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REVIEW ARTICLE

A Review on Antidiabetic Edible Plants Used by the Garo Community of Meghalaya, India

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Abstract

Metabolic syndrome is characterized by inadequate insulin secretion. Globally, 2.8% of the population is affected by diabetes, which is projected to reach 4.4% by 2030. Recently, plant-based products have provided significant results for curing diabetes. In this review article, we have summarized the taxonomic classification, phytochemical investigation, toxicological study, and antidiabetic activity of nine edible plants traditionally used by the Garo community of Meghalaya to cure diabetes mellitus. The book "Antidiabetic Plants in India and Herbal Based Antidiabetic Research" by K Chandrasekhar Naidu and T Pullaiah (2003) helps to choose the anti-diabetic plant varieties in Meghalaya. Scopus, Web of Science, PubMed, and Google Scholar databases were used to collect complete information on plants. Each of the chosen plants, according to books and journals, has biologically active components, does not provide a toxic effect at the highest level of dose, and gives significant anti-diabetic activity. This review article serves as a guide for researchers to discover new antidiabetic drugs.

Keywords: Anti-diabetic Edible Plants, Anti-diabetic Activity, Garo Community, Toxicity Study

1. Introduction

Since thousands of years ago plants have been used as a source of drugs. Recently, all over the world, traditional medicines have been getting good responses for the management of diabetic conditions[1]. Owing to their low cost and minimal side effects, natural products play an important role in drug development and discover[2]. Ninety percent of people worldwide, mostly in impoverished countries, utilize shrubs and tree-related products to cure diseases, as reported by the World Health Organization for curing diseases[3]. The WHO has already documented 21,000 medicinal plant species globally, among which 2, 500 originate in India[4]. Northeastern India is rich in medicinal plants and herbs. Meghalaya is a state in northeast India. Garo, Khasi, and Jaintia are the major tribes of Meghalaya. The Garo people live in the Garo Hills, the Khasi people live in the East and West Khasi Hills, and the Jaintia people live in the Jaintia Hills of the state. These three tribes have vast knowledge of medicinal plants and traditional medicinal systems. The Garo people's primary occupation is agriculture, which includes permanent and shifting hill cultivation. This cultivation method is also known as jhum cultivation. The Garo are divided into nine subtribes, which are geographic, vernacular, and subcultural. These subtribes are Awe, Chisak, Matchi-Dual, Matabeng, Ambeng, Ruga-Chibox, Gara-Ganching, Atong, and Megam. Only 15.8% of the Garo population has a primary education.

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The distinctive traditional practices of the Garo make them readily identifiable compared to other ethnic groups[5]. There are approximately 820 medicinal antidiabetic plants in the vicinity of Meghalaya[6].

Diabetes mellitus (DM) is a noticeably long-lasting deteriorating disorder. It is a disorder in which the body does not produce enough insulin, causing blood sugar levels to be too high[7]. Diabetes is characterized by metabolic deregulation, primarily of carbohydrate metabolism[8]. The causes of diabetes are obesity, not being physically active, high blood pressure or high cholesterol, and uncontrolled diets[9].

The current scenario of diabetes globally is about 422 million people and 1.5 million people die due to diabetes each year[10]. In India, 77 million adults suffer from diabetes, making India the second most affected country in the world after China[11]. 95% of Indians suffer from type-2 diabetes. Type-1 diabetes is rare in India compared to other countries. Approximately 20% of people in Kerala suffer from diabetes, which makes Kerala the highest diabetic state in India[12].

The word "Garo" is employed to describe an ethnic community that is mostly centered within the Garo highlands and is a member of the Austro-Mongoloid family[13].The Garos are of Tibetan and Burman ancestry and have migrated from Tibet into Meghalaya and Burma. Similarities between their spoken tongue and Tibetan still exist[14]. Garo tribes are the second largest tribal community in Meghalaya. Garo hills are good resources for medicinal plants.From ancient times Garo people used various traditional healthcare systemsto prevent and cure various diseases[15]. In this review article, we have summarized nine edible anti-diabetic plants traditionally used by the Garo community of Meghalaya, India.

2. Antidiabetic Plants Used by Garo Community of Meghalaya

2.1 Onion (*Allium cepa*)

The onion (*Allium cepa*) (Figure 1a), belonging to the Amaryllidaceae family, is widely recognized as Rasin Gitchak by the Garo tribe of Meghalaya. It is a multi-purpose plant used in traditional medicines owing to its nutritional and health-promoting effect[16]. Currently cultivated in warmer countries, this species is assumed to have originated in southern Asia[17]. The Garo tribes of Meghalaya use this plant as an antidiabetic medicine. The taxonomic classification of onions is presented in Table 1.

2.1.1 Phytochemical Investigation

The most common phytoconstituents of onions are flavonoids, anthocyanins, phenolic acids, and fructose-oligosaccharides18. Flavonoids are major phenolic compounds in onions and are present in different forms such as flavones, flavanols, etc[19]. Anthocyanins are mainly present in red onions[20].

2.1.2 Toxicological Study

Demerdash and Naga (2005) conducted a study of ripe onion extract at doses of 5, 10, 15, 20, and 25 ml/kg in six male Sprague Dawley outbred rats and then kept it for approximately two weeks. They studied the activity of mice for a dozen hours per day for two weeks. No rats died, indicating that all doses of oral gastric gavages employed in the present study did not show any hazardous side effects, because the habits of the laboratory mice were not altered significantly. This therapy did not affect the body weight of mice[21].

2.1.3 Antidiabetic Activities

The introduction of *A. cepa* in its raw form into meals for individuals with diabetes mellitus has been shown to decrease blood glucose level subject decrease[22]. Flavonoids increase the secretion of insulin by controlling hormonal release from pancreatic cells, which in turn increases glucose uptake by cells, resulting in controlled blood glucose levels[23]. The blood glucose-lowering activity of onion is due to the sulfur-containing compound allyl propyl disulfide, which lowers glucose levels by competing with insulin for insulin-activating sites in the liver[24]. Flavonoids present in onion keep blood glucose in control and promote immunity in diabetic patients[25]. Onion acts as

Table 1. Taxonomical classification of *Allium cepa*

Kingdom	Plantae
Order	Liliales
Family	Amaryllidaceae
Class	Liliopsida
Genus	Allium
Species	*A. cepa*

a hypoglycemic agent by directly acting on the muscle and liver and lowers the blood glucose level[26]. If raw onion juice is taken regularly, it can normalize the blood glucose level[27].

2.2 Garlic (*Allium sativum*)

Allium sativum (Figure 1b), which is garlic, belongs to the Amaryllidaceae family. It is an Indian spice with several health benefits[28]. Garlic is known as a rasingipok by the Garo tribe of Meghalaya. Garlic has antineoplastic and hypoglycemic properties. Garlic is used for the treatment of diabetes by Meghalaya people[29]. The taxonomic classification of garlic is given in Table 2.

2.2.1 Phytochemical Investigation

The bioactive compounds in garlic are organosulfur, saponins, phenolics, and polysaccharides[30]. The organosulfur compounds contained allicin, diallyl sulfide, diallyl trisulfide, and alliin[31].Allicin is an amino acid that gives a strong odor to garlic[32]. Saponin compounds are mainly present in purple garlic. Several saponin compounds, such as desgalactotigonin, proto-desgalactotigonin, sativosides B1-rhamose, and sativosides R1, only exist in purple garlic[33]. Garlic contains more phenolic compounds than any other common vegetables[34]. The main phenolic compounds are gallic acid, rutin, pyrogallol, and quercetin[35]. Garlicpolysaccharides in garlic contain 80% fructose, 14% glucose, and 1% galactose[36].

2.2.2 Toxicology Studies

Chronic toxicity of garlic extract was studied in outbred albino rats through oral administration for 6 months. There was no toxic effect on outbred albino rats when garlic juice was administered at a dose of 2000 mg/kg[37]. A high dose of garlic extract had no effect on the body weight of male or female rats[38]. No harmful effects were observed in the organs or tissues according to the diagnosis and study of diseases of the tissues[39].

2.2.3 Antidiabetic Activities

Garlic acts as an anti-diabetic agent by enhancing insulin release from the pancreas from beta cells[40]. Consuming garlic clove daily lowers bloodstream glucose values and increases insulin sensitivity in patients with type 2 diabetes[41]. Oral administration of garlic extracts decreased serum glucose, urea, uric acid, and total cholesterol[29]. Vitamin C present in garlic plays an important role in maintaining blood sugar levels[42].

2.3 Neem (*Azadirachta indica*)

Neem (*Azadirachta indica*) (Figure 1c) belongs to the family Meliaceae. Neem trees are found mainly in India, Pakistan, Bangladesh, and Nepal. Neem is often developed from seeds but can be spread from cuttings[43]. The bark and seeds of the leaves are used in medicine. Neem possesses antibacterial and antifungal properties. Neem leaves are used in the management of hyperglycemia. Its fruits and seeds are a source of neem oil[44]. The taxonomic classification of neem is given in Table 3.

2.3.1 Phytochemical Investigation

The neem leaves contain proteins, carbohydrates, minerals, calcium, vitamin C, glutamic acid, tyrosine, aspartic acid, alanine[45], etc. The leaves mainly contain quercetin, which is a flavonoid with antibacterial and antifungal properties[46]. The neem flower contains nimbosterol and flavonoids such as kaempferol, melicitrin, etc[47]. Flowers also yield waxy materials such as fatty acid, stearic acid, oleic acid, and linolic acid[48]. Seeds of neem contain high levels of lipids as well as

Table 2. Taxonomical classification of *Allium sativum*

Kingdom	Plantae
Order	Asparagales
Family	Amaryllidaceae
Class	Liliopsida
Genus	*Allium*
Species	*A. sativum*

Table 3. Taxonomical classification of *Azadirachta indica*

Kingdom	Plantae
Order	Sapindales
Family	Meliaceae
Class	Magnoliopsida
Genus	*Azardirachta*
Species	*A. indica*

bitter principles such as azadirachtin, azadiradione, nimbin, salanin, salannol, and vepininetc[49]. The trunk bark contains nimbinin, nimbidin, nimbosterol, essential oils, and tannins[50].

2.3.2 Toxicology Studies

Dorababu *et al.,* experimented with extracting neem leaves from the mice using different doses of 200, 500, 1000, and 2500 mg/kg and observed the animals for 24 hours. No death was observed, and the median lethal dose value was considered higher than 2500 mg/kg[51]. The weights of the mice did not change. Kumar *et al.,* experimented with neem leaf extract in mice at dose of 1250, 2500, and 5000 mg/kg. No toxic effect was observed, and mice were found to be healthy and normal with no weight change and no record of allergy or other symptoms[52].

2.3.3 Antidiabetic Activity

Neem leaves are loaded with flavonoids and glycosides, which may help manage blood sugar levels[53]. Daily consumption of neem extract lowers high cholesterol levels and lowers blood sugar levels[54]. Neem leaves contain vitamins A and C, which are powerful antioxidants that regulate insulin release and manage blood sugar levels[45]. Neem reduces inflammation in the body caused by diabetes. Neem leaf powder was found to control type 2 diabetes mellitus[55]. Neem leaves contain calcium, which is essential for diabetes patients[56].

2.4 *Aloe vera* (*Aloe barbadensis*)

Aloe vera (*Aloe barbadensis*) (Figure 1d) belongs to the Asphodelacea family. *Aloe vera* is commonly known as Dikgikamchon by the Garo tribe of Meghalaya. The species has been widely utilized medicinally in India, Mexico, Egypt, Japan, and China for centuries. *Aloe vera* plants have fleshy leaves, fruits, and seeds. Leaves contain the gel, which is 99% water[57]. *Aloe vera* has antifungal, antiviral, antitumor, laxative, antiseptic, and antidiabetic activities. The taxonomic classification of *Aloe vera* is given in Table 4.

2.4.1 Phytochemical Investigation

The major active constituents of *Aloe vera* are vitamins, enzymes, minerals, sugar, lignin, saponins, salicyclic acids and amino acid[58]. *Aloe vera* contains vitamins A, C, and E, which are antioxidants[59]. *Aloe vera* contains minerals such as calcium, chromium, copper, potassium, and sodium, which are essential for the functioning of the enzyme system[60]. Liquid and carbohydrate molecules found in *Aloe vera* gel include cellulose and glucomannan[61]. *Aloe vera* enzymes include alkaline phosphatase, amylase, catalase, lipase, and peroxidase[62]. *Aloe vera* contains 12 anthraquinones[63].

2.4.2 Toxicology Studies

An acute toxicity test of *Aloe vera* extract was conducted on female outbred albino rats at concentrations of 175, 550, 1750, and 5000 mg/kg. outbred albino rats were spotted daily for 14 days. No death of single animals was found, and a lethal dose of *Aloe vera* extract was observed at 5000 mg/kg. The body weight of animals does not changed[64].

2.4.3 Antidiabetic Activity

By a powerful suppression of pancreatic amylopsin action, *Aloe vera* juice functions as an antidiabetic drug and helps to control blood sugar levels[65]. If *Aloe vera* juice is taken for a few weeks, it will reduce the blood glucose levels[66]. The methanol extract of *Aloe vera* contains methyl glyoxal and arginine, which can reduce the blood sugar levels in diabetic patients[67].

2.5 Indian Gooseberry or Amla (*Phyllantus emblica*)

The Indian gooseberry or amla (*Phyllantus emblica*) (Figure 1e) belongs to the family Phyllanthaceae. Amla is known as ambri by the Garo tribe, Meghalaya. It is a medium-sized plant that is 8–18 m in length. Greenish-yellow hues characterize the amla flowers. Ripe crops are tough. Amla is a plant that can grow in both thin and fine clay soils. amla are cultivated in hot and humid environments. Amla has antioxidant,

Table 4. Taxonomical classification of *Aloe barbadensis*

Kingdom	Plantae
Order	Asparagales
Family	Asphodelaceae
Class	Liliopsida
Genus	*Aloe*
Species	*A. barbadensis*

antidiabetic, antifungal, and anti-inflammatory properties[68]. The taxonomic classification of amla is given in Table 5.

2.5.1 Phytochemical Investigations

Amla contains a variety of potent substances, including 3,4,5-trihydroxybenzoic acid, eutannin, citrus bioflavonoids, and robigenin molecules[69]. The Indian gooseberry fruit is also rich in vitamin C[70]. Amla also contains fatty acids such as linolenic acid, linoleic acid, oleic acid, and stearic acid, etc[71].

2.5.2 Toxicology Studies

An acute toxicity test of amla was performed on Swiss albino mice. Male and female Swiss albino mice were collected and subsequently separated into six separate sets of ten each. Swiss albino mice were confined in cages and hungry for the entire night while receiving the liquid. Every set received various doses of 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 g/kg body weight of an amla methanolic extract. It appears that no mice died during the period in which they were constantly monitored. mortality was recorded, and the LD_{50} (lethal dose) was found to be 1125 mg/kg. The weight of Swiss albino mice did not change, and no side effects were observed in the mice[72].

2.5.3 Antidiabetic Activity

Preclinical studies have shown that amla is effective in reducing cholesterol-induced hypercholesterolemia and atherosclerosis in experimental animals[73]. Akhtar *et al.*, have shown that regular intake of amla (3 g/day) causes a dramatic drop in values of total cholesterol, blood sugar levels and triglycerides[74]. Another study by Chen *et al.*, showed that epigallocatechin gallate is a major active constituent of amla, which reduces diabetes[75].

Table 5. Taxonomical classification of *Phyllantus emblica*

Kingdom	Plantae
Order	Malpighiales
Family	Phyllanthaceae
Class	Magnoliopsida
Genus	*Phyllanthus*
Species	*P. emblica*

2.6 Ash Gourd (*Benincasa hispida*)

Benincasa hispida (Figure 1f) is the scientific name of an ash gourd and a member of the Cucurbitaceae family. Ash gourd is known as akarukobok by the Garo tribe of Meghalaya. Ash gourd is a vegetable which is cultivated throughout India. Ash gourd is native to Japan. Winter melon, white pumpkin, and wax gourds are further names for ash gourds. Indigenous therapy frequently uses ash gourds to avoid or alleviate a variety of illnesses. It is further thought that ash gourd aids in maceration, lessens irritation, and stops bacterial infection, and is used in the treatment of type 2 diabetes[76]. The taxonomical classification of ash gourds is given in Table 6.

2.6.1 Phytochemical Investigation

Ash gourd's major active constituents are volatile oil, flavonoids, proteins, saccharides, glycosides, and vitamins[77]. Ash gourd also contains chemicals composed of phenolic structure[78]. (*E*)-2-hexenal, n-hexanal, and n-hexyl formate are the main chemical compounds in ash gourds. Ash gourds also contain various pyrazine molecules as well[78,79].

2.6.2 Toxicology Studies

Ash gourd extract treated with maggots (first and second instar larvae) at 24, 48, and 72 hrs.After 24 hours treatment shows the toxicity effect of ash gourd extract.The calculated LC_{50} is 13.9 g/100 ml[80].

2.6.3 Antidiabetic Activity

Ash gourds reduce blood sugar, triglyceride, and insulin levels. Ash gourds are minimal in energy and great for individuals with hyperglyccemia[81]. Sulforaphanes and other isothiocyanates found in ash gourd increase the natural synthesis of protective enzymes and have been shown to have antidiabetic and antioxidant effects in

Table 6. Taxonomical classification of *Benincasa hispida*

Kingdom	Plantae
Order	Cucurbitales
Family	Curcurbitaceae
Class	Magnoliopsida
Genus	*Benincasa*
Species	*B. hispida*

individuals with diabetes[82]. Ash gourd has zero amounts of glucose and sugar-related compounds, which makes it an ideal food for diabetes patients and helps to reduce blood sugar levels. Taking ash gourd juices continuously lowered the circulating glucose values of individuals with type 2 diabetes within twenty-one days[83].

2.7 Black Plum (*Syzygium cumini*)

Black plum or jamun (*Syzygium cumini*) (Figure 1g) belongs to the family Myrtaceae. The black plum is known as jambu by the Garo tribe of Meghalaya. The black plum tree is found in India, Thailand, Sri Lanka, Nepal, etc[84]. This species bears small, round fruits. When unripe, the plum fruits are green, and when ripe, they are black or violet. The taxonomic classification of the black plum is given in Table 7.

2.7.1 Phytochemical Investigations

The major bioactive compounds in black plum are water-soluble pigments, 2,3,7,8-tetrahydroxy[1] benzopyrano[5,4,3-cde][1]benzopyran-5,10-dione, isotrifoliin, 3,5,7-trihydroxy-2-(4-hydroxyphenyl) chromen-4-one, jambolin, and 3,5,7-trihydroxy-2-(3,4,5-trihydroxyphenyl) -4H-1-benzopyran-4-one[85]. Black plum fruits are also rich in oligosaccharides, monosaccharides, 2-hydroxypropane-1,2,3-tricarboxylic acid, 2-hydroxybutanedioic acid, and 3,4,5-trihydroxybenzoicacid[86].3,4,5-trihydroxybenzoic acid, which has been recognized as the main phenolic component present in black plum[87].

2.7.2 Toxicology Studies

A methanol extract (70%) of black plum was used for toxicology examination. Three separate sets of nine animals were formed. Three animals were included in each set. Groups 1, 2, and 3 received oral doses of 10, 100, and 1000 mg/kg, respectively. No toxic effect was observed even at the highest dose level[88].

2.7.3 Antidiabetic Activity

Black plum stem bark reduced circulating glucose Black plum stem bark reduced the circulating glucose concentration. Because of their ability to scavenge free radicals, substances like 15-carbon flavone skeleton, tannic acid, and isoprenoid terpenes found in black plums demonstrated antioxidant effects and helped lower cholesterol levels[89].

2.8 Mulberry (*Morus alba*)

Mulberry (*Morus alba*) (Figure 1h) belongs to the family Moraceae. It is known as mesgurie by the Garo tribe, Meghalaya. Other names for mulberry include *Ramulus folia* (leaves) and *Ramulus mori* (twigs). Mulberries are fast-growing plants. Mulberry fruits turn from pinkish or crimson to purple or black when ripe and emit a pleasant flavor. Mulberry is native to South Asia. Mulberries decrease blood cholesterol, enhance circulating glucose regulation, minimize the risk of carcinoma, prevent flu and cold, and promote brain health[90]. The taxonomical classification of mulberry is given in Table 8.

2.8.1 Phytochemical Investigations

Important amino acids found in mulberry fruits include (2S,3S)-2-amino-3-methylpentanoic acid, 2-amino-4-methylpentanoic acid, 2-amino-3-hydroxybutanoic acid, L-2,6-diaminohexanoic acid, valic acid, 4-hydroxyphenylalanine, (2*S*)-2-amino-3-(1*H*-indol-3-yl)propanoic acid, alpha-amino-4-imidazole propanoic acid,and 2-amino-3-sulfhydrylpropanoic acid, together with seven dispensable amino acids[91]. The fruits of *M. alba are* rich in fibers, organic compounds, nutrients, lipids, and carbohydrates[92]. Duvoglustat and 1,4-dideoxy-1,4-imino-D-arabinitol are the few significant alkaloids identified in mulberry plants[93,94]. Mulberry fruits contain acidic substances such as

Table 7. Taxonomical classification of *Syzygium cumini*

Kingdom	Plantae
Order	Myrtales
Family	Myrtaceae
Class	Magnoliopsida
Genus	*Syzygium*
Species	*S. cumini*

Table 8. Taxonomical classification of *Morus alba*

Kingdom	Plantae
Order	Rosales
Family	Moraceae
Class	Magnoliopsida
Genus	*Morus*
Species	*M. alba*

(2*E*)-but-2-enedioic acid, 2-hydroxypropane-1,2,3-tricarboxylic acid, and 2,3-dihydroxybutanedioic acid[95]. Mulberry fruit has a high content of phenolic compounds[96].

2.8.2 Toxicology Studies

The acute toxicity test of mulberry leaf extract was performed on 15 rats of both sexes. A single oral dose of 2,000 mg/kg body weight was administered to the rats. After two weeks, no changes in animal behaviors or toxic signs were detected in the treatment rats[97].

2.8.3 Antidiabetic Activity

Polysaccharides from *M. alba* fruit have antidiabetic activity. *M. alba* fruit polysaccharides reduced fasting serum insulin, glycated albumin amount, and fasting blood sugar value observed in diabetic rats after seven weeks of treatment. It also decreases blood and plasma glucose levels. M. Alba leaf juice enhanced post-prandial glucose management in individuals who had impaired sugar metabolism[98].

2.9 Holy Basil (*Ocimum sanctum*)

Holy basil (Figure 1i), also known as tulsi, is a member of the Lamiaceae family. It is a flowering plant that is grown for its aromatic leaves[99]. The leaves were either green or purple in hue. The flowers of tulsi can be pink, purple, white, or red. Tulsi has antioxidant, anti-inflammatory, antifungal, antimicrobial, antidiabetic, and anticancer properties. The taxonomic classification of tulsi is given in Table 9.

2.9.1 Phytochemical Investigations

Retinol, ascorbic acid, micronutrients such as calcium, zinc, and iron, and a variety of other plant-based nutrients are present in holy basil[100]. Tulsi stems and leaves are rich in chemical compounds, such as flavonoids and tannins that might exhibit biological activity[101]. It has been discovered that phenolic compounds protect human cells against free radicals and are used to reduce inflammation. In normal circulatory cells, the hydrophilic flavonoids Orientin and Vicenin have been found to resist radiation-induced chromosomal disruption[102]. Clove oil, urson, and beta-caryophyllene are all present in the tulsi leaf volatile oil[103]. Oil from seeds consists of plant sterols and fatty substances. Carbohydrates and water-soluble vacuolar pigments are found in seed mucilage.

2.9.2 Toxicology Studies

Adult Swiss albino mice of any sex weighing around twenty to twenty-five g were utilized in the study and starved for an entire night before a trial on the toxicology study of tulsi. Four separate sets of mice were created. First, mice in the control group were administered a 0.5% biphasic dosage form of carboxymethyl cellulose, while the remaining three sets received dosages of 200, 600, and 2000 mg/kg of tulsi extract suspended in 0.5% carboxymethyl cellulose[104]. For the initial four hours, the mice were watched for any signs of toxic impact, such as enhanced motor movements, salivary flow, convulsions, stupor, a decrease in weight, and death. Normal inspections were conducted for the entire day. Swiss albino mice were monitored for as long as 14 days, and the number of Swiss albino mice that perished during the investigation was recorded. In administered animals, the 2000 mg/kg dose did not affect any fatalities or adverse symptoms. The animals were completely healthy throughout the study.

2.9.3 Antidiabetic Activity

In streptozotocin-induced diabetic rats, tulsi ethanolic extract effectively reduced circulating sugar, glycosylated hemoglobin, and urea while concurrently increasing glycogen, hemoglobin, and protein levels[105]. Additionally, these compounds led to an increase in insulin levels and improved glucose tolerance in individuals with diabetes[106]. Tulsi leaf components have an impact on the pharmacological mechanisms of insulin release, which could account for its purported anti-diabetic properties. According to Grover *et al.*, feeding healthy rats fructose for a month and then treating them with tulsi leaf juice for a month resulted in greatly decreased blood sugar levels[107].

Table 9. Taxonomical classification of *Ocimum sanctum*

Kingdom	Plantae
Order	Lamiales
Family	Lamiaceae
Class	Magnoliopsida
Genus	*Ocimum*
Species	*O. sanctum*

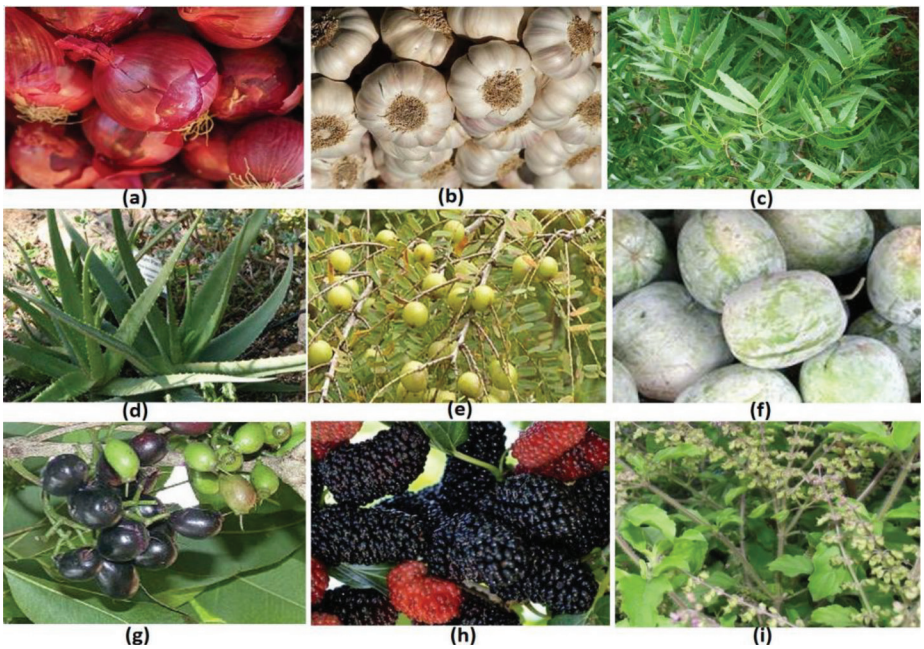

Figure 1. **(a).** *Allium cepa*; **(b).** *Allium sativum*; **(c).** *Azadirachta indica*; **(d).** *Aloe barbadensis*; **(e).** *Phyllantus emblica;* **(f).** *Benincasa hispida*; **(g).** *Syzygium cumini;* **(h).** *Morus alba*; **(i).** *Ocimum sanctum*.

3. Conclusion

Due to their low cost and fewer side effects, plant products play an important role in drug discovery; more than 50% of people suffer from diabetes mellitus in India. Recently, many new drugs have been discovered using traditional knowledge applied by various tribal communities of India. Since ancient times, the Garo community of Meghalaya has used various plant-based traditional medicines to cure diseases. In this article, we summarize nine edible plants that are used by the ethnic community of Meghalaya for anti-diabetic purposes. From these nine edible plants, *A. indica*, *A. cepa*, *O. sanctum*, and *A. barbadensis* show significant anti-diabetic activity. This review article will help natural researchers to discover new anti-diabetic drugs.

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