

Ethno-ecological survey of wild plants for the management of Diabetes in Hamirpur district, Himachal Pradesh, India

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Abstract Diabetes is an endocrinological disorder that comprises, Insulin-dependent diabetes mellitus (IDDM), Non-insulin-dependent diabetes mellitus (NIDDM), and Gestational diabetes, which has become a very serious problem throughout the world. To cure diabetes, several oral hypoglycemic agents and insulin therapy are applied as the primary forms of treatment. However, due to the prominent side effects of such drugs, people are seeking alternative therapies that may have fewer or no side effects. In the present study, an ethnoecological survey has been conducted to collect information regarding the remedies for various diseases among the local communities of Hamirpur district, Himachal Pradesh. It was found that 58 wild medicinal plants belonging to 41 families have been used for the treatment of diabetes. The plants used against diabetes predominantly belong to Fabaceae and Moraceae followed by Rutaceae, Lamiaceae, Combretaceae, and Solanaceae (39.65%). Leaves (34.48%) are often used in the form of powder and decoction (70%). Most recommended or cited plants were *Syzygium cumini* (40 citations), *Tinospora cordifolia* (40 citations), *Gymnema sylvestre* (38), *Aegle marmelos* (38), *Azadirachta indica* (38), *Asparagus racemosus* (33), *Momordica dioca* (28), *Berberis asiatica* (27), *Moringa oleifera* (29), *Asparagus racemosus* (27), *Solanum nigrum* (24), *Ajuga bracteosa* (24), *Acacia catechu* (22) and *Swertia chirata* (15). The main objective of this study is to gather information of ethno-medicinal plants used to cure diabetes mellitus. In conclusion, ethno-botanical knowledge on traditional use of anti-diabetic plants is a key to design the pharmacological and clinical trial for the treatment of diabetes. Further, study should be conducted on plants which have no previous records in the literature

Keywords Ethno-medicinal. Traditional folklore. Diabetes mellitus. Endocrinological.

1. Introduction

Diabetes comprises a group of etiologically and clinically heterogeneous disorders with a common set of symptoms described by ancient Egyptians in the Ebers Papyrus about 3500 years ago by the Greek physicians Aretaeus the Cappadocian (A.D. 30-90) and Galen (A.D. 130-200)[23]: excessive thirst and hunger, muscular weakness and weight loss, excessive urination, and elevation of the blood glucose level which, when it exceeds the renal threshold, results in the excretion of glucose in the urine. The main diabetic mellitus is i) Insulin-dependent diabetes mellitus (IDDM), which is characterized by loss of insulin-producing β -cell of the islet of Langerhans in the pancreas and a level of insulin secretion insufficient to restrain the excessive secretion of glucagon leading to insulin deficiency [4]. It is traditionally termed "Juvenile diabetes" as it represents a majority of diabetic cases in children. ii) Non-insulin-dependent diabetes mellitus (NIDDM); which occurs predominantly in older people, for example, 16.8 % of persons over 65 years of age in the United States have NIDDM, and it is often associated with obesity [24,34]. NIDDM represents a variety of diabetic states in which the cells are usually low in number relative to α -cells and insulin secretion is usually sufficient to oppose the ketogenic actions of

glucagon but not to prevent hyperglycemia. iii) Gestational diabetes; which develops in some women when they are pregnant. Most of the time, this type of diabetes goes away after the baby is born. Patients with type 2 diabetes are at high risk of vascular injuries [18], cardiovascular disease [10], and hip fractures [50]. Current therapies for diabetes including insulin and various oral anti-diabetic agents such as sulphonylureas and biguanides have limitations including hypoglycemia and weight gain [20]. Medicinal plants have previously been reported beneficial in hyperglycemia control worldwide and have largely been used as anti-diabetic remedies [41].

The diabetic population is estimated to increase from 4% in 1995 to 5.4% by 2025 worldwide [47]. It is predicted that there are approximately 33 million adults with diabetes in India and expected that this number is likely to increase to 57.2 million by the year 2025 and a total of 700 million people by the year 2045 [34]. At present, every sixth diabetic person in the world is Indian, increasing rapidly in the urban population [44]. Diabetes Federation reported that 194 million people are suffering from diabetes worldwide and the number will increase to 333 million people by 2025. The factors responsible are urbanization, lifestyle changes with high-fat diets and few physical activities, and obesity. In urban areas, diabetes is well managed, and patients have easy access to medicines. However, the expensive cost of treatments, poor medicine availability, and the culture and religious beliefs of the population has led the patient to rely on traditional healers and medicinal plants for the management of diabetes, especially in rural areas [39].

Herbs and plant preparations have served man for thousands of years before modern medicine came into effect. In the case of food, mankind has been educated about its medicinal properties and remedial powers. Even today, it is estimated that more than 80% of the population in developing countries depend on traditional medicine for their primary healthcare [11, 47]. India has a vast ethnobotanical knowledge resource from ancient times viz. Rig-Veda, Charak Samhita, Sushrut Samhita, and Ayurveda and old Indian literature, give an extensive description of thousands of medicinal plants that were being used to cure various diseases and ailments in ancient times [57]. Although modern medicine is widely used in all Asian countries, traditional medicine is still important to a very high proportion of the population [11, 47]. The dense forest cover in India is the primary storehouse of a large number of medicinal plants, which are mostly collected as raw materials for manufacturing drugs. The unique medicinal wealth provides material for the pharmaceutical, phytochemicals, food, flavoring, and cosmetic industries [28].

In Himachal Pradesh, there are about 1,500 species of medicinal and aromatic plants [13]. Hamirpur district is a well-known region of the western Himalayas which is surrounded by intense forest cover rich in floral diversity [31, 58]. The old villages of this area have huge traditional knowledge associated with the use of plants. Several medicines that are extensively used in today's time were once used in traditional medicine such as metformin, a biguanide derived from *Galega officinalis* L. [40] is used to treat diabetes.

It is essential to document traditional medicinal knowledge regarding plants since the utilization of medicinal plants plays a vital role in the lives of rural area inhabitants. Remote areas of developing countries are mostly deprived of health and transport facilities, particularly due to insufficient expenses in the health sector. It makes them dependent for the most part on what they get from the plants. Forests are the only source for them to get vegetables, fruits, and medicines. It may be the best way to get to know about the uses of plants and make such knowledge available for rural communities for their use of traditional medicine, as well as for pharmaceutical discovery.

2. Materials and Methods

2.1 Study Area

Hamirpur (31.6862° N, 76.5213° E) is a district in Himachal Pradesh India, located approximately 90 km from the summer capital Dharamshala (Figure 1). The area is hilly with a rich floral and faunal diversity, encompassed by the Shivalik range that has an elevation varying from 450-1,000 meters. This region possesses plant diversity of rich herbal or medicinal wealth which needs exploration. This region is rich in diverse flora and suitable for ethnobotanical exploration various plants are used for various health problems and diseases, especially diabetes. Our study has explored 54 plant species that have been reported to cure diabetes by local people/ the natives of district Hamirpur.

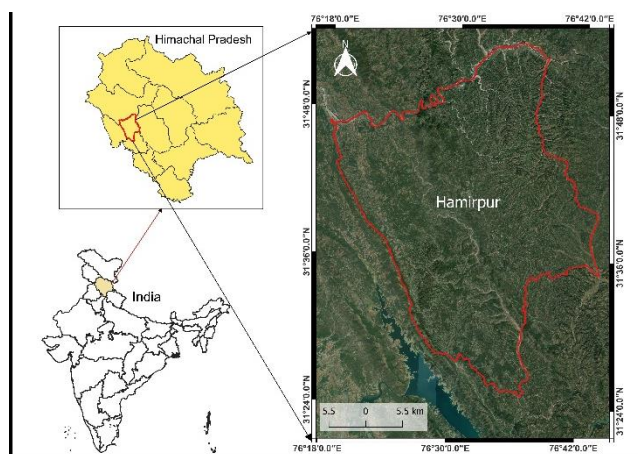


Figure 1. Map of the study area.

2.2 Methodology

The Ethno-botanical survey was conducted in different localities of the study area in Hamirpur district. An open-ended questionnaire approach was used for the documentation of ethnomedicinal information. The questionnaire surveys were carried out in the local community where about 500 informants were selected on a random basis. The selection of respondents was made irrespective of their sex, education, and occupation, and subject to their availability and willingness to share their knowledge. Knowledgeable elders/informants aged 45-65, were usually contacted, including the traditional healers, medicine-selling men, and women in the study area. Discussions and personal interviews were conducted to obtain data about ethnomedicinal plants, plant products, local plant names, methods of preparation of medicine, and their administration, dosage, and their timing as per age. Then it was also accompanied by the field study for collecting plant samples. The plant specimens collected during the survey were preserved in the form of a herbarium. Intensive ethnobotanical exploration was undertaken to find out various medicinal plants used for the treatment of diabetes either in the vegetative, flowering, or fruiting stages. The anti-diabetic plants reported during the study were authenticated from the relevant standard Floras [14] and with the help of voucher specimens available in the herbarium of the Department of Botany, Panjab University, Chandigarh.

3. Result and Discussion

3.1 Diversity of medicinal plant species used against diabetes

In this study, information on 58 plant species of 52 genera belonging to 41 families used for diabetes ailments was documented from sub-divisions (Nadaun, Barsar, Hamirpur, Bhoranj, and Sujampur Tira) of Hamirpur district, Himachal Pradesh (Figure 3). A total of 500 respondents (259 females and 241 males) were selected randomly from diverse educational and occupational profiles which include the homemakers, mid-wives, shopkeepers, farmers, village chiefs, local practitioners, and the “vaidyas.” The 58 anti-diabetic plant species along with their common names, useful part(s), availability status, modes of preparation, and administration were documented. The information regarding the uses for diabetes and their mode of administration is given in Table 1. Plants have been listed according to the family alphabetic order, local name, plant’s part(s) used, and the traditional preparation, in vivo and/or in vitro anti-diabetic activity and other pharmacological activities applied traditionally. Moreover, studies conducted on the medicinal significance of plants, in particularly, diabetes from various regions of the world has been mentioned in Table 2. The researchers now a days exploring the nations traditional medicine to find and alternative for the antidiabetic drugs [2]. However, clinical trials are necessary to provide a conclusive finding on the effectiveness and success of medicinal plant extract for the management of diabetes [17].

3.2 Life forms

In the present study, trees were the primary source of medicinal plants accounted about 37.93% followed by herbs (34.48%), shrubs (20.69%), and creepers (6.9 %), respectively (Figure 2). A similar finding was reported

by Kumar and Bharati, [68] from Uttar Pradesh. The plants in our study have belonged to 41 families with the most projecting family Fabaceae and Moraceae (04 species each) followed by Solanaceae, Rutaceae, Apocynaceae, Lamiaceae, and Combretaceae (3 species each), Liliaceae, Poaceae, Gentianaceae (02 species each) and other families have one species each (Figure3). Medicinal plants from these families could be recognized in wider availability for their use in the study area. In agreement with this, Gohre et al. [19] reported Fabaceae has the highest species richness followed by Asteraceae and Euphorbiaceae from northern Angola; whereas, Chassange et al. [12] from Combodia and Verma [53] from Bundelkhand, India also found Fabaceae as the dominant family followed by Asteraceae and Zingiberaceae in his study. Rahman and Parvin [43] recorded Fabaceae as the largest family among all recorded medicinal plant species from Bangladesh.

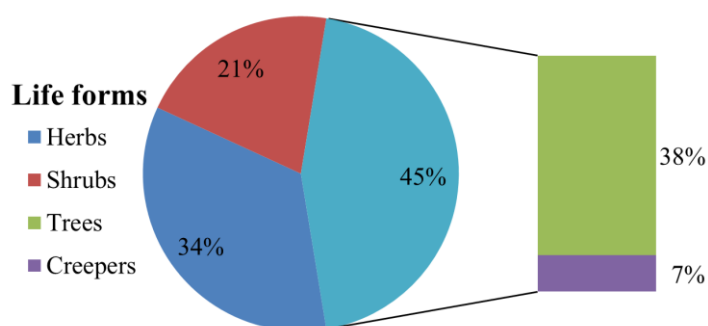


Figure 2. Life forms of the plants in the study region.

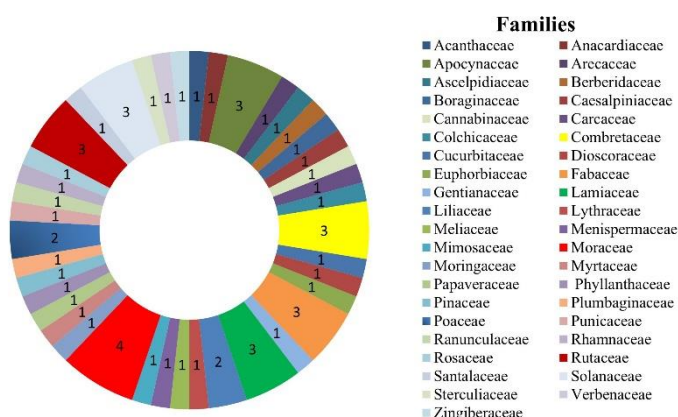


Figure 3. Family-wise distribution of medicinal plants.

3.3 Plant Parts used

In addition to this, out of the recorded total plant species, the leaf component was the most commonly used in the preparation of ethnomedicine. Twelve plant species have been utilized as leaf parts followed by fruit (12 species), Flower (08), Bark (06), Whole Plant (05), Stem (04 species), Seed (3) Stem (02 species), and others only

one species each (Figure 4). Our results conform with other reports in the literature [3, 53]. Wherein leaves and aerial Fruit and flowers were major components used for the preparation of medicines. The powder is a major form of preparation used by the local community followed by Juice, decoction, and fresh form. In most cases of diabetic patients, doses are taken early in the morning on an empty stomach for better results.

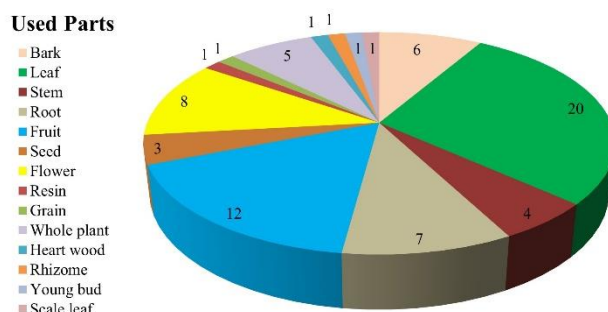


Figure 4. Contribution of plant’s part in the preparation of diabetic medicines.

3.5 Medicinal plants for diabetes disorders.

The medicinal importance of each species depends upon the uses of the plants cited by the informants and the total citations quoted by all informants of the same species. The major parts used are leaves, fruits, seeds, bark, flower, and even whole plants. These parts are taken orally in the form of infusion, decoction, and powder. In previous studies, 46 anti-diabetic species were suggested by 251 respondents [51] and 21 species by the 240 natives of a rural district of Assam [52]. Out of 58 recorded species in Puducherry as anti-diabetic, 22 are similar to the present study [15]. In our study, 1024 citations were made by the 500 informants for 58 plant species that have been implemented for curing diabetes disorder. It means that each species is cited at least 17 times to cure diabetes ailments and it is cited 14 times the most commonly cited plants used to cure diabetes by the local peoples are *Syzygium cumini* (40 citations), *Tinospora cordifolia* (40 citations), *Gymnema sylvestre* (38), *Aegle marmelos* (38), *Azadirachta indica* (38), *Asparagus racemosus* (33), *Momordica dioca* (28), *Berberis asiatica* (27), *Moringa oleifera* (29), *Asparagus racemosus* (27), *Solanum nigrum* (24), *Ajuga bracteosa* (24), *Acacia catechu* (22) and *Swertia chirata* (15) But, it may depend upon the availability of the plants in the locality; hence, least cited plants may be important and more effective. Some newly reported plants from the selected site cited by the community are *Osyris arborea*, scale leaves of *Pinus roxburghii*, *Colebrookea oppositifolia*, *Clematis gouriana*, *Curcuma aromatic*, *Dioscorea bellophylla* and *Gloriosa superba*, there is scope for scientists to work on these plants for scientific validations.

Table 1.Plants used for the treatment of Diabetes by the people of Hamirpur district, Himachal Pradesh

S. No	Plants	Local name	Family	Part of the Plant used	Preparation of medicine
1	<i>Acacia catechu</i> (L.f.) Willd	Khair	Mimosaceae	The heartwood of the root and stem	Root and stem heartwood are cut into small pieces; these pieces are kept in water overnight and the filtrate is given in the morning on empty stomach for blood sugar.
2	<i>Aegle marmelos</i> Linn.	Bil/Bael	Rutaceae	Leaf and Fruit	4-5 leaves eaten raw in the morning before breakfast. Fruit drink is also used daily on empty stomach.
3	<i>Andrographis paniculata</i> (Burm.f.) Nees	Kalmegh	Acanthaceae	Leaf	About 20-25 ml leaf juice is given early morning on empty stomach daily.
4	<i>Ajuga bracteosa</i> Wall ex. Benth	Neelkanthi	Lamiaceae	Whole plant	The whole plant is dried in shade, grounded into powder, and taken one spoon daily two times on an empty stomach.
5	<i>Aloe vera</i> (L.) Burm.f	Ghee kuwaar	Liliaceae	leaf	Fresh leaf juice about 50ml taken on an empty stomach daily in the morning.
6	<i>Argemone mexicana</i> L.	Lee	Papaveraceae	Root	Root powder of about 5-10 gm with water is taken daily two times a day
7	<i>Asparagus racemosus</i> Willd.	Sahanspa	Liliaceae	Root	Root powder of about 5-10 gm with water is taken daily two times a day
8	<i>Azadirachta indica</i> A. Juss.	Neem	Meliaceae	Leaf	Leaves powder mixed with a small amount of black pepper 5-10 g is given daily on empty stomach. Fresh young leaves are eaten daily in the morning on empty stomach.
9	<i>Bauhinia variegata</i> Linn.	Karaal/Kachnaar	Caesalpiniaceae	Bark, Flower, bud	Bark powder 5-10 gm after a meal is taken one time a day. Fresh vegetable of bud and flower is also eaten which is beneficial for curing sugar.

10	<i>Berberis asiatica</i> DC	Kashmal/ Tree turmeric	Berberidaceae	Root and stem	Rasaut prepared from the roots or old stem is given daily in the morning on empty stomach. Roots are crushed and kept in water overnight and the filtrate is taken in the morning on empty stomach. (Rasaut is the product prepared from root and old stem by heating them in water under low flame after that a semi-liquid substance is collected which turned into hard form over time.
11	<i>Butea monosperma</i> Linn	Palash/Dhaak	Fabaceae	Resin, Flower	Resin is taken with water on an empty stomach in the morning, Flowers decoction is also given.
12	<i>Cannabis sativa</i> Linn.	Bhang	Cannabinaceae	Leaf	Few leaves are eaten directly on empty stomach in the morning
13	<i>Carica papaya</i> Linn.	Papita	Carcaceae	Leaf	Leaf juice 20-25 ml is taken on an empty stomach in the morning daily.
14	<i>Cassia occidentalis</i> Linn.	Bari Elvan	Fabaceae	Leaf	Leaf extract 20-25 ml is given on empty stomach daily for 3-4 weeks
15	<i>Cassia tora</i> L.	Chhoti elvan	Fabaceae	Flower	Flowers dried in shade, grounded into powder, and prepared tablets with water about 5-10 g, given two times daily with water.
16	<i>Catharanthus roseus</i> (Linn.) G. Don.	Sadabahar	Apocynaceae	Leaf and Flower	Fresh leaves are chewed directly on empty stomach daily in the morning. Flowers 2-3 g are grounded and given with water on an empty stomach daily.
17	<i>Clematis gouriana</i> Roxb. Ex DC.	Gudbel	Ranunculaceae	Leaf	Leaves are chewed daily in the morning on empty stomach for reducing the blood sugar
18	<i>Colebrookea oppositifolia</i> Sm.	Safed Basuti	Lamiaceae	Flower	Decoction of flowers in 25-30 ml is given on empty stomach in the early morning
19	<i>Cordia dichotoma</i> G. Forst	Lassoda	Boraginaceae	Fruit	Ripened fruits are eaten directly
20	<i>Curcuma aromatica</i> Salisb.	Jangli Haldi	Zingiberaceae	Rhizome	One spoon powder of rhizome is taken with water on an empty stomach daily

21	<i>Cynodon dactylon</i> (Linn.) Pers.	Drubh	Poaceae	Whole plant	Decoction of whole plants in 25-40 ml is given two times daily 30 minutes before a meal
22	<i>Dioscorea bellophylla</i> Voight	Taradi	Dioscoraceae	Leaf	Fresh few leaves are eaten in the morning on empty stomach and taken one glass of water over it. Sometimes it may be taken in the form of Powder along with powder of Bael leaf (<i>Aegle marmelos</i>) 5-10 g daily.
23	<i>Ficus benghalensis</i> Linn.	Badgad	Moraceae	Young buds	Young buds' powder 5-10 g is taken two times daily. Fruit powder is also eaten
24	<i>Ficus palmata</i> L	Dogla/Anjir	Moraceae	Fruit	Fruit is taken daily in the morning
25	<i>Ficus glomerata</i> Roxb.	Gular	Moraceae	Fruit	Fruit juice of about 30-40 ml is given daily two times before a meal
26	<i>Ficus religiosa</i> Linn	Pipal	Moraceae	Fruit	Fruit powder of 5-10 g is used daily, Fresh bark is crushed, and kept in water overnight and the filtrate is taken in the morning on an empty stomach.
27	<i>Gloriosa superba</i> Linn.	Languli	Colchicaceae	Whole plant	The whole plant is dried in shade, grounded into powder, and taken one spoon daily two times on an empty stomach.
28	<i>Gymnema sylvestre</i> B.Br. ex. Schult.	Gudmaar	Asclepiadiaceae	Leaf	Three to four leaves are eaten daily in the morning on an empty stomach
29	<i>Helicteres isora</i> Linn.	Marorphali	Sterculiaceae	Roots	Roots are crushed, kept in water overnight, and then given filtrate in the morning on empty stomach.
30	<i>Holarrhena antidysenterica</i> (Linn.) Wall	Kutaj	Apocynaceae	Bark	Bark powder 5-10 g is taken two times daily before or after a meal
31	<i>Justicia adhatoda</i> Linn.	Vasaka	Apocynaceae	Leaf and Flower	Leaf, flower, and root powder is taken 5-10 g two times daily
32	<i>Leucas aspera</i> (Willd.) Linn.	Chitrak	Lamiaceae	leaf	5-10 g leaves are grounded with 2-3 seeds of black pepper and eaten daily in the morning on empty stomach for 2-3 weeks.
33	<i>Mangifera indica</i> L.	Aam	Anacardiaceae	Seed	Two-three seeds are grounded with 2-3 seeds of black pepper and given 5-10 gm daily two times.

34	<i>Melilotus indicus</i> L.	Ban Methi/Methi ghangs	Fabaceae	Whole plant	Whole plant extract 20-30 ml is given in the morning on an empty stomach
35	<i>Momordica dioca</i> Roxb	Kakora/Ban Karela	Cucurbitaceae	Fruit	Fruit juice about 40-50 ml is given in the morning on empty stomach daily for 8-12 weeks.
36	<i>Moringa oleifera</i> (Lam.)	Sahjan/Sunan	Moringaceae	Stem Bark, Flowers, pods	Powder of the different parts is taken in 5-10 g daily on an empty stomach
37	<i>Murraya koenigii</i> (Linn.) Spreng.	Kurry Patta	Rutaceae	Leaf	Fresh leaf extract or powder is given empty stomach in the morning, Fruits are given for the relief of diabetes.
38	<i>Osyris arborea</i> Wall.	Kayala/Kaila	Santalaceae	Bark Powder	Bark powder 5-10 g after a meal is taken daily.
39	<i>Phoenix sylvestris</i> Roxb.	Jangli Khajoor	Arecaceae	Leaf	Leaf juice of about 20-30 ml is given on empty stomach daily.
40	<i>Phyllanthus nirui</i>	Bhui aambla	Euphorbiaceae Phyllanthaceae	Whole plant	Taken 5-10 g dry powder or fresh form, mixed powder in a small amount of Black pepper and Tulsi.
41	<i>Pinus roxburghii</i> Sarg.	Chir	Pinaceae	Scale leaf	Scale leaves are kept in water overnight, filtrate is taken on an empty stomach in the morning
42	<i>Plumbago zeylanica</i> Linn.	Chitrak	Plumbaginaceae	Root	Roots dried in shade, grounded into powder, and given 5-10 g two times daily
43	<i>Punica granatum</i> Linn.	Daran	Punicaceae	Fruit	The outer part of the fruit dried, powder 5-10 g one spoon used daily for the control of sugar
44	<i>Physalis minima</i> L.	Rashberry	Solanaceae	Fruit, Leaf,	Fresh leaves and fruits are consumed with water on an empty stomach.
45	<i>Pyrus pashia</i> Buch. & Ham.	Kainth	Rosaceae	Bark	Bark extract is taken on an empty stomach
46	<i>Solanum nigrum</i> Linn.	Makua/Karyun mayun	Solanaceae	Leaf	Leaves freshly consumed with water on an empty stomach in the early morning daily

47	<i>Swertia chirata</i> (Wall.) C.B. Clarke	Chirayata	Gentianaceae	Root	Root powder 5-10 g taken two times daily. Root crushed, kept in water, added powder of 2-3 black pepper in it, and taken on an empty stomach daily in the morning
48	<i>Syzygium cumini</i> Linn.Skeels.	Jamun	Myrtaceae	Seed/ Fruit	Seed powder 5-10 g is given on an empty stomach early in the morning. Bark powder is also used, Powder in an equal number of seeds of <i>Ziziphus</i> , <i>Trigonella</i> , and <i>Emblिकासpecies</i> is taken in one teaspoon daily on an empty stomach.
49	<i>Terminalia arjuna</i> (Roxb ex DC) W&A	Arjun	Combretaceae	Bark	The fresh bark is crushed and kept in water overnight and the filtrate is taken orally in the morning on an empty stomach. Bark powder in a 50:50 ratio of Arjun and Jamun mixed may be taken in one teaspoon daily in the morning.
50	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	Harar	Combretaceae	Fruit	Fruit powder of <i>Terminalia bellirica</i> , <i>Terminalia chebula</i> , <i>Phyllanthus emblica</i> in 5-10 g is given on an empty stomach daily.
51	<i>Terminalia Chebula</i> Retz.	Bahera	Combretaceae	Fruit	Fruit powder of <i>Terminalia bellirica</i> , <i>Terminalia chebula</i> , <i>Phyllanthus emblica</i> in 5-10 g is given on an empty stomach daily.
52	<i>Tinospora cordifolia</i> (Willd.) Miers. Ex. Hook. f. &Thoms.	Gulanj/Giloy	Menispermaceae	Stem	Stem crushed and kept in water overnight and filtrate of 40-50 ml taken in the morning on an empty stomach, it may be taken as a decoction or powdered form.
53	<i>Triticum aestivum</i> L.	Gehun	Poaceae	Grain	Wheat grain sprouts are given on an empty stomach daily, it will lower sugar levels within 24 hrs. Straws of wheat kept in water overnight filtrate is given 50-100 ml daily on an empty stomach.
54	<i>Vitex negundo</i> L.	Bana	Verbenaceae	Root	Root powder 5-10 g is given with water two times daily on an empty stomach for 2-3 weeks.
55	<i>Withania somanifera</i> L.	Aswgandha	Solanaceae	Leaf	Two leaves are eaten daily in the morning before breakfast
56	<i>Woodfordia fruticosa</i> (Linn.) Kurtz	Dhavin/Dhaaya	Lythraceae	Flower	Decoction of flowers in 25-30 ml is given on an empty stomach in the early morning

57	<i>Zanthoxylum alatum</i> Roxb	Tirmira	Rutaceae	Leaf, fruit	Leaves are chewed daily in the morning on empty stomach for reducing the sugar. Fruit boiled in water under low flame and decoction is given 20-30 ml on empty stomach in the morning.
58	<i>Zizyphus jujuba</i> Mill.	Ber	Rhamnaceae	Seed	Seed powder 5-10 g is given on empty stomach early in the morning. Powder in an equal number of seeds of <i>Zizyphus</i> , <i>Trigonella</i> , and <i>Emblica</i> is taken one teaspoon daily on an empty stomach.

Table 2. Plants documented in previous studies

Sr No.	Plant species	Family	References
1	<i>Acacia catechu</i> (L.f.) Wild	Mimosaceae	[20]
2	<i>Aegle marmelos</i> Linn.	Rutaceae	[9]
3	<i>Andrographis paniculata</i> (Burm.f.) Nees	Acanthaceae	[2]
4	<i>Aloe vera</i>	Liliaceae	[30]
5	<i>Azadirachta indica</i> A. Juss.	Meliaceae	[46]
6	<i>Bauhinia variegata</i> Linn.	Caesalpiniaceae	[21]
7	<i>Berberis asiatica</i> DC	Berberidaceae	[8]
8	<i>Carica papaya</i> Linn.	Carcaceae	[49]
9	<i>Cassia tora</i> L.	Fabaceae	[34]
10	<i>Catharanthus roseus</i> (Linn.) G. Don.	Apocynaceae	[33]
11	<i>Ficus benghalensis</i> Linn.	Moraceae	[1]
12	<i>Ficus palmata</i> L	Moraceae	[25]
13	<i>Ficus religiosa</i> Linn	Moraceae	[27]
14	<i>Helicteres isora</i> Linn.	Sterculiaceae	[55]
15	<i>Holarrhena antidysenterica</i> (Linn.) Wall Kutaj	Apocynaceae	[56]
16	<i>Justicia adhatoda</i> Linn.	Apocynaceae	[5]
17	<i>Leucas aspera</i> (Willd.) Linn.	Lamiaceae	[6]
18	<i>Mangifera indica</i> L.	Anacardiaceae	[48]
19	<i>Mallotus philippensis</i> (Lam.) Muell. Arg.	Euphorbiaceae	[38]
20	<i>Momordica dioica</i> Roxb	Cucurbitaceae	[22]
21	<i>Moringa oleifera</i> (Lam.)	Moringaceae	[54]
22	<i>Mucuna pruriens</i> (L.) DC.	Fabaceae	[35]
23	<i>Murraya koenigii</i> (Linn.) Spreng.	Rutaceae	[45]
24	<i>Pinus roxburghii</i> Sarg.	Pinaceae	[29]
25	<i>Punica granatum</i> Linn.	Punicaceae	[16]
26	<i>Solanum nigrum</i> Linn.	Solanaceae	[7]
27	<i>Terminalia arjuna</i> (Roxb ex DC) W&A	Combretaceae	[42]
28	<i>Vitex negundo</i> L.	Verbenaceae	[37]
29	<i>Withania somnifera</i> L.	Solanaceae	[36]
30	<i>Zanthoxylum alatum</i> Roxb	Rutaceae	[26]

4. Conclusion

The following plant species are discovered to be medicinally significant to treat diabetes: *Syzygium cumini*, *Tinospora cordifolia*, *Gymnema sylvestre*, *Aegle marmelos*, *Azadirachta indica*, *Momordica dioca*, *Berberis asiatica*, *Moringa oleifera*, *Asparagus racemosus*, *Solanum nigrum*, *Ajuga bracteosa* and *Acacia catechu*. Several plants were used in comparable ways by other ethnic groups in other parts of the world, according to a literature analysis. Additionally, research on some of the medicinal plants' pharmacological properties may support claims that they are successful in treating diabetic conditions. However, there is room for scientists to concentrate on other medicinal plants, such as *Osyris arborea*, scale leaves of *Pinus roxburghii*, *Colebrookea oppositifolia*, *Clematis gouriana*, *Curcuma aromatic*, *Dioscorea bellrophylla*, and *Gloriosa superba*, in order to validate their use scientifically.

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