asphodelaceae family. It is available in many South Asian countries. Phytochemicals that are present in this plant are flavonoids, alkaloids, saponins and tannins. Aloe gum products effectively enhance rats with normal and diabetes' glucose tolerance [41]. Fluids from Aloe barbadensis leaves were administered chronically but not just once, and they had a hypoglycemic impact on diabetic rats that had been alloxanized. In diabetic rats, bitter principle from the *Aloe vera* plant in both acute and chronic doses had a hypoglycemic effect. Aloe vera's activity and its bitter component stimulate the production and/or release of insulin from pancreatic beta cells [42].

Figure 9: *Aloe vera* [43]

3.1.2.9. Momordica charantia

The local name for *Momordica charantia* is “Bitter Melon”. It is available in India, Bangladesh, China, Vietnam and other South Asian countries. It is a member of the Cucurbitaceae family. The fruit, seeds and callus have anti diabetic properties. These contain some proteins that are similar to insulin. Important phytochemicals of this plant are alkaloid, steroidal saponins, tannins etc. It consistently reduced blood sugar levels when tested on gerbils, rats, langurs, and people. Indeed, numerous studies have demonstrated that its bioactivities considerably reduce the amount of glucose in the blood. These studies on bitter melon also showed that it can improve glucose tolerance in humans, as well as in normal and diabetic rats [44] [45] [46]. In an alloxan-induced diabetic rabbit model, Charantin, Vicine, and Polypeptide-P were found to behave as insulin-like proteins, lower blood sugar levels, boost insulin secretion, increase tissue consumption of glucose, reduce hepatic gluconeogenesis, boost glucose uptake and utilization, and hinder intestinal glucose absorption by 200 mg/kg body weight [47].

Figure 10: *Momordica charantia* [48]

3.1.2.10. Panax ginseng C.A Meyer

The local name for Panax ginseng C.A Meyer is “Man Root”. It belongs to Araliaceae family. It is available in South Asian countries like Korea. The root of *Panax ginseng* have antidiabetic effects. This plant contain triterpene glycosides, saponins that are also known as ginsenosides. Ginsenosides, which are saponins that are unique to ginseng, are the most significant class of phytochemicals found in Panax ginseng. By lowering blood glucose levels, Ginsenosied Rb2 was perhaps the most successful of these components in treating streptozotocin-induced diabetic mice [49]. Furthermore, fermented red ginseng extracts substantially raised plasma insulin levels as well as decreased blood glucose levels in streptozotocin-induced diabetic rats by being ingested at 10 a.m. daily for three weeks at doses of 100 or 200 mg/kg of extracts dissolved in water. This is because fermented red ginseng extracts contain greater quantities of ginsenoside Rg2, Rg3, and Rh2 than regular ginseng [50].

Figure 11: *Panax ginseng* [51]

3.1.2.11. Ocimum sanctum L

The local name for *Ocimum sanctum* L is "Holy Basil"**.** It is available in South Asian countries like India, Vietnam, Bangladesh. It is a member of Lamiaceae family. Its leaf has anti diabetic effects. This plant contain terpenoids, phenols, flavonoids and other bioactive compounds. Four fractions of *Ocimum sanctum*, including the ethyl acetate, ethanol and aqueous butanol fractions, were generated in Hannan's study to clarify the process of this plant's antihyperglycemic effect as described in the available research [52]. This finding demonstrated the fractions' ability to increase the release of insulin. The research also shows that the ethanol extract may lower blood glucose levels and boost the release of insulin, making this plant a promising herbal remedy for the management of diabetes. Additionally, an in-vivo trial revealed that the *O. sanctum* extract might boost liver glycogen production, lower serum glucose, and boost oral glucose tolerance [53].

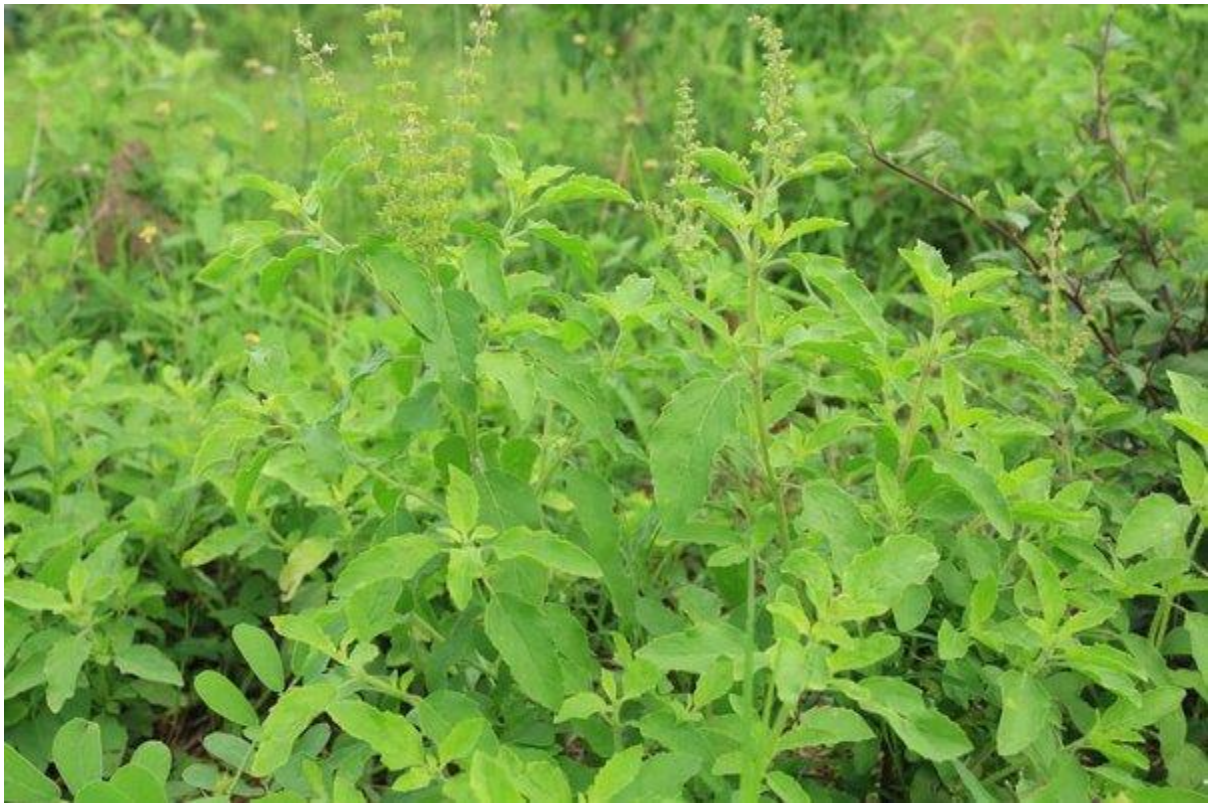

Figure 12*: O. sanctum* [54]

3.1.2.12. Eugenia jambolana

Eugenia jambolana is locally known as “black plum or jamun”. It belongs to the family Myrtaceae. Its seed, fruit and bark has anti diabetic properties. It is available in Indian subcontinent and other South Asian countries such as Burma, Nepal, Sri Lanka, Pakistan, Indonesia and Bangladesh. Prior the development of insulin, jamun was even a first-line antidiabetic drug in Europe. Jamun has been claimed to be utilized in many complimentary and alternative medical systems of India. The plant is rich in divertive bioactive components such as glucoside, isoquercetin, anthocyanins, ellagic acid, tannins. The brew made from jamun seeds and boiling water has been utilized in India's many conventional medical systems [55]. The alkaloid and glycoside jamboline found in the seeds delays the diastatic conversion of starch to sugar [56]. Eugenia jambolana's ability to reduce blood sugar levels may be a result of enhanced pancreatic release of insulin or a suppression of insulin breakdown [57]. When Eugenia jambolana seeds and powdered seeds were added, alloxan-induced diabetic rats' blood sugar levels were decreased, and the histology of their pancreatic islets improved [58]. It has also been shown that the amounts of blood urea and glycosuria have decreased. Multiple studies on dogs and rabbits also produced outcomes that were comparable [59] [60].

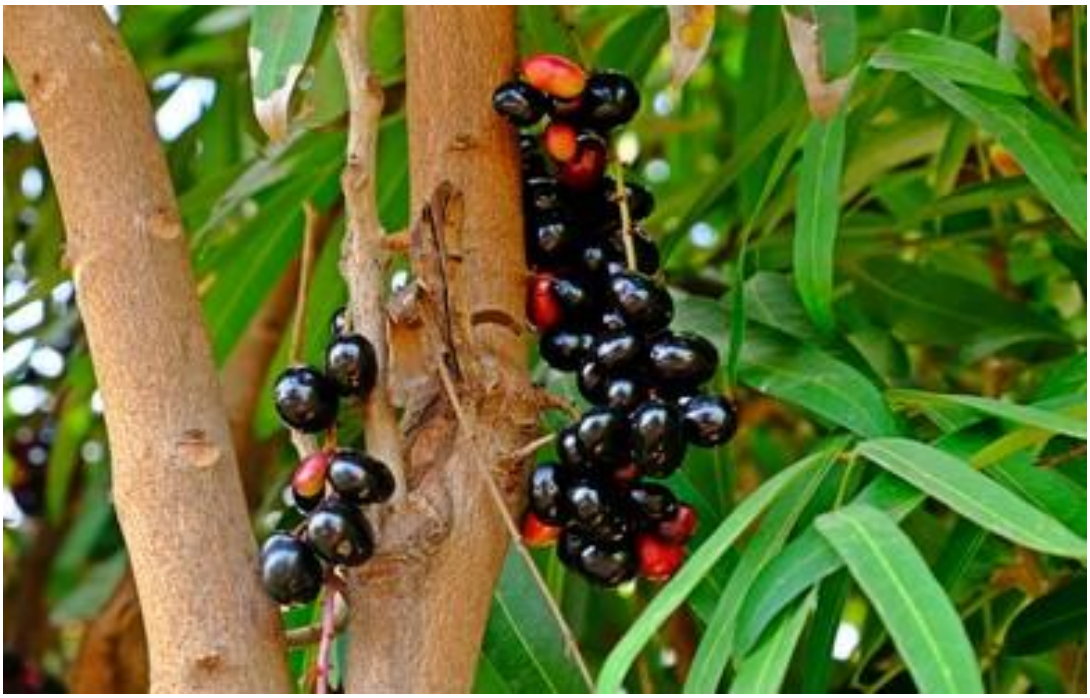

Figure 13: *Eugenia jambolana* [61]

3.1.2.13. Trigonella foenum-graecum

The local name for *Trigonella foenum-graecum* is “Fenugreek/Methi”. It belongs to Fabaceae family. It is used and cultivated in India, Pakistan, Nepal and other South Asian countries. Researchers have established that fenugreek has potent anti-diabetic activities using a variety of research methods [62] [63]. Human studies have also supported fenugreek's capacity to decrease cholesterol and blood sugar [64]. It has galactomannan, 4-hydroxyisoleucine, diosgenin, trigoneosides that lower blood sugar. Fenugreek seed extract, mucilage from seeds, and leaves have been shown in numerous trials to lower blood glucose and cholesterol levels in both people and diabetic experimental models [65] [66]. High plasma glucagon levels and a reduction in somatostatin have been linked to the antihyperglycemic impact [67]. It has been demonstrated that fenugreek seed powder can restore normal levels of creatinine kinase function in diabetic rats' hearts, skeletal muscles, and liver [68]. When given to diabetic rats, the steroids in methi have been shown to lower blood glucose levels [69].

Figure 14: *Trigonella foenum-graecum* [70]

3.1.2.14. Centella asiatica

The local name for *Centella asiatica* is “Thankuni”. It belongs to Apiaceae family. Its leaf has anti diabetic effects. This plant contains quercetin, luteolin, rutin, gallic acid, rutin etc. It can be found in Indian subcontinent, Southeast Asia. Sen et al. (2009) used two groups of healthy rats in their investigation. Both were kept on a conventional lab diet, but one group was given a smooth paste made from fresh CA leaves every day for 15 days at a dose of 150 mg/kg. In the CA treated group contrasted with the control group, they found a large drop in blood glucose and a considerable rise in liver glycogen levels [71]. Low dose STZ-induced obese-diabetic mice fed a high-fat diet experienced a substantial decrease in blood glucose levels when given an ethanol extract of CA at a dosage of 300 mg/kg per day for four weeks [72]

Figure 15: *Centella asiatica* [73]

3.2 Medicinal Plants Having Anti Diabetic Effects From Different South Asian Countries:

Now plants that are traditionally used and available in different South Asian countries for their anti-diabetic effects have been discussed here.

3.2.1. Plants from India:

Scientific Name	Local Name	Family	Parts used	Bioactive Compounds	References
Pterocarpus marsupium	Kino tree	Fabaceae	Heartwood	Tannins, Phenols	[74]
Gymnema sylvestre	Gurmar	Asclepiadaceae	Leaves	Myoinositol, Scyllitol and Phytol	[75]
Kickxia ramosissima	Indian Toadflax	Apocynaceae	Whole Plant	Tannins, Saponins, Glycosides, Alkaloids	[76]
Bombax pentaridrum	Kapok	Bombacaceae	Leaves, Bark	Phenols, Flavonoids	[77]
Abrus precatorious L.	Rosary pea	Fabaceae	Roots, Leaves, Seeds	abrol, pre-casine, abrasine, precol	[78]

3.2.1.1. Discussion: Among these plants *Pterocarpus marsupium* (Kino tree) is indigenous to the woodlands of Central India and the Western Ghats in the Karnataka-Kerala area. *Gymnema sylvestre* (Gurmar tree) is available in southern and western part of India. *Kickxia ramosissima* (Indian Toadflax) is available in Punjab and Chandigarh. *Bombax pentaridrum* (Kapok) is available in Bengalru. Abrus precatorious L. (Rosary pea) is

also available in India. These plants are experimented *in vivo* for their anti-hyperglycemic activities [79].

3.2.2 Plants from Pakistan:

Scientific Name	Local Name	Family	Parts Used	Bioactive Compounds	References
Justicia adhatoda	Malabar Nut	Acanthaceae	Fruits, Buds, Leaves	Phenols, Saponins, Tannins	[80]
Viburnum foetens	Stinking Himalayan viburnum	Adoxaceae	Leaves	Coumarins, Tannins, Flavonoids	[81]
Alisma plantagoaquatica L	European water-plantain	Alismataceae	Leaves	Triterpene, Alisolide, alisol P, alisol O	[82]
Achyranthes aspera L	Prickly chaff flower	Amaranthaceae	Seed	Alkaloids, Saponins, Ketones	[83]
Caralluma tuberculata	Pamanay	Apocynaceae	Whole plant	Terpenoids, Tannins	[84]

3.2.2.1. Discussion: *Justicia adhatoda* (Malabar Nut) is distributed throughout Pakistan. *Viburnum foetens* (Stinking Himalayan viburnum) is native to Himalayas of Pakistan. *Alisma plantagoaquatica L* (European water-plantain) is native to West Pakistan. *Achyranthes aspera L* (Prickly chaff flower) is available in Pakistan. *Caralluma tuberculata* (Pamanay) is native to hilly areas of Pakistan. These plants are experimented in vivo for their hypoglycemic activities [85].

3.2.3. Plants from Bangladesh:

Scientific Name	Local Name	Family	Parts Used	Bioactive Compounds	References
Alocasia macrorrhizos	Mankachu	Araceae	whole plant	Phenols, Alkaloids, Flavonoids	[86]
Asparagus racemosus	Sotomuli	Asparagaceae	whole plant	Rutin, Diosgenin, Quercetin, Saponins	[87]
Caesalpinia crista	Nata	Fabaceae	Leaf	Triterpenoids, Flavonoids, Alkaloids, Saponins	[88]
Carissa carandas	Koromcha	Apocynaceae	Fruits	Steroids, Alkaloids, Flavonoids	[89]
Coccinia cordifolia	Telakucha	Cucurbitaceae	Leaf, root, stem	Terpenoids, Tannins, Saponins, Alkaloids	[90]

3.2.3.1. Discussion: *Alocasia macrorrhizos* (Mankachu) is available in everywhere in Bangladesh even in rural areas. *Asparagus racemosus* (Sotomuli) is mostly found in Bangladesh's Modhupur Sal Forest and Ratargul Swamp Forest. *Caesalpinia crista* (Nata) is native in Tangragiri WS., Barguna, Taltoli in Bangladesh. *Carissa carandas*

(Koromcha) is available in north region of Bangladesh. *Coccinia cordifolia* (Telakucha) is available throughout Bangladesh. All of these plants are experimented for their anti-diabetic activities [91].

3.2.4. Plants from Nepal:

Scientific Name	Local Name	Family	Parts Used	Bioactive Compounds	References
Acorus calamus	Sweet flag	Araceae	Rhizomes	Squiterpenes, Flavonoids, Monoterpenes, Quinine	[92]
Amomum subulatum	Black cardamom	Zingiberaceae	Pods	α-terpinyl acetate	[93]
Berberis aristata	Citra	Berberidaceae	Stem	Phenols, Alkaloids, Triterpenes, Flavonoids	[94[95]
Bergenia ciliata	Fringed bergenia	Saxifragaceae	Rhizome	Tannic acid, Gallic acid	[96]
Moringa oleifera	Moringa	Moringaceae	Leaves	Tannins, Phenolic acid, Flavonoids, Saponins	[97] [98] [99]

3.2.4.1. Discussion: *Acorus calamus* (Sweet flag) is available in Kaski district of Nepal. *Amomum subulatum* (Black cardamom) is found in Eastern Nepal. *Berberis aristata*

(Citra) is available in mountains of Northern Nepal. *Bergenia ciliate* (Fringed bergenia) can be found in Himalayan region of Nepal. *Moringa oleifera* (Moringa) is available in foot hills and mid hills region of Nepal. These plants are also experimented in vivo for their blood sugar reducing activities [100].

3.2.5. Plants from Myanmar:

Scientific Name	Local Name	Family	Parts Used	Bioactive Compounds	References
Hyalobathra crenulata	Thanaka	Crambidae	Stem, Bark	Flavonoids, Tannins, Alkaloids, Triterpenes	[100] [101]
Mansonia gagei	Mansonia gagei	Malvaceae	Heartwood	Mansonones, Coumarins	[102] [103]
Caladium lindenii	Spoonflower	Araceae	Tuber	Saponins, Flavonoids	[104] [105]
Plumbago zeylanica	Wild leadwort	Plumbaginaceae	Roots, Leaves	Alkaloids, Flavonoids, Terpenes	[106] [107]
Coptis teeta	Gold thread	Ranunculaceae	Rhizome	Saponins, Triterpenes, Alkaloids	[108]

3.2.5.1. Discussion: *Hyalobathra crenulata* (Thanaka) is available in Myanmar. *Mansonia Gagei*(Mansonia gagei) is found in Taninthayi and Mandalay. *Caladium Lindenii* (Spoonflower) is available in Myanmar. *Plumbago Zeylanica* (Wild leadwort) is available throughout Myanmar. *Coptis teeta* (Gold thread) is found in Sagaing Region and Kawlin Township. All these plants are experimented for their anti-diabetic effects [109].

3.3. Conclusion:

In Herbal Medicine Studies there exists a lot of plants that have anti hyperglycemic effects. But only few of them have been scientifically proven. These plants are being researched more and more as these have less side effects, more activity and cheap. This review has discussed about 40 plants from different families. This review will facilitate inform future research project towards the event of novel anti diabetics medicine.

Chapter 4: References

4.1. References:

1. Shivashankar M, Mani D. A brief overview of diabetes. International Journal of Pharmacy and Pharmaceutical Sciences. 2011;3(4):22-7.

2. Dabelea D, Mayer-Davis EJ, Saydah S, Imperatore G, Linder B, Divers J, Bell R, Badaru A, Talton JW, Crume T, Liese AD. Prevalence of type 1 and type 2 diabetes among children and adolescents from 2001 to 2009. Jama. 2014 May 7;311(17):1778-86.

3. Research, Science and Therapy Committee of The American Academy of Periodontology. Position paper; Diabetes and periodontal diseases. Journal of periodontology. 1999 Aug;70(8):935-49.

4. Deshpande AD, Harris-Hayes M, Schootman M. Epidemiology of diabetes and diabetes-related complications. Physical therapy. 2008 Nov 1;88(11):1254-64

5. Tao Z, Shi A, Zhao J. Epidemiological perspectives of diabetes. Cell biochemistry and biophysics. 2015 Sep;73:181-5.

6. Rafe MR. A review of five traditionally used anti-diabetic plants of Bangladesh and their pharmacological activities. Asian Pacific journal of tropical medicine. 2017 Oct 1;10(10):933-9.

7. Wasana KG, Attanayake AP, Jayatilaka KA, Weerarathna TP. Antidiabetic activity of widely used medicinal plants in the Sri Lankan traditional healthcare system: new insight to medicinal flora in Sri Lanka. Evidence-Based Complementary and Alternative Medicine. 2021 Feb 9;2021:1-2.

8. Modak M, Dixit P, Londhe J, Ghaskadbi S, Devasagayam TP. Indian herbs and herbal drugs used for the treatment of diabetes. Journal of clinical biochemistry and nutrition. 2007;40(3):163-73.

9. Tran N, Pham B, Le L. Bioactive compounds in anti-diabetic plants: From herbal medicine to modern drug discovery. Biology. 2020 Aug 28;9(9):252.

10. Tran N, Pham B, Le L. Bioactive compounds in anti-diabetic plants: From herbal medicine to modern drug discovery. Biology. 2020 Aug 28;9(9):252.

11. Leelarasamee A, Trakulsomboon S, Sittisomwong N. Undetectable anti-bacterial activity of Andrographis paniculata (Burma) wall. ex ness. Journal of the Medical Association of Thailand= Chotmaihet Thangphaet. 1990 Jun 1;73(6):299-304.

12. Borhanuddin M, Shamsuzzoha M, Hussain AH. Hypoglycaemic effects of Andrographis paniculata Nees on non-diabetic rabbits. Bangladesh Medical Research Council Bulletin. 1994 Apr 1;20(1):24-6.

13. Subramanian R, Asmawi MZ, Sadikun A. In vitro α-glucosidase and α-amylase enzyme inhibitory effects of Andrographis paniculata extract and andrographolide. Acta biochimica polonica. 2008 May 29;55(2):391-8.

14. Reyes BA, Bautista ND, Tanquilut NC, Anunciado RV, Leung AB, Sanchez GC, Magtoto RL, Castronuevo P, Tsukamura H, Maeda KI. Anti-diabetic potentials of Momordica charantia and Andrographis paniculata and their effects on estrous cyclicity of alloxan-induced diabetic rats. Journal of ethnopharmacology. 2006 Apr 21;105(1-2):196-200.

15.https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.banyanbotanicals.com%2Finfo%2Fblog-the-banyan-insight%2Fdetails%2Fgetting-to-know-your-herbal-allies-kalmegh%2F&psig=AOvVaw2Z9rmWWjlVdHAHHiNpcMlE&ust=1682006866897000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCODZg4Sqtv4CFQAAAAAdAAAAABAD

16. Sekar BC, Mukherjee B, Chakravarti RB, Mukherjee SK. Effect of different fractions of Swertia chirayita on the blood sugar level of albino rats. Journal of ethnopharmacology. 1987 Nov 1;21(2):175-81.

17. Chandrasekar B, Bajpai MB, Mukherjee SK. Hypoglycemic activity of Swertia chirayita (Roxb ex Flem) Karst. Indian Journal of Experimental Biology. 1990 Jul 1;28(7):616-8.

18. Saxena AM, Bajpai MB, Murthy PS, Mukherjee SK. Mechanism of blood sugar lowering by a swerchirin-containing hexane fraction (SWI) of Swertia chirayita. Indian journal of experimental biology. 1993 Feb 1;31(2):178-81.

19.https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.indiamart.com%2Fproddetail%2Fchirata-leaves-26264735297.html&psig=AOvVaw1S4MwrpH2DB5ty_cAKGIoI&ust=1682008805856000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCMCwjqSxtv4CFQAAAAAdAAAAABAI

20. Sumitra M, Manikandan P, Kumar DA, Arutselvan N, Balakrishna K, Manohar BM, Puvanakrishnan R. Experimental myocardial necrosis in rats: role of arjunolic acid on platelet aggregation, coagulation and antioxidant status. Molecular and Cellular Biochemistry. 2001 Aug;224:135-42.

21. Manna P, Sinha M, Sil PC. Prophylactic role of arjunolic acid in response to streptozotocin mediated diabetic renal injury: activation of polyol pathway and oxidative stress responsive signaling cascades. Chemico-biological interactions. 2009 Oct 30;181(3):297-308.

22.https://www.google.com/url?sa=i&url=http%3A%2F%2Fwww.floraofbangladesh.com%2F2016%2F05%2Farjun-terminalia arjuna.html&psig=AOvVaw29VOOwLWGBN8q5uXIW3h7K&ust=1682009733847000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCPiZjdi0tv4CFQAAAAAdAAAAABAD

23. Pillai NR, Santhakumari G. Hypoglycaemic activity of Melia azadirachta Linn (neem). Indian journal of medical research. 1981.

24. Bhat M, Kothiwale SK, Tirmale AR, Bhargava SY, Joshi BN. Antidiabetic properties of Azardiracta indica and Bougainvillea spectabilis: in vivo studies in murine diabetes model. Evidence-Based Complementary and Alternative Medicine. 2011 Jan 1;2011.

25. Akter R, Mahabub-Uz-Zaman M, Rahman MS, Khatun MA, Abdullah AM, Ahmed NU, Islam F. Comparative studies on antidiabetic effect with phytochemical screening of Azadirachta indicia and Andrographis paniculata. IOSR Journal of Pharmacy and Biological Sciences. 2013 Jan 9;5(2):122-8.

26. Kar A, Choudhary BK, Bandyopadhyay NG. Comparative evaluation of hypoglycaemic activity of some Indian medicinal plants in alloxan diabetic rats. Journal of ethnopharmacology. 2003 Jan 1;84(1):105-8.

27.https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.cleanairgardening.com%2Fneem-plant%2F&psig=AOvVaw1c-2Tw9s-RvhnN1ukA9T17&ust=1682010587572000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCODWwu-3tv4CFQAAAAAdAAAAABAD

28. S. Mahluji, V. E. Attari, M. Mobasseri, L. Payahoo, A. Ostadrahimi, and S. E. Golzari, "Effects of ginger (Zingiber officinale) on plasma glucose level, HbA1c and insulin sensitivity in type 2 diabetic patients," International Journal of Food Sciences and Nutrition, vol. 64, no. 6, pp. 682–686, 2013.

29. W. K. S. M. Abeysekera, A. Chandrasekera, and P. K. Liyanage, "Amylase and glucosidase enzyme inhibitory activity of ginger (Zingiber officinale Roscoe) an in vitro study," Tropical Agricultural Research, vol. 19, pp. 128–135, 2007.

30. W. K. S. M. Abeysekera, A. Chandrasekera, and P. K. Liyanage, "Amylase and glucosidase enzyme inhibitory activity of ginger (Zingiber officinale Roscoe) an in vitro study," Tropical Agricultural Research, vol. 19, pp. 128–135, 2007.

31.https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.respectfood.com%2Farticle%2Fknow-your-food ginger%2F&psig=AOvVaw2NNrB7pSqLjcX3CYQQ8MvQ&ust=1682014729113000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCPiN5K3Htv4CFQAAAAAdAAAAABAD

32. Karunanayake, E.H., Welihinda, J., Sirimanne, S.R., and Sinnadorai, G.: Oral hypoglycemic activity of some medicinal plants of Sri Lanka. J. Ethnopharmacol., 11, 223–231, 1984

33. Karunanayake, E.H., Welihinda, J., Sirimanne, S.R., and Sinnadorai, G.: Oral hypoglycemic activity of some medicinal plants of Sri Lanka. J. Ethnopharmacol., 11, 223–231, 1984

34. Roman-Ramos, R., Flores-Saenz, J.L., and Alaricon-Aguilar, F.J.: Antihyperglycemic effect of some edible plants. J. Ethnopharmacol., 48, 25–32, 1995

35. K., Mathew, B.C., and Augusti, K.T.: Antidiabetic and hypolipidaemic effects of S-methyl cysteine sulfoxide, isolated from Allium cepa Linn. Ind. J. Biochem. Biophys., 32, 49–54, 1995.

36. Mathew, P.T. and Augusti, K.T.: Hypoglycemic effects of onion, Allium cepa Linn. on diabetes mellitus- a preliminary report. Ind. J. Physiol. Pharmacol., 19, 213–217, 1975

37.https://www.google.com/url?sa=i&url=https%3A%2F%2Fthediplomat.com%2F2019%2F12%2Fhow-onion-prices-are-shifting-politics-in-south-asia%2F&psig=AOvVaw3-aloq1C3tm18R8SQ0PhFR&ust=1682016350731000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCLD08KrNtv4CFQAAAAAdAAAAABAD

38. Bever, B.O. and Zahnd, G.R.: Plants with oral hypoglycemic action. Quart. J. Crude Drug Res., 17, 139–146, 1979.

39. Zacharias, N.T., Sebastian, K.L., Philip, B., and Augusti, K.T.: Hypoglycemic and hypolipidaemic effects of garlic in sucrose fed rabbits. Ind. J. Physiol. Pharmacol., 24, 151–154, 1980.

40.https://www.google.com/url?sa=i&url=https%3A%2F%2Ftimesofindia.indiatimes.com%2Flife-style%2Ffood-news%2Fghee-v%2Fs-butter-which-one-is-better%2Farticleshow%2F69374164.cms&psig=AOvVaw0jCJS09HXhJghzrUb-1DOr&ust=1682017165699000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCNDR07LQtv4CFQAAAAAdAAAAABAD

41. Al-Awadi, F.M. and Gumaa, K.A.: Studies on the activity of individual plants of an antidiabetic plant mixture. Acta Diabetologica, 24, 37–41, 1987

42. Ajabnoor, M.A.: Effect of aloes on blood glucose levels in normal and alloxan diabetic mice. J. Ethnopharmacol., 28, 215–220, 1990.

43.https://www.google.com/url?sa=i&url=https%3A%2F%2Fthefinancialexpress.com.bd%2Fnational%2Fcountry%2Faloe-vera-farming-becomes-popular-in-naogaon-1582138932&psig=AOvVaw0k5WCeb5q9pzlObDv9JUka&ust=1682017915402000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCNjk6ZbTtv4CFQAAAAAdAAAAABAn

44. Keller, A.C.; Ma, J.; Kavalier, A.; He, K.; Brillantes, A.M.; Kennelly, E.J. Saponins from the traditional medicinal plant Momordica charantia stimulate insulin secretion in vitro. Phytomedicine 2011, 19, 32–37.

45. Sasa, M.; Inoue, I.; Shinoda, Y.; Takahashi, S.; Seo, M.; Komoda, T.; Awata, T.; Katayama, S. Activating effect of momordin, extract of bitter melon (Momordica Charantia L.), on the promoter of human PPAR delta. J. Atheroscler. Thromb. 2009, 16, 888–892.

46. Khanna, P.; Jain, S.C.; Panagariya, A.; Dixit, V.P. Hypoglycemic activity of polypeptide-p from a plant source. J. Nat. Prod. 1981, 44, 648–655. [Google Scholar] [CrossRef]

47. Akhtar, N.; Khan, B.A.; Majid, A.; Khan, H.M.S.; Mahmood, T.; Gulfishan; Saeed, T. Pharmaceutical and biopharmaceutical evaluation of extracts from different plant parts of indigenous origin for their hypoglycemic responses in rabbits. Acta Pol. Pharm. 2011, 68, 919–92

48.https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.specialtyproduce.com%2Fproduce%2FIndian_Bitter_Melon_9184.php&psig=AOvVaw2yrnuUDGZmILM0_UUz4RAK&ust=1682019124965000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCKC-hNfXtv4CFQAAAAAdAAAAABAI

49. Yokozawa, T.; Kobayashi, T.; Oura, H.; Kawashima, Y. Studies on the mechanism of the hypoglycemic activity of ginsenoside-Rb2 in streptozotocin-diabetic rats. Chem. Pharm. Bull. 1985, 33, 869–872

50. Kim, H.-J.; Chae, I.-G.; Lee, S.-G.; Jeong, H.-J.; Lee, E.-J.; Lee, I.-S. Effects of Fermented Red Ginseng Extracts on Hyperglycemia in Streptozotocin-induced Diabetic Rats. J. Ginseng Res. 2010, 34, 104–112

51. https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.flordis.co.za%2Fhealth-insights%2Fenergy-immune-system%2Fa-history-of-ginseng%2F&psig=AOvVaw35I-bFOP7hgoMYjqIDm2KV&ust=1682019858221000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCMjC6LTatv4CFQAAAAAdAAAAABAI

52. Hannan, J.M.; Marenah, L.; Ali, L.; Rokeya, B.; Flatt, P.R.; Abdel-Wahab, Y.H. Ocimum sanctum leaf extracts stimulate insulin secretion from perfused pancreas, isolated islets and clonal pancreatic beta-cells. J. Endocrinol. 2006, 189, 127–136

53. Hannan, J.M.A.; Ojo, O.O.; Ali, L.; Rokeya, B.; Khaleque, J.; Akhter, M.; Flatt, P.R.; Abdel-Wahab, Y.H.A. Actions Underlying Antidiabetic Effects of Ocimum sanctum Leaf Extracts in Animal Models of Type 1 and Type 2 Diabetes. Eur. J. Med. Plants 2014, 5, 1–12

54. https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.quora.com%2FWhere-is-the-tulsi-found-in-the-world&psig=AOvVaw2Cx4uSVISbu-_8D9VqSgUU&ust=1682020687774000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCIDCtL_dtv4CFQAAAAAdAAAAABAI

55. M. S. Baliga, S. Fernandes, K. R. Thilakchand, P. D'souza, and S. Rao, "Scientific validation of the antidiabetic effects of Syzygium jambolanum DC (Black Plum), a traditional medicinal plant of India," Journal Alternative and Complemenaryt Medicine, vol. 19, no. 3, pp. 191–197, 2013.

56. M. Ayyanar and P. Subash-Babu, "Syzygium cumini (L.) Skeels: a review of its phytochemical constituents and traditional uses," Asian Pacific Journal of Tropical Biomedicine, vol. 2, no. 3, pp. 240–246, 2012.

57. M. J. Aybar, A. N. Sánchez Riera, A. Grau, and S. S. Sánchez, "Hypoglycemic effect of the water extract of Smallantus sonchifolius (yacon) leaves in normal and diabetic rats," Journal of Ethnopharmacology, vol. 74, no. 2, pp. 125–132, 2001.

58. N. Singh and M. Gupta, "Effects of ethanolic extract of Syzygium cumini (Linn) seed powder on pancreatic islets of alloxan diabetic rats," Indian Journal of Experimental Biology, vol. 45, no. 10, pp. 861–867, 2007.

59. D. S. Shrotri, "Investigation of hypoglycemic properties of Vinca rosea, Cassia auriculata and Eugenia jambolana," Indian Journal of Medical Research, vol. 51, p. 464, 1963.

60. P. Kedar and C. H. Chakrabarti, "Effects of jambolan seed treatment on blood sugar, lipids and urea in streptozotocin induced diabetes in rabbits," Indian Journal of Physiology and Pharmacology, vol. 27, no. 2, pp. 135–140, 1983.

61.https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.shutterstock.com%2Fsearch%2Fjamun-

tree&psig=AOvVaw1qjzmExZ914J2VV0TbBGcO&ust=1682058994228000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCNj22Jnst_4CFQAAAAAdAAAAABAD

62. P. Kumar, R. K. Kale, and N. Z. Baquer, "Antihyperglycemic and protective effects of Trigonella foenum graecum seed powder on biochemical alterations in alloxan diabetic rats," European Reviews in Medicine and Pharmacology Sciences, vol. 16, no. 3, pp. 18–27, 2012.

63. K. T. Roberts, "The potential of fenugreek (Trigonella foenum-graecum) as a functional food and nutraceutical and its effects on glycemia and lipidemia," Journal of Medicinal Food, vol. 14, no. 12, pp. 1485–1489, 2011.

64. R. D. Sharma, T. C. Raghuram, and N. S. Rao, "Effect of fenugreek seeds on blood glucose and serum lipids in Type I diabetes," European Journal of Clinical Nutrition, vol. 44, no. 4, pp. 301–306, 1990.

65. A. Gupta, R. Gupta, and B. Lal, "Effect of Trigonella foenum-graecum (fenugreek) seeds on glycaemic control and insulin resistance in type 2 diabetes mellitus: a double blind placebo controlled study," Journal of Association of Physicians of India, vol. 49, pp. 1057–1061, 2001.

66. V. Vats, J. K. Grover, and S. S. Rathi, "Evaluation of anti-hyperglycemic and hypoglycemic effect of Trigonella foenum-graecum Linn, Ocimum sanctum Linn and Pterocarpus marsupium Linn in normal and alloxanized diabetic rats," Journal of Ethnopharmacology, vol. 79, no. 1, pp. 95–100, 2002.

67. G. Ribes, Y. Sauvaire, C. Da Costa, and M. M. Loubatieres-Mariani, "Antidiabetic effects of subfractions from fenugreek seeds in diabetic dogs," Proceedings of the Society for Experimental Biology and Medicine, vol. 182, no. 2, pp. 159–166, 1986.

68. S. Genet, R. K. Kale, and N. Z. Baquer, "Effects of vanadate, insulin and fenugreek (Trigonella foenum graecum) on creatine kinase levels in tissues of diabetic rat," Indian Journal of Experimental Biology, vol. 37, no. 2, pp. 200–202, 1999.

69. K. Hamden, B. Jaouadi, S. Carreau et al., "Potential protective effect on key steroidogenesis and enzymes and sperm abnormalities by fenugreek steroids in testis and epididymis of surviving diabetic rats," Archives of Physiology and Biochemistry, vol. 116, no. 3, pp. 146–155, 2010.

70.https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.herbazest.com%2Fherbs%2Ffenugreek&psig=AOvVaw0V4UIP1WohUl0eJpgQjyrT&ust=1682060631653000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCKi-k6byt_4CFQAAAAAdAAAAABAM

71. Sen, Sreya. Studies on physiological and nutritional importance of Centella asiatica with special reference to uric acid level of blood. Thesis. University of Calcutta, Kolkata. Shodhganga, 2009. Available from:

http://hdl.handle.net/10603/162403. [Last Accessed on 2020 September 2]

72. Maulidiani, Abas F, Khatib A, Perumal V, Suppaiah V, Ismail A et al. Metabolic alteration in obese diabetes rats upon treatment with Centella asiatica extract. J Ethnopharmacol. 2016; 180:60-69. doi:10.1016/j.jep.2016.01.001

73. https://www.google.com/url?sa=i&url=https%3A%2F%2Falchetron.com%2FCentella-asiatica&psig=AOvVaw08MaUcxRWZawuFZ0iRJAsA&ust=1682061651808000&source=images&cd=vfe&ved=0CBEQjRxqFwoTCLDz3432t_4CFQAAAAAdAAAAABAD

74. Handa SS. An overview of extraction techniques for medicinal and aromatic plants. Extraction technologies for medicinal and aromatic plants. 2008;1(1):21-40.

75. Nagaraju N, Rao KN. Folk–medicine for diabetes from rayalaseema of andhra pradesh. Ancient science of life. 1989 Jul;9(1):31.

76. Kosersky DS, Dewey WL, Harris LS. Antipyretic, analgesic and anti-inflammatory effects of Δ9-tetrahydrocannabinol in the rat. European Journal of Pharmacology. 1973 Oct 1;24(1):1-7.

77. Yin K, Yang J, Wang F, Wang Z, Xiang P, Xie X, Sun J, He X, Zhang X. A preliminary study of the chemical composition and bioactivity of Bombax ceiba L. flower and its potential mechanism in treating type 2 diabetes mellitus using ultra-performance liquid chromatography quadrupole-time-flight mass spectrometry and network pharmacology analysis. Frontiers in Nutrition. 2022;9.

78. Das A, Jain V, Mishra A. A brief review on a traditional herb: Abrus precatorius (L.). Int J Forensic Med Toxicol Sci. 2016;1(1):1-0.

79. Rai MK. A review on some antidiabetic plants of India. Ancient Science of Life. 1995 Jan;14(3):168.

80. Ahmad M (2006) Checklist of medicinal flora of Tehsil Isakhel, District Mianwali-Pakistan. Ethnobot Leaflets 10:41–48

81. Hussain J, Ullah R, Rehman N, Khan AL, Muhammad Z, Khan FU, Hussain ST, Anwar S (2010c) Endogenous transitional metal and proximate analysis of selected medicinal plants from Pakistan. J Med Plant Res 4:267–270

82. Yassin MM, Mwafy SN (2007) Protective potential of glimepiride and Nerium oleander extract on lipid profile, body growth rate, and renal function in streptozotocin-induced diabetic rats. Turk J Biol 31:95–102

83. Qureshi R, Bhatti G (2009) Folklore uses of Amaranthaceae family from Nara desert, Pakistan. Pak J Bot 41:1565–1572

84. Adnan M, Ullah I, Tariq A, Murad W, Azizullah A, Khan AL, Ali N (2014b) Ethnomedicine use in the war affected region of Northwest Pakistan. J Ethnobiol Ethnomed 10(16):1–16

84. Ocvirk S., Kistler M., Khan S., Talukder S.H., Hauner H. Traditional medicinal plants used for the treatment of diabetes in rural and urban areas of Dhaka, Bangladesh—An ethnobotanical survey. *J. Ethnobiol. Ethnomed.* 2013;9:43. doi: 10.1186/1746-4269-9-43.

85. Ozturk M, Hakeem KR, editors. Plant and Human Health, Volume 1: Ethnobotany and Physiology. Springer International Publishing; 2018 Oct 2.

86. Rahman M.M., Mishuk A., Halder S., Rouf A.S.S. A survey on traditional medicinal plants used for the treatment of diabetes in urban areas of Dhaka and Khulna, Bangladesh. *Glob. J. Med. Res. Pharma Drug Disc. Toxicol. Med.* 2013;13:21–26

87. Rahman A., Nitu S.K., Ferdows Z., Islam A. Medico-botany on herbaceous plants of Rajshahi, Bangladesh. *Am. J. Life Sci.* 2013;1:136–144. doi: 10.11648/j.ajls.20130103.20.

88. Biswas K.R., Ishika T., Rahman M., Swarna A., Khan T., Monalisa M.N., Seraj S., Rahman M.A., Mou S.M., Rahmatullah M. A review of scientific literature on anti-diabetic activity in medicinal plants used by folk medicinal practitioners of two villages in Narail and Chuadanga districts, Bangladesh for treatment of diabetes. *Am. Eurasian J. Sustain. Agric.* 2011;5:196–208.

89. Rahmatullah M., Mollik M.A.H., Islam M.K., Islam M.R., Jahan F.I., Khatun Z., Seraj S., Chowdhury M.H., Islam F., Miajee Z.U.M. A survey of medicinal and functional food plants used by the folk medicinal practitioners of three villages in Sreepur Upazilla, Magura district, Bangladesh. *Am. Eurasian J. Sustain. Agric.* 2010;4:363–373.

90. Dong W, Yang D, Lu R. Chemical constituents from the rhizome[40]of Acorus calamus L. Planta Med 2010; 76(5): 454-7.http://dx.doi.org/10.1055/s-0029-1186217 PMID: 19847743 *(16) (PDF) A Review on Nepalese Medicinal Plants Used Traditionally as Alpha-Amylase and Alpha-Glucosidase Inhibitors Against Diabetes Mellitus*. Available from: https://www.researchgate.net/publication/353060944_A_Review_on_Nepalese_Medicinal_Plants_Used_Traditionally_as_Alpha-Amylase_and_Alpha-Glucosidase_Inhibitors_Against_Diabetes_Mellitus [accessed Apr 28 2023].

91. Rafe MR. A review of five traditionally used anti-diabetic plants of Bangladesh and their pharmacological activities. Asian Pacific journal of tropical medicine. 2017 Oct 1;10(10):933-9.

92. Hussain SA, Hameed A, Fu J, Xiao H, Liu Q, Song Y. Compara tive in vitro analysis of anti-diabetic activity of Indo-Pak black car-damom (Amomum subulatum Roxb.) and Chinese black carda-mom (Amomum tsao-ko Crevost et Lemaire). Prog Nutr 2018;20(3): 403-14 *(16) (PDF) A Review on Nepalese Medicinal Plants Used Traditionally as Alpha-Amylase and Alpha-Glucosidase Inhibitors Against Diabetes Mellitus*. Available from: https://www.researchgate.net/publication/353060944_A_Review_on_Nepalese_Medicinal_Plants_Used_Traditionally_as_Alpha-Amylase_and_Alpha-Glucosidase_Inhibitors_Against_Diabetes_Mellitus [accessed Apr 28 2023].

93. Anwar F, Abbas A, Alkharfy KM. Cardamom (Elettaria cardamomum Maton) Oils. InEssential oils in food preservation, flavor and safety 2016 Jan 1 (pp. 295-301). Academic Press.

94. Vavaiya RB, Patel A, Manek R. Anti-diabetic activity of Amomum subulatum Roxb. fruit constituents. Int. J. Parm. Innov. 2010;2:50-65.

95. Bhandari MR, Jong-Anurakkun N, Hong G, Kawabata J. α-Glu-[53]cosidase and α-amylase inhibitory activities of Nepalese medici-nal herb Pakhanbhed (Bergenia ciliata,

Haw.). Food Chem 2008;106(1): 247-52.http://dx.doi.org/10.1016/j.foodchem.2007.05.077
(16) (PDF) A Review on Nepalese Medicinal Plants Used Traditionally as Alpha-Amylase and Alpha-Glucosidase Inhibitors Against Diabetes Mellitus. Available from: https://www.researchgate.net/publication/353060944_A_Review_on_Nepalese_Medicinal_Plants_Used_Traditionally_as_Alpha-Amylase_and_Alpha-Glucosidase_Inhibitors_Against_Diabetes_Mellitus [accessed Apr 28 2023].

96. Gupta R, Mathur M, Bajaj VK, et al. Evaluation of antidiabetic[69]and antioxidant activity of Moringa oleifera in experimental dia-betes. J Diabetes 2012; 4(2): 164-71.http://dx.doi.org/10.1111/j.1753-0407.2011.00173.x PMID:22103446
(16) (PDF) A Review on Nepalese Medicinal Plants Used Traditionally as Alpha-Amylase and Alpha-Glucosidase Inhibitors Against Diabetes Mellitus. Available from: https://www.researchgate.net/publication/353060944_A_Review_on_Nepalese_Medicinal_Plants_Used_Traditionally_as_Alpha-Amylase_and_Alpha-Glucosidase_Inhibitors_Against_Diabetes_Mellitus [accessed Apr 28 2023].

97. Magaji UF, Sacan O, Yanardag R. Alpha amylase, alpha glucosi-[70]dase and glycation inhibitory activity of Moringa oleifera extracts.S Afr J Bot 2020; 128: 225-30.http://dx.doi.org/10.1016/j.sajb.2019.11.024
(16) (PDF) A Review on Nepalese Medicinal Plants Used Traditionally as Alpha-Amylase and Alpha-Glucosidase Inhibitors Against Diabetes Mellitus. Available from: https://www.researchgate.net/publication/353060944_A_Review_on_Nepalese_Medicinal_Plants_Used_Traditionally_as_Alpha-Amylase_and_Alpha-Glucosidase_Inhibitors_Against_Diabetes_Mellitus [accessed Apr 28 2023].

98. Natsir H, Wahab AW, Laga A, Arif AR. Inhibitory activities of[71]Moringa oleifera leaf extract against α-glucosidase enzyme invitro. J Phys Conf Ser 2018; 979(1)
(16) (PDF) A Review on Nepalese Medicinal Plants Used Traditionally as Alpha-Amylase and Alpha-Glucosidase Inhibitors Against Diabetes Mellitus. Available from: https://www.researchgate.net/publication/353060944_A_Review_on_Nepalese_Medicinal_Plants_Used_Traditionally_as_Alpha-Amylase_and_Alpha-Glucosidase_Inhibitors_Against_Diabetes_Mellitus [accessed Apr 28 2023].

99. Wangthong S., Palaga T., Rengpipat S., Wanichwecharungruang S. P., Chanchaisak P., Heinrich M. Biological activities and safety of Thanaka (*Hesperethusa crenulata*) stem bark. *Journal of Ethnopharmacology*. 2010;132(2):466–472. doi: 10.1016/j.jep.2010.08.046. [PubMed] [CrossRef] [Google Scholar] [Ref list]

100. Shrestha D, Sharma P, Adhikari A, Mandal AK, Verma A. A Review on Nepalese medicinal plants used traditionally as alpha-amylase and alpha-glucosidase inhibitors against diabetes mellitus. Current Traditional Medicine. 2021 Oct 1;7(5):63-72.

101. Nayar M. N. S., Bhan M. K. Coumarins and other constituents of *Hesperethusa crenulata*. *Phytochemistry*. 1972;11(11):3331–3333. doi: 10.1016/s0031-9422(00)86402-x. [CrossRef] [Google Scholar] [Ref list]

102. Tiew P., Ioset J.-R., Kokpol U., Chavasiri W., Hostettmann K. Antifungal, antioxidant and larvicidal activities of compounds isolated from the heartwood of *Mansonia gagei*. *Phytotherapy Research*. 2003;17(2):190–193. doi: 10.1002/ptr.1260. [PubMed] [CrossRef] [Google Scholar] [Ref list]

103. Baghdadi M. A., Al-Abbasi F. A., El-Halawany A. M., Aseeri A. H., Al-Abd A. M. Anticancer profiling for coumarins and related O-naphthoquinones from *Mansonia gagei* against solid tumor cells in vitro. *Molecules*. 2018;23 doi: 10.3390/molecules23051020. [PMC free article] [PubMed] [CrossRef] [Google Scholar] [Ref list]

104. Essien E. E., Jacob I. E., Thomas P. S. Phytochemical composition, antimicrobial and antioxidant activities of leaves and tubers of three *Caladium* species. *International Journal of Medicinal Plants and Natural Products*. 2015;1:24–30. [Google Scholar] [Ref list]

105. Akhigbemen A. M., Ozolua R. I., Bafor E. E., Okwuofu E. O. Subacute toxicological profile of *Caladium bicolor* Aiton (Araceae) methanolic leaf extract in rat. *Journal of Pharmacy & Pharmacognosy Research*. 2018;6:503–516. [Google Scholar] [Ref list]

106. Sunil C., Duraipandiyan V., Agastian P., Ignacimuthu S. Antidiabetic effect of plumbagin isolated from *Plumbago zeylanica* L. root and its effect on GLUT4 translocation in streptozotocin-induced diabetic rats. *Food and Chemical Toxicology*. 2012;50(12):4356–4363. doi: 10.1016/j.fct.2012.08.046. [PubMed] [CrossRef] [Google Scholar] [Ref list]

107. Pendurkar S. R., Mengi S. A. Antihyperlipidemic effect of aqueous extract of Plumbago zeylanicaroots in diet-induced hyperlipidemic rat. *Pharmaceutical Biology*. 2009;47(10):1004–1010. doi: 10.1080/13880200902973779. [CrossRef] [Google Scholar] [Ref list]

108. Wang J., Wang L., Lou G.-H., et al. Coptidis Rhizoma: a comprehensive review of its traditional uses, botany, phytochemistry, pharmacology and toxicology. *Pharmaceutical Biology*. 2019;57(1):193–225. doi: 10.1080/13880209.2019.1577466. [PMC free article] [PubMed] [CrossRef] [Google Scholar] [Ref list]

109. Zhang D, Arunachalam K, Wang Y, Zhang Y, Yang J, Hein PP, Mon AM, Li J, Inta A, Yang X. Evaluation on antidiabetic properties of medicinal plants from Myanmar. The Scientific World Journal. 2021 Jan 1;2021.