Review

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Posted Date: 23 August 2023

doi: 10.20944/preprints202308.1622.v1

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Diabetes and Ethnomedicine: A Comprehensive Review of Scientific Literature on Traditional Medical Practices

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Abstract: Diabetes mellitus, a metabolic disorder that is persistent in nature, is identified by an elevated concentration of glucose in the bloodstream. The disease has become a major public health problem, affecting millions of people globally, and is associated with significant morbidity and mortality. The increasing prevalence of diabetes and the lack of effective therapeutic interventions have led to the exploration of alternative and complementary forms of therapy, including ethnomedicine. Ethnomedicine is the study of traditional medical systems and the medicinal plants used by Indigenous communities. In other words, Ethnomedicine refers to the traditional medical practices and beliefs of a particular cultural or ethnic group. The most popular example of traditional medicine is the use of Aloe vera for the treatment of various diseases such as sunburn, cuts, burns, hypertension, diabetes, and jaundice for thousands of years [1]. In recent years, there has been increasing interest in the potential role of ethnomedicine in the management of diabetes, given its widespread use in many communities and its potential to offer cost-effective and culturally acceptable treatment options. It encompasses a range of traditional healing practices, including herbalism, acupuncture, and massage therapy. Despite the inconsistencies, there is growing evidence to suggest that certain ethnomedical practices may be effective in the management of diabetes [2,3]. For example, several studies have shown that certain herbal remedies, such as cinnamon, ginseng, and bitter melon, may have potential benefits in terms of improving glucose control and reducing the risk of complications associated with diabetes. Evidence-based ethnomedicine is an approach that applies scientific principles and methods to evaluate the efficacy and safety of traditional medical practices. This approach is crucial in the development of effective and safe ways to treat diabetes. To date, there have been numerous studies conducted to examine the efficacy and safety of various ethnomedical interventions for diabetes, including herbal remedies, dietary changes, and physical activity [4]. However, it is important to note that not all ethnomedical interventions for diabetes have been thoroughly evaluated, and many remain unproven. Furthermore, some interventions may be associated with significant risks, particularly in terms of drug interactions and adverse effects. As such, it is crucial that any ethnomedical interventions for diabetes be carefully evaluated using rigorous scientific methods and that patients be advised to consult with their healthcare provider before using any such interventions. It is important to note that the results of these studies have been mixed, with some showing promising results, while others have failed to demonstrate significant benefits. In this chapter, the evidence-based current state of ethnomedicine for diabetes was reviewed. We first provide an overview of diabetes and its pathophysiology, followed by a discussion of traditional medicinal practices used to treat the disease. We then present a systematic review of the scientific literature on the use of ethnomedicine for diabetes, focusing on herbal remedies and dietary interventions. Our review found that several medicinal plants offered promising results to treat all types of diabetes. For

example, Gymnema sylvestre, a traditional Indian herb, has been shown to reduce blood glucose levels and improve insulin sensitivity [5]. Additionally, the use of bitter melon (Momordica charantia) has been shown to reduce fasting blood glucose levels and improve glucose tolerance in individuals with type 2 diabetes [6]. Another important aspect of ethnomedicine for diabetes is the use of dietary interventions [7]. Traditional diets, such as the Mediterranean diet, have been shown to have beneficial particularly in terms of improving glycaemic control, reducing the risk of cardiovascular disease, and insulin sensitivity [8]. Additionally, the use of low-carbohydrate diets, such as the ketogenic diet, has been shown to improve glycaemic control in individuals with type 2 diabetes [9]. Traditional medicine has a long history of treating the symptoms and managing the condition. However, the efficacy and safety of these traditional practices have not always been scientifically tested, and there is a lack of standardization and regulation in the production and use of traditional remedies for diabetes. This creates a challenge for healthcare providers and patients, who need to ensure that the treatments they use are safe and effective. Additionally, there is a need for further research to understand the mechanisms by which traditional remedies may be effective in managing diabetes and to determine the optimal dosage and administration methods [9]. Finally, it is also important to understand that the use of traditional remedies may interact with conventional medications, leading to adverse effects; for example, the use of Chinese traditional medicine, known as "herb ginseng," for the treatment of various health conditions, including diabetes sometimes cause the side effect such as dizziness, confusion, and fainting while interacting with the anti-diabetic medications [10]. Therefore, it is important to approach the use of ethnomedicine for diabetes with caution and under the guidance of a qualified healthcare professional. In conclusion, evidence-based ethnomedicine offers a promising approach to the treatment of diabetes. While further research is needed to fully understand the mechanisms and safety of these interventions, the results to date suggest that traditional remedies and dietary interventions have the potential to be effective in the management of this disease. However, it is important to approach the use of ethnomedicine for diabetes with caution and under the guidance of a qualified healthcare professional and to continue to conduct rigorous scientific research to fully understand the benefits and risks associated with these interventions.

Keywords: Diabetes mellitus; Ethnomedicine; Herbal remedies; Dietary interventions; Evidence-based review

1. Introduction

Ethnomedicine is the study of the cultural knowledge and traditional practices of different ethnic groups regarding health and disease over centuries. It encompasses various aspects of traditional medicine, such as the beliefs, values, norms, symbols, rituals, and therapies that shape the understanding and management of health problems in each society [11]. It also includes the use of natural substances, such as plants and animals, that have bioactive properties and are employed for healing purposes. It is an important source of information for understanding the diversity and complexity of human health and illness across cultures and contexts. It also reveals how people perceive, interpret and cope with their health issues in relation to their social, environmental, spiritual, and historical circumstances. Ethnomedicine also provides insights into the local ecological knowledge and practices that sustain the health and well-being of people and their environments [11].

To simplify the study of Ethnomedicine history, it can categorise into the following sections: *i)* ***Ancient Civilizations and Traditional Healing Systems*** such as *a)* In ancient India over five thousand years ago, a holistic healing of traditional system of medicine was originated, latter known as Ayurveda, based on the concept of balance among five elements (ether, air, water, fire, and earth) and three doshas (vata, pitta and kapha) that govern the physiology and psychological functions of the body [12]. Ayurvedic texts, such as the Charaka Samhita and Sushruta Samhita, discuss diabetes-

 doi:10.20944/preprints202308.1622.v1

like symptoms and propose herbal formulations and lifestyle modifications for managing the condition. Ayurveda uses various herbs, minerals, metals, and animal products to treat diabetes, such as turmeric, fenugreek, bitter gourd, neem, gymnema and shilajit [12]. *b)* Traditional Chinese Medicine, dating back more than 2,500 years, incorporates various therapeutic modalities such as acupuncture, herbal medicine, and dietary practices. TCM emphasizes restoring the balance of vital energy (qi) and recognizes diabetes as a condition related to imbalances in bodily systems [13]. *c)* The historical records from ancient Egypt reveal the use of natural substances like *fenugreek, aloe vera*, and *myrrh* to treat symptoms resembling diabetes. The Ebers Papyrus, an Egyptian medical document dating to 1550 BCE, contains references to diabetes and recommends plant-based remedies [14]. *ii)* ***Indigenous Medicinal Practices*** such as *a)* a diverse system of medicine practised by various indigenous tribes in North America, based on the concept of harmony among spirit, mind and body and respect for nature. The various native American tribes possess a long history of ethnomedicine for diabetes management [15]. For instance, the Ojibwa tribe in North America used a blend of herbs, including blueberry leaves, to lower blood sugar levels. The Cherokee tribe utilized the bark of the black gum tree as an antidiabetic remedy [15]. *b)* In addition, Aboriginal cultures in Australia also have traditionally relied on medicinal plants like *Gymnema Sylvestre*, which has hypoglycemic properties, for managing diabetes. The Pintupi people in Central Australia also employed the use of desert raisins (*Solanum centrale*) to control blood sugar levels [16]. *c)* Furthermore, in many African countries, traditional healers have employed a wide range of plant-based remedies for diabetes treatment. Bitter melon (*Momordica charantia*) and African bush mango (*Irvingia gabonensis*) are among the commonly used plants due to their hypoglycemic effects [17]. *iii)* ***Modern Ethnomedicine Practices*** such as countries like Indonesia, Malaysia, and the Philippines have a rich heritage of ethnomedicine practices [18]. For instance, the leaves of the insulin plant (*Costus igneus*) have been used in traditional Indonesian medicine to regulate blood sugar levels. Furthermore, traditional remedies in South America involve the use of plants like yacon (*Smallanthus sonchifolius*) and stevia (*Stevia rebaudiana*) to manage diabetes. These plants have a natural sweetness and are known for their hypoglycemic effects [18].

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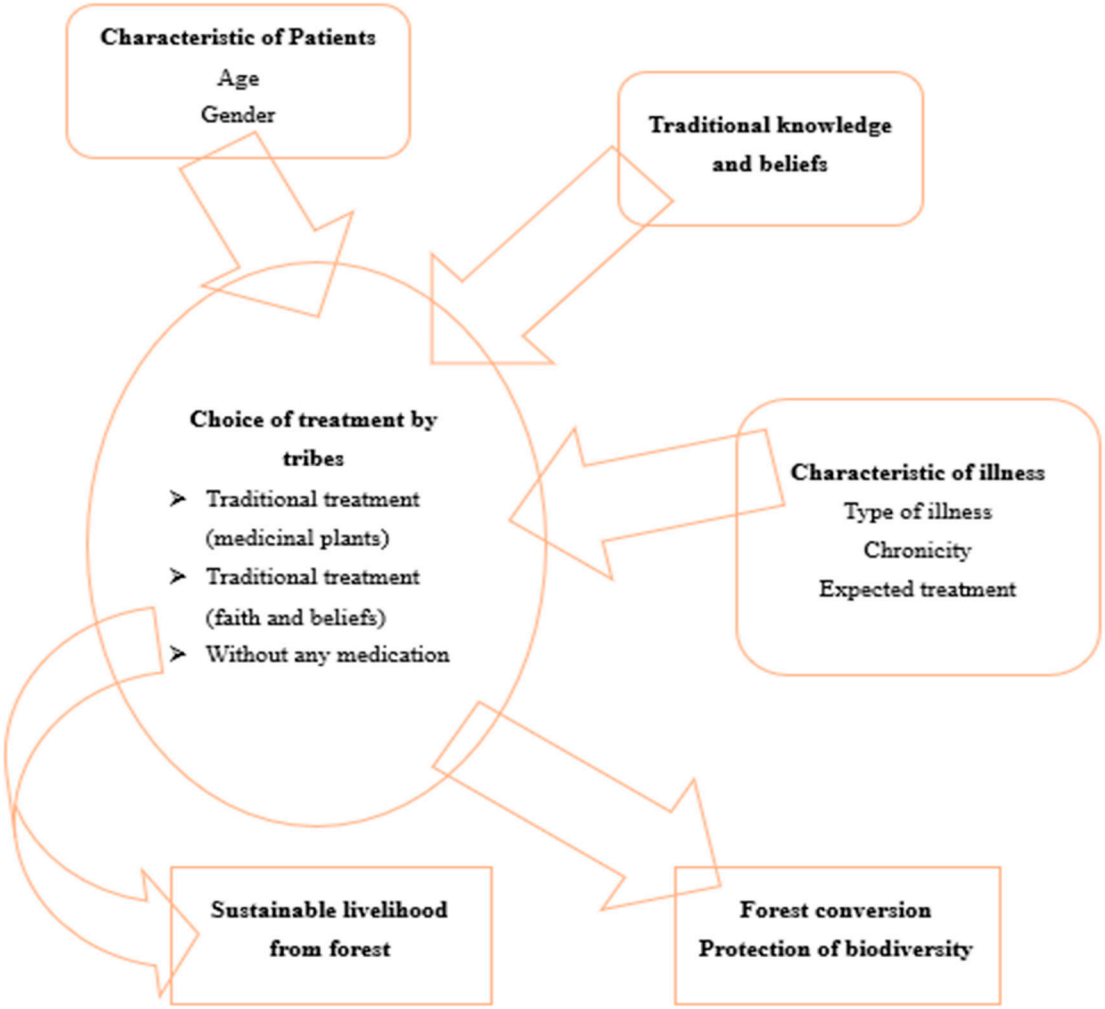

Figure 1. Pictorial view origin and sustainability of ethnomedicines.

Ethnomedicine can offer several advantages over conventional therapeutic interventions, such as being more accessible, affordable, and acceptable to the people; being more holistic, personalized, and culturally sensitive; being more preventive, promotive, and empowering; and being more compatible with the local ecology and biodiversity [19]. One of the main focuses of ethnomedicine is the study of traditional medical systems, which are coherent and comprehensive sets of concepts, theories and methods that guide the diagnosis, prevention, and treatment of health problems in a specific culture. Traditional medical systems are based on empirical observations, experiential learning, oral transmission, and practical application of health knowledge over generations [20]. Traditional medical systems vary widely in their scope, content, structure, and function, depending on the cultural and ecological context in which they operate. Another major focus of ethnomedicine is the study of medicinal plants, which are plants that have pharmacological effects and are used for therapeutic purposes by various ethnic groups[21–23]. Medicinal plants are an integral part of many traditional medical systems, as they provide accessible, affordable, and effective remedies for a range of health conditions. Medicinal plants are also a valuable resource for drug discovery, as they contain numerous chemical compounds that have potential biological activities and can serve as leads for developing new pharmaceuticals [20]. However, ethnomedicine for diabetes not only encompasses plant-based remedies but also incorporates cultural and spiritual beliefs. Traditional healing practices often involve rituals, ceremonies, and community support systems, which play a crucial role in holistic diabetes management. It also faces other challenges and risks, such as lack of scientific validation, standardization, and regulation; lack of integration and collaboration with the

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mainstream health system; lack of protection and preservation of the indigenous knowledge and resources; and potential adverse effects or interactions with other therapies [20]. The chapter will discuss the historical sources, concepts, methods, and practices of ethnomedicine for diabetes; the identification, classification, and uses of medicinal plants for diabetes; the challenges and opportunities for ethnomedicine for diabetes in the context of modern medicine; and the prospects for ethnomedicine for diabetes research and development.

2. Diabetes Mellitus (DM)

2.1. Introduction

WHO reports that diabetes has become a major global public health challenge affecting millions of people. From 1980 to 2014, diabetic peoples have increased approx. 108 million at a very faster rate in low-income (like Afghanistan) and middle-income nations (like India, and Nigeria) compared to high-income nations (like the USA and Canada) [24]. In 2019, diabetes is directly involved in 1.5 million deaths whereas 460 000 deaths were recorded due to kidney disease with diabetes as a comorbidity [24]. The Greek physician Aretaeus of Cappadocia named the condition diabetes in the second century AD, meaning "siphon" or "flowing through." Later, the term mellitus was added by the English physician Thomas Willis in the 17th century, meaning "honeyed" or "sweet". Diabetes mellitus is a prevalent and chronic endocrine disorder that affects the metabolism of carbohydrates, leading to persistent hyperglycemia (high blood sugar levels) [24]. Hyperglycemia can cause acute and long-term complications that impair the life-quality and increase mortality risks. Some of the acute complications include diabetic ketoacidosis, hyperosmolar hyperglycemic state, and hypoglycaemia. Some of the long-term complications bring in macrovascular diseases (like stroke, and peripheral arterial and coronary heart disease), microvascular diseases (such as diabetic retinopathy, nephropathy, and neuropathy) and diabetic foot ulcers [24].

2.2. Type of Diabetes

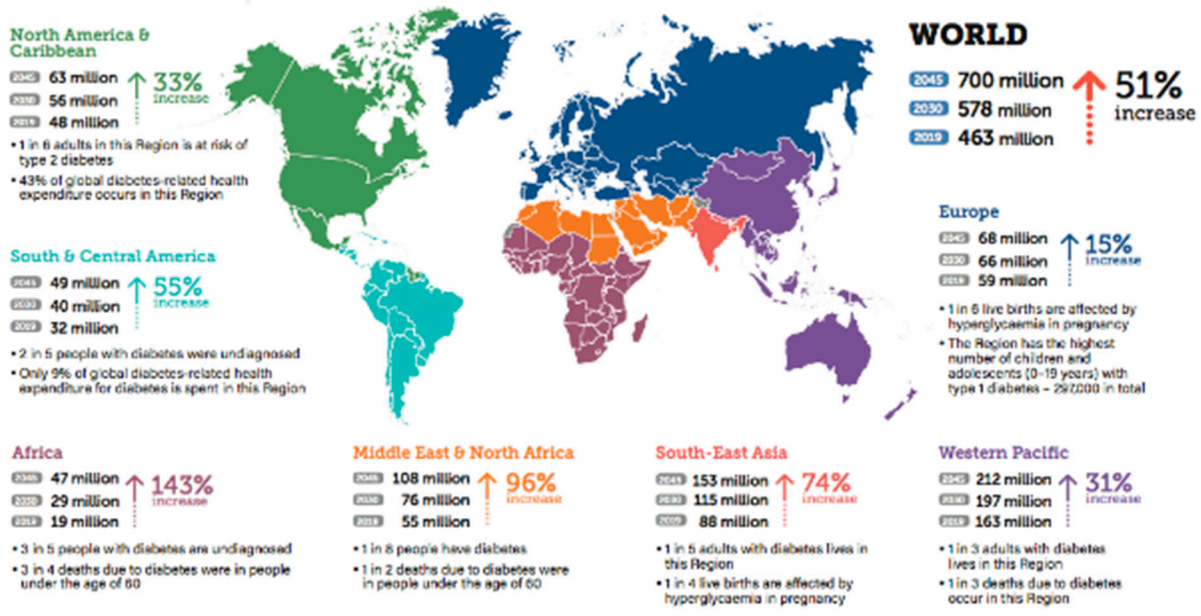

Figure 2. No. of adult between age 20-79 with diabetes worldwide. (Source: IDF Diabetes Atlas 2019 [150].)

Mainly two types of diabetes were found: type 1 (T1DM) and 2 (T2DM).

2.2.1. Type 1 diabetes

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In T1DM, our immune system mistakenly recognises the pancreatic beta cells as foreign elements, therefore attacking and destroying it, and resulting in an absolute deficiency of insulin. This causes glucose to accumulate in the blood and spill into the urine, leading to symptoms like urination, increased thirst, hunger, fatigue, weight loss, and ketone formation [25]. As a result, patients have an absolute insulin deficiency and require exogenous insulin therapy for survival. Type 1 diabetes mellitus usually manifests in childhood but it also report at any age of life. The exact aetiology of T1DM is still unknown, but some environmental and genetic factors are involved [25].

2.2.2. Type 2 diabetes

In type 2 diabetes, the cells become resistant to the action of insulin, meaning that they do not respond properly to the signals that insulin sends. This causes a relative deficiency of insulin, as the pancreas tries to compensate by producing more insulin but cannot keep up with the demand [24]. This also causes glucose to build up in the blood and urine, leading to symptoms similar to type 1 diabetes, but usually milder and slower in onset. Type 2 diabetes mellitus is more common in adults, especially those who have a diabetic family history, are physically inactive, and are overweight[26–29]. However, type 2 diabetes is also increasing in kids and youths due to the rising prevalence of obesity and sedentary lifestyles [30]. By manging our lifestyle like diet, weight loss, and exercise, as well as oral medications that lower blood sugar levels by different mechanisms, type 2 diabetes can be managed too. Sometime T2DM patients also require insulin injections if oral medications are insufficient or contraindicated. Other factors that can affect the mechanism of diabetes include genetic mutations, diseases of the pancreas or other endocrine organs, infections, drugs or chemicals, pregnancy, ageing, and stress [30]. These factors can influence the production or action of insulin or alter the metabolism or demand of glucose by the cells. Besides T1DM and T2DM, other diabetic forms are also found such as gestational diabetes, which occurs in pregnancy and usually disappears after delivery, but the chance of T2DM development in the future for both the mother and the child is increased; prediabetes, which is a state of high blood sugar levels that do not qualify as DM, but the chance of T2DM development are again increased with its complications if left untreated; and other specific types of diabetes mellitus that are caused by genetic defects, diseases of the pancreas or other endocrine organs, infections, drugs or chemicals [31].

2.3. Pathology of diabetes

The main mechanism of diabetes is the dysfunction of insulin, a hormone that regulates the uptake and utilization of glucose by the cells. The pancreas secretes insulin from its beta cells into the blood when blood glucose levels are elevated. Insulin binds to specific receptors on the cell surface and activates a cascade of signals that allow glucose entry into the cell and later utilised as energy or gathered as glycogen or fat [32]. Glucose transporter (GLUT) and hexokinase (HK) are two key proteins involved in the uptake and metabolism of glucose by the cells. GLUT belongs to the membrane-bound proteins family and facilitates glucose transport through passive diffusion across the cell membrane. Glucose-6-phosphate is produced from glucose by the enzyme HK through a phosphorylation reaction which is the first step of glycolysis and other metabolic pathways [33]. GLUT and HK work together to regulate the flux of glucose into the cells according to their energy needs and availability. There are several isoforms of GLUT and HK that have different tissue distribution and functional regulation. For example, Skeletal muscle and adipose tissue are the main tissues for insulin-induced glucose uptake and they express GLUT4 and HKII predominantly [34]. A signal transduction pathway is activated when insulin interacts with its receptor on the cell surface, which facilitates the movement of GLUT4 from intracellular compartments to the plasma membrane, where it enhances the entry of glucose into the cell [35]. Insulin also enhances the activity and expression of HKII, which increases the phosphorylation of glucose and prevents its back diffusion out of the cell [35].

Table 1. Classification of HK Function and Glucose Transporter by Tissue-Specific Distribution and Regulation [35].

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Organ	HK computer	Glucose transporter	Classification
Erythrocyte	HK I	GLUT1	Glucose-dependent
Brain	HK-I	GLUT1	Glucose-dependent
GK beta-cell	HK IV B (glucokinase)	GLUT2	Glucose-sensor
Liver	HK IV L	GLUT2	Glucose-sensor
Kidney	-----	GLUT3 symporter	Sodium-dependent
Gut	-----	GLUT3 symporter	Sodium-dependent
Muscle	HK II	GLUT4	Insulin-dependent
Adipocyte	HK II	GLUT4	Insulin-dependent

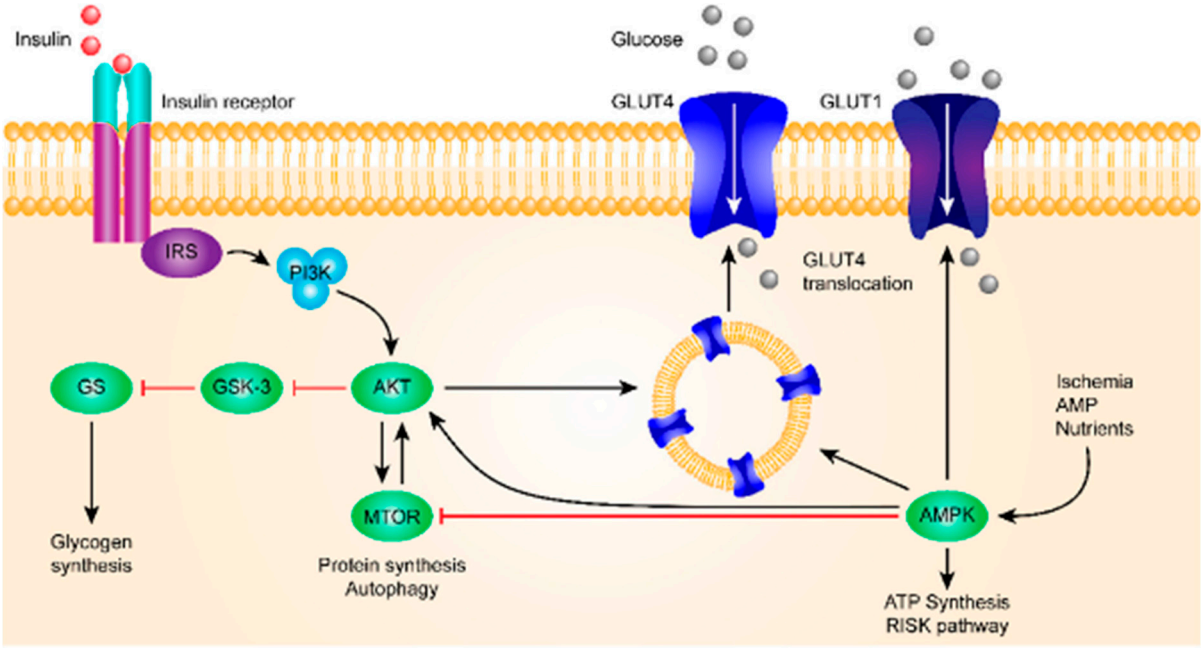

Figure 3. The insulin signalling pathway is depicted in this figure. The metabolic functions of insulin are mediated by the insulin receptor, which binds insulin and poses kinase activity of tyrosine-protein. Resultant the downstream effectors like IRS-1 and PI3K, open for insulin binding. The p85 regulatory subunit of PI3K can be directly bound by the insulin receptor, resulting in the production of PIP3, or indirectly activated by phosphorylation, leading to the AKT activation. Subsequently, GSK-3β activity is inhibited by AKT phosphorylation at the Ser9 site. This signalling pathway, PI3K/AKT/GSK-3β, is involved in transducing insulin signals, and insulin regulates and modulates GSK-3β in this pathway, which is related to the control of glycogen synthesis. (Source: This has been taken from a published paper by Borros et al., 2019 [33]).

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The role of GLUT and HK in diabetes is crucial. The absolute lack of insulin results from the autoimmune destruction of the pancreatic beta cells in type 1 diabetes, and impairs the translocation of GLUT4 and the activity of HKII in muscle and adipose tissue, resulting in reduced glucose uptake and utilization [33]. In type 2 diabetes, the insulin resistance of the cells reduces the responsiveness of GLUT4 and HK-II to insulin stimulation, resulting in impaired glucose uptake and utilization. Both types of diabetes cause glucose to accumulate in the blood and urine, leading to various acute and chronic complications that affect multiple organs and tissues. Therefore, targeting GLUT and HK for diabetes management is a promising strategy that aims to enhance glucose uptake and metabolism by the cells and lower blood glucose levels [34]. Several natural compounds derived from food sources have been shown to modulate the expression or activity of GLUT and HK by different mechanisms, such as stimulating insulin secretion, enhancing insulin sensitivity, inhibiting glucose absorption or production, or increasing glucose excretion. Some examples include bitter melon, fenugreek, ginseng, cinnamon, garlic, ginger, turmeric, aloe vera, nopal, berberine, and ethnomedicine [35]. Moreover, raised blood glucose levels accounted for about 20% of cardiovascular deaths. The current treatment options for diabetes mellitus include pharmacological agents that lower blood glucose levels by stimulating insulin secretion, enhancing insulin sensitivity, inhibiting glucose absorption or production, or increasing glucose excretion. However, these drugs have limitations such as adverse effects, contraindications, interactions, cost, and poor adherence. Moreover, some patients may not achieve adequate glycaemic control or may develop drug resistance over time. Therefore, there is a need for discovering new and alternative treatments for diabetes mellitus that are safe, effective, accessible, and affordable [36].

3. Traditional Medicinal Practices for Diabetes

Many people with diabetes rely on conventional medicine to manage their condition, such as oral hypoglycaemic agents or insulin injections. However, some people also use Traditional Medicine (TM) as a complementary or alternative approach to treat diabetes. TM can have various benefits for people with diabetes, such as improving blood glucose control, reducing oxidative stress and inflammation, enhancing insulin sensitivity and secretion, and preventing or delaying complications [37]. However, TM can also have potential risks, such as adverse effects, interactions with conventional drugs, contamination, misidentification, or inappropriate use. Therefore, it is important to understand the different types of TM practices for diabetes and their evidence of effectiveness and safety There is a growing interest in the potential role of ethnomedicine in the management of diabetes among researchers, practitioners, and patients. Some of the common TM practices for diabetes are herbalism, acupuncture, massage therapy, and diet [38,39]:

3.1. Ethnomedicinal plants (Herbalism)

Ethnomedicinal plants are plants or plant parts that are used for medicinal purposes based on traditional knowledge or experience [40]. Ethnomedicinal plants can be prepared in various forms such as teas, decoctions, infusions, tinctures, capsules, tablets, powders, syrups, oils, creams, or ointments. Ethnomedicinal plants can contain multiple active ingredients that may have synergistic or antagonistic effects on the body. Herbalism is one of the most widely used TM practices for diabetes. Ethnomedicinal plants are one of the most widely used ethnomedicine practices for diabetes where various parts of plants are used as drugs [40].

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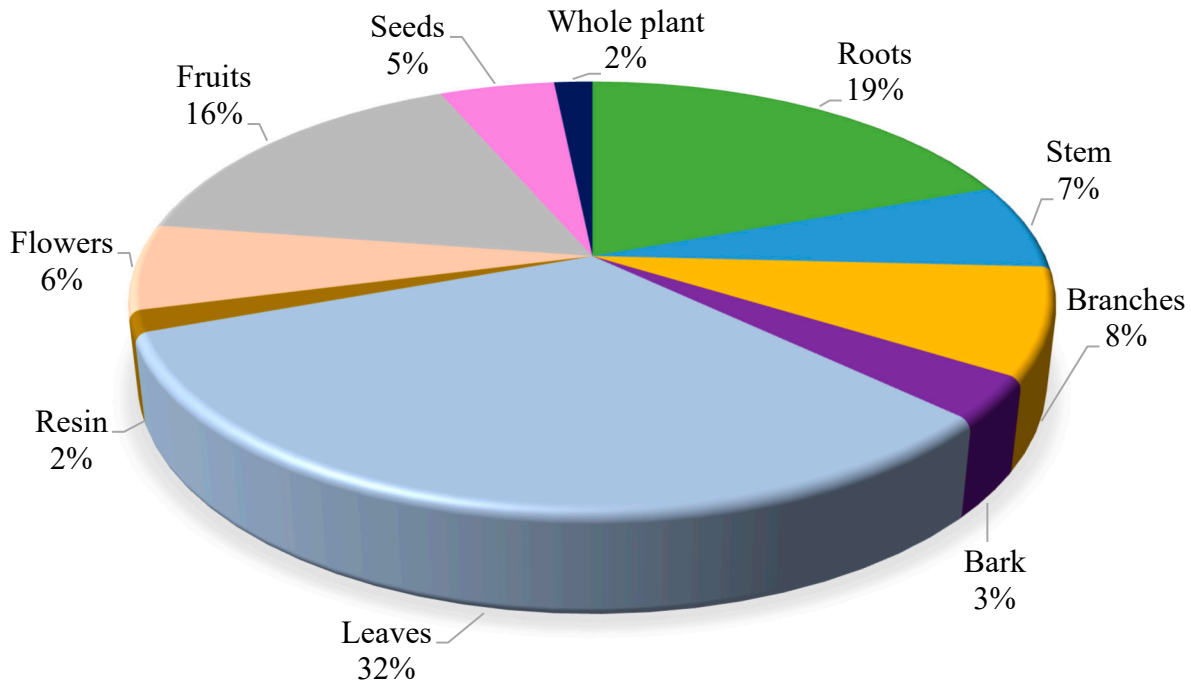

Figure 4. Status of plant parts used as ethnomedicines, source: Pervaiz et al., 2018 [45].

According to a cross-sectional study conducted in Tanzania [19], 67.2% of diabetic patients managed their diabetes using traditional medicines and practices. The accessibility and availability of TM and the high conventional treatment cost were some of the reasons for using traditional medicines. The evidence of effectiveness and safety of herbal medicines for diabetes varies depending on the type of quality dosage preparation and duration of use of the herbal products[41–43]. Some herbal medicines may have beneficial effects on blood glucose control lipid profile insulin resistance or oxidative stress in animal studies or human trials. For example, between December 2013 and June 2014, conducted a study to examine the utilization of traditional medicinal practices (TMPs), including their types, frequencies, reasons, and modes, among community members randomly selected for the study [44]. A total of 481 adults participated in the study, of whom 45 individuals (9.4%) were diagnosed with diabetes. Among those with diabetes, the prevalence of TMP use was found to be 77.1% (95% CI 58.5–89.0%), and the concurrent use of TMPs and biomedicines was reported by 37.6% of participants (95% CI 20.5–58.4%). Many individuals specifically utilized TMPs for the treatment of diabetes, accounting for 40.3% of participants (95% CI 20.5–63.9%). Various plants based TMPs were identified for the management of diabetes, namely *Cymbopogon Citrullus, Moringa oleifera, Aloe vera, Hagenia abyssinica, Clausena anisata, Artimisia afra, Cajanus cajan,* and *Persea americana.* However, some herbal medicines may also have adverse effects such as gastrointestinal disturbances allergic reactions hypoglycaemia or hepatotoxicity. Moreover, some herbal medicines may interact with conventional drugs or other herbal products potentiating or antagonizing their effects [44].

Table 2. List important medicinal plant families with at least two species used as ethnomedicine, source: Pervaiz et al., 2018 [45].

S. No	Family	No. of species
1	Apiaceae	2
2	Asteraceae	9
3	Boraginaceae	2
4	Brassicaceae	2

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S. No	Family	No. of species
5	Brassicaceae	2
6	Caprifoliaceae	2
7	Curpessaceae	2
8	Euphorbiaceae	2
9	Fumariaceae	2
10	Lamiaceae	4
11	Pinaceae	4
12	Ranunculaceae	5
13	Rosaceae	3
14	Rubiaceae	2
15	Solanaceae	3

3.2. Acupuncture

Acupuncture is a form of TM that originated in Indian and China more than 2000 years ago. It involves the insertion of fine needles into specific points on the body called acupoints which are believed to correspond to different organs or systems in the body [39]. Acupuncture aims to restore the balance of qi (vital energy) and blood flow in the body thus promoting health and healing. Acupuncture has been used for various conditions such as pain nausea anxiety depression and diabetes. Acupuncture may have various mechanisms of action on the body such as stimulating nerve endings releasing endorphins modulating neurotransmitters regulating hormones or influencing immune function. Acupuncture may have beneficial effects on people with diabetes by improving blood glucose control insulin sensitivity beta-cell function or lipid profile [44]. Acupuncture may also reduce diabetic complications such as neuropathy retinopathy or nephropathy by improving nerve conduction velocity visual acuity or renal function. Moreover, acupuncture may improve quality of life or psychological well-being by reducing stress depression or anxiety in people with diabetes [44]. The evidence of the effectiveness and safety of acupuncture for diabetes varies depending on the type of quality frequency duration location or combination of acupuncture techniques used in different studies[46–49]. Some studies have shown positive results of acupuncture on glycaemic control or diabetic complications compared to placebo sham acupuncture or conventional treatment. However, some studies have shown no significant difference or inconsistent results of acupuncture on diabetes outcomes. Therefore, more high-quality randomized controlled trials are needed to confirm the efficacy and safety of acupuncture for diabetes [39]. It is generally considered safe when performed by a trained acupuncturist using sterile needles. However, some minor adverse events may occur such as bleeding bruising infection pain dizziness or fainting. Moreover, some serious adverse events may occur rarely such as pneumothorax cardiac tamponade nerve damage or organ injury [44]. Therefore, it is important to consult with a qualified health care provider before undergoing acupuncture for diabetes.

Table 3. Acupuncture types and point and their effects on diabetes management.

Acupuncture types and points	Effect on diabetes
Wrist-ankle acupuncture	Reduce pain caused by diabetic neuropathy
Electroacupuncture	Lower blood glucose levels, increase insulin sensitivity and improve pancreatic islet function

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Acupuncture types and points	Effect on diabetes
Herbal acupuncture	Enhance the effects of anti-diabetic medication, such as metformin
ST36 (Zusanli)	Improves blood glucose levels, insulin levels and glucose tolerance
SP6 (Sanyinjiao)	Improves blood glucose levels, insulin levels and glucose tolerance
LI11 (Quchi)	Improves blood glucose management, weight loss and insulin resistance
LI4 (Hegu)	Improves blood glucose management, weight loss and insulin resistance
ST25 (Tianshu)	Improves blood glucose management and weight loss
ST40 (Fenglong)	Improves blood glucose management and weight loss

3.3. Massage Therapy

Massage therapy is a form of TM that involves manipulating soft tissues of the body such as muscles, tendons, ligaments, fascia, skin, or joints using various techniques such as stroking, kneading, tapping, friction, vibration, compression, or stretching. Massage therapy aims to enhance physical, mental, emotional, or spiritual well-being by improving blood circulation, lymphatic drainage, muscle relaxation, pain relief, stress reduction, mood enhancement, or immune function [50]. Massage therapy has been used for various disease conditions such as pain, inflammation, injury, stress, anxiety, depression, insomnia, headache, migraine, fibromyalgia, chronic fatigue syndrome, asthma, arthritis, osteoporosis, hypertension, cardiovascular disease, cancer, HIV/AIDS, dementia, Alzheimer's disease, Parkinson's disease, multiple sclerosis, autism spectrum disorder, attention deficit hyperactivity disorder, post-traumatic stress disorder, and diabetes. Massage therapy has beneficial effects on people with diabetes by improving blood glucose control, insulin sensitivity, beta-cell function, or lipid profile [13]. Massage therapy also reduces diabetic complications such as neuropathy, retinopathy, or nephropathy by improving nerve conduction velocity, visual acuity, or renal function. The evidence of the effectiveness and safety of massage therapy for diabetes varies depending on the type of quality dosage preparation and duration of use of the massage techniques. Some studies have shown positive results of massage therapy on glycaemic control or diabetic complications compared to placebo sham massage or conventional treatment as mentioned in table 4 [51,52]. However, some studies have shown no significant difference or inconsistent results of massage therapy on diabetes outcomes. Therefore, more high-quality randomized controlled trials are needed to confirm the efficacy and safety of massage therapy for diabetes. Massage therapy is generally considered safe when performed by a trained massage therapist using appropriate hygiene and precautions. However, some minor adverse events may occur such as soreness bruising swelling allergic reactions or skin irritation. Moreover, some serious adverse events may occur rarely such as infection bleeding nerve damage or organ injury. Therefore, it is important to consult with a qualified health care provider before receiving massage therapy for diabetes [51].

Table 4. Type of massage and their effect on diabetes patients.

Type of massage	Effects on diabetes treatments
Swedish massage	Lower blood glucose levels [53]
Connective tissue massage	Improve circulation in the lower limbs and slow the progression of the peripheral arterial disease [51]
Thai foot massage	Improve range of motion, ability to stand up, and foot sensation [53]
Other types of foot massage	Increase balance and mobility [53]

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Type of massage	Effects on diabetes treatments
Traditional Chinese massage	Improve neuropathy symptoms [52]
Abdominal massage	Regulate muscle, pancreatic, and inflammatory factors, and islet function to improve disorders of lipid and glucose metabolism [54]
Massage at the site of insulin injection	Lower levels of blood glucose and enhance action of serum insulin in type 1 diabetes patients [52]

3.4. Dietary interventions for diabetes prevention

Diet is an integral part of the ethnomedicinal treatment of diabetes mellitus. Diet plays a vital role in the prevention, management, and control of diabetes mellitus by influencing blood glucose levels, insulin sensitivity, body weight, and cardiovascular risk factors. It influences the bioavailability, efficacy, and safety of ethnomedicinal plants for diabetes mellitus by modulating their absorption, distribution, metabolism, and excretion. Diet can also affect the prevention, management, and control of diabetes mellitus by influencing blood glucose levels, body weight, and cardiovascular risk factors. Dietary recommendations for ethnomedicinal treatment of diabetes mellitus vary depending on the type, severity, and duration of diabetes mellitus, as well as the individual's age, gender, ethnicity, lifestyle, and comorbidities. A balanced diet consisting of low glycaemic index foods, high fibre foods, moderate fat intake, limited sugar intake, and adequate hydration is recommended for people with diabetes mellitus who use ethnomedicinal plants for their treatment and further details of ethno-diet are given in upcoming below sections.

4. Evidence-based Ethnomedicine for Diabetes

Evidence-based ethnomedicine is the application of scientific methods and standards to evaluate the safety, efficacy, and mechanisms of action of ethnomedicinal plants and products. Evidence-based ethnomedicine aims to combine current medical practices and ancient science to develop new therapeutic approaches that are safe and effective for various diseases and disorders [55]. Ethnomedicine offers a rich diversity of medicinal plants that have been traditionally used for managing diabetes across different cultures and regions. These plants may contain bioactive compounds that can modulate various pathways involved in glucose metabolism and insulin signalling. It identifies novel antidiabetic agents from natural sources that can be further developed into new drugs or nutraceuticals. Ethnomedicine can also provide holistic and personalized care that considers the physical, mental, social, and spiritual aspects of the patients. Moreover, ethnomedicine can be more affordable, accessible, and acceptable than conventional medicine for many people, especially in developing countries. It also contributes to the preservation and promotion of the cultural heritage and biodiversity of different regions [55,56]. Ethnomedicine has various applications, challenges and future perspectives which will be discussed in the upcoming sections. Ethnomedicine has some advantages over allopathic medicine in terms of being more natural, holistic, and personalized than synthetic drugs that may have side effects or contraindications. It is more affordable, accessible, and acceptable than expensive drugs that may not be available or suitable for some people or regions. Ethnomedicines are more compatible with the cultural beliefs and preferences of some patients who may prefer traditional remedies over modern ones and are more diverse and flexible than standard drugs that may not work for everyone or every situation [40]. Despite its vast application, it also has some limitations such as it may not be effective against deadly diseases. Furthermore, it may not be scientifically validated or standardized and may have adverse effects or interactions with other drugs or treatments. It may be endangered by the loss of biodiversity, displacement of tribal communities, urbanization, and acculturation. It may face legal, ethical, and cultural challenges in terms of intellectual property rights, biopiracy, informed consent, and cultural sensitivity [57]. Some case study examples that proved drawbacks of ethnomedicine are *i)* According to a study, ethnomedicine is a type of intercultural health programme and found that

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despite some positive outcomes, there were also many challenges and limitations in implementing intercultural health programs. Some of these were: lack of political will and institutional support; insufficient funding and human resources; inadequate training and supervision of health workers; poor coordination and communication among stakeholders; low quality and availability of ethnomedicines; and cultural barriers and conflicts between different health systems [58]. *ii)* Another study documented that the traditional healers were facing several problems such as depletion and degradation of medicinal plants due to overexploitation, habitat loss, and climate change; loss of indigenous knowledge due to migration, modernization, and education; lack of recognition and regulation of their practices by the government; and competition and mistrust from the allopathic practitioners [59]. Overall, ethnomedicine for diabetes cannot be considered a substitute for current allopathic medicine but rather as a complement or an alternative depending on the individual needs and circumstances of each patient. Ethnomedicine for diabetes should be used with caution and under the guidance of qualified professionals who can monitor its effects and interactions with other medications or therapies.

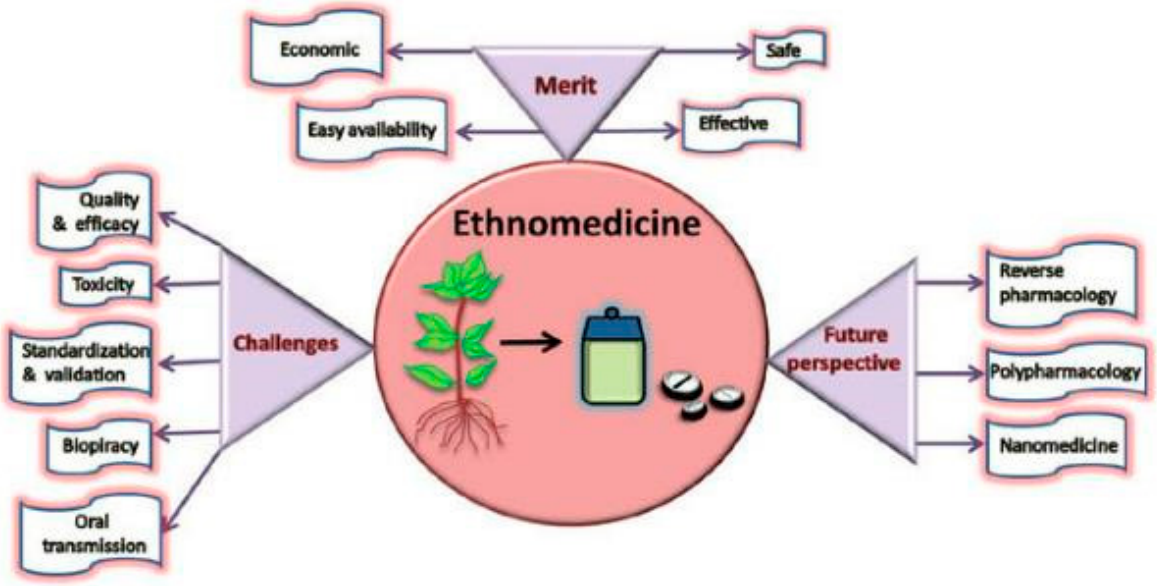

Figure 5. Summary of evidence based ethnomedicine.

5. Herbal Remedies for Diabetes[1]

Medicinal plants are a rich source of bioactive compounds that can modulate different pathways involved in glucose metabolism, insulin secretion or action, oxidative stress, inflammation, and angiogenesis. Medicinal plants can also provide synergistic effects, enhance the efficacy of conventional drugs, or reduce their side effects [60]. Several medicinal plants have been investigated for their antidiabetic properties using various experimental models and clinical trials. Some of these plants have shown promising results for treating diabetes and its complications. A systematic review of ethnomedicinal plants for diabetes reported 2004 plant species belonging to 1112 genera and 197 families among the 92 countries. Some of the most commonly used plants include *Momordica charantia* (bitter gourd), *Syzygium cumini* (black plum), *Allium sativum* (garlic), *Azadirachta indica* (neem), *Catharanthus roseus* (periwinkle), *Olea europaea* (olive), *Trigonella foenum-graecum* (fenugreek), *Gymnema Sylvestre* (gurmar), *Aloe vera* and *Allium cepa* (onion) [61]. These plants have been shown to possess various antidiabetic properties such as stimulating insulin secretion, enhancing glucose uptake, inhibiting glucose absorption and production, and modulating inflammatory pathways and

[1] ***Note:*** *Apart from these described, there are other medicinal plant are also used an ethnomedicines and therefore a details list of ethnomedicinal plant is given in Annexure 1.*

 doi:10.20944/preprints202308.1622.v1

antioxidant activity. Several bioactive compounds have been isolated and identified from these plants, such as alkaloids, flavonoids, terpenoids, saponins, glycosides and phenolic acids [62].

There are some limitations too on the use of herbal remedies. There is no clear evidence that herbal treatments or vitamin and mineral supplements will benefit people with diabetes unless they have underlying deficiencies [63]. Many studies on herbs and diabetes are of low quality, have small sample sizes, or have conflicting results. Some herbs and supplements may cause adverse effects. For example, Cinnamon may interact with blood thinners or increase the risk of liver damage if taken with other medications that affect the liver. Some herbs and supplements may interfere with the absorption, metabolism, or effectiveness of other drugs that people with diabetes take. For example, bitter melon may enhance the effect of insulin or oral hypoglycemic agents and cause hypoglycemia [63]. Several case studies show that ethnomedicines are restricted in their use. A case report of a 63-year-old woman who developed severe hypoglycemia after taking a Chinese herbal medicine containing ginseng and astragalus for 3 months. She was taking metformin and glipizide for her type 2 diabetes. The herbal medicine was found to contain a high amount of ginsenosides, which may have potentiated the effect of her medications. Similarly, another case report of a 54-year-old woman who developed acute kidney injury after taking a herbal tea containing licorice root for 2 weeks. She was taking insulin glargine and lispro for her type 1 diabetes. The tea was found to contain a high amount of glycyrrhizin, which is a natural compound in liquorice root that may cause sodium retention, potassium depletion, hypertension, and renal dysfunction [63].

Despite the limitation and restricted use of methenamine for debates, here are some of the ethnomedicinal plant and their use are described:

5.1. Momordica charantia L. (bitter melon)

This plant is widely used in Asia, Africa, and Latin America to treat diabetes. It contains several bioactive compounds such as momordicoside, karaviloside, cucurbitacin, charantin, charantoside, flavonoids, phenolic acids, saponins, alkaloids, and glucosinolates that can lower blood glucose levels by inhibiting intestinal glucose absorption, stimulating insulin secretion, enhancing glucose uptake in peripheral tissues, or modulating hepatic glucose production [64]. Several clinical trials have shown that *M. charantia* can enhance glucose and lipid metabolism in T2DM. It also has properties like hypoglycemic, antioxidant, anti-inflammatory, and immunomodulatory effects and is used to treat various health conditions such as malnutrition, hypertension, and anaemia [65,66].

5.2. Syzygium cumini (L.) Skeels (black plum)

This plant is also known as black plum or jamun and is widely cultivated in tropical and subtropical regions such as India, China, Brazil, and other countries to treat diabetes. It contains several bioactive compounds such as cuminoside, anthocyanins, ellagic acid, gallic acid, myricetin, quercetin, kaempferol, and tannins that can lower blood glucose levels by inhibiting α-glucosidase activity, enhancing insulin secretion or action, reducing oxidative stress or inflammation, or modulating hepatic glucose production. Several clinical trials have shown that *S. cumini* can improve glycemic control and lipid profile in patients with T2DM. *Syzygium* fruit, seeds, bark, and leaves have been used for various ailments such as diarrhea dysentery infection and diabetes. *Syzygium* contains anthocyanins ellagic acid gallic acid and tannins that may have antidiabetic antimicrobial and antioxidant properties [67,68].

5.3. Allium sativum L. (garlic)

Garlic is another name for this plant, which originates from Central Asia and northeastern Iran. Garlic bulbs have been used for various diseases such as hypertension hyperlipidemia infection and diabetes [69]. Garlic contains organosulfur compounds such as allicin ajoene and diallyl disulfide that have hypoglycemic antihypertensive antilipidemic and antimicrobial effects. It contains S-allyl cysteine sulfoxide (SAC), which improves glycemic control by increasing insulin secretion, reducing hepatic gluconeogenesis, and enhancing peripheral glucose uptake. It also contains several bioactive

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compounds like allicin, diallyl trisulfide (DATS), diallyl disulfide (DADS), and ajoene [68]. This plant is used by many cuisines and folk medicines to treat various diseases including diabetes [70].

5.4. Gymnema Sylvestre

It is a woody climber from India and Africa which belongs to the Asclepiadaceae family. It is commonly known as gurmar or meshashringi, which means "sugar destroyer" in Sanskrit. The leaves of *G. sylvestre* contain several bioactive compounds such as gymnemic acids, gurmarin, gymnemasaponins, and flavonoids [61]. Various pharmacological effects have been reported for these compounds, such as; *i)* Inhibiting the intestinal absorption of glucose and sucrose by interfering with the brush border enzymes. *ii)* Stimulating the pancreatic β-cells function and regeneration by increasing the insulin genes expression and enhancing insulin secretion. *iii)* Enhancing insulin sensitivity and glucose uptake in peripheral tissues by activating the insulin receptor and GLUT4 translocation [71]. *iv)* Reducing hepatic glucose production by inhibiting gluconeogenic enzymes and enhancing glycogen synthesis [72]. *v)* Reducing oxidative stress and inflammation by scavenging free radicals and modulating cytokine levels. v*i)* Preventing or delaying diabetic complications such as nephropathy, retinopathy, neuropathy, and cardiomyopathy by improving renal function, protecting the retinal cells, restoring the nerve conduction velocity, and reducing lipid peroxidation. Several clinical trials have evaluated the efficacy and safety of *G. sylvestre* extracts or tablets in patients with T1DM or T2DM. The results have shown that *G. sylvestre* can significantly reduce fasting blood glucose, postprandial blood glucose, haemoglobin A1C, serum lipids, body weight, and medication requirements in diabetic patients. The adverse effects reported were mild and transient such as gastrointestinal discomfort, hypoglycemia, headache, and dizziness [73]. However, some limitations of these trials include small sample size, short duration, lack of standardization of G. sylvestre preparations, and lack of long-term follow-up [72,73].

Figure 6. Pictorial view of all described medicinal plants.

5.5. Cymbopogon Citrullus

Lemongrass is another name for this plant, which is commonly grown in tropical and subtropical regions. Lemongrass has been used for various ailments such as fever, pain, infection, and diabetes. Lemongrass contains essential oils that may have antidiabetic, antimicrobial, and antifungal properties [74,75].

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5.6. Hagenia abyssinica

This plant is endemic to Africa and has been used for various diseases such as malaria, worms, diarrhea, and diabetes. *Hagenia* bark contains anthraquinones, tannins, and flavonoids that may have antidiabetic, antimalarial, and anthelmintic effects [76,77].

5.7. Aloe vera

This plant is native to Africa and Asia and has been used for various skin conditions such as burns, wounds, eczema, and psoriasis. Aloe gel contains polysaccharides, sterols, lectins, and anthraquinones that may have hypoglycemic, anti-inflammatory, wound-healing, and laxative effects. It also contains chrysalides that can improve glycemic control by increasing insulin secretion, reducing hepatic gluconeogenesis, and enhancing peripheral glucose uptake [78].

5.8. Clausena anisata

This plant is also known as the African wild orange and is found in tropical Africa. *Clausena* leaves and roots have been used for various disorders such as fever, malaria, cough, and diabetes. Clausena contains coumarins, flavonoids, and terpenoids that may have antidiabetic, antimalarial, and antitussive effects [79,80].

5.9. Cajanus cajan

This plant is also known as pigeon peas and is widely cultivated in tropical and subtropical regions. Pigeon pea seeds are rich in protein, fibre, and minerals and have been used as a staple food in many countries. Pigeon pea leaves and flowers have been used for various conditions such as anaemia, inflammation, infection, and diabetes. Pigeon pea contains flavonoids, phenolic acids, and saponins that may have hypoglycemic, antioxidant, anti-inflammatory, and antimicrobial effects [81,82].

5.10. Artemisia afra

This plant is also known as African wormwood and is native to Africa and Asia. *Artemisia* leaves have been used for various diseases such as fever, malaria, asthma, and diabetes. *Artemisia* contains sesquiterpene lactones that may have antidiabetic antimalarial antiasthmatic and antipyretic effects [83,84].

5.11. Persea americana

This plant is also known as avocado and is native to Central America and Mexico. Avocado fruit is rich in monounsaturated fatty acids vitamins minerals and antioxidants and has been used as a nutritious food in many cultures. The avocado seed has been used for various ailments such as diarrhea dysentery inflammation and diabetes. Avocado seed contains phenolic compounds alkaloids saponins and flavonoids that may have hypoglycemic antidiarrheal anti-inflammatory and antioxidant effects [85,86].

5.12. Azadirachta indica

This plant is also known as neem and is native to India and other parts of South Asia. Neem leaves bark seeds and oil have been used for various disorders such as skin diseases worms' fever and diabetes. Neem contains limonoids such as azadirachtin nimbin and salannin that have antidiabetic antiparasitic antipyretic and anti-inflammatory effects. By stimulating the secretion of insulin, enhancing the uptake of glucose, and reducing the absorption of glucose, limonoids have antidiabetic effects. [87,88].

5.13. Catharanthus roseus

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This plant is also known as Madagascar periwinkle or vinca and is native to Madagascar. *Catharanthus* leaves flowers and roots have been used for various conditions such as cancer hypertension menstrual disorders and diabetes. *Catharanthus* contains alkaloids such as vincristine vinblastine ajmalicine and serpentine that have antidiabetic anticancer antihypertensive and antispasmodic effects. It also contains other alkaloids such as vindoline, vindolidine, vindolicine and vindolinine that lower blood glucose levels by inhibiting the α-glucosidase enzyme and enhancing insulin sensitivity [89,90].

5.14. Olea europaea

This plant is also known as olive and is native to the Mediterranean region. Olive fruit, oil leaves, and bark have been used for various health benefits such as cardiovascular protection anti-inflammatory action wound healing and diabetes [91]. Olive contains phenolic compounds such as oleuropein hydroxytyrosol tyrosol and oleanolic acid that have hypoglycemic antioxidant anti-inflammatory and wound-healing effects. Oleuropein and oleanolic acid improve glycemic control by increasing insulin secretion, reducing hepatic gluconeogenesis and enhancing peripheral glucose uptake [92,93].

5.15. Trigonella foenum-graecum

This plant is also known as fenugreek and is native to western Asia southern Europe and northern Africa. Fenugreek seeds, leaves, and sprouts have been used for various purposes such as food spice lactation enhancement weight loss and diabetes. Fenugreek contains flavone C-glycosides such as nicotinic acid, choline, lecithin, vitamins, minerals, amino acids, fibres, volatile oils, steroids, alkaloids, flavonoids, tannins, phenols, glycosides, lipids, proteins, carbohydrates, fats, enzymes, hormones, etc. The flavone C-glycosides like vicenin-1, isoschaftoside, and schaftoside reduce blood glucose levels by inhibiting α-amylase and α-glucosidase enzymes and enhancing insulin sensitivity [94,95].

6. Dietary Interventions for Diabetes

According to scientific communication, a diet is defined as “the kinds and amounts of food available to or eaten by an individual, group, or population” [96]. whereas “the habitual frequency and combination of various foods and beverages in diets, and their proportions, quantities, or diversity” is the definition of a dietary pattern [97]. A meta-analysis of RCTs, which stands for randomized controlled trials, showed lower T2DM risk with various dietary patterns, except low-GI, than control diets [98]. However, these patterns had inconsistent effects on glycemic control and risk factors for cardiovascular in diabetic people. Recent RCTs found no evidence of the superiority of any dietary pattern for improving glycemia, body weight, blood pressure, or lipid profile in diabetic people [99]. Thus, personalized dietary advice based on preferences, culture, and metabolic goals may be better than a single dietary pattern for all diabetic people.

6.1. Traditional diets for diabetes

Traditional diets are dietary patterns that reflect the food habits and preferences of different cultures and regions [100]. Some traditional diets examples are the Asian diet, the Mediterranean diet, the Nordic diet, and the Native American diet. All four diets have demonstrated improvement in blood glucose control and reduction in T2DM and the risk of its complications [100].

6.1.1. Examples of key traditional types

6.1.1.1. The Mediterranean diet:

It is a dietary pattern that displays the food choice, habits, and preferences of the countries bordering the Mediterranean Sea. It is exemplified through the high consumption of vegetables, fruits, nuts, whole grains, olive oil, legumes, fish, and moderate wine intake. It uses healthy fats, like

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avocado oil, canola oil, and nut oils. It incorporates herbs and spices for flavour and health benefits [100,101].

6.1.1.2. The Asian diet

It is a dietary pattern that reflects the food habits and preferences of various countries in Asia. It is characterized by high consumption of rice or noodles, vegetables, soy products (such as tofu and tempeh), fish or seafood, fruits, tea, and a moderate intake of meat and dairy. It limits processed foods, refined grains, added sugars, and trans fats. It uses healthy fats, such as sesame oil, peanut oil, coconut oil, and fish oil [102,103]. It also incorporates herbs and spices for flavour and health benefits.

6.1.1.3. The Nordic diet:

It is a dietary pattern that reflects the food habits and preferences of the Nordic countries, such as Norway, Denmark, and Iceland. It is characterized by high consumption of whole grains (especially oats, rye, and barley), vegetables (specifically root vegetables), fruits (particularly berries) [104], fatty fish (such as mackerel, salmon, sardines, and tuna), legumes, and low-fat dairy (such as Skyr yogurt). It also includes moderate amounts of eggs, game meat (such as venison, rabbit, and bison), and wine. It limits processed foods, refined grains, added sugars, and trans fats. It uses healthy fats, such as canola oil, olive oil, avocado oil, and nut oils. As above both diaries patter, also incorporates herbs and spices for flavour and health benefits [105,106].

6.1.1.4. The Native American diet:

It is a dietary pattern that reflects the food habits and preferences of Native American communities across the United States. It is characterized by high consumption of corn, beans, squash, fruits, and grains. These foods are also known as the "three sisters" because they grow well together and provide complementary nutrients. The Native American diet also includes moderate amounts of wild game (such as deer, elk, bison, and turkey), fish (such as salmon, trout, and herring), eggs, nuts, seeds, and berries. It limits processed foods, refined grains, added sugars, and trans fats. It uses healthy fats, such as sunflower oil, corn oil, walnut oil and flaxseed oil [107,108]. Like all diet patterns, it also incorporates herbs and spices for flavour and health benefits.

6.1.2. Some common features of these traditional diets are -

⇒ Emphasize plant-based foods, like vegetables, fruits, nuts, whole grains, seeds, etc.
⇒ Incorporate moderate portions of animal-based foods, such as poultry, fish, lean meats, eggs, and dairy.
⇒ Limit processed foods, refined grains, added sugars, and trans fats.
⇒ Use healthy fats, like canola oil, olive oil, avocado oil, and nut oils.
⇒ Incorporate spices and herbs for flavour and health benefits.

6.1.3. The benefits of the traditional diets are [101,104–110] -

⇒ Abundant in omega-3 fatty acids from nuts and fish which can lower triglyceride levels improve blood vessel function lower blood pressure and prevent or reduce insulin resistance.
⇒ Rich in fibre which can slow down the digestion and absorption of carbohydrates lower blood sugar spikes after meals improve insulin sensitivity lower cholesterol levels and promote satiety.
⇒ Rich in antioxidants phytochemicals and micronutrients which can protect against oxidative stress inflammation and cellular damage caused by high blood sugar levels.
⇒ Moderate in protein from plant and animal sources which can help preserve muscle mass increase metabolic rate regulate appetite hormones and prevent or delay the onset of diabetic kidney disease.

6.1.4. Traditional dietary interventions for different populations and settings

Dietary interventions for people with diabetes should be tailored to their individual needs, preferences, cultural background, socioeconomic status, and environmental context. Diabetes management requires personalized nutrition therapy from a registered dietitian nutritionist or a diabetes self-management education program with nutrition education [106]. No universal diet exists

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for diabetes. Some of the factors that may influence the choice and implementation of dietary interventions are -

6.1.4.2. Age

Older adults with diabetes may have different nutritional needs and goals than younger adults. They may require more protein to prevent sarcopenia, more calcium and vitamin D to prevent osteoporosis, more fluid to prevent dehydration, or more fibre to prevent constipation. They may also have comorbidities, cognitive impairment, functional limitations, or social isolation that affect their dietary intake and adherence [111]. Therefore, older adults with diabetes may need more individualized and flexible dietary interventions that consider their nutritional status, comorbidities, medications, and quality of life.

6.1.4.3. Ethnicity

People with diabetes from different ethnic backgrounds may have different dietary patterns, preferences, beliefs, and traditions that influence their food choices and behaviours. They may also have different genetic and environmental factors that affect their metabolic responses and risk of complications [112]. Therefore, dietary interventions for people with diabetes from diverse ethnic groups should be culturally appropriate and sensitive to their specific needs and preferences.

6.1.4.4. Pregnancy

Women with gestational diabetes or pre-existing diabetes who become pregnant have special nutritional needs and challenges. They need to balance their energy and nutrient requirements for fetal growth and development with their glycaemic control and prevention of maternal complications. They may also experience nausea, vomiting, food aversions, or cravings that affect their dietary intake and adherence [111]. Therefore, dietary interventions for pregnant women with diabetes should be individualized and monitored by a dietitian nutritionist.

6.1.4.1. Socioeconomic status

People with diabetes from low socioeconomic status may face barriers to accessing healthy foods, such as limited availability, affordability, or transportation. They may also have limited health literacy, education, or skills to make informed dietary decisions and changes. Therefore, dietary interventions for people with diabetes from low socioeconomic status should address these barriers and provide practical and feasible solutions that are tailored to their resources and circumstances [113].

6.1.4.5. Environmental context

People with diabetes may encounter various environmental influences that affect their dietary behaviours, such as social norms, peer pressure, media messages, food marketing, or food policies. They may also have different opportunities and challenges to access and consume healthy foods in different settings, such as home, school, work, or community [111,113]. Therefore, dietary interventions for people with diabetes should consider the environmental context and provide strategies to cope with or modify the environmental factors that facilitate or hinder healthy eating.

6.2. Examples of evidence-based ethno-diets

6.2.1. Macronutrient's diet

'Macros' are the nutrients that provide you with energy and are often referred to as macronutrients that include carbohydrates, protein, and fat. They have the food components that your body requires to sustain its structures and systems. The optimal proportions of macronutrients for people with diabetes are also controversial. The American Diabetes Association (ADA) recommends that macronutrient allocation should be personalized based on metabolic objectives,

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existing eating habits, and preferences. However, some general principles can be derived from the evidence [114]. For carbohydrate intake, the quality (type and source) rather than the quantity may be more important for glycemic control. Whole grains, fruits, vegetables, legumes, and dairy products are preferable sources of carbohydrates than refined grains, added sugars, and processed foods. For protein intake, the ADA recommends that diabetic people should adhere to the same recommendations as the general public: 10-35% of total daily energy intake. However, some studies have suggested that higher protein intake may have beneficial effects in diabetic people on weight loss, glycemia, appetite regulation, and cardiovascular risk factors. An RCT meta-analysis uncovered that rich-protein diets (>20% of total energy intake) reduced HbA1c, fasting glucose, triglycerides, and blood pressure in T2DM people compared to lower-protein diets (<20% of total energy intake) [115,116]. However, the long-term efficacy and safety of these diets for diabetic people are uncertain, especially for those with renal impairment or cardiovascular disease. For fat intake, the ADA suggests that diabetic people should restrict saturated fat consumption to <10% of total energy intake and minimize trans-fat intake. The quality and type of fat may be more important than the quantity for cardiovascular health. Lipid profile and inflammation in diabetic people have been improved by monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs), especially omega-3 fatty acids. A meta-analysis of RCTs found that replacing saturated fat or carbohydrate with MUFAs or PUFAs improved HbA1c, fasting insulin, and HDL (high-density-lipoproteins) cholesterol in T2DM people [116]. However, the optimal ratio of MUFAs to PUFAs and the balance between omega-3 and omega-6 fatty acids are still unclear.

6.2.2. Micronutrients diets

Micronutrients are vitamins and minerals that are essential for various metabolic processes and physiological functions. People with diabetes may have increased requirements or losses of certain micronutrients due to hyperglycemia, oxidative stress, inflammation, or medication use [117]. However, the evidence for routine supplementation of micronutrients for people with diabetes is limited and inconclusive. The ADA recommends that people with diabetes should obtain micronutrients from natural food sources or fortified foods and avoid supplementation unless there is a clear deficiency or increased risk. Some of the micronutrients that have been studied in relation to diabetes outcomes are –

6.2.2.1. Magnesium:

It is involved in glucose metabolism, insulin secretion, and insulin action. Low magnesium intake or status is correlated with a bigger risk of T2DM and impaired glycemic control. Mg supplementation improved insulin sensitivity and fasting glucose in diabetic people or at diabetic risk [117,118]. However, the optimal dose, duration, and form of magnesium supplementation are uncertain.

6.2.2.2. Zinc:

It is needed for the synthesis, storage, and secretion of insulin, as well as the function of insulin receptors. Zn deficiency impairs glucose metabolism and increases oxidative stress and inflammation and Zn supplementation reduced fasting glucose, HbA1c, and triglycerides in people with diabetes [117,119]. However, the effects of zinc supplementation on insulin resistance and other cardiovascular risk factors were inconsistent.

6.2.2.3. Chromium:

It is a cofactor for insulin action and may enhance glucose uptake and metabolism. Cr deficiency impairs glucose tolerance and increases insulin requirements and Cr supplementation improve fasting glucose and HbA1c in people with diabetes [114]. However, the effects of chromium supplementation on insulin sensitivity and lipid profile were variable.

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6.2.2.4. Vitamin D:

It is involved in calcium homeostasis, bone health, immune function, and inflammation. Vitamin D deficiency impairs insulin secretion and action, increases insulin resistance, and promotes beta-cell dysfunction and its supplementation improves fasting glucose and insulin resistance in people with diabetes or at risk of diabetes [118]. However, the effects of vitamin D supplementation on HbA1c and cardiovascular outcomes were unclear.

6.2.2.5. Vitamin B12:

It is essential for the synthesis of DNA, RNA, and myelin. Vitamin B12 deficiency causes megaloblastic anaemia, peripheral neuropathy, cognitive impairment, and cardiovascular disease. People with diabetes may have an increased risk of vitamin B12 deficiency due to dietary restrictions, malabsorption, or the use of metformin. A meta-analysis showed metformin use linked to lower vitamin B12 levels and higher deficiency risk in T2DM [118,120]. However, the clinical significance of these findings and the benefits of routine screening or supplementation of vitamin B12 for people with diabetes are uncertain.

6.2.3. Low-carbohydrate diets

Low-carbohydrate diets are dietary patterns that restrict the intake of carbohydrates, such as grains, starchy vegetables, fruits, and sugars [121]. Instead, they emphasize foods that are high in protein and fat, such as meat, eggs, cheese, nuts, and oils. There are different types of low-carbohydrate diets, such as the diet of ketogenic, low-carb high-fat (LCHF), Atkins diet, and low-carb Mediterranean [109]. The allowed carbohydrate amount varies depending on the type of diet but generally ranges from 20 to 150 grams per day. It has potential benefits for diabetes management and prevention. One of the main factors that influence blood sugar levels is the amount and type of carbohydrates consumed. Glucose is produced from carbohydrates breakdown, which raises blood sugar levels and enters the bloodstream. Reducing carbohydrate intake can reduce sugar levels in the blood and resultant reduced for-insulin needs/medication [122]. Some studies have also reported that low-carbohydrate diets can lead to lower blood pressure, weight loss, lower cholesterol levels, and lower inflammation. These effects can help reduce the risk of diabetes-related complications and cardiovascular disease. However, low-carbohydrate diets are not suitable for everyone and may have some drawbacks or risks. Some people may experience side effects such as fatigue, headache, nausea, constipation, bad breath, muscle cramps, or nutrient deficiencies [123]. It is difficult to follow in the long term or may not provide enough variety or enjoyment. Moreover, some studies have suggested that very low-carbohydrate diets (<50 grams per day) may increase the risk of diabetic ketoacidosis (DKA), a serious condition that happens when too many ketones (acids) produce in our body due to a lack of insulin [122,123]. Therefore, people with diabetes who want to follow a low-carbohydrate diet should consult their doctor or dietitian before starting and monitor their blood sugar and ketone levels regularly.

6.2.4. Other dietary factors that influence diabetes outcomes are

6.2.4.1. Fibre:

It is the indigestible part of plant foods that can be classified into soluble or insoluble types. Fibre slows down gastric emptying, reduces postprandial glucose absorption, lower cholesterol levels, and increases satiety. Increasing dietary fibre intake improves fasting glucose, HbA1c, and body weight in T2DM. The ADA recommends that diabetic people ought to eat at least fourteen grams of fibre per thousand kcal per day [124,125].

6.2.4.2. Alcohol:

It can affect blood glucose levels and insulin action in various ways, depending on the amount and type of alcohol consumed, the presence or absence of food, and the use of medications. Glycemia

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and cardiovascular risk factors in diabetic people may benefit from moderate alcohol intake (up to one drink and two drinks daily for women and men respectively) [126,127]. However, excessive alcohol intake can cause hypoglycemia, hyperglycemia, weight gain, liver damage, and other complications. The ADA advises alcoholic diabetic people to do it in moderation and with food.

6.2.4.3. Non-nutritive sweeteners (NNS):

NNS are substances that provide sweetness without adding calories or carbohydrates. They include artificial sweeteners (such as aspartame, saccharin, sucralose, and acesulfame potassium) and natural sweeteners (such as stevia, monk fruit, and erythritol). NNS help reduce calorie and carbohydrate intake and promote weight loss or maintenance in people with diabetes [128,129]. However, the evidence for their effects on glycemia and long-term health outcomes is limited and inconsistent. The ADA says that NNS are usually safe for diabetic people when consumed within the FDA-set acceptable daily intake levels.

7. Challenges and their reason

Natural remedies, known as ethnomedicine, are often perceived as safer, better, and more effective than synthetic drugs because they are believed to be closer to nature and free of harmful chemicals. However, this perception is not always accurate or supported by scientific evidence. In fact, natural remedies can have serious safety concerns, adverse effects, interactions, and limitations that need to be carefully considered before using them [130]. Therefore, Despite the promising potential of ethnomedicine for diabetes, there are some limitations and challenges that need to be addressed before it can be widely adopted in clinical practice which have been listed in the following bullet points [130–136].

7.1. Lack of standardization

Ethnomedicinal products lack standardization and quality control, leading to potential safety, efficacy, and consistency issues. It also lacks standardized methods for identification, authentication, extraction, and analysis of plant materials, leading to variability in quality, potency, purity, and dosage [137,138].

7.2. Contamination

Natural remedies can be contaminated with substances like pesticides, heavy metals, or microbes, posing health risks. For example, some Ayurvedic herbal products in the US have been found to contain harmful substances [139].

7.3. Lack of regulation

Ethnomedicine is often not regulated or monitored, leaving users vulnerable to risks such as adulteration, contamination, toxicity, and interactions with other drugs or foods [138,139].

7.4. Variability

Natural remedies can vary in composition, quality, potency, and purity due to factors like sourcing, harvesting, processing, and storage conditions. This variability can affect their efficacy and safety [140].

7.5. Lack of methodology

Ethnomedicine's complexity requires suitable methodology, biomarkers, and endpoints for designing, conducting, and analyzing clinical trials and studies [130,141].

7.6. Adverse effects

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Natural remedies may have unintended harmful effects on the body, such as allergic reactions, liver damage, bleeding disorders, or hormonal imbalances. Careful consideration of potential adverse effects is important [142,143].

7.7. Interactions

Natural remedies can interact with medications, supplements, or foods, altering their effects or causing adverse reactions. Awareness of potential interactions is necessary for safe usage [130].

7.8. Limitations

Natural remedies may not be effective or sufficient for treating serious or chronic conditions that require medical attention and supervision. For example, some studies have shown limited effectiveness of echinacea for colds and flu [144,145].

7.9. Lack of evidence

Ethnomedicine often relies on empirical evidence, and there is a scarcity of well-designed clinical trials and mechanistic studies to evaluate its efficacy, safety, and molecular targets [146,147].

7.10. Insufficient scientific evidence

Many ethnomedicinal plants lack robust scientific evidence supporting their clinical effectiveness, especially regarding long-term outcomes, adverse effects, drug interactions, and optimal dosage. More research is needed to evaluate their efficacy and safety [146,148].

7.11. Inadequate clinical trials

Ethnomedicine for diabetes lacks sufficient clinical trials and studies due to factors such as lack of funding, regulation, collaboration, and appropriate methodology and tools [148].

7.12. Limited availability and accessibility

In some regions, ethnomedicinal plants may be scarce or inaccessible due to overexploitation, habitat loss, or climate change. This hinders their availability for use in treatments [130,136].

7.13. Ethical concerns

The traditional knowledge of ethnomedicinal plants is held by indigenous communities, raising ethical issues regarding intellectual property rights, benefit-sharing, and informed consent. Respecting and addressing these concerns is crucial. Ethnomedicine also lacks standardized methods, guidelines, and ethical/legal frameworks for production, processing, quality control, and clinical trials[146,148].

7.14. Cultural barriers and prejudices

Acceptance and integration of ethnomedicine with conventional medicine may be hindered by cultural barriers and prejudices among patients, practitioners, and policymakers. Overcoming these barriers is necessary for effective collaboration [132,133].

7.15. Lack of funding and collaboration

Ethnomedicine faces neglect and a lack of financial support for research, leading to a scarcity of clinical trials and studies. I also lack collaboration and communication, hindering the development of clinical trials and studies [131,148].

8. Future direction to use of ethnomedicine for Diabetes

 doi:10.20944/preprints202308.1622.v1

Despite the various challenge, ethnomedicine for diabetes has a bright future as it offers a complementary or alternative option for the prevention and treatment of this chronic condition. However, more rigorous research is needed to establish its scientific validity, safety and effectiveness in comparison with conventional medicine. Moreover, more efforts are needed to conserve the biodiversity of ethnomedicinal plants and protect the rights of traditional healers who possess valuable knowledge of their uses [146]. In the upcoming research programme and development, researchers should focus on; Rigorous mechanistic studies that can uncover the molecular and cellular mechanisms underlying the antidiabetic effects of ethnomedicine. Translational research based on biomarkers [149] and endpoints that can measure the effects and outcomes of ethnomedicine for diabetes in clinical settings would bridge the gap between basic science and clinical practice to provide evidence-based recommendations and guidelines for the appropriate use of ethnomedicine for diabetes. This can help identify new targets and pathways for therapeutic intervention. Moreover, mechanistic studies should use standardized methods and tools for the identification, characterization and quantification of the active ingredients and metabolites of ethnomedicine [137]. Holistic approaches combining different disciplines and methods such as pharmacology, biochemistry, genomics, proteomics, metabolomics, and systems biology can help understand the complex interactions between ethnomedicine and the body systems. Standardizing the production, processing, and quality control of ethnomedicine ensures consistency and reliability [140]. Rigorous safety studies are needed to monitor adverse effects, interactions, contamination, and variability of ethnomedicine. Testing ethnomedicine in human trials can validate its efficacy and safety for diabetes management, bridging the gap between basic science and clinical practice which will compare it with placebo or conventional treatments. Ethnomedicine should be regulated and monitored to ensure its quality and safety for human consumption. Following best practices and guidelines is crucial and the research on natural remedies can determine their clinical effectiveness for various health conditions, providing evidence-based recommendations and guidelines [148]. Furthermore, more collaboration and communication are needed among different stakeholders to promote awareness, education, and integration of ethnomedicine with conventional medicine for diabetes care.

9. Conclusion

The following are some of the key conclusions that are derived from this study The following are some of the key conclusions that are derived from this chapter:

- Ethnomedicine is a valuable source of knowledge and medicine for the treatment of diabetes mellitus, a chronic metabolic disorder with complex pathogenesis and varied presentation.
- It comprises the traditional use of plants and natural products for treating diabetes mellitus, which has been practised for centuries by different cultures and regions around the world.
- Glucose metabolism is influenced by ethnomedicine through various mechanisms, such as reducing absorption and production of glucose in the gut and liver respectively, increasing utilization in muscles and adipose tissues, and stimulating insulin secretion.
- Ethnomedicine may also have beneficial effects on other aspects of diabetes mellitus, such as oxidative stress, inflammation, lipid profile, and complications.
- Several ethnomedicinal plants and natural products have been evaluated in clinical trials for their efficacy and safety in treating diabetes mellitus, such as bitter melon, fenugreek, ginseng, cinnamon, garlic, ginger, turmeric, aloe vera, nopal, berberine, and ethnomedicine.
- Various ethnomedicinal plants and natural products contain antidiabetic compounds that work through different mechanisms, such as momordicoside, karaviloside, cucurbitacin, charantin, charantoside, cuminoside, S-allyl cysteine sulfoxide, limonoids, vindoline, vindolidine, vindolicine, vindolinine, oleuropein, oleanolic acid, vicenin-1, isoschaftoside, schaftoside, gymnemosides, gymnemagenin, pregnane glycosides and chysalodin.
- Low-carbohydrate diets restrict carbohydrate intake and emphasize protein and fat sources and thus show potential benefits for diabetes management and prevention by lowering blood sugar levels and reducing the need for insulin or medication. However, it is not suitable for everyone and may have some drawbacks or risks.

- However, despite the promising results of ethnomedicine in treating diabetes mellitus, there are still many challenges and limitations that need to be addressed before they can be widely accepted and used in clinical practice.
- Some of these challenges include the lack of standardization, quality control, pharmacokinetic and pharmacodynamic data, dose-response relationship, long-term safety and efficacy data, biomarker evaluation, patient compliance, regulatory approval, and intellectual property rights.
- Therefore, more rigorous and comprehensive research is needed to validate the ethnomedicinal plants and natural products for diabetes mellitus and to explore their mechanisms of action, optimal dosage, potential interactions, adverse effects and cost-effectiveness.

Declaration(s)

Authors' contributions: VR was responsible for manuscript conceptualization, writing - original draft, ethical approvals, consent, and sample collection. VC participated in writing - review & editing. PY contributed to manuscript writing, formatting, revision and communication with all authors.

Funding: This research was unfunded by any public, commercial, or not-for-profit agencies.

Ethical Approval and Consent to Participate: Not applicable.

Consent for publication: All authors consented to manuscript publication.

Availability of data and materials: Data and materials are available upon request.

Acknowledgements: Not applicable.

Competing interests: The authors report no conflicts of interest. Author 1 declared no conflict of interest. Author 2 declared no conflict of interest. Author 3 declared no conflict of interest.

Guarantor: The article's full responsibility lies with PY, who is the corresponding author and the third author in the list.

Annexure 1.

List of plant species and their ethnomedicinal uses. (This table has been taken from a published paper by Pervaiz et al., 2018 [45] and all the corresponding references and citations are available on that paper)

S. No.	Local Name	Taxon Name	Family	Part(s) Used	Ethnomedicinal Uses	Altitude Range; Flowering Phenology
1.	Aal	Viscum album	Loranthaceae	Whole plant	Laxative And Fractures	1000-700m. Flowering: Sept- Dec.
2.	Alua	Solanum tuberosum	Solanaceae	tuber	Burns On The External Body Parts And Tightly Fastened With A Woollen Cloth.	1600-2500; March-April
3.	Anjeer	Ficus carica	Moraceae	Stem, milky	Insect Bite and Warts. Birth Rate Control, Latex, Fruit Pulp	5,420m Flowering: May-August.
4.	Bann Hulla	Tussilago farfara	Asteraceae	Leaves	Astringent, Emollient, Expectorant, Stimulant and Tonic	2800-3800 m. Flowering: January-April.

S. No.	Local Name	Taxon Name	Family	Part(s) Used	Ethnomedicinal Uses	Altitude Range; Flowering Phenology
5.	Banwangun	Podophyllum hexandrum	Berberidaceae	leaves and roots	Skin Diseases, Gastric Problem	2400-4500 m. Flowering: May-August.
6.	Bazarbang	Hyoscyamus niger	Solanaceae	Seed	Tooth Ache	2100-3300 m. Flowering: May-September
7.	Bhang	Cannabis sativa	Cannabaceae	Leaves, seeds	Ear-Ache, Blood Purifier, Scabies	2000-2500m Flowering: May-July
8.	Bhuz	Betula utilis	Betulaceae	bark	Antiseptic	4000-4,500m Flowering: April-May.
9.	Bithur	Juniperus communis	Curpessaceae	Leaves	Rheumatism	1800-3600 m. Flowering: April-May.
10.	Brag Kund	Ziziphus mauritiana	Rhamnaceae	Leaves	Skin rashes	1300-1800m; Flowering: April-May
11.	Brand	Phytolacca acinosa	Phytolaccaceae	Root	Narcotic Effect, Sedative	1500-3000m. Flowering: June-Sept.
12.	Bunufsha	Viola odorata	Violaceae	Leaves,	Seeds And Flowers Respiratory Problems	1800-2600m; Flowering: May-July
13.	Chad	Pinus roxburghii	Pinaceae	Seeds and gums	General Weakness After Child Birth	600-2300 m Flowering: March-June
14.	Chella lubbar	Atropa acuminata	Solanaceae	Roots and leaves	Cough and Antispasmodic	1800-3040 m. Flowering: June-July.
15.	Choora	Angelica glauca	Apiaceae	Root	Vomiting	1800-3700 m. Flowering: June-August

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S. No.	Local Name	Taxon Name	Family	Part(s) Used	Ethnomedicinal Uses	Altitude Range; Flowering Phenology
16.	Daan kul	Punica granatum	Punicaceae	Seed	Jaundice and Anaemia	2000 m-2500m Flowering: Jan–Feb
17.	Dadueja id	Aquilegia fragrans	Ranunculaceae	Flowers	Indigestion	2400-3600 m. Flowering: June-August.
18.	Daech	Vitis vinifera	Vitaceae	Leaves	Skin Rashes, Sores, Eruptions	1700-2100m; Flowering: April-May
19.	Dand jari	Rhodiola himalensis	Crassulaceae	bark	Infection Of Teeth	3300-4800 m. Flowering: June-August.
20.	Danival	Coriandrum sativum	Apiaceae	Seeds	Hair Fall	500-800m Flowering: April-May.
21.	Danthiveer	Salix wallichiana	Salicaceae	Leaves	Fever, Head Ache, General Body Pain	1900-2400; Flowering: April-June
22.	Daraunm	Cynodon dactylon	Poaceae	Whole plant	Common Cold	2600m Flowering: Aug -Oct.
23.	Datur	Datura stramonium	Solanaceae	Seeds	Rheumatism, Frost Bite, Toothache, Tonic	50-2200m Flowering: July-Sept.
24.	Desibangara	Gentiana kurroo	Gentianaceae	Root	Stomach-ache and Urinary Infections	1800-2700 m. Flowering: August-October
25.	Divdar	Cedrus deodara	Pinaceae	Stem, Bark	Skin Rashes and External Ulcers	1,500–3,200 m Flowering: May-July.
26.	Doan kul	Juglans regia	Juglandaceae	Leaf, Bark	Tooth Infection, Scrofula, Rickets And Leucorrhoea	3,000-4,000 m Flowering: March -April

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S. No.	Local Name	Taxon Name	Family	Part(s) Used	Ethnomedicinal Uses	Altitude Range; Flowering Phenology
27.	Gautheer	Dryopteris sp	Pteridaceae	Aerial portion	Cure Kidney and Gall Stones.	1600-2000
28.	Gulab	Rosa webbiana	Rosaceae	Flowers	Cough and Colds.	1500 m - 4000 m. Flowering: May-July
29.	Guri-dud/ Harbi	Euphorbia wallichii	Euphorbiaceae	Stem, leaves, latex	Skin Diseases	2200-4100 m. Flowering: May-August.
30.	Gurisochol, Gandi booti	Euphorbia helioscopia	Euphorbiaceae	Seeds, roots and latex	Abdominal Cramps, Cholera And Eruptions	300-1800 m. Flowering: April-June.
31.	Hand	Taraxacum officinale	Asteraceae	Roots	Back Pain, Common Cold, Chest Infection	1600-2400; Flowering: May-July
32.	Hapatmakei	Arisaema jacquemontiana	Araceae	Rhizome	Muscular Strength and Skin Infections	582 m. - 3819 m Flowering: November - February
33.	Hapatfal	Sambaucus wightiana	Caprifoliaceae	Root	Leaves Chest Congestion, Boils	1500-3600m. Flowering: June-July.
34.	Jandi	Indigofera heterantha	Leguminosae	Leaves	Internal Body Disorders	1500-3000 m. Flowering: May-June.
35.	Jangli dodal	Gnaphalium affine	Asteraceae	Leaves	Antiperiodic, Antitussive, Expectorant and Febrifuge	1200-3000 m. Flowering: Feb-Oct.
36.	Jawand	Thymus serpyllum	Lamiaceae	Leaves, Seeds	Skin Eruptions; (Alopecia). Seed Powder Is Given To Children Against Worm Infection.	1800-2300; Flowering: May-July

S. No.	Local Name	Taxon Name	Family	Part(s) Used	Ethnomedicinal Uses	Altitude Range; Flowering Phenology
37.	Kaenak	Triticum aestivum L.	Poaceae	Seeds	For The Treatment Of Worms	1600-1900; Flowering: March-April
38.	Kah Zaban	Arnebia benthamii	Boraginaceae	Rhizome	Common Cold, Cough, Fever, Blood Purifier	1300-4500 m Flowering: May-July.
39.	Kashkhas	Papaver somniferum	Papaveraceae	Fruit Dry	Cough, Diarrhoea	585- 2056m Flowering: April-June
40.	Kauri booti	Ajuga bracteosa	Lamiaceae	Stem, leaves	Ulcer, Colic and Jaundice	1000-1500m. Flowering: March-December
41.	Kawdach	Berberis lyceum	Berberidaceae	Roots	Indigestion, Constipation	900-2900 m Flowering: March-June
42.	Kazal-Handh	Cichorium intybus	Asteraceae	Root	Rheumatism Sore Throat, Jaundice,	4000-5000 metres. Flowering: June- Sept.
43.	Kim	Morina longifolia	Dipsacaceae	Roots	Insecticide	3000-4000 m. Flowering: June-September
44.	Kour	Picrorhiza kurrooa	Scrophulariaceae	Roots, Rhizome	Fever, Appetizer	3300-4300 m. Flowering: June-August
45.	Kown	Sambucus wightiana	Sambucaceae	roots, leaves and	Diuretic, Purgative	1300-4500 m : Flowering: May –Nov.
46.	Kraeth	Dioscorea deltoidei	Discoreaceae	Leaf	ophthalmic Infections, Urinary Infections	450-3100 m. Flowering: May-July.

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S. No.	Local Name	Taxon Name	Family	Part(s) Used	Ethnomedicinal Uses	Altitude Range; Flowering Phenology
47.	Kuklipo rte	Cuscuta	Cuscutacea e	Whole Plant	Joint Pains, Wound Healing and Falling Of Hairs	1400 m Flowering: Dec - Feb
48.	Kulhak	Nasturti um officinal e	Brassicacea e	Leaf	Stomachic	1500-4000m. Flowering: April-June.
49.	kulman ch	Viburnu m grandifl orum	Caprifoliac eae	Seed	Typhoid, Whooping Cough	2700-3600 m. Flowering: April-May.
50.	kulwaut h	Prunella vulgaris	Lamiaceae	flower	Headache, Fever, Muscular Pain	1600-1900m Flowering:Jun e-July
51.	kuth	Saussur ea costus	Asteraceae	Rhizom e	Joint Pain, Back Pain, Sole Ulcers, Dysentery, Fever, Urinary Problems	2000-3300 m. Flowering: July-August.
52.	Loothar	Galium aparine	Rubiaceae	Leaves	Jaundice, Antiseptic	3500 m. Flowering: March-July.
53.	Losdhi	Stellaria media	Caryophyll aceae	Seed	Skin Infection, Allergy	1500-2500; Flowering: April-Sept.
54.	Mazarm und	Iris kashmir iana	Iridaceae	Whole plant	Joint Pains	1500-1800 m. Flowering: April-June
55.	Meth	Trigonel la foenum-graecu m	Fabaceae	Seeds	Back Pain	1300-1400m. Flowering: Jan- Apr.
56.	Mongol	Senecio grandifl orus	Asteraceae	Leaves, flowers	Dermatitis, Stomach-ache	1200 -4100 m Flowering: March-Sept.
57.	Neelaan	Hackeli a	Boraginace ae	Flowers	Expectorant, Healing Wounds, Treating Tumours	2700-4200 m. Flowering: June-August.

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S. No.	Local Name	Taxon Name	Family	Part(s) Used	Ethnomedicinal Uses	Altitude Range; Flowering Phenology
		uncinatum				
58.	Nuner	Portulaca oleracea	Portulacaceae	leaves	For Liver Inflammation, Cough, Extract Of Whole Plant Is Taken. For Burns Crushed Plant Is Applied On Affected Area	2000-2800 m. Flowering: March-June
59.	Obej	Rumex acetosa	Fabaceae		For Stomach Problems, Whole Plant Is Eaten As Vegetable. For sting of nettles, leaves are rubbed on affected part to get relief.	2100-4100 m Flowering: April-June
60.	Paewakh	Aconitum heterophyllum	Ranunculacea,	Root	Antidote For Snake Bites, To Treat Headache and Cough.	2,400–4,500 m Flowering: April-May
61.	Pahal gassesh	Achillea millefolium Berguer	Asteraceae	Rhizome,	Leaves Headache, Cough, Tooth Ache	1050-3600 m. Flowering: Sept-Oct
62.	Pahal-laish	Cardamine impatiens	Brassicaceae	Whole plant	Asthma, Hay Fever	1500-4000 m. Flowering: May-July.
63.	Pambechalan	Rheum emodi	Polygonaceae	Leaves	Rheumatic Pain, Wounds, Dislocated Joints, Boils	2500-3500; June-August
64.	Parglas	Asparagus officinalis	Liliaceae	whole plant, root	Toothache, Rheumatism, Female Infertility	1,500–3,200 m Flowering: April –July
65.	Phughood	Arctium lappa	Asteraceae	Leaves, root	Skin Disease, Boils, Body Pain	2100-3700 m, Flowering: July-September.

 doi:10.20944/preprints202308.1622.v1

S. No.	Local Name	Taxon Name	Family	Part(s) Used	Ethnomedicinal Uses	Altitude Range; Flowering Phenology
66.	Poshkar	Lamium album	Lamiaceae	Whole plant, leaves, flowers	Cough, Metrorrhagia	1500-3700 m Flowering: April-July.
67.	Pugsley, Shahtaur	Fumaria indica	Fumariaceae	Whole plan	Dyspepsia, Rheumatism	2400 m. Flowering: April-May.
68.	Rubes	Rubia cordifolia	Rubiaceae	Roots	Stomach-ache, Jaundice	300-2800 m. Flowering: June-August.
69.	Sal	Abies pindrow	Pinaceae	Bark	Rheumatism	2100-3600 m. Flowering: April-May.
70.	Sangi-harb	Corydalis govaniana	Fumariaceae	leaves	Respiratory Disorders, Chest Infections, Asthma	2400-4800m. Flowering: May-August.
71.	Shoonkar	Geum elatum	Rosaceae	Root	Astringent, Dysentery and Diarrhoea	3500--5400 m. Flowering: June-August.
72.	Soi	Urtica dioica	Urticaceae	Leaves and Roots	Rheumatism	1000-2500 m. Flowering: Aug-Sept.
73.	Sotal	Malva sylvestris	Malvaceae	seeds	Cough, Fever, Eye Sight	2500-3500 m Flowering: April-June
74.	Sozposh	Lavatera kashmiriana	Malvaceae	Flower	Mumps, Skin Irritation In Pregnant Women	1500-3200m Flowering: July – Sept.
75.	Srub	Anemone obtusiloba	Ranunculaceae	Seeds	Rheumatism	2100-4300 m. Flowering: May-July.
76.	Tethwan	Artemisia	Asteraceae	Leaves	Obesity, Diabetes, Liver Infection	1,500-2,100 m. Flowering: June onwards

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S. No.	Local Name	Taxon Name	Family	Part(s) Used	Ethnomedicinal Uses	Altitude Range; Flowering Phenology
		absinthium				
77.	Tilla	Aconitum violaceum	Ranunculaceae	Root	Antidote for Snake Bites	3600-4800 m. Flowering: July-September.
78.	Trul	Impatiens glandulifera	Balsaminaceae	Leaves	Skin Burn, Joint Pain	July to August 1800–3200 meters
79.	Tsok-tsen	Oxalis corniculata	Oxalidaceae ion, Diarrhoea	Whole plant, leaves.	Toothache, Convulsions, Blood Purification	500-800m Flowering: April-June.
80.	Uzmposh	Androsace rotundifolia	Primulaceae	Rhizome	Cataract	1500-3600 m. Flowering: June-July.
81.	Vangogil	Nepeta raphanorhiza	Lamiaceae	Whole plant,	Dysentery, Toothache	1300-1500m Flowering: Jun-Sept.
82.	Via-gander	Acorus calamus	Acoraceae	Rhizome	Stomachic, Diarrhoea, Cough, Swellings, Joint Pain and Piles	1600-2800.Flowering: July-September
83.	Wantamook	Verbascum Thapsus	Scrophulariaceae	Flowers and stem	Cough, Pneumonia	2500-4500 m. Flowering: June-Aug.
84.	Zakhmi hayat	Berginia ligulate	Saxifragaceae	leaves and roots	Intestine Complaints and Stomach Ulcers	1800-4300m. Flowering: March-July.
85.		Caltha alba	Ranunculaceae	Leaves	Pain And Cramps, For Menstrual Disorders	2400-4000 m. Flowering: May-August.
86.		Juniperus recurve	Curpessaceae	Leaves	Rheumatism Insecticide	3,000-4,000m Flowering: May-June.

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