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Review Article

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

Dr. Vishal Chandra[1], Pramod Yadav[1,2*], Vikas Raghuvanshi[3] and Prakhar Pandey[1]

[1]*School of Life Sciences and Biotechnology, Chhatrapati Shahu Ji Maharaj University Kanpur, Uttar Pradesh, India*

[2]*Amity Institute of Neuropsychology and Neurosciences, Amity University Uttar Pradesh, India, Orcid - 0000-0003-4990-8020, Scopus profile - 58284090500*

[3]*Madurai Kamaraj University, Madurai, Tamil Nādu, 625021, India, Orcid: 0000-0001-8340-0752*

***Corresponding Author**
Pramod Yadav, Amity Institute of Neuropsychology and Neurosciences, Amity University Uttar Pradesh, Noida Campus, 201313, India.

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Abstract

Ethnomedicine, the traditional medical practices and beliefs of a particular cultural or ethnic group, may offer cost-effective and culturally acceptable treatment options for diabetes. Ethnomedicine encompasses various traditional healing practices, such as herbalism, acupuncture, and massage therapy. This article reviews the current evidence-based state of ethnomedicine for diabetes, focusing on the efficacy, safety, and mechanisms of action of selected ethnomedical interventions. The results indicate that some ethnomedical practices, such as herbal remedies and dietary interventions, may have beneficial effects on glycaemic control, insulin sensitivity, and oxidative stress in diabetes. However, the evidence is inconsistent and limited by methodological flaws, such as small sample size, lack of control group, and inadequate reporting. Moreover, some ethnomedical interventions may pose significant risks, such as drug interactions and adverse effects. Therefore, it is essential that patients consult with their healthcare provider before using any ethnomedical interventions for diabetes and that these interventions be rigorously evaluated using scientific methods.

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 [01]. 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 [01].

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 [02]. Ayurvedic texts such as the Charaka Samhita and Sushruta Samhita discuss diabetes-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 [02]. b) Traditional Chinese Medicine (TCM), 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 [03]. 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 [04]. 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 [05].

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 [05]. 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 [06]. 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 [07]. iii) Modern Ethnomedicine Practices such as countries like Indonesia, Malaysia, and the Philippines have a rich heritage of ethnomedicine practices [08]. 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 [08]. 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 [09]. The review 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.

1.1. 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 [10]. It offers novel antidiabetic agents from natural sources that can be further developed into new drugs or nutraceuticals [10, 11]. Ethnomedicine has some advantages over allopathic medicine such as being more affordable, accessible, and acceptable than expensive drugs for various people and regions [12].

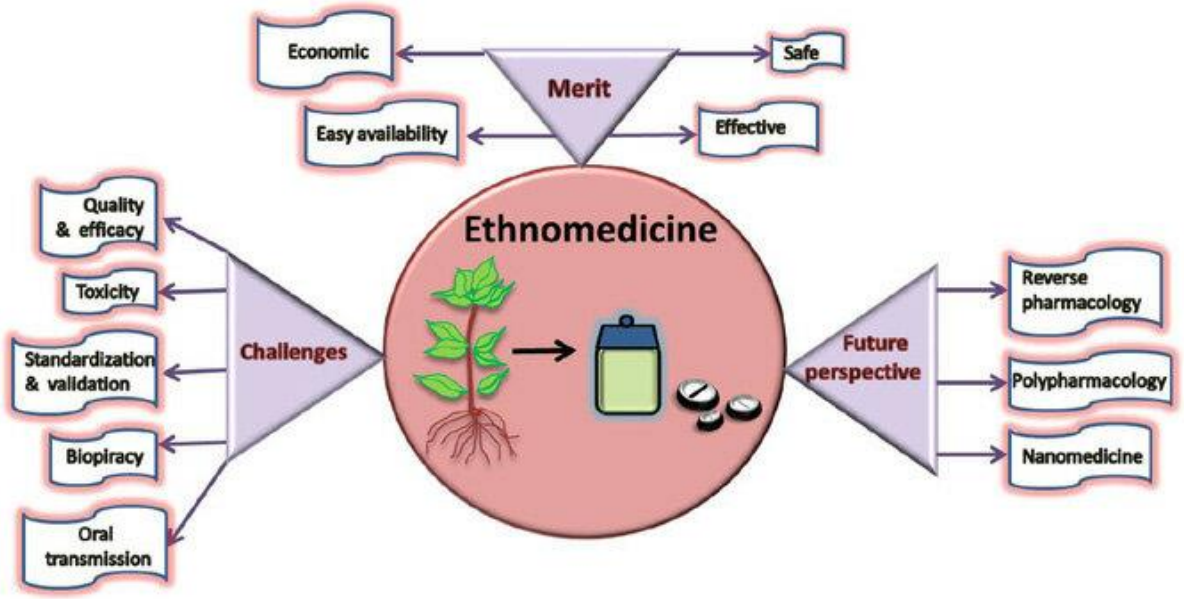

Figure 1: Summary of evidence based ethnomedicine.

1. 2. Herbal Remedies for Diabetes

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 to enhance the efficacy of conventional drugs or reduce their side effects [13]. These plants have shown promising results for treating diabetes and its complications [12]. 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) [14].

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.

Annexure 1.

List of plant species and their ethnomedicinal uses. (This table has been taken from a published and all the corresponding references and citations are available on that paper) [14].

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	Solanumtuberosum	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.
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
16.	Daan kul	Punica granatum	Punicaceae	Seed	Jaundice and Anaemia	2000 m-2500m Flowering: Jan–Feb
17.	Daduejaid	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
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.	Hapat makei	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
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.
47.	Kukliporte	Cuscuta	Cuscutaceae	Whole Plant	Joint Pains, Wound Healing and Falling Of Hairs	1400 m Flowering: Dec - Feb

48.	Kulhak	Nasturtium officinale	Brassicaceae	Leaf	Stomachic	1500-4000m. Flowering: April-June.
49.	kulmanch	Viburnum grandiflorum	Caprifoliaceae	Seed	Typhoid, Whooping Cough	2700-3600 m. Flowering: April-May.
50.	kulwauth	Prunella vulgaris	Lamiaceae	flower	Headache, Fever, Muscular Pain	1600-1900m Flowering:June-July
51.	kuth	Saussurea costus	Asteraceae	Rhizome	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	Caryophyllaceae	Seed	Skin Infection, Allergy	1500-2500; Flowering: April-Sept.
54.	Mazarmund	Iris kashmiriana	Iridaceae	Whole plant	Joint Pains	1500-1800 m. Flowering: April-June
55.	Meth	Trigonella foenum-graecum	Fabaceae	Seeds	Back Pain	1300-1400m. Flowering: Jan- Apr.
56.	Mongol	Senecio grandiflorus	Asteraceae	Leaves, flowers	Dermatitis, Stomach-ache	1200 -4100 m Flowering: March-Sept.
57.	Neelaan	Hackelia uncinatum	Boraginaceae	Flowers	Expectorant, Healing Wounds, Treating Tumours	2700-4200 m. Flowering: June-August.
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.
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 absinthium	Asteraceae	Leaves	Obesity, Diabetes, Liver Infection	1,500-2,100 m. Flowering: June onwards
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.

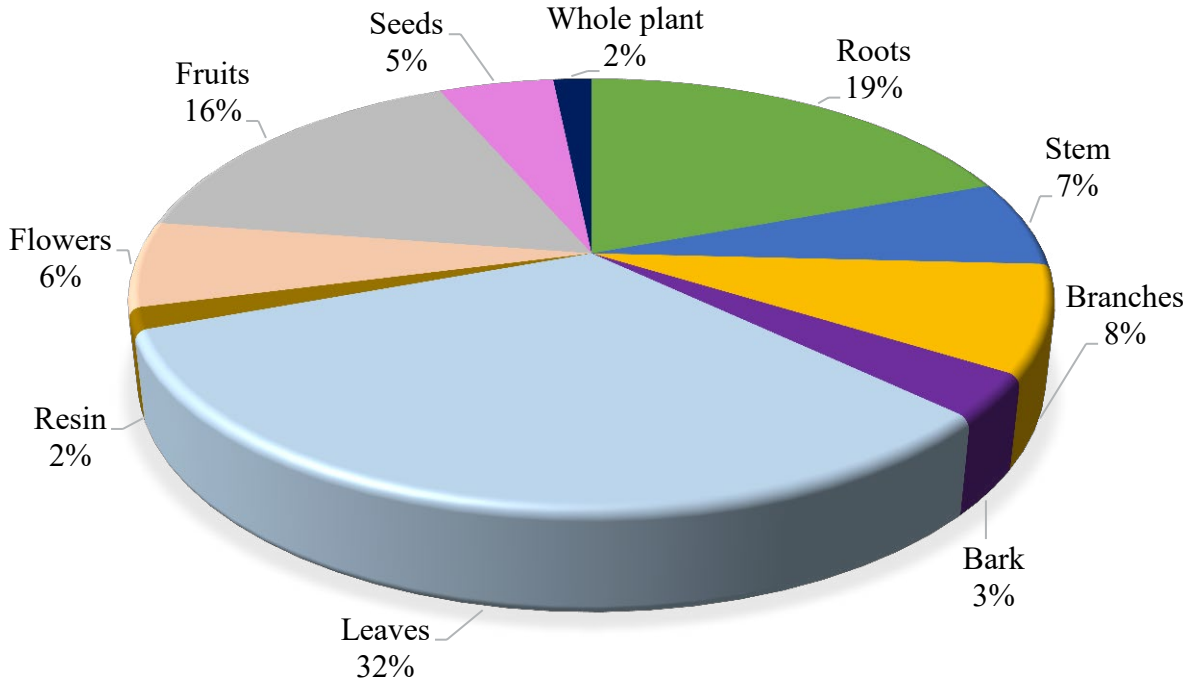

Figure 2: Status of plant parts used as ethnomedicines; source: [15].

Following are some examples of the ethnomedicinal plant and their use are described:

1.2.1. Momordica Charantia L. (bitter melon)

It 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 [16]. 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 [17. 18].

1.2.2. Syzygium Cumini (L.) Skeels (black plum)

Black plum or jamun 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 by 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 [18, 19]

1.2.3. Allium Sativum L. (garlic)

Garlic is originated from central Asia and northeastern Iran. Garlic bulbs have been used for various diseases such as hypertension hyperlipidemia infection and diabetes [20]. 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 compounds like allicin, diallyl trisulfide (DATS), diallyl disulfide (DADS), and ajoene [19] This plant is used by many cuisines and folk medicines to treat various diseases including diabetes [18].

Figure 3: Pictorial view of some medicinal plants.

1.2.4. 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 [13]. 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 [19]. iv) Reducing hepatic glucose production by inhibiting gluconeogenic enzymes and enhancing glycogen synthesis [20]. v) Reducing oxidative stress and inflammation by scavenging free radicals and modulating cytokine levels. vi) 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 [21, 22]. 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, hypoglycaemia, headache, and dizziness [23]. 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 [20, 23].

1.2.5. Aloe Vera

It 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 [24].

1.2.6. Clausena Anisata

African wild orange 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 [24, 25].

1.2.7. Cajanus Cajan

Pigeon peas 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 [26, 27].

1.2.8. Persea Americana

Avocado 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 [28, 29].

1.2.9. Azadirachta Indica

Neem 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 [30, 31].

1.2.10. Catharanthus Roseus

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 [30, 31].

1.2.11. Olea Europaea

Olive 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 [31]. 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 [32, 33].

1.2.12. Trigonella Foenum-Graecum

Fenugreek 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 [34, 35].

1.3. 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" (Healthy Diet, n.d.). 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 [36]. A meta-analysis of RCTs, which stands for randomized controlled trials, showed lower T2DM risk with various dietary patterns except low- glycaemic index (GI), than control diets (Glycemic Index and Diabetes - GI Diet, GI Foods & Benefits of Low GI, n.d.). 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 [37]. Thus, personalized dietary advice based on preferences, culture, and metabolic goals may be better than a single dietary pattern for all diabetic people.

1.3.1. Traditional Diets for Diabetes

Traditional diets are dietary patterns that reflect the food habits and preferences of different cultures and regions [38]. 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 [38].

Examples of key traditional type

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 avocado oil, and nut oils. It incorporates herbs and spices for flavour and health benefits [39, 40]

The Asian Diet: It is a dietary pattern 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 ((2) (PDF) TRADITIONAL FOODS OF INDIA, n.d.; [41]. It also incorporates herbs and spices for flavour and health benefits.

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), fatty fish (such as mackerel, salmon, sardines, and tuna), legumes, and low-fat dairy (such as Skyr yogurt) [42]. 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 olive oil, avocado oil, and nut oils. As above both diaries patter, also incorporates herbs and spices for flavour and health benefits [43, 44].

The Native American Diet: It is a dietary pattern 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 Like all diet patterns, it also incorporates herbs and spices for flavour and health benefits [45, 46].

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 olive oil, avocado oil, and nut oils.
• Incorporate spices and herbs for flavour and health benefits.

The benefits of the traditional diets are [39-46].
• 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.

1.3.2. Examples of Evidence-Based Ethno-Diets

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. Our body requires it 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, existing eating habits, and preferences. However, some general principles can be derived from the evidence [47]. 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). However, the long-term efficacy and safety of these diets for diabetic people are uncertain, especially for those with renal impairment or cardiovascular disease [48, 49].

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 [50]. However, the evidence for routine supplementation of micronutrients for people with diabetes is limited and inconclusive. Some of the micronutrients that have been studied in relation to diabetes outcomes are – 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 [50, 51]. 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 [51, 52]. 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 [47]. 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. Its supplementation improves fasting glucose and insulin resistance in people with diabetes or at risk of diabetes [50]. 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 [50, 53].

Low-Carbohydrate Diets: Low-carbohydrate diets are dietary patterns that restrict the intake of carbohydrates, such as grains, starchy vegetables, fruits, and sugars [54]. 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 [46]. 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. Reducing carbohydrate intake can reduce sugar levels in the blood and resultant reduced for-insulin needs/medication [55]. Some people may experience side effects such as fatigue, headache, nausea, constipation, bad breath, muscle cramps, or nutrient deficiencies [56]. 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 [55, 56].

1.4. 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 [56]. 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 has beneficial effects on people with diabetes by improving blood glucose control insulin sensitivity beta-cell function or lipid profile [57]. Acupuncture also reduces diabetic complications such as neuropathy retinopathy or nephropathy by improving nerve conduction velocity visual acuity or renal function [57]. 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. 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 [56]. It is generally considered safe when performed by a trained acupuncturist using sterile needles. However, some serious adverse events may occur rarely such as pneumothorax cardiac tamponade nerve damage or organ injury [57].

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
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

Table 1: Acupuncture types and point and their effects on diabetes management.

1.5. 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 [58]. Massage therapy has beneficial effects on people with diabetes by improving blood glucose control, insulin sensitivity, beta-cell function, or lipid profile [03]. Massage therapy also reduces diabetic complications such as neuropathy, retinopathy, or nephropathy by improving nerve conduction velocity, visual acuity, or renal function. 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 2 [59 60]. However, some studies have shown no significant difference or inconsistent results of massage therapy on diabetes outcomes [60].

Type of massage	Effects on diabetes treatments
Swedish massage	Lower blood glucose levels (Chatchawan et al., 2015)
Connective tissue massage	Improve circulation in the lower limbs and slow the progression of the peripheral arterial disease (mahluji, 2019)
Thai foot massage	Improve range of motion, ability to stand up, and foot sensation (Chatchawan et al., 2015)
Other types of foot massage	Increase balance and mobility (Chatchawan et al., 2015)
Traditional Chinese massage	Improve neuropathy symptoms (Ezzo et al., 2001)
Abdominal massage	Regulate muscle, pancreatic, and inflammatory factors, and islet function to improve disorders of lipid and glucose metabolism (Xie et al., 2022)
Massage at the site of insulin injection	Lower levels of blood glucose and enhance action of serum insulin in type 1 diabetes patients (Ezzo et al., 2001)

Table 2: Type of massage and their effect on diabetes patients.

Challenges

In some case, natural remedies can have serious safety concerns, adverse effects, interactions, and limitations that need to be carefully considered before using them [61]. 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 [61-67. 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 [68, 69]. 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 [70]. It is often not regulated or monitored, leaving users vulnerable to risks such as adulteration, contamination, toxicity, and interactions with other drugs or foods [68, 70]. 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 [71]. Ethnomedicine's complexity requires suitable methodology, biomarkers, and endpoints for designing, conducting, and analyzing clinical trials and studies [61, 72]. It 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 (Natural Doesn't Necessarily Mean Safer, or Better | NCCIH, n.d.; Toxic, Not Healthy: Surprising Liver Dangers of Herbal Products | Everyday Health, n.d.). It can interact with medications, supplements, or foods, altering their effects or causing adverse reactions [61]. It 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 [73, 74]. 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 [75, 76]. 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 [76, 77]. Ethnomedicine for diabetes lacks sufficient clinical trials and studies due to factors such as lack of funding, regulation, collaboration, and appropriate methodology and tools [77]. 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 [61, 63]. 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 are crucial. Ethnomedicine also lacks standardized methods, guidelines, and ethical/legal frameworks for production, processing, quality control, and clinical trials [76, 77]. 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 [62, 67]. Ethnomedicine faces neglect and a lack of financial support for research, leading to a scarcity of clinical trials and studies. It also lacks collaboration and communication, hindering the development of clinical trials and studies [64, 77].

Future Direction to use of Ethnomedicine for Diabetes

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 [76]. 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 (Focus on Biomarkers Research | National Institute of Neurological Disorders and Stroke, n.d.) 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 [69].

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 [71]. 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 [77]. Furthermore, more collaboration and communication are needed among different stakeholders to promote awareness, education, and integration of ethnomedicine with conventional medicine for diabetes care [78-95].

2. Conclusion

Ethnomedicine is a valuable source of knowledge and medicine for the treatment of diabetes mellitus, and it comprises the traditional use of plants and natural products for treatments. 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.

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