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By

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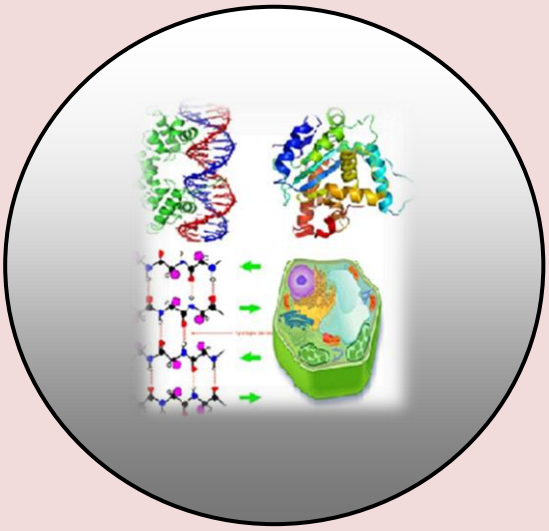

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ABSTRACT

Persimmon is naturally bestowed with bioactive molecules including proanthocyanidins, flavonoids, tannins (), phenolic, carotenoids, dietary fiber, and etc. Persimmon leaves and fruit have imperative significance for coronary health because of hypocholesterolemic, anti-atherosclerosis and antioxidant perspectives. Although hypotensive and anticancer responses have been reported for persimmon and its bioactive especially condensed tannin and flavonoids too but yet demands further probing to unveil their therapeutic mechanisms. In the last, utilization of persimmon and its bioactive components can be effective in reducing the burden of diabetes mellitus. However, coherent and systematic research is still required to bring meticulousness. Extensive literature survey revealed that the plant D. kaki has a long history of traditional uses for the wide range of diseases. The rich phytochemistry of persimmon opened new avenues of research in diet based regimen to cure various ailments. The health promoting potential of persimmon includes its effectiveness against free-radical production, hypercholesterolemia, diabetes mellitus, dermal disorders, hypertension, etc. Total dietary fibers including soluble and insoluble, total phenolics including epicatechin, gallic, and p-coumaric acids, and concentrations of minerals like Na, K, Mg, Ca, Fe, and Mn are high in peel, pulp, and whole persimmon fruit. The antioxidant potential of persimmon can be exploited to cure various maladies including degenerative disorders, cancer, and improving the skin tone.

Persimmon is high in vitamin A and a moderate source of ascorbic acid, calcium and potassium. This review article is aimed at appraising the chemical profile of persimmon fruit with reference to prospective bioactive components and at exploring their functionality and potential applications in disease prevention.
Kewords: Phytochemistry, Free-radicals, Hypercholesterolemia, Diabetes mellitus, Pharmacological explorations and Carotenoid contents.

INTRODUCTION

Fruits and vegetables are important component of human diet and play important role in maintaining the human health. The health promoting potentials associated with their consumption are mainly due to presence of phytochemicals which are distinct bioactive molecules widely acknowledged for their beneficial roles in human physiology. Number of plants gained popularity as wholesome food entities but still many horizons demand researchers' attention. Amongst, persimmon (Diospyros kaki) is one of these nutritious fruits bestowed with strong antioxidant activity. Diospyros kaki L commonly called as persimmon or Japanese persimmon is a deciduous plant native to China, Korea and Japan (Persimmon is traditionally used for medicinal purposes), however now it is grown in many East Asian countries and Southern Europe (Butt, et.al 2015, Liu 2003). The persimmon (*Diospyros kaki* L.), locally called Japani phal is the most important temperature deciduous tree (Fig 1).

Figure 1. Persimmom Decicuous Tree.

Figure 2 and 3 Persimmon Fruit.

Ancient references to the persimmon as "food for the gods" have led to its classification in the genus Diospyros of the Ebony family (Dios means God, pyros means grain or food). The English word persimmon is derived from the Algonquian language of the eastern United States meaning "dry fruit".

In India, persimmon was introduced by European settlers around twentieth century and is grown in the states like Himachal Pradesh, Jammu and Kashmir, Uttarkhand and Tamil Nadu. Persimmon, also known as the 'Divine Fruit' due to its scientific name of Greek origin, is found during autumn. While there are various varieties of this fruit (Fig. 2) being cultivated, the popular one is the Chinese native, Diospyros kaki, widely known as the Japanese persimmon. There are some best benefits of persimmon fruit. The brilliant orange colored skinned fruit that shares a close resemblance with tomato in appearance, in fact, is a berry. The fruit in Indian markets is limited for a number of reasons mostly because of low demand and paucity of supply (Akter, 2010, Sattar, 1992, Chen, 2008). The bioactive components present in it especially carotenoids and tannin are helpful in quenching free radicals, decreasing cardiovascular risk factors (blood pressure and cholesterol) and reducing the risk of diabetes mellitus along with effectiveness against cancer insurgence. These bioactive components plays an important role in reducing arterial stiffness and prevent oxidation of low-density lipoproteins (LDL) thus resulting in the prevention of atherosclerotic plaque formation. Many phytochemicals also possess anti-mutagenic effects and regulate and trigger the immune system thus resulting in the normal functioning of metabolism. Among the fruits, persimmon (Diospyros kaki) is a popular and widespread fruit that is enriched with many bioactive compounds, including polyphenols, terpenoids, steroids, flavonoids, carotenoids, minerals, and dietary fiber. The persimmon fruit looks like an orange red tomato with a pointed end (Kondo, 2004, Xu and Zhang 2000; Kawase, 2003). The whole fruit is edible, with the exemption of its seed and calyx. The color of the fruit varies from yellow or orange to deep red depending upon the concentration of carotenoid contents. Hence, higher carotenoid contents are imperative to get maximum market value of the fruit. Some components like phenolics, antioxidants, sterols, and flavonoids have a beneficial effect on human health owing to their ability to prevent or control various ailments. These bioactive components play an important role in reducing arterial stiffness and prevent oxidation of low-density lipoproteins (LDL) thus resulting in the prevention of atherosclerotic plaque formation. Many phytochemicals also possess antimutagenic effects and regulate and trigger the immune system, thus resulting in the normal functioning of metabolism. A number of them also serve as chemopreventive, anticancer, anti-inflammatory, and immunomodulatory agents. Hence, persimmon, like other fruits, contains a number of functional compounds which are useful in promoting human health (Gorinstein, 2001, Yuan, 2006, Zhao, 2011, Plaza, 2012).

Phytochemistry

Various parts of the plant are widely used in folk medicines. In recent years, emphasis of research has been on utilizing traditional medicines that have long and proven history of treating various diseases. So, further studies need to be carried out to explore D. Kaki potantial in curing and treating various diseases. Persimmon is enriched with many nutritious and bioactive components including proteins, sugar, vitamin A, vitamin B6, vitamin B12, vitamin D, ascorbic acid (AA), vitamin E, polyphenols, flavonols, flavonoids and carotenoids. Some components like phenolics, antioxidants, sterols, and flavonoids have a beneficial effect on human health owing to their ability to prevent or control various ailments. These bioactive components play an important role in reducing arterial stiffness and prevent oxidation of low-density lipoproteins (LDL) thus resulting in the prevention of atherosclerotic plaque formation (Niikawa, 2007, Britton 1995).

Many phytochemicals also possess anti-mutagenic effects and regulate and trigger the immune system thus resulting in the normal functioning of the metabolism. They also serve as chemopreventive, anti-cancer, antiinflammatory and immunomodulatory agents Elemental micronutrients present in persimmon fruit include potassium, sodium, iron, calcium and many others. Not just the fruit, the leaves, calyx and other parts have importance in health. Persimmon fruit contains 79% water, 0.7% pectin, 0.4% protein, and crude fiber. It also contains various bioactive substances like vitamins (A, B complex, C, E, and K) and minerals (Zn, Cu, Fe, Mg, Ca, and P) that are valuable for the proper physiology of human health. Proanthocyanidins (Fig) are potent antioxidants and show 20 and 50 times more activity than vitamins C and E, respectivelyIn the edible part (pulp) of the persimmon, the major phenolic acids (Fig. 1~ 9)are ferulic acid, p-coumaric acid, and gallic acid, and the antioxidant activity of these phenolic acids is affected by their chemical structures [number of hydroxyl groups (-OH) attached] (Chen, 2007, Singh, 2011).

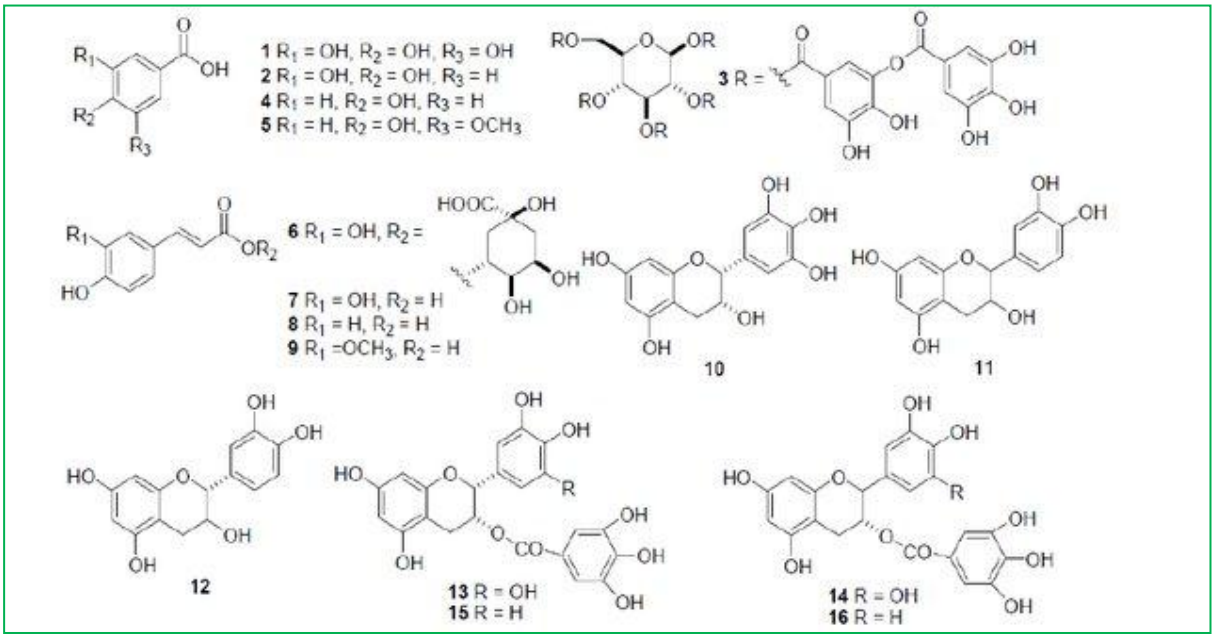

Figure 4. Chemical structures of phenolic acids (1 ~ 9) and catechin (10 ~ 16). 1: gallic acid, 2: protocatechuic acid, 3: tannic acid, 4: p -hydroxylbenzoic acid, 5: vanillic acid, 6: chlorogenic acid, 7: caffeic acid, 8: p -coumaric acid, 9: ferulic acid, 10: epigallocatechin, 11: catechin, 12: epicatechin, 13: epigallocatechin gallate, 14: gallocatechin gallate, 15: epicatechin gallate, 16: catechin gallate.

Palmitic acid, oleic acid, and linoleic acid are the major fatty acids found in persimmon seeds, ranging from 70.4% to 78.3% of total fatty acids. Among the fatty acids, oleic acid plays a role in cancer prevention. The effect of oleic acid on the same lines of breast cancer cells was examined and it supported the theory that oleic acid is chemopreventative. Moreover, omega-6 fatty acid (linoleic acid) diminishes the risk of cardiovascular diseases. In persimmon, soluble tannins consist of catechin, catechin-3-gallat, galocatechin and galocatechin-3-gallat. They further contain substantial amounts of gallic acid esters, for instance, epicatechin gallate and epigallocatechin gallate. Persimmon leaves contain 4 flavonols (Zillich 2015, Palafox-Carlos, 2011, Ratz-Łyko, 2015, Sun, 1998).

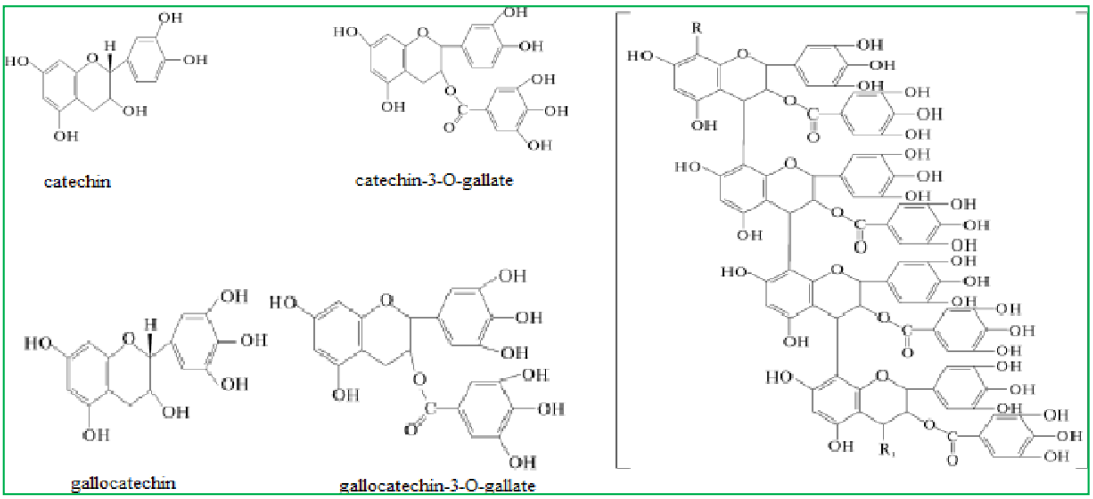

Figure 5. Chemical structures of persimmon tannin and related catechin.

The leaves of persimmon have been reported to contain the following compounds: 40-dihydroxy-a-truxillic acid, tatarine C, myricetin, annulatin, trifolin, astragalin, hyperin, isoquercetin, rutin, quercetin, kampferol, kakispyrone, and kaki saponin. Total dietary fibers including soluble and insoluble, total phenolics including epicatechin, gallic, and p-coumaric acids, and concentrations of minerals like Na, K, Mg, Ca, Fe, and Mn are high in peel, pulp, and whole persimmon fruit compared to apple. Hence, persimmon must be given preference over apples and some other fruits in selecting an antiatherosclerotic diet. It is rich in Vitamin A compared to apple. Vitamin C content varies depending upon the variety. It also contains various bioactive components, nutrients like Vitamin A, B, C, E and K as well as minerals that are valuable for the proper physiology of human healt (Rice-Evans, 1996, Tsao 2010, Mallavadhani, 1998, Datta 2000, Tapiero, 2004, Fujiki, 2005, George, 2008). Persimmon pulp is rich in nutrients such as vitamin C (70 mg/100 g), vitamin A (65 mg/100 g), calcium (9 mg/100 g), and iron (0.2 mg/100 g). In the edible part (pulp) of the persimmon, the major phenolic acids are ferulic acid, p-coumaric acid, and gallic acid, and the antioxidant activity of these phenolic acids is affected by their chemical structures (number of hydroxyl groups attached). Carotenoids are the major pigment present in persimmon. They contribute to both colour and nutritional value. Carotenoid contents rapidly increase as green mature fruit changes to soft mature persimmon, except for lutein and lycopene that decrease during fruit maturation. Among them β-cryptoxanthin content is the highest (50%), followed by lycopene (Fig) (10%), β-carotene (10%), zeaxanthin (5%) and lutein (5%). They are all excellent source of lipid-soluble antioxidants (especially lutein, zeaxanthin and astaxanthin) having the ability to scavenge free radicals in a lipidsoluble environment and thus preventing the oxidation of lipids (Fujiki, 2005, George, 2008, Dillard and German 2000, Dixon, 2005, Ercisli, 2007). Role of Persimmon in the treatment of different diseases: Persimmons are delicious and exotic fruits that do more than serving as a sweet and tasty treat; they have a wealth of health benefits packed inside them, including their ability to improve eye health, reduce signs of aging, prevent various types of cancer, improve digestion, boost immune system, lower cholesterol, increases metabolism, strengthens bones, boost cognitive function, lower blood pressure, and skincare. Furthermore, they help the body to heal faster, aid in weight loss, reduce inflammation, and increase blood circulation throughout the body.

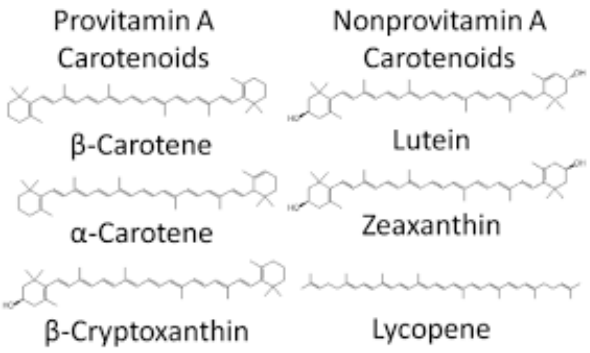

Figure 6. Structure of Provitamin and Non provitamin carotenoids.

Carotenoid supplementation improves the antioxidant status and reduces lipid peroxidation. Carotenoids like Carotenoids identified in persimmon fruits are cis-mutatoxanthin, antheraxanthin, zeaxanthin, neolutein, cryptoxanthins, α-carotene, and β-carotene and also fatty acid esters of β-cryptoxanthin, lycopene, and lutein have been found to be associated with inflammation and mortality risks. In addition, lutein (carotenoids) present in persimmon peel can help protect eye vision. Carotenoid contents rapidly increase as green mature fruit changes to soft mature (Sun, 2011, Suzuki 2005, Takahashi, 2006, Veberic, 2010). Among them β-cryptoxanthin (Fig. 7) content is the highest (50%), followed by lycopene (10%), β-carotene (10%), zeaxanthin (5%), and lutein (5%).

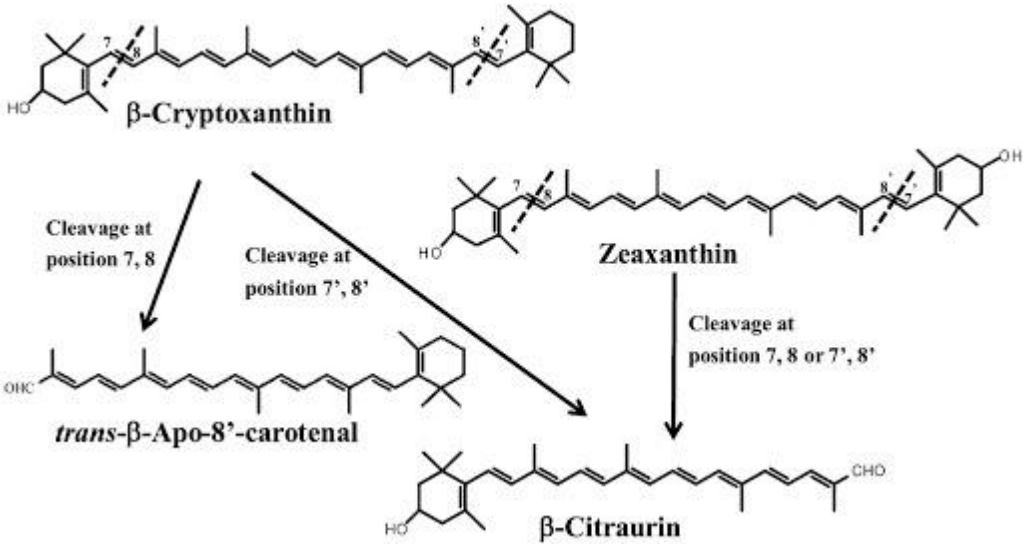

Figure 7. Structure of β-Crytoxanthin and Cleavage products.

They are all excellent lipid-soluble antioxidants, especially lutein, astaxanthin, and zeaxanthin, having the ability to scavenge free radicals in a lipid-soluble environment and thus preventing the oxidation of lipids. The final composition and concentration of carotenoid contents are properly regulated to some extent by the different developmental stages of plant tissues.

Pharmacological Attriibutes

Scientific research-based knowledge regarding the impact of food on human health has steered to substantial nutritional discoveries, product innovations, and mass production on an unprecedented scale. The starring role of food for improving health by decreasing the risk of illness and disease has highlighted a new class of foods, now known as functional foods. Functional foods and therapeutic agents are obtained either directly or indirectly from different natural sources. The therapeutic value of functional foods depends upon the presence of biologically active compounds (bioactive compounds). These bioactive compounds can offer various health benefits beyond the basic nutritional value of a food product. Recently, natural bioactive compounds have been acknowledged with greater consideration. Fruits and vegetables are vital parts of the diet and a rich source of bioactive compounds including dietary fiber, natural antioxidants, and various phytochemicals. Most bioactive compounds (phytochemicals, phenolics, and carotenoids) are nonnutritive but effective against different diseases as they play important roles as chemopreventive or chemotherapeutic agents (Duck, Kang Su tae, Lim Jong Woo and Cho Kye Man, Comparative studies of Antioxidant activities and Nutritional constituents of Persimmon Juice (Diospyros, 2015, Alba-Mir, 2015).

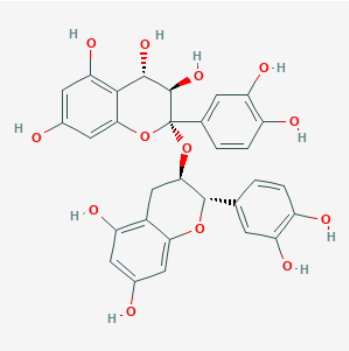

Figure 8. Structure of Proanthocyanidins.

Persimmon has been used for various medicinal purposes owing to the therapeutic properties such as diuretic effect, blood pressure-lowering capability and the cough treatment, viral and bacterial infectious diseases, and dental caries. Various bioactive compounds including polyphenols, carotenoids, vitamins, and dietary fiber in the fruit are responsible for beneficial properties. Proanthocyanidins (Fig.8) components accumulate in enormous amount in persimmon fruit during early development stages. They are secondary metabolites providing safeguard against various problems including environmental stress. In recent years, persimmon has been the focus of attention for potential medicinal applications for prevention of cancer. Carotenoids are nature's most widespread pigments and have also received substantial attention because of both their provitamin (Fig. 9) and antioxidant roles. Carotenoids possess antioxidant properties that have been associated with cellular protection, regulation of cell growth, differentiation, and apoptosis. Not only are the carotenoid contents responsible for the superficial appearance (color) and nutritional quality of fruit but also they provide potential health benefits and disease prevention by quenching singlet oxygen and scavenging free radicals. Chemoprotective effects of persimmon against various forms of cancer are due to the carotenoid contents.

Persimmon was shown to be effective in the treatment of prostate and breast cancers, oral carcinoma cells, human lymphoid leukemia cells, and precancerous colon polyps in women. The bioactive compounds in persimmon may also affect multidrug resistant (MDR) inhibiting activity. It enhances the accumulation of cancer cells due to the reduced activity of efflux pumps. MDR inhibitors from persimmon may help to treat noncurable cancer because of the modulating effects. The calyx (persimmon) extracts act as anticonvulsants and may alleviate the side effects of barbituric acid compounds. Some Carotenoids are the major pigment present in persimmon. They contribute to both color and nutritional value.

Carotenoids present in persimmon are precursors of vitamin A and also have immunoregulatory and antiaging effects. Carotenoids are inversely linked with inflammation, atherosclerosis, cardiovascular diseases, sarcopenia, and mortality.

Persimmon is a fruit potent for obesity and diabetes. Proanthocyanidin is the major component isolated from persimmon peel and has been demonstrated to play a role in obesity and diabetes. Administration of proanthocyanidin from the peel of persimmon decreases the elevation of lipid peroxidation, suppresses generation of reactive oxygen species, decreases serum glucose, glycosylated haemoglobin (HbA1c), serum urea nitrogen, urinary protein, and renal advanced glycation end-products under diabetic conditions. It also provides an overall protective effect against stress-related inflammatory processes and diabetes. Persimmon is rendered a hypoglycaemic effect from its antioxidant effect from its antioxidant defence mechanisms (Wang, 2004, Alba-Mir, 2015, Amreen, 2016, Singh and Joshi 2011, Butt, 2015).

Tannins derived from persimmon pulp have hydroxyl radical scavenging antioxidant capacities. Persimmon fruits enhance the bile acid excretion through faeces. The excretion of bile acids is closely linked with reduced concentration of lipids in liver and blood. The mechanism of action remained centred around up-regulation of expression of the sterol regulatory element-binding protein-2 gene, 7α-hydroxylase, and the low-density lipoprotein receptor. The effectiveness of dietary persimmon prevented the incidence of stroke due to radical scavenging action and inhibition of lipid peroxidation. Not only it decreases serum triglycerides, it also reduces total cholesterol and liver total cholesterol levels. It also provides protection against lipid peroxidation by increasing liver nonesterified carnitine level. The extract from leaf and fruit suppresses alcohol-induced hepatoxicity. Persimmon has been the focus of attention for potential medicinal applications for prevention of cancer. Carotenoids are nature's most widespread pigments and have also received substantial attention because of both their provitamin and antioxidant roles. Carotenoids possess antioxidant properties that have been associated with cellular protection, regulation of cell growth, differentiation and apoptosis. Not only carotenoid contents responsible for the superficial appearance (colour) and nutritional quality but they also provide potential health benefits and disease prevention by quenching singlet oxygen and scavenging free radicals. Chemopreventive effects of persimmon against various forms of cancer are due to carotenoid contents. Persimmon was shown to be effective in the treatment of prostate and breast cancers, oral carcinoma cells, human lymphoid leukemia cells and precancerous colon polyps in women.

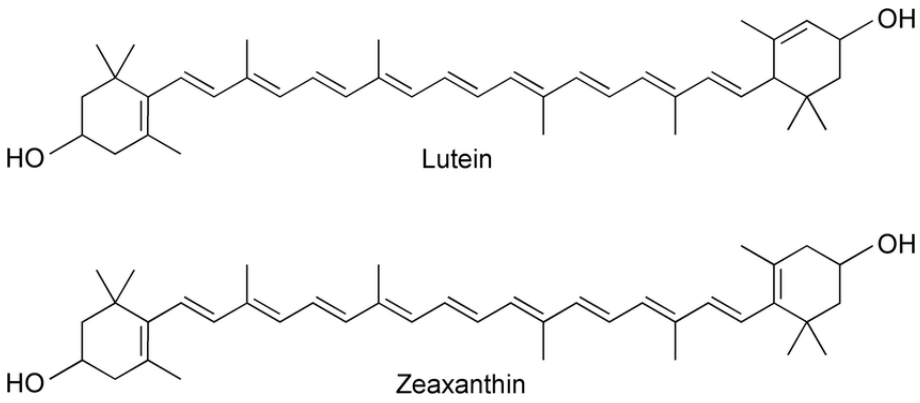

Figure 9. Structure of Lutein and Zeaxanthin.

The bioactive compounds in persimmon may also affect multidrug resistant (MDR) inhibiting activity. It enhances the accumulation of cancer cells due to the reduced activity of efflux pumps. MDR inhibitors from persimmon may help to treat non-curable cancer because of the modulating effects.

Persimmon contains two ingredients- Lutein (Fig. 8) and Zeaxanthin (Fig. 8) that help keep the vision in perfect condition and prevent retina damage. Persimmon also contains Vitamin A, C and K, which are highly antioxidant in nature and that are critical to eye protection, particularly from retinal damage. Persimmon leaves shows beneficial effects on eye diseases in humans. It has protective effects on retinal degeneration induced by oxidative stress and optic nerve damage. Diospyros kaki is used as a medicinal plant in Chinese traditional medicine especially in cosmetics and dermatological applications. Traditionally this plant is used to treat different skin conditions including pimples, skin eruptions and eczema.

Extracts from Diospyros kaki folium decreases number of skin pores' size, removes solidified sebum from the skin and can facilitate removal of Demodex mites (causative microbe for rosacea and seborrheic dermatitis) from the skin. The crude extracts, its purified fractions and various phytonutrients obtained from persimmon have a great potential for both dermatological and cosmetic application. Persimmon leaves and extracts are being used as a oriental medicines, deodorants, antiallergic substrates, and cosmetics (especially for dermatitis) as they prevent skin problems and have an antiwrinkle effect and skin whitening effect. The leaves of persimmon possess antithrombotic activity. Based on their antimicrobial properties, persimmon leaf-based products have been incorporated into athlete's foot socks and soaps, and persimmon leaves have been used as a sushi ingredient (Duck, 2015, Amreen, 2016, Singh and Joshi 2011).

Culinary Uses

Persimmon is eaten as fresh or dried fruits. During drying, persimmon peel is removed; otherwise it produces bitter taste because of its astringency. Usually whole fruit and slices (Fig. 10, 11 and 12) are dried to make dried persimmon (13) products. Juices (Fig. 14), shake, (Fig. 15) or puree is prepared from peeled persimmon pulp. However, unpeeled whole persimmon fruit can be used for persimmon vinegar and wine production. Fully ripe fruits are usually eaten out-of-hand. The flesh may be added to salads, blended with ice cream mix or yoghurt, used in pastries, puddings or made into jam or marmalade. Ripe fruits can be frozen whole or pulped.


Figure 10-11-12. Whole Fruit and Slice of Persimmom.



Figure 13. Dried Persimmom **Figure 14. Persimmom Juice** **Figure. 15 Persimmom Milk Shake**

Drying is commonly practised. Roasted seeds have served as a coffee substitute. Tea can also be made from fresh or dried leaves. D. kaki is high in vitamin and a moderate source of ascorbic acid. Tannin from unripe fruits has been employed in brewing shake. Fruit may be converted into molasses, cider, beer and wine. Juice of small, inedible wild fruits. Persimmon is a fruit containing high levels of phenolics that could be used for making vinegar. Administration of persimmon vinegar provides a protection to metabolic disorders induced by chronic alcoholic ingestion. Decline in blood triglyceride and total cholesterol contents after intake of persimmon vinegar for 6 weeks has been reported. The leaves are brewed into a beverage to release their antioxidant activity and antitumor effects and to inhibit angiotensin converting enzymes as well as alpha amylase. Dried persimmon snacks were found to be effective in reducing the concentration of alcohol in the blood. Persimmon leaves and extracts are being used as a green tea. It has been established that addition of persimmon in the diet hinders the increase in plasma lipid level and hence works as antiatherosclerosis which reduces the chances of mortality by the action of polyphenols. It has also been reported that the persimmon peel supplemented diet shows hypocholesterolemic and antioxidative effect (Amreen, 2016, Singh, 2011, Butt 2015). Low in carbohydrates, fat, and sodium, this fruit comes with lots of good properties. Reap the persimmon health benefits right away!

CONCLUSION

Fruits and vegetables are important component of human diet and play important role in maintain the human health. The health promoting potentials associated with their consumption are mainly due to presence of bioactive components and these phytochemicals are distinct bioactive molecules widely acknowledged for their beneficial roles in human physiology. Number of plants gained popularity as wholesome food entities but still many horizons demand researchers attention.

Amongst, persimmon (Diospyros kaki L.) is one of these nutritious fruits bestowed with strong antioxidant activity. Bioactive compounds particularly phenolics (ferulic, p-coumaric, and gallic acids) and carotenoids (β-cryptoxanthin, lycopene, β-carotene, and lutein) are of major interests in persimmon fruit. These valued bioactive components have strong antioxidant potential which relates to the variety, stage of maturity, and fruit parts. These functional compounds can play a significant role in preventing and curing various ailments like diabetes, hypercholesterolemia, and cancer. Hence, the known impact of natural bioactive compounds to improve human health, has introduced a substantial area of research resulting in extensive advances in biochemical and nutritional sciences. Extensive research has related the consumption of persimmon with the reduced risk of various diseases and particularly highlighted the presence of bioactive phenolic compounds for their therapeutic properties. They are important to prevent oxidation of low-density lipoproteins, safeguard beta cells of the pancreas, and reduce cardiovascular diseases, cancer, diabetes mellitus, and damage caused by chronic alcohol consumption. In this paper, the chemistry and health benefits of bioactive compounds present in persimmon are reviewed to encourage impending applications and to facilitate further research activities.

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