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Review Article

Antidiabetic Properties of Some Dietary Fruits and Vegetables Commonly used in Bangladesh: A Comprehensive Review

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A B S T R A C T

The number of diabetic people in the world has been increased dramatically over recent years. Currently, in addition to insulin supplements, many modern oral hypoglycemic agents and traditional medicines formulated with medicinal plants are used largely for the treatment of diabetes worldwide. Due to having several limitations of these existing therapies, the search for alternative therapeutic strategy is going on for the successful management and treatment of diabetes. There are numerous plants which are used as both food and medicine simultaneously to improve health status. The great advantages of these plants are that they are safer, readily available, affordable and acceptable. Given the above aspects, regular use of plants having antidiabetic activity in the daily diet may be a new strategy and be used individually or along with other therapies for better treatment and prevention of this disease. The present review reports on some common vegetables and fruits of Bangladesh like Black plum, Guava, Tamarind, Amla, Gooseberry, Jackfruit, Wood apple, Pomegranate, Bitter gourd, Spine gourd, Drumstick tree, Sweet potato, Banana, Water spinach and Cabbage which have shown antidiabetic properties in several scientific studies. Information is collected by thorough literature search from Google Scholar, PubMed and other internet sources. The observed results of this study indicate the possibility of developing a therapeutic strategy called alternative and complementary medicine for the management of diabetes. The results also provide a starting point for researchers working with bioactive dietary plants having antidiabetic potential.

Keywords: Diabetes Mellitus, Antidiabetic Medicinal Plants, Fruits, Vegetables, Bangladesh

Introduction

One of the most common endocrine metabolic disorders is Diabetes Mellitus, the incidence of which is growing at an alarming rate and affecting all parts of the world. It caused 1.5 million deaths in 2012. The economic burden of diabetes generated chiefly by type 2 diabetes (T2D) is also very high for all nations. However, developing countries bear the highest-burden since more than 80% of cases occur in these countries.[1]

Modern medicine cannot cure this disease fully, rather merely attempts to control the symptoms of diabetes e.g. hyperglycemia and tries to mitigate its secondary complications. Besides, many modern medicines have severe side-effects, high cost, and poor availability as well as require long term use. The ethnopharmacological use of herbal medicines for the treatment of diabetes has gained importance in both developed and developing countries of the world. However, their efficacy, bioactive compounds, mechanism of action and safety profiles are not fully examined. Many of traditional plants used in herbal medicine are part of our diet as spices, vegetables and fruits. Several foods contain biologically active components and constitute part of a normal diet particularly some fruits and vegetables. Fruits and vegetables are rich in nutrients, fibre, antioxidants, and many other phytochemicals. Consumption of food or dietary supplement high in antioxidants protects against free-radicals and reactive oxygen species (ROS), and protect us from different chronic diseases like diabetes.[2] To maintain adequate glycemic control, multiple antidiabetic agents are required in most diabetic patients. It is presumed that different constituents of fruits and vegetables induce hypoglycemic effects by several mechanisms like insulin sensitization, increasing insulin release, and α-glucosidase inhibition.[3] Therefore, fruits and vegetables may play a role in the successful treatment of diabetes because they induce pancreatic β-cells for insulin secretion, or bioactive compounds acting as insulin-like molecules or insulin secretagogues.[4] This review article focuses on some common plants constituting part of the regular diet as fruits and vegetables in Bangladesh, a developing country in South Asia, to find out a complementary and alternative therapy (food therapy) for the treatment and prevention of this morbid disorder-diabetes along with or without other available antidiabetic agents.

Materials and Methods

At first, an extensive literature search has been performed regarding the medicinal plants with antidiabetic property and then commonly used dietary antidiabetic plants of Bangladesh were recognized among these numerous plants. In the next step, a considerable amount of literature was collected and analyzed to compile available information related to these dietary plants. This review then presents short details of some plants which are most commonly mentioned in the treatment of diabetes and its associated complications as well as pharmacologically tested for verifying their efficacy on different experimental animal models using presently available experimental techniques. The searches were performed using various electronic databases including Pubmed and Google Scholar. The keywords used in the search were antidiabetic plants; various fruits and vegetables with antidiabetic activity; antidiabetic plants of Bangladesh.

Result

After analysis of information regarding the anti-diabetic potential of dietary plants from various research journals, this review has enumerated a total of such 15 plants (8 Fruits and 7 vegetables) belonging to 11 families. The mentioned plant species are *Syzgium cumini, Psidium guajava, Tamarindus indica, Phyllanthus emblica, Phyllanthus acidus, Artocarpus heterophyllus, Aegle marmelose, Punica granatum, Momordica charantia, Momordica dioica, Moringa oleifera, Ipomoea batatas, Musa sapientum, Ipomoea aquatic and Brassica oleracea var. Capitata*. The following paragraphs present the list of fruits and vegetables having anti-diabetic properties with their scientific name, their family and the name of the country in which they are largely available. A summary of enlisted plants with bioactive agents and activity about diabetes is tabulated at the end of the review (Table 1). Here antidiabetic properties of edible plant parts have been considered only.

Fruits Having Antidiabetic Activity

Fruits are highly nutritious natural food eaten both in raw or processed form. According to different studies, fruits contain high number of antioxidants such as flavonoids, carotenoids, hydroxycinnamic acids, etc. which may protect human body against functional damage caused by reactive oxygen species. Radical scavenging ability of antioxidant rich foods is correlated with their potentiality for the management of degenerative diseases like diabetes.[5]

Black Plum: *Syzigium Cumini*

A very large evergreen tropical tree which belongs to the family Myrtaceae and is native to India (Figure 1).[6] Today these trees are also found in Asian subcontinent, Eastern Africa, South America, Madagascar and Florida and Hawaii in the United States of America.[7] It has been found that that the pulp extract of this fruit produced a very significant hypoglycemic effect in normoglycemic and streptozotocin (STZ) induced diabetic rat model over oral administration of the dose and it was thought to be mediated by enhancing the endogenous insulin secretion. Interestingly, the seeds of this fruit extract were found to produce the similar effect but in a very delayed mode i.e., around after 24 hours of oral administration.[8,9]

(a)

(b)

Figure 1.(a). Black Plum fruits in tree stem; (b). Black Plum fruits

(Source: www.floraofbangladesh.com&https://www.hindustantimes.com, respectively)

Guava: *Psidium Guajava*

It is a medium sized evergreen tree of the family Myrtaceae. Though it is native to tropical America but now cultivated throughout the tropics of suitable climate (Figure 2).[10] The fruit of *Psidium guajava* is rich in natural antioxidant compounds such as vitamin C and polyphenolic compounds. *P. guajava* unripe fruit peel aqueous extract showed marked hypoglycaemic and anti-hyperglycaemic effect in normal, STZ induced mild and severely diabetic rats' model.[11] Powder of PG ripe fruits without seeds supplemented orally in STZ-induced diabetic showed a significant antihyperglycemic effect associated with its antioxidative activity.[12]

Figure 2.Guava Fruits

(Source: www.palmnursery.com.au)

Tamarind: *Tamarindus Indica*

It is an important tropical fruit of the family Fabaceae found in Africa and Asia. Different parts of this plants like fruit pulp, seeds and stem barks are also reported to possess antidiabetic and hypoglycemic properties in several studies (Figure 3).[13,14] Moreover, in a different study, it had been elucidated that the ethanolic extracts of the fruit pulp of *Tamarindus indica* possessed a very good antidiabetic as well as hepatoprotective activity when administered in alloxan induced diabetic rats through oral route.[15]

Figure 3.Fruits of Tamarind

(Source: www.biobotanica.com)

Amla: *Phyllanthus Emblica*

This plant belongs to the family Euphorbiaceae and grows abundantly in tropical and subtropical parts of China, India, and the Malay Peninsula (Figure 4).[16] This highly nutritious fruit is of high value in traditional system of medicine and is being used in several indigenous medical preparations against headache, liver injury, atherosclerosis and diabetes.[17] Ethanolic fruit extracts of *P. emblica* possesses antidiabetic effect in streptozotocin-induced diabetic rats.[17]

Figure 4.Amlafruits

(Source: www.nutriketo.it)

Gooseberry: *Phyllanthus Acidus*

This plant belongs to the family Euphorbiaceae. It is originated in Madagascar and commonly grown in Indonesia, South Vietnam, Loa, and Thailand in home gardens (Figure 5). In a study over Swiss-albino mice, orally

administered Methanolic extracts of *Phyllanthus acidus* fruits pulp showed effective blood glucose lowering activity in a Glucose Tolerance Test (GTT).[18]

Figure 5.Gooseberry fruits
(Source: www.wallpaperflare.com)

Jackfruit: *Artocarpus Heterophyllus*

It is a large, evergreen tree of the Moraceae family. The jackfruit tree is believed indigenous to the rain forests of the Western Ghats of India but now grows abundantly in many parts of Southeast Asia (Figure 6).[19] Flakes and seeds of ripe fruits taken as foods are high in nutritive value. Through a study, it had been showed that the oral administration of aqueous extracts of *A. heterophyllus* fruit had the capability of lowering the serum glucose level as well as increasing glucose tolerance in diabetic rats.[20]

Figure 6.Jackfruit
(Source: www.amazon.in)

Wood apple: *Aegle marmelose*

It is a medium sized perennial tree belonging to the Rutaceae family and is native to India but also grows in several areas of Southeast Asia (Figure 7).[21] *A. marmelos* is traditionally used as an excellent remedy for diabetes mellitus. Aqueous extract of *Aegle marmelos* fruit has shown hypoglycaemic effect against streptozotocin-induced diabetes in rats when administered orally.[22] Its hypoglycaemic effect may be due to the presence of coumarins in the fruit extract.[22]

Figure 7.Wood apple fruits
(Source:www.hippopx.com)

Pomegranate: *Punica granatum*

It is a shrub or small tree of the Punicaceae family and appears to be native to some parts of Asia (Iran, Malesia, and India), America (USA, Peru), Africa (Equatorial region), and Europe (Turkey) (Figure 8). Because of its bioactive compounds pomegranate is used traditionally for the treatment of various disorders including diabetes. Both for the short-term and long-term experiment on alloxan induced Wistar rats, it has been found that the oral dose of the aqueous extract of pomegranate fruits are capable of normalizing glycemia which has been proven through showing a noticeable reduction in Fasting Blood Glucose (FBG) level. Moreover, through a study operated on streptozotocin-nicotinamide induced T2DM it has been shown that the fresh juice of ripe sweet pomegranate has significant lipid lowering activity along with its capability of improving the health of pancreatic islets of Langerhans on those mice.[24] These effects are helpful in amelioration of diabetes-associated complications.

Figure 8.Pomegranate fruit
(Source: www.planetayurveda.com)

Vegetables Having Antidiabetic Activity

Every day we take vegetables in our regular diet. Many scientific evidences are supporting the role of vegetables against different diseases. Villegas and his co-workers proposed that regular consumption of cruciferous vegetables, green leafy vegetables, yellow vegetables, allium vegetables, tomatoes and others decrease the risk of type 2 diabetes.[25] Vegetables are ideal food for diabetic people because most vegetables are low in calories and carbohydrates as well as great source of fiber, vitamins, minerals, and antioxidants.

Bitter gourd: *Momordica charantia*

It is a useful medicinal and vegetable plant belonging to the family Cucurbitaceae. Bitter gourd fruit is used indigenously for the treatment of diabetes and related ailments in Asia, South America, India and East Africa (Figure 9).[26] One experiment carried on alloxan-induced diabetic albino rats supported that *Momordica charantia* fruit extract enhances insulin secretion by the islets of Langerhans, reduces glycogenesis in liver tissue, improves peripheral glucose utilization, raises serum protein levels and repairs the altered histological features of the islets of Langerhans to its normal state.[27] In an intervention study among prediabetic individuals bitter gourd supplementation lowered elevated fasting plasma glucose.[28] A clinical study also showed the beneficial effects on glycemic control and potential systemic complications of type 2 diabetes mellitus.[29]

Figure 9.Bitter Gourd fruits
(Source: Google image)

Spine gourd: *Momordica dioica*

It is an important medicinal herb and vegetable belonging to the family Cucurbitaceae. *Momordica dioica* is a perennial dioeciously climber with tuberous roots, native to Asia and extensively distributed in India and Bangladesh (Figure 10).[30] Methanolic extract of *M. dioica* fruit showed an anti-diabetic and renoprotective effect in streptozotocin-induced diabetic rats in a study.[31] Another study performed on alloxan-induced diabetic Wistar rats revealed that aqueous extract of *M. dioica* fruit possesses good anti-diabetic activity.[32]

Figure 10.Fruits of Spinegoard
(Source: www.bonanza.com)

Drumstick Tree: *Moringa oleifera*

This member of the family Moringaceae is an exceptionally nutritious vegetable, native to India and also grows in the tropical and subtropical regions of the world (Figure 11).[33] Researchers reported its hypoglycemic potential in several studies. In normoglycemic and alloxan-induced diabetic rats, an aqueous extract of *M. oleifera* leaves exhibits hypoglycemic activity.[34] Besides the methanolic extract of *M. oleifera* pods shows enhanced cellular antioxidant defences and minimizes hyperglycemia in streptozotocin (STZ)-induced diabetic albino rats.[35]

(a)

(b)

Figure 11.Leaves (a) and pods (b) of Drumstick tree
(Source: Google image)

Sweet potato: *Ipomoea batatas*

It is a trailing herb belonging to the family Convolvulaceae. It is native from Central or South America and cultivated for its succulent tuberous roots in many tropical and subtropical countries (Figure 12). A study done by Kusano and Abe showed that oral administration of Ipomoea batatas revealed remarkable antidiabetic activity and improved abnormality of glucose and lipid metabolism by reducing insulin resistance along with re-granulation of pancreatic beta cells in obese Zucker fatty rats.[36]

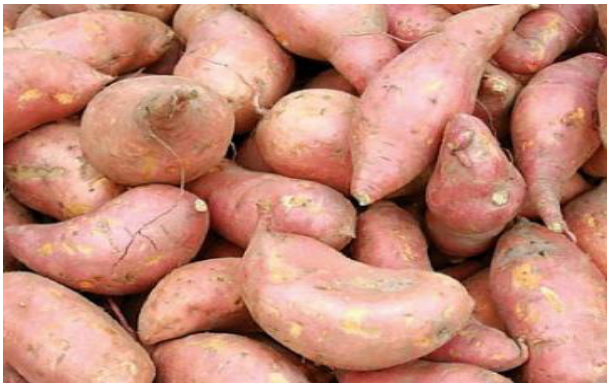

Figure 12.Sweet potato roots
(Source: www.dairyknowledge.in)

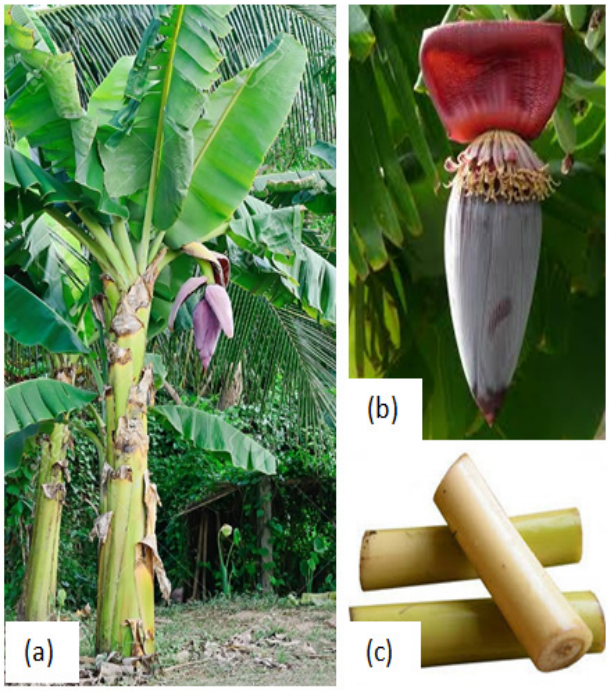

Figure 13.a) Whole Banana tree; b) Infructescence stalk; c) Inner stem
(Source: www.dairyknowledge.in)

Banana: *Musa sapientum*

This herbaceous plant of the Musaceae family is a major fruit crop grown globally and consumed in many countries throughout tropics and subtropics (Figure 13).[37] Aqueous extract of banana (*Musa sapientum*) infructescence stalks reduces blood glucose level prominently in streptozotocin-induced diabetic rats if consumed on daily basis instead of drinking water.[38] The juice of the central part of the stem of the *M. sapientum* has a significant hypoglycemic effect in streptozotocin-induced diabetic rats.[39] Numerous biologically effective phytochemicals like plant tannins, pectins, dopamine, serotonin, noradrenaline, sitosterol, and stigmasterol are found in its fruit part.[39]

Water spinach: *Ipomoea aquatica*

This aquatic plant belonging to the family Convolvulaceae is a common green leafy vegetable consumed in many parts of the world and grows abundantly in marshy areas (Figure 14). Boiled and blended *Ipomea aquatica* extract showed oral hypoglycemic activity in normoglycaemic healthy, male Wistar rats in single and multiple doses.[40] In another study, a similar extent of hypoglycemic effect as Tolbutamide was exhibited by aqueous extract of *Ipomoea aquatica* in glucose-challenged Wistar rats.[41] Additionally, the oral hypoglycaemic effect of this plant has been demonstrated in streptozotocin-induced diabetic Wistar rats and patients with Type II diabetes.[42]

Figure 14.Leaves of Water Spinach
(Source: Google image)

Figure 15.Cabbage
(Source: Google image)

Cabbage: *Brassica oleracea var. Capitata*

It is a species of Brassica belonging to the Brassicaceae family and native to Coastal Southern and Western Europe (Figure 15).[43] Few animal studies have been performed on Brassica oleracea var. Capitata for its anti-diabetic properties. In a study, in alloxan-induced diabetic rabbits, oral administration of Methanolic extract of Brassica oleracea var. capitata (MEB) exhibited hypoglycemic and hypolipidemic effects.[43] Another study ascertains that oral administration of ethanolic extracts of Brassica oleracea var. Capitata plant leaves reveal antihyperglycemic and antioxidant properties in alloxan-induced diabetic rats.[44]

Table 1.Summary of plants with bioactive agents and activity or mode of action

S. No.	Scientific Name	Bioactive constituents	Activity or mode of action	References
1.	*Syzygium cumini*	anthocyanins, delphinidin, petunidin, malvidin-diglucosides, isoquercetin, quercetin, mycaminose, gallic acid, ellagic acid, tannin	Decrease blood glucose level, free radical scavenging activity, Increase insulin secretion from beta cells of pancreas, Increase glucose tolerance activity	[48, 49, 7]
2.	*Psidium guajava*	Terpen, Flavonoid, Strictinin, isostrictinin, Pedunculagin, Polysaccharide	Decrease blood glucose level, Increase insulin sensitivity, enhance peripheral glucose metabolism	[50, 47, 49]
3.	*Tamarindus indica*	Flavonoid, Polysaccharide, tartaric acid, ascorbic acid.	Antidiabetic, Antioxidant and hepato-protective, hepatoregenerative activity	[50, 15]
4.	*Phyllanthus emblica*	Tannin, Flavonoids, gallic and ellagic acid	Increase pancreatic secretion of insulin, Free radical scavenging activity, Glucosidase enzyme inhibition	[50, 16, 17]
5.	*Phyllanthus acidus*	Tannin	Not available	[50]
6.	*Artocarpus heterophyllus*	Sapogenin	Not available	[50]
7.	*Aegle marmelose*	Aegeline 2, Coumarin, Flavonoid, Alkaloid	Decrease blood glucose & glycosylated Hb, Increase glucose tolerance	[50]
8.	*Punica granatum*	Tannin Vitamin C, protein, gallic acid, pelletierine	Reduce blood sugar level	[48]
9.	*Momordica charantia*	Momordicine alkaloid Ascorbic acid Charantin, Momordicin, Galactose binding lectin Non-bitter, Diosgenin, Cholesterol, lanosterol, β-sitosterol, Cucurbitacin glycoside	Reduce blood glucose level Enhance insulin secretion and peripheral glucose utilization	[50, 27, 48]
10.	*Momordica dioica*	Alkaloids, Ascorbic Acid Lectin, β-sitosterol, glycosides, saponins, triterpenes	Antidiabetic and Renoprotective activity	[31, 32]
11.	*Moringa oleifera*	Not available	β-cell protective action, enhancement of cellular antioxidant defense	[31]
12.	*Ipomoea batatas*	β-carotene, manganese, and vitamins	Reduce insulin resistance and blood glucose level	[51, 47, 48]
13.	*Musa sapientum*	Starch, vitamins, and minerals	Reduce blood glucose & glycosylated Hb	[51, 48]
14.	*Ipomoea aquatica*	Carotene	Reduce fasting blood sugar level & serum glucose level	[48]
15.	*Brassica oleracea var. Capitata*	polyphenolics, glucosinolates, carotenoids and vitamins	Not available	[2]

Discussion

During the last two decades, diet therapy has become an important aspect of controlling diabetes. It is well known that most of the fruits, vegetables and spices contain a high of antioxidants and other phytochemicals. Diabetes can be treated by antioxidants due to their various therapeutic benefits.[45] Antioxidants can preserve ß-cell function, lower oxidative stress which increases the progression of diabetes and prevent the production of secondary complications by inhibiting diabetes-induced ROS formation.[46] Fruits and vegetables reduce the risk of diabetes due to their anti-oxidant activity after their consumption through diet. So, antioxidant-rich foods like fruits and vegetables can be beneficial in the treatment as well as prevention of diabetes. The protective action of these food crops has been attributed to the presence of antioxidants such as polyphenols, flavonoids, alkaloids, tannins, Vitamin C, Vitamin E etc. and other constituents which show a reduction in blood glucose levels through a different mechanism of action like effects on the activity of pancreatic ß-cells (synthesis, release, cell regeneration/revitalization), enhancing protective/inhibitory effect against insulinase and the increase of the insulin sensitivity or the insulin-like activity of the plant extracts, improvement of glucose homeostasis, increase of peripheral utilization of glucose, increase of synthesis of hepatic glycogen and/or decrease of glycogenolysis, inhibition of intestinal glucose absorption, reduction of the glycaemic index of carbohydrates, reduction of the effect of glutathione.[47] Diabetic complications may also be reduced or removed due to these actions. There is scope to prove the long-term beneficial effect of dietary fruits and vegetables, to recognize the active component, to clarify the mode of action and toxicology, which is not well-defined at present for exploiting their antidiabetic potency. Hence, it is important to be listed and presented in a single place to discover any possibilities of new antidiabetic strategy. Furthermore, one can look forward to a future of integrated therapies and anticipate that research in alternative medicine will help to determine successful treatment and recovery of diabetes as well as its complications.

Conclusion

In the above study, it has been demonstrated that many of the elements of this review were defined in previous studies about diabetes by different researchers. However, the present research provides a direction to select specific food ingredients for the diet of diabetic people and normal day-to-day food consuming system in order to prevent such diseases. Several fruits, vegetables and spices which form constituents of our normal diet were used traditionally as efficient antidiabetic agents in rural as well as urban areas due to their plentiful availability. Abundant experimental studies in animal models and a few number of clinical studies with humans have also confirmed their antidiabetic potential. So it can be concluded that their dietary application may be an easy, feasible and cost effective measure to prevent and manage diabetes mellitus. An attempt has been made in this review to enlist them and compile their available information with a view of encouraging their use in regular diet towards reducing the prevalence of diabetes globally. Though this study only compiles their botanical identity, origin, dietary application, bioactive compounds and activity in experimentally induced diabetic animal models, there is a scope of further study and continuing research is essential to explain the exact mode of action, well characterization of bioactive components and toxic effects of these food materials in order to develop new antidiabetic agents.

Conflict of Interest: None

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