



## EDIBLE FRUITS - NATURE'S GIFT FOR DIABETIC PATIENTS - A COMPREHENSIVE REVIEW

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### ABSTRACT

Diabetes is a chronic metabolic disorder with altered carbohydrate, fat and protein metabolism characterized by increased fasting and post-prandial blood sugar levels resulting from either insulin insufficiency or insulin dysfunction. There are many herbal remedies suggested for diabetes and diabetic complications. Fruits and vegetables are an important part of the human diet and a major source of biologically active substances such as vitamins and secondary metabolites. As per the studies on diabetic patients, health practitioners prefer including more amount of fibre rich fruits in their diet. These fruits with low sugar concentration help in controlling blood sugar level to a maximum extent. Moreover, intake of fibre rich fruits helps in maintaining cholesterol level which in turn normalizes the metabolic rate of the body. This review gives an insight to the logical use of fruits like *Prunus cerasus*, *Eugenia jambolana*, *Actinidia deliciosa*, *Psidium guajava* L, *Punica granatum* and *Persea Americana* with scientific evidence in diabetes patients.

**Keywords:** Fruits, antidiabetic activity, anthocyanins, inositol, tannins, polysaccharide.

### INTRODUCTION

Diabetes mellitus is a complex metabolic disorder resulting from either insulin insufficiency or insulin dysfunction. Type I diabetes (insulin dependent) is caused due to insulin insufficiency because of lack of functional beta cells. Patients suffering from Type I diabetes are therefore totally dependent on exogenous source of insulin while patients suffering from Type II diabetes are insulin independent (insulin resistance with obesity and diet as contributors), can be treated with dietary changes, exercise and medication with oral hypoglycaemic agents like sulphonyl ureas, biguanides, meglitinides, thiazolidinediones or alpha glucosidase inhibitors. Type II diabetes is the more common form of diabetes constituting 90% of the diabetic population. Symptoms of diabetes include hyperglycaemia, polydipsia (unusual thirst) polyuria (frequent urination), polyphagia (extreme hunger) and loss of weight, blurred vision, nausea and vomiting, extreme weakness and tiredness; irritability, mood changes etc.<sup>1</sup> Though pathophysiology of diabetes remains to be fully understood, experimental evidences suggest the involvement of free radicals in the pathogenesis of diabetes<sup>2</sup>. Many recent studies reveal that antioxidants capable of neutralizing free radicals are effective in preventing experimentally induced diabetes in animal models<sup>3</sup> as well as reducing the severity of diabetic complications.

Ten years ago, the International Diabetes Federation Diabetes Atlas indicated that just over 150 million people had diabetes worldwide. Now, the survey shows 285 million worldwide cases, more than half of those aged between 20 and 60. At this growth rate the number should reach above 435 million by 2030. Since a majority

of cases are type II (insulin resistance with obesity and diet as contributors) we need to target the food and food services industries and the way the consumer is informed of their decision.

Based on the evidence that the incidence of diabetes is lower in vegetarians, some studies have investigated vegan interventions.<sup>4-6</sup> These studies have shown that a vegan diet may be effective in managing type 2 diabetes.<sup>7,8</sup> Switching diabetics to a vegan diet lowered hemoglobin A1C and LDL levels.<sup>7</sup> A vegan diet may improve blood filterability.<sup>9</sup> Vegan diets may lower advanced glycation end products.<sup>10</sup> Some of the protection that vegetarian diets provide may come from the diet's protection against obesity.<sup>11</sup>

As per the studies made on diabetic patients, health practitioners prefer including more amount of fibre rich fruits in their diet. These fruits with low sugar concentration helps in controlling blood sugar level to a maximum extend. Moreover, intake of fibre rich fruits helps in maintaining cholesterol level which in turn normalizes the metabolic rate of the body. It is better to prefer fresh fruits rather than dry fruits for maximum utilization of food intake. Apple, pear, peach, orange, kiwi and plum are fruits favourable for diabetic patients. These fruits are rich with high protein concentration than sugar concentration. Extracts from some fruits like guava helps in lowering blood sugar level. Grape fruit coming under citrus fruit family is yet another favourable fruit helping for maintaining controlled blood glucose level. Intake of these fruits promotes insulin production there by managing diabetes. Certain fruits like Jackfruit, raisins and apricot are rich with more carbohydrate concentration than protein. Consumption of such fruits creates a



negative impact on diabetic patients. Fruits like cherry; papaya and pineapple are equipped with a moderate level of sugar concentration. Certain chemical substance present in some fruits enhances insulin production. Anthocyanin is an example for this. Anthocyanin equipped in fruits is a chemical substance helping in insulin formation. Fruits like cherries are blessed with a rich concentration of anthocyanin promoting low blood sugar level.

In this review we have included fruits like *Prunus cerasus* (Tart Cherries), *Eugenia jambolana* (Jambul), *Actinidia deliciosa* (kiwi fruit), *Psidium guajava* L (Gauva), *Punica granatum* (pomegranate), *Persea Americana* (Avocado).

### PRUNUS CERASUS (TART CHERRIES)



**Figure 1:** *Prunus cerasus* (Tart Cherries)

*Prunus cerasus* (Family Rosaceae) is also known as sour cherry, pie cherry, tart cherry, montmorency cherry, balaton cherry etc; they are the smallest members of the stone fruit family. Cherries are typically classified as either sweet or tart. Sweet cherries include Bing cherries, Lambert cherries, and Rainier cherries and are grown mainly in Washington, Oregon and Idaho. Tart cherries include the Montmorency and Balaton varieties and are produced primarily in Michigan. Both sweet and tart cherries and cherry juice have long been used by traditional healers as a folk remedy for gout<sup>12</sup>, because cherries are thought to lower urate levels in the body. Tart cherries are used for conditions involving inflammation and pain, such as: arthritis, muscle pain, back pain, diabetes. Both sweet and tart cherries contain phenolics, a naturally-occurring plant compounds that have anti-inflammatory<sup>13</sup> and antioxidant effects<sup>14</sup>. The main type of phenolic in cherries is called anthocyanins. In general, the darker the cherry color, the higher the anthocyanin content.

Anthocyanins have been found to block two enzymes, COX-1 and COX-2, which play a role in the production of inflammatory compounds called prostaglandins. In test tube studies, cherry anthocyanins have been found to protect neurons from damage by oxidative stress. However, there have been no studies that have looked at whether cherry extracts could prevent or slow the

progression of neurodegenerative diseases such as Alzheimer's disease or Parkinson's disease in humans.

Tart cherries and their compounds appear to aid in diabetes control and in reducing the complications associated with this disease. In a study from Michigan State University, the effects of extracts of anthocyanins from tart cherries were tested on mouse pancreatic cells, which produce the hormone insulin in the presence of glucose (sugar). Results showed that anthocyanin-exposed cells increased insulin production by 50 percent compared to cells not exposed to anthocyanins. The researchers conclude that cherries might be useful in the prevention of type 2 diabetes<sup>15</sup>. In another study on rats, a single dose of anthocyanins decreased fasting blood glucose levels by 19 percent and improved glucose tolerance by 29 percent. After one month of treatment with anthocyanins, fasting blood glucose levels had dropped to half of the pretreatment levels and glucose tolerance had improved by up to 41 percent<sup>16</sup>.

Small blood vessels, called capillaries, are damaged in diabetes as a result of elevated blood sugar levels. Collagen proteins become linked to the elevated sugar and form abnormal complexes that damage tissues and blood vessels. One study on rats found that anthocyanins significantly reduced the formation of these abnormal protein complexes<sup>17</sup>. Retinopathy is a serious complication of diabetes, resulting from the overproduction of abnormal proteins produce when the body attempts to repair damaged capillaries. Anthocyanins appear to prevent this damage to blood vessels and also might prevent production of abnormal proteins. In another study, this damage was significantly reduced in 12 diabetic patients who consumed 600 milligrams of anthocyanins a day for two months<sup>18</sup>. In one more study, 31 patients with diabetic retinopathy showed marked improvement in permeability and a reduced tendency to hemorrhage when treated with anthocyanins<sup>19</sup>. Studies have shown that tart cherries have a low glycemic index (GI) score of 54 (any score less than 55 is considered low), thus producing only a mild rise in blood sugar levels associated with lowered risks for diabetes and weight gain.

Anthocyanins are polyphenol components and the largest group of water-soluble plant pigments responsible for the color of many fruits including cherries. They also are potent antioxidants, highly active chemicals that have been increasingly associated with a variety of health benefits, including protection against atherosclerosis, cardiovascular disease, cancer and diabetes<sup>20</sup>. Beneficial effects of different anthocyanins in controlling blood glucose or insulin resistance have been shown in diabetic samples<sup>21-23</sup>.

Anthocyanins are found in many kinds of fruits. However, the biggest insulin effects seem to come from the anthocyanins found in cherries. Sour cherry is native to Iran and it is a rich source of several anthocyanins, especially cyanidine-3-glucoside<sup>24</sup>. Concentrated sour



cherry juice beneficially alters serum glucose, lipids and blood pressure in diabetes type 2 subjects. It is an anthocyanin-rich food, which produces significant improvements in weight, glycaemia and blood pressure in diabetic type 2 patients. It also improves blood lipids in diabetic patients with hyperlipidemia. So, this juice or the fruit could be suitable in diabetic diet.<sup>25</sup>

### EUGENIA JAMBOLANA (JAMBUL, JAMUN)



**Figure 2:** *Eugenia jambolana* (Jambul, Jamun)

*Eugenia jambolana* (Family Myrtaceae) is also known as *Syzygium jambolanum* and *Syzygium cumini*. It is an evergreen beautiful tropical tree, native to India, Pakistan and Indonesia. Other common names are Jambul, Black Plum, Java Plum, Indian Blackberry, Jamblang, Jamun etc. It grows readily in other tropical climates and has been carried to eastern Africa, Brazil, and Southeast Asia. The tree grows fast and reaches heights of up to 30 m and can survive for more than 100 years. Leaves of this tree are smooth, glossy, oblong and placed opposite to one another having a turpentine smell. Its wood is strong and water resistant. The trees start flowering from March to April. The flowers are greenish-white in color, small and fragrant. The fruits are ripe in June and the fruit is oblong. It turns from green, to pink to shining crimson black as it ripens. The taste of the fruit is sweet and sour. Raw fruits are used for making wine and vinegar. The juice of ripe fruit is used for preparing jams, jelly, sauces and other beverages.

Jamun juice acts as a diuretic and gives a soothing effect on human digestive system. Diabetic patients can consume Jamun fruit daily during the season to control sugar levels. It is an ideal choice of fruit for diabetic patients. Nutritionists prefer core portion or inner portion of jambul fruits for controlling diabetes. The area of origin may make a huge difference as one study showed that *Eugenia* fruit grown in Brazil lacked the hypoglycemic effect found in Indian jambul.

Traditionally the jambul fruits, leaves, seeds, and bark are all used in ayurvedic medicine. The tasty fruits are also

consumed as food. The bark contains tannins and carbohydrates, accounting for its long-term use as an astringent to combat ailments like dysentery<sup>27</sup> A glycoside in the seed, jamboline, is considered to have antidiabetic properties.<sup>27</sup> Older French research shows that the seeds have a significant hypoglycemic effect in diabetic rabbits.<sup>28</sup> The seeds have also shown anti-inflammatory effects in rats and antioxidant properties in diabetic rat<sup>29,30</sup>. Older reports from Indian medical journals suggest jambul seed and bark can be beneficial in humans with diabetes.<sup>31,32</sup> *E. jambolana* Lam., *E. uniflora* L., and *E. punctifolia* DC are used in traditional medicine for diabetes.

Jamun fruit seeds and pulp have been reported to serve various purposes in diabetic patients, such as lowering blood glucose levels and delaying diabetic complications including neuropathy and cataracts. Jamun fruits have been valued in both Ayurvedic and Unani systems of medicine for possessing a wide variety of therapeutic properties<sup>33, 34</sup>. Jamun is most often recognized as an adjuvant therapy in type-2 diabetes. This has been traced not only to its anthocyanin-rich, dark-purple fleshy pulp, but also to its seeds, which have been most studied for their antidiabetic principles. Jamun seeds are reported to be a rich source of ellagitannins (ETs), including corilagin, 3,6-hexa hydroxyl diphenoyl glucose and its isomer 4,6-hexahydroxy diphenoyl glucose, 1-galloylglucose, 3-galloylglucose, gallic acid, and ellagic acid (EA).<sup>33</sup> When alloxan induced diabetic rats were fed with Jamun seed extract, the blood glucose, blood urea, serum cholesterol and serum triglyceride levels were found to decrease significantly<sup>35</sup>. Jamun fruit reduces the sugar in the blood and is very good in the control of diabetes. Its seeds contain Glucoside, Jamboline and Ellagic acid, which are reported to have the ability to check the conversion of starch into sugar in case of excess production of glucose. Therefore, Jamun seeds are also used as a remedy for Diabetes.

In a study, *E. jambolana* leaf extract showed hypoglycemic action in diabetic rats<sup>36</sup>. The seed powder of *E. jambolana* is reported to have hypoglycemic action in streptozotocin- diabetic rats<sup>37,38</sup>. Its effect may be persistent, as in one study, homeostasis was maintained in the rats for two weeks after the cessation of treatment.<sup>39</sup> In alloxan-diabetic rabbits the water extract of *E. jambolana* fruit pulp was more effective than the ethanol extract at reducing fasting blood glucose and improving blood glucose levels in the glucose tolerance test. *E. jambolana* also increased blood insulin levels in both diabetic and severely diabetic rabbits.<sup>40, 41</sup> Another study also found that *E. jambolana* seed extract reduced blood glucose, glycosylated hemoglobin, and increased plasma insulin<sup>42</sup>. *E. jambolana* fruit combined with bitter melon decreased insulin levels that were raised in diabetic rats fed a fructose diet.<sup>43</sup>

Ayurvedic texts suggest that 1–3 g of seed powder per day is an average dose<sup>44</sup> additionally, Juice of ripe fruits in



the amount of 0.5– 2 tsp (2.5– 10 ml) at least three times daily have been recommended for the treatment of diabetes. Administration of 100 and 200 mg/kg body weight of aqueous extract of *Syzygium cumini pulp* significantly decreased the blood glucose level in the experimental rats suggesting that it has hypoglycemic properties. The decreased body weight in diabetic rats is due to excessive breakdown of tissue proteins. Treatment with *Syzygium cumini* improved body weight significantly in a dose dependent manner, indicating prevention of muscle wasting due to hyperglycemic condition<sup>27</sup>.

In a study, the oral anti-hyperglycemic effect of the water and ethanolic extracts of the fruit-pulp of *Eugenia jambolana* (EJ) was investigated in alloxan induced diabetic with fasting blood glucose between 120 and 250 mg/dl as well as severely diabetic rabbits (fasting blood glucose above 250 mg/dl). Water extract was found to be more effective than the ethanolic extract in reducing fasting blood glucose and improving blood glucose in glucose tolerance test. The *in vitro* studies with pancreatic islets showed that the insulin release was nearly two and half times more than that in untreated diabetic rabbits. The mechanism of action appears to be both pancreatic by stimulating release of insulin and extra pancreatic by directly acting on the tissues. The same study also showed that even the partially purified water extract acts by increasing release of insulin many folds probably through beta cells stimulation like some of the sulphonyl ureas such as tolbutamide. The diabetics have greater insulinase activity than non-diabetics. The inhibition of insulinase activity from liver and kidney by extract of *Eugenia jambolana* also has been reported, which points out to its extra-pancreatic mechanism.<sup>45</sup>

### ACTINIDIA DELICIOSA (KIWI FRUIT)



**Figure 3:** *Actinidia deliciosa* (kiwi fruit)

*Actinidia deliciosa* (family *Actinidiaceae*) is an edible berry and is the "National Fruit" of the People's Republic of China. The most common cultivars of kiwifruit are oval, about the size of a large hen's egg (5–8 cm / 2–3 in long and 4.5–5.5 cm / 1¾–2 in diameters). It has a fibrous, dull brown-green skin and bright green or golden flesh with

rows of tiny, black, edible seeds. The fruit has a soft texture and a unique flavour, and it is a commercial crop in Italy, New Zealand, Brazil and Chile. Other species of *Actinidia* are also found in India and Japan and north into southeastern Siberia.

Kiwifruit is a rich source of vitamin C, Its potassium content by weight is slightly less than that of a banana. It also contains vitamin E, and a small amount of vitamin A. The skin is a good source of flavonoid antioxidants. The kiwifruit seed oil contains on average 62% alpha-linolenic acid, an omega-3 fatty acid. Usually a medium size kiwifruit contains about 46 calories, 0.3 g fat, 1 g protein, 11 g carbohydrates, and 2.6 g dietary fiber found partly in the edible skin. Kiwifruit is often reported to have mild laxative effects, due to its significant level of dietary fiber.<sup>46</sup>

Kiwifruit components, possibly involving vitamin E and omega-3 fatty acids from its numerous edible seeds, have potential properties of a natural blood thinner. A study performed at the University of Oslo in Norway reported consuming two to three kiwifruit daily for 28 days significantly reduced platelet aggregation and blood triglyceride levels, potentially reducing the risk of blood clots.<sup>47</sup> Kiwifruit is a natural source of carotenoids, such as provitamin A, beta-carotene,<sup>47</sup> lutein and zeaxanthin.<sup>49</sup> Inositol, a sugar alcohol naturally occurring in kiwifruit, may play a positive role in regulating diabetes. Inositol supplements may improve nerve conduction velocity in diabetic neuropathy. Inositol plays a role in intracellular responses to hormones and neurotransmitters. It acts as a second messenger in cell signaling processes.

Kiwifruit is rich in bioactive compounds especially in polyphenols<sup>50</sup>. It is an established fact that supplementation of diet with fruits and vegetables prevents atherosclerosis and other diseases.<sup>51,52</sup> In another study, leukocyte activation action and the antioxidant effect of kiwifruit were discussed<sup>53,54</sup> It was shown that consumption of kiwifruit lowered blood triglycerides levels by 15% compared with control. All these data indicate that consuming kiwifruit may be beneficial in cardiovascular disease.

Adipocyte dysfunction is strongly associated with the development of insulin resistance and diabetes, and regulation of adipogenesis is important in prevention of diabetes. A methanolic extract from unripe kiwi fruit, when applied to 3T3-L1 preadipocyte cells, it promoted adipocyte differentiation, increased glycerol-3-phosphate dehydrogenase (GPDH) activity, and increased triglyceride (TG) content. It markedly increased mRNA expression of peroxisome proliferator-activated receptor gamma (PPARGgamma)-the master adipogenic transcription factor- and its target genes. Moreover, it increased mRNA expression and protein secretion of adiponectin, whereas mRNA expression and secretion of monocyte chemo attractant protein-1 (MCP-1) and interleukin-6 (IL-6) were decreased. Compared with troglitazone, methanolic extract of kiwi decreased the production of reactive

oxygen species (ROS) and nuclear factor-kappaB (NFkappaB) activation. Glucose uptake was stimulated by the extract in differentiated 3T3-L1 adipocytes. These results indicate that the methanolic extract of kiwi fruit exert beneficial effects against diabetes via its ability to regulate adipocyte differentiation and function.<sup>52</sup>

#### PSIDIUM GUAJAVA L (GAUVA)



Figure 4: *Psidium guajava* L (Gauva)

*Psidium guajava* L (family Myrtaceae) is a fruit-bearing tree commonly known as guava. It is a low evergreen tree or shrub 6 to 25 feet high, with wide spreading branches and square, downy twigs, is a native of tropical America.<sup>55</sup> Guava trees have spread widely throughout the tropics because they thrive in a variety of soils, propagate easily and bear fruits quickly. The fruits are enjoyed by birds and monkeys, which disperse guava seeds and cause spontaneous dumps of guava saplings to grow throughout the rainforest. Cultivated varieties grow about 10 m in height and produce fruits within 4 years. Wild trees grow up to 20 m high and are well branched. The tree can be easily identified by its distinctive thin, smooth, copper-colored bark that flakes off, showing a greenish layer beneath.

The leaves and bark of guava tree have a long history of medicinal uses. In India, decoction of the leaves and bark of guava is used to cure diarrhea, dysentery, vomiting and sore throats, and to regulate menstrual cycles. The tribes of the Amazon use leaf decoction for mouth sores, bleeding gums, as douche for vaginal discharge and to tighten and tone up vaginal walls after labor. Commercially, the fruit is consumed raw or used in making jams, jellies, pastes and juice. Guava leaves are official in Dutch Pharmacopoeia. Guavas are free from fat and cholesterol. They are also an excellent source of fiber, potassium and vitamin A.

Gauva Fruit is small, 3 to 6 cm long, pear-shaped, reddish-yellow when ripe and it consists of Vitamin C, vitamin A, iron, calcium, Manganese, phosphoric, oxalic and malic acids, saponin combined with oleanolic acid. Morin-3-O- $\alpha$ -L-lyxopyranoside and morin-3-O- $\alpha$ -L-arabopyranoside,

flavonoids, guaijavarin, Quercetin. Essential oil contains hexanal, 2-hexenal, 2,4-hexadienal, 3-hexenal, 2-hexenal, 3-hexenyl acetate and phenol, while  $\beta$ -caryophyllene, nerolidol, 3-phenylpropyl acetate, caryophylleneoxide, pentane-2-thiol, 3-penten-2-ol and 2-butenylacetate, 3-hydroxy-2-butano-3-methyl-1-butanol, 2,3-butanediol, 3-methylbutanoic acid, (Z)-3-hexen-1-ol, 6-methyl-5-hepten-2-one, limonene, octanol, ethyl octanoate (pink guava fruit)<sup>56-60</sup>.

The ethanolic stem bark extract exhibited statistically significant hypoglycaemic activity in alloxan-induced hyperglycaemic rats but was devoid of significant hypoglycaemic effect in normal and normal glucose loaded rats (OGTT). In both acute and sub-acute tests, the water extract, at an oral dose of 250 mg/kg, showed statistically significant hypoglycemic activity<sup>61, 62</sup> in a study, i.p. treatment with 1 g/kg guava juice produced a marked hypoglycemic action in normal and alloxan-treated diabetic mice. The blood glucose lowering effect of guava was obtained by oral administration in maturity-onset diabetic and healthy volunteers. They suggested that guava may be employed to improve and/or prevent the disease of diabetes mellitus<sup>63</sup>.

#### PUNICA GRANATUM (POMEGRANATE)



Figure 5: *Punica granatum* (pomegranate)

*Punica granatum* (Family Punicaceae) is commonly known as Pomegranate, Granada (Spanish), Grenade (French). It is an attractive tree that grows up to 5 m in height. The pomegranate is native from Iran to the Himalayas in northern India and was cultivated and naturalized over the whole Mediterranean region since ancient times. It is widely cultivated throughout India and the drier parts of Southeast Asia, Malaya, the East Indies and tropical Africa. The tree was introduced into California by Spanish settlers in 1769. Pomegranates prefer a semi-arid mild-temperate to subtropical climate and are naturally adapted to regions with cool winters and hot summers. It is usually deciduous, but in certain areas the leaves will persist on the tree. The trunk is covered by a red-brown

bark which later becomes gray. The branches are stiff, angular and often spiny. There is a strong tendency to sucker from the base. Pomegranates are also long-lived. The pomegranate tree, which is said to have flourished in the garden of Eden, has been used extensively in the folk medicine of many cultures. In ancient Greek mythology, pomegranates were known as the "fruit of the dead" and in the ancient Hebrew tradition, pomegranates adorned the vestments of the high priest. The Babylonians regarded pomegranate seeds as an agent of resurrection, the Persians believed the seeds conferred invincibility on the battlefield, and for the ancient Chinese the seeds symbolized longevity and immortality.<sup>64</sup>

The foliage of pomegranate has glossy, leathery leaves that are narrow and lance-shaped. The flowers are attractive scarlet, white or variegated flowers are over an inch across and have 5 to 8 crumpled petals and a red, fleshy, tubular calyx which persists on the fruit. The flowers may be solitary or grouped in twos and threes at the ends of the branches. The distinctive shape of the spherical fruit (2.5 to 5 inches in diameter) is imparted by the prominent fleshy red calyx which persists after flowering. The fruit has a tough leathery skin that is variously referred to as the rind, husk, or pericarp. The interior of the fruit is compartmentalized by membranous walls (carpels) and white spongy pith. The resulting locules are packed with 600 to 800 sacs or arils, each of which contains one seed and juicy pulp. Conventional pomegranate juices normally constitute 45 to 65% of the whole fruit. The 50% edible portion (the arils) consists of approximately 80% juice pulp and 20% seeds; traditionally the entire aril is crushed to make the juice so the expressed juice contains liquid from the seeds and the surrounding aril<sup>65</sup>.

Fresh juice contains 85% water, 10% total sugars, and 1.5% pectin, ascorbic acid, and polyphenolic flavonoids. Pomegranate seeds are a rich source of crude fibers, pectin, and sugars. Dried pomegranate seeds contain the steroid estrogen estrone, the isoflavone phytoestrogens genistein and daidzein, and the phytoestrogen coumestrol. In pomegranate juice (PJ), fructose and glucose are present in similar quantities, calcium is 50% of its ash content, and the principal amino acids are glutamic and aspartic acids. The soluble polyphenol content in PJ varies within the limits of 0.2–1.0%, depending on variety, and includes mainly anthocyanins (such as cyanidin-3-glucoside, cyanidin-3,5-diglucoside, and delphinidin-3-glucoside), catechins, ellagic tannins, and gallic and ellagic acids. Fermented PJ and cold-pressed pomegranate seeds possess antioxidant activity and can reduce prostaglandin and leukotriene formation by inhibition of cyclooxygenases and lipoxygenases. In humans, pomegranate juice consumption decreased LDL susceptibility to aggregation and retention and increased the activity of serum paraoxonase (an HDL-associated esterase that can protect against lipid peroxidation) by 20%. Pomegranate juice had potent antiatherogenic

effects in healthy humans and in atherosclerotic mice that may be attributable to its antioxidative properties<sup>64</sup>.

In general, epidemiological studies show that consumption of fruits and vegetables with high phenolic content correlates with reduced cardio and cerebrovascular diseases and cancer mortality. Among fruits, pomegranate is an interesting rich source of anthocyanins and other phenolic compounds, with a demonstrated antioxidant activity. The presence of vitamin C has also been reported in this fruit. The potent antiatherogenic effects of pomegranate juice have been recently demonstrated in healthy humans and in atherosclerotic mice. Also, the antioxidant and antitumoral activity of pomegranate bark tannins (punicalic acid) and the antioxidant activity of the fermented pomegranate juice have been reported. Pomegranate juice has important clinical implications, and it has even been recommended in the treatment of acquired immune deficiency syndrome (AIDS) owing to the fruit rich concentration of diverse bioflavonoids and to their known free radical scavenging activity and inhibition of lipoxygenase. Furthermore, pomegranate is one of nine herbs included in a Japanese-patented formula for treating AIDS<sup>66</sup>.

Antidiabetic action of ethanolic extracts of seed and rind of *Punica granatum* L. was evaluated on alloxan-induced diabetic albino rats. Both the extracts, each at a dose of 200mg/kg/d, were administered orally for two weeks to alloxan-induced diabetic rats. Both the extracts significantly reduced the rise in blood glucose induced by alloxan, with the rind extract exhibiting significantly better activity than seed extract. Both the extracts also produced significant increase in liver glycogen and significantly reduced adrenaline-induced hyperglycemia. These results support strong antidiabetic action in favor of *P. granatum* seed and rind extracts.<sup>67</sup>

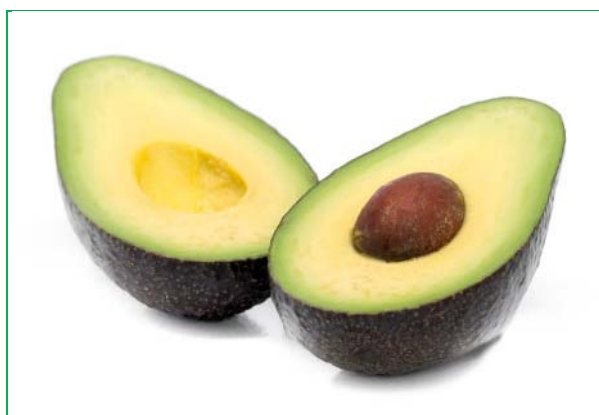
People with diabetes have increased risk for atherosclerosis, which contributes to coronary heart disease, heart attacks, strokes, and other circulation problems. Drinking pomegranate juice may help people with diabetes reduce their risk of heart disease. In most juices, sugars are present in free, in pomegranate juice, however, the sugars are attached to unique antioxidants, which actually make these sugars protective against atherosclerosis. In the small study, published in the journal *Atherosclerosis*, researchers examined the effects of drinking a specially prepared concentrated pomegranate juice every day for three months in 10 healthy adults and 10 adults with type 2 diabetes (who were not dependent on insulin therapy). Drinking pomegranate juice did not affect overall cholesterol levels, but researchers found it reduced the uptake of oxidized "bad" LDL cholesterol by immune cells, which is a major contributing factor to atherosclerosis. Although pomegranate juice contains a similar level of sugars as other fruit, it did not worsen diabetes markers, such as blood sugar levels, in the participants with diabetes<sup>68</sup>.





Pomegranate juice is a polyphenol-rich fruit juice with high antioxidant capacity. In limited studies in human and murine models, pomegranate juice has been shown to exert significant antiatherogenic, antioxidant, antihypertensive, and anti-inflammatory effects. Pomegranate juice significantly reduced atherosclerotic lesion areas in immune-deficient mice and intima media thickness in cardiac patients on medications. It also decreased lipid peroxidation in patients with type 2 diabetes, and systolic blood pressure and serum angiotensin converting enzyme activity in hypertensive patients. Thus, the potential cardioprotective benefits of pomegranate juice deserve further clinical investigation, and evidence to date suggests it may be prudent to include this fruit juice in a heart-healthy diet<sup>69</sup>

### PERSEA AMERICANA (AVOCADO)



**Figure 6:** *Persea Americana* (Avocado)

*Persea americana* (family Lauraceae) is a tree native to Puebla, Mexico,<sup>70</sup> is commonly known as alligator pear, avocado, avocado-pear, butter fruit. Avocado or alligator pear also refers to the fruit of the tree, which may be pear-shaped, egg-shaped or spherical. Avocados are commercially valuable, and are cultivated in tropical climates throughout the world, producing a green-skinned, pear-shaped fruit that ripens after harvesting. The word 'avocado' comes from the Mexican Spanish *aguacate* which in turn comes from the Nahuatl word *ahuácatl* (testicle, a reference to the shape of the fruit). Avocados were known by the Aztecs as 'the fertility fruit'.<sup>71</sup>

The plant is used in traditional medicine for the treatment of various ailments, such as monorrhagia, hypertension, stomach ache, bronchitis, diarrhea, and diabetes. *P. americana* is a medium to large tree, 9-20 m in height. Avocado tree is distributed geographically. The avocado is classified as an evergreen, although some varieties lose their leaves for a short time before flowering. The tree canopy ranges from low, dense, and symmetrical to upright and asymmetrical. Leaves are 7-41 cm in length and variable in shape (elliptic, oval, and lanceolate). They are often pubescent and reddish when young, becoming smooth, leathery, and dark green when mature. Flowers are yellowish green and 1-1.3 cm in diameter. The many-

flowered inflorescences are borne in a pseudoterminal position. The central axis of the inflorescence terminates in a shoot. The fruit is a berry, consisting of a single large seed, surrounded by a buttery pulp. It contains 3-30% oil. The skin is variable in thickness and texture. Fruit color at maturity is green, black, purple, or reddish, depending on the variety. Fruit shape ranges from spherical to pyriform, and weighs up to 2.3 kg.<sup>72</sup>

The fruit of horticultural cultivars has a markedly higher fat content than most other fruit, mostly monounsaturated fat, and as such serves as an important staple in the diet of various groups where access to other fatty foods is limited. The fruit is not sweet, but fatty, and subtly flavored, and of smooth, almost creamy texture. The avocado is very popular in vegetarian cuisine, as substitute for meats in sandwiches and salads because of its high fat content.

Avocados are high in valuable, health-promoting fats, about 75% of an avocado's calories come from fat, most of which is monounsaturated fat. Avocados also have 60% more potassium than bananas. They are rich in B vitamins, as well as vitamin E and vitamin K. Avocados have high fiber content among fruits – including 75% insoluble and 25% soluble fiber.<sup>73</sup> A fatty triol (fatty alcohol) with one double bond, avocadene (16-heptadecene-1, 2, 4-triol), is found in avocado.

High avocado intake has been shown to have a beneficial effect on blood serum cholesterol levels. Specifically, after a seven-day diet rich in avocados, mild hypercholesterolemia patients showed a 17% decrease in total serum cholesterol levels. These subjects also showed a 22% decrease in both LDL (harmful cholesterol) and triglyceride levels and 11% increase in HDL (helpful cholesterol) levels<sup>74</sup>. Reports shows that aqueous fruit extract has significant antidiabetic activity in Alloxan-induced diabetic rats<sup>75</sup>. In another study, partial replacement of complex digestible carbohydrates with monounsaturated fatty acids (avocado as one of its main sources) in the diet of patients with non-insulin-dependent diabetes mellitus improved the lipid profile favorably, maintained an adequate glycemic control, and offers a good management alternative<sup>76</sup>.

### CONCLUSION

Diabetes is a chronic metabolic disorder which can be well controlled by maintaining a balanced diabetic diet. So the main goal of therapy in patients with diabetes mellitus is improving metabolic control. The specific goals of therapy are maintaining normal or near-normal blood glucose concentrations by synchronizing hypoglycemic drugs with food intake and physical activity, optimizing serum lipid and lipoprotein concentrations, helping patients attain desirable body weights, preventing and treating complications of diabetes, and improving overall health. Physicians and nutritionists should assess a patient's ability and willingness to accept nutrition intervention, taking into consideration the patient's

cultural, ethnic, and financial background. Diets rich in *cis*-monounsaturated fats may be advantageous for improving lipoprotein and glycemic profiles in patients with diabetes mellitus.<sup>77</sup> Inclusion of fruits in diet plays a vital role in leading a healthy lifestyle. Fruits and vegetables are an important part of the human diet and a major source of biologically active substances such as vitamins and secondary metabolites. The consumption of fruits and vegetables remains globally insufficient, so it should be encouraged, and it may be useful to propose to consumer's fruits and vegetables with enhanced concentrations in vitamins and secondary metabolites. Various secondary metabolites from fruits, like triterpenes, flavonoids, sterols, coumarins, saponins, tannins, polysaccharides *etc.* have been exerting wide range of anti-diabetic activity<sup>75</sup>.

Anthocyanins content of the *Prunus cerasus* juice beneficially alters serum glucose, lipids and blood pressure in diabetes type 2 subjects. It is an anthocyanin-rich food, which produces significant improvements in weight, glycemia and blood pressure in diabetic type 2 patients. It also improves blood lipids in diabetic patients with hyperlipidemia. Jamboline and Ellagic acid present in the fruit of *Eugenia jambolana* is found to be responsible for its antidiabetic activity. The water extract of pulp helps to stimulate insulin release and it also acts by inhibiting the insulinase activity from liver and kidney thus helping in diabetes. Inositol, a sugar alcohol naturally occurring in *Actinidia deliciosa*, plays a positive role in regulating diabetes. Inositol supplements can improve nerve conduction velocity in diabetic neuropathy. It acts as a second messenger in cell signaling processes. Polysaccharide from *Psyidium guajava*, tannins from *Punica granatum* and *Persea americana* with its richness of monounsaturated fatty acid are found to be responsible for their antidiabetic activity. Thus the fruits mentioned in this review are the nature's real gifts that are easily available which can produce wonderful effects in diabetic patients.

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