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REVIEW ARTICLE

A Scientific Review on Three Species of *Diospyros*

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ABSTRACT

Diospyros species plants belong to *Ebenaceae* family are grown in most tropical areas and helpful for treating many diseases and disorders, which is mostly used by tribal people, but very few scientific evidence is available for approving its folklore uses. Hence, an attempt has been made to collect information regarding three of its genus plants known as *Diospyros virginiana, Diospyros kaki,* and *Diospyros chloroxylon*. Cultivational requirements, morphological characters, folklore uses, pharmacological evidence, phytochemical evidence has been discussed. This review will be helpful for plant researchers to proceed further work on these genus plant.

Key words: Diospyros chloroxylon, Diospyros kaki, Diospyros virginiana, Ebenaceae

INTRODUCTION TO *DIOSPYROS* SPECIES

Diospyros is a genus of over 700 species of deciduous and evergreen trees and shrubs. The majority are native to the tropics, with only a few species extending into temperate regions.[1] Depending on their nature, individual species are commonly known as ebony or persimmon trees. Some are valued for their hard, heavy, dark timber, and some for their fruits. Some are useful as ornamentals, and many are of local ecological importance. The generic name *Diospyros* comes from a Latin name for the *Caucasian persimmon* (*Diospyros lotus*), derived from the Greek *diós* and *pŷrós*. The Greek name literally means "Zeus's wheat" but more generally intends "divine food" or "divine fruit" [Tables 1-4].[2]

Taxonomical Details[3]

Kingdom - *Plantae*	
Subkingdom	- *Tracheobionta*
Division	- *Magnoliophyta*
Class	- *Magnoliopsida*
Subclass	- *Dilleniidae*
Order	- *Ebenales*
Family	- *Ebenaceae*
Genus	- *Diospyros L*
Species	- *virginiana/kaki/chloroxylon*.

GEOGRAPHICAL SOURCE

- *Diospyros virginiana* is a deciduous tree with a rounded oval crown that grows to 35–60' inches. It is native from Connecticut to Kansas South to Florida and Texas.[4] In Missouri, it typically occurs in rocky or dry open woods, limestone glades, prairies, thickets, abandoned fields, and along roadsides. It is one of the easiest trees to identify in winter because of its distinctive thick, dark gray bark that is broken into rectangular blocks
- *Diospyros kaki* is a tall and deciduous tree growing to 12 m (39 feet) ×7 m (23 feet) at a medium rate with broad stiff leaves.[5] This species is native to China, but cultivation extends to other parts of East Asia, including Japan where it is very popular
- *Diospyros chloroxylon* is a small tree to 6–10 m, deciduous rough bark, thorns found on young growth. It enjoys the full sun, component of deciduous forest type, rarely found in mature evergreen stands.

COMING TO CULTIVATIONAL REQUIREMENTS

Diospyros virginiana

Persimmon tree grows around in all types of forest soils and mainly in sandy loamy soils with a pH range of 6.5–7.5.[8] The soil should be well deeply ploughed and well prepared with enriched organic matters, etc., Seedlings are used for propagation and grow very fast in the hilly terrain areas. Fruiting is very fast in the plants those which are exposed to much sunlight. Excessive nitrogen fertilizers may cause shedding of fruits. The seeds are sown with onset of spring at low temperature hampers seed germination.

Diospyros kaki

D. kaki needs a subtropical to mild temperate climate. The soil should be well prepared, deeply plowed, and enriched with organic matter. Trees should be set out at spacing ranging from 4.5/1.5 to 6/6 m, depending on the habit of the cultivator. In Japan, 1000 plants/ha may be planted at the outset but thinned down to 200 trees/ha in 10–15 years.

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Table 1: Geographical distribution of the selected species

Type	Location
Diospyros virginiana	South Atlantic, Gulf States[6] Mississippi River Basin , Coastal area of Florida South-Eastern Iowa, Southern Missouri Green Land, Alaska , Nebraska , North America Texas, Louisiana, Oklahoma, Kansas, Iowa
Diospyros kaki	Japan, China, Korea, Burma, Nepal, Italy, USA, Spain In India, kaki is grown in the following states Himachal Pradesh Jammu and Kashmir Uttarakhand and Tamil Nadu
Diospyros chloroxylon	India: Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh

Table 2: Folklore uses of selected species

Type	Uses
Diospyros virginiana	The powder of the unripe fruit, inner bark or the bark of the root taken in wine for treatment of dysentery, diarrhea, fevers, hemorrhoids, and other conditions. Used for making beer, spirits, and wine[7] The inner bark and unripe fruit are sometimes used in treatment of fevers, diarrhea, and hemorrhage and as a mouth rinse in the treatment of thrust and sore throats and as a wash for warts or cancers Unripe fruit is used to treat bloody stools. The leaves are used as an antiscorbutic
Diospyros kaki	Fruit is used to treat Ischemia stroke, angina, internal hemorrhage, hypertension, atherosclerosis and some infectious diseases Anti-diarrheal, improve eye movement, aid digestion, lower blood pressure, bleeding hemorrhoids, reduce cholesterol level, strengthen bones, boosts cognitive function, fight intestinal disorders and boosts body's immune system, bitter astringent, anti-viral, anti-bacterial, astringent, stypic, treat various respiratory abnormalities such as influenza, cold, cough
Diospyros chloroxylon	*Diospyros chloroxylon* are used in Siddha medicine The traditional uses of this plant are used medicinally to cure fever, diabetes, snake bite, diarrhea, biliousness, ulcer, etc., The young leaves are grounded and mixed with camphor powder and applied over wounds. Leaf paste with those of *Diospyros chloroxylon* (*Illintha*) and mud is used as an external application on swellings in animals. During dog bite, slightly warmed stem bark paste is used externally; stem bark paste is administered orally once a day at early morning

Diospyros chloroxylon

D. chloroxylon is able to grow in a wide range of soils, but all soils need to be free draining. The tree is propagated by seeds.

PHARMACOLOGICAL EVIDENCE

Diospyros virginiana

Priya and Nethaji have reported that the ethanolic leaf and bark of *D. virginiana* have produced antipyretic effect more effectively than paracetamol. They have conducted the experiments on rats using yeast-induced pyrexia. The *D. virginiana* both extracts caused a dose-dependent decrease in rectal temperature when compared to the control. The ethanolic *D. virginiana* leaf extracts revealed a significant decrease ($P < 0.05$) in temperature between 2 and 5 h after administration. *D. virginiana* bark extract showed the significant decrease ($P < 0.05$) in temperature 3–5 h, respectively. However, paracetamol (10 mg/kg) used as the reference drug caused a greater reduction in the rectal temperature of the rats at the onset, which was significant different ($P < 0.05$), when compared to both control and control-treated groups. The antipyretic effect started as from the 1st h after drug and extract administration and was sustained for 4 h while the control showed no antipyretic effect in the entire period of experiment. The results of the present study indicate that the ethanol leaf extracts of *D. virginiana* possesses significant antipyretic effect compared to the effect of bark extract on yeast-induced hyperthermia in rats.[9]

Priya, *et al.* have reported that the ethanolic extract of the leaves and bark of *D. virginiana* has shown antidiarrheal effects. The extract was evaluated for castor oil-induced diarrhea and intestinal transit in rats. *D. virginiana* significantly dose-dependently reduced frequency of stooling in castor oil-induced diarrhea and intestinal motility in rats. Castor oil + *D. virginiana* leaves at 500 mg/kg concentration reduced the gastrointestinal (GI) mobility up to the level of 79.95% and castor oil + *D. virginiana* bark at the same concentration reduced 62.7% GI mobility, whereas loperamide-treated animal group showed only 45.10% reduction of antidiarrheal activity. These findings suggest that the ethanolic extract of the leaves and bark of *D. virginiana* may contain some biologically active ingredients that are active for the treatment of diarrhea in herbal traditional medicine.[10]

Sirisha *et al.* have concluded that the berries of *D. virginiana* were found to be good gastroprotective agents as well as nutrient supplements. In this research, they have used chloroform, ethanol, and petroleum ether as extractive material to extract the active chemical constituents in *D. virginiana*. Results shown by chloroform extract at a dose of 200 mg/kg b.w are almost significant with that of standard drug and it was found 70% protection against gastric ulcers. Moderate significant action was shown by ethanolic extract whereas minimum action or least action was shown by petroleum ether extract. From this work, they had concluded that chloroform extract at a dose of 200 mg/kg b.w has shown the best protective action against ulcer induced by pyloric ligation; it could be due to the presence of flavonoids and alkaloids. Hence, folklore usage has been validated for *D. virginiana* as antiulcer agent.[4]

Diospyros kaki

Quan *et al.* have reported that the use of *D. kaki* peel reduced the fat content in mice body and it also reduces the atherosclerotic plaque level in the mice. Experiments were conducted on low-density lipoprotein (LDL) receptor-deficient mice with emphasis on lipid metabolism. Mice were fed high-fat diet supplemented with 10% dried and powdered persimmon peel (PP) for 12 weeks. High-fat diet feeding increased plasma level of oxidized 2-glycoprotein 1 complexes regarded as an atherogenic autoantigen, while PP supplementation significantly blocked the increment ($P < 0.05$). After a 12-week feeding of PP to mice, the atherosclerotic autoantigen concentration has been decreased by 70% as compared to that of mice fed with high-fat diet. PP feeding also reduced urinary 11-dehydro-thromboxane B2, a stable metabolite of the platelet activation marker thromboxaneA2, but level of IgM antioxidant LDL antibodies was not changed. Thus, the above results show that the PP has antiatherotic property through normalization of lipid metabolism and reduced production of atherogenic complexes.[11]

Singh *et al.* have conducted various experiments using *D. kaki* extract on pathogenic fungi, which cause various diseases in humans. The pathogenic fungi are *Candida albicans* MTCC 227, *Candida tropicalis* ATCC 6258, *Candida krusei* ATCC 750, *Cryptococcus neoformans* ITCC 1672, *Sporothrix shenkii* ITCC 2317, *Fusarium oxysporum* ITCC 4998, *Trichophyton mentegrophytes* ITCC 3572, *Microsporon gypseum*

Table 3: Morphological characters

Part	*Diospyros virginiana*	*Diospyros kaki*	*Diospyros chloroxylon*
Leaves	Alternate, simple, 4-6 inches (152 mm) long, oval, or cordate at base[8]	These are alternate, entire, ovate-elliptic, oblong-ovate, or obovate, 7.5-25cm long, 5-10 cm wide	These are alternate, oval or oval-oblong, usually rounded at base and mucornate at apex, pubescent, persistent
Petioles	These are stout, pubescent, one-half to an inch in length	These are 2 cm long, brown and hairy	These are usually 5-6 mm long
Flowers	These are greenish yellow or creamy white, tubular, four-lobed; lobes imbricate in bud[7]	These are cream colored and solitary in nature	These are yellowish-white, dioecious, cymose, densely pubescent
Bark	These are deeply divided into plates whose surface is scaly. The bark somewhat broken by longitudinal fissures	Barks droop as the tree grows and will require pruning for pedestrian	It is longitudinally deeply fissured and transversally cracked
Fruit	A juicy berry containing one to eight seeds. Flesh astringent while green, sweet and luscious when ripe	These are round, conical, oblate, nearly square, capped by the persistent calyx. A juicy fruit containing one to eight seeds	The fruit of Diospyros chloroxylon is a globose berry. The fruit is green and turns orange-reddish when ripe

Table 4: Phenology of selected species

Type	Phenology
Diospyros virginiana[19]	Flowering – March-June Fruiting – August-December
Diospyros kaki	Flowering - mid summer Fruiting - mid-November
Diospyros chloroxylon	Flowering – February-June Fruiting season – May-September

ITCC 5277, *Aspergillus flavus* ITCC 5290, *Aspergillus fumigatus* ITCC 4880, *Curvularia lunatus* ITCC 5248, *Rhizomucor pusillus* ITCC W-14, *Phialophora verrucosa* MCCL 32006, and *Pseudallescheria boydii* MCCL W-14. The antifungal activity of petroleum ether, ethyl acetate, chloroform, methanol, and aqueous extracts of the root bark of *D. kaki* was evaluated against 14 human pathogenic fungi using agar diffusion method. The results showed that all the five extracts except aqueous have shown antifungal activity. The chloroform extract has shown maximum antifungal activity with the minimum inhibitory concentration (MIC) in the range of 160–2500 μg/ml. The results obtained in the present study authenticate and support the use of *D. kaki* in folklore medicine for the treatment of various skin diseases.[12] The MIC values of the above-mentioned pathogenic fungi are provided in Table 5.

Diospyros chloroxylon

Georgios tsoulfas, Waseem Rizvi, and Weiting Wang have reported that the methanolic leaf extract of *D. chloroxylon* ameliorates oxidative stress, DNA damage, and cell proliferation in the liver of rats. They also reported that the combination of dimethylamine (DMA) and *D. chloroxylon* leaf extract (DCLE) has reduced the weight of rat, suggesting that the potential of a phytochemicals present in the extract for weight regulation. When compared with DMA and malondialdehyde (MDA), DCLE significantly ($P < 0.05$) increased superoxide dismutase and catalase activities and lowered MDA level in serum and liver against DMA treatment; however, it significantly lowered DNA fragmentation in the (DCLE + DMA) group. Histological data reveal that DMA caused periportal cell infiltration in hepatocytes whereas the control, DCLE, and DCLE + DMA groups showed no visible lesions. Immunohistochemical staining of CD34 showed a strong expression in DMA group, while DCLE + DMA showed a moderate expression.[13]

PHYTOCHEMICAL EVIDENCE

Diospyros virginiana

Priya *et al.* have identified 40 bioactive phytochemical compounds and 30 compounds in leaves and bark of *D. virginiana*. The identified compounds predominantly consist of phenolic derivatives. They also include hydrocarbons, carbohydrates, fatty acid, fatty acid ester, alcoholic compounds, alkaloids, ketones, and alkenes compounds. These phytochemical compounds were screened by gas chromatogram-mass spectrometry method of analysis. From the results, it was observed that hexadecanoic acid, 3,7,11,15-tetramethyl-2-hexadecen-1-ol, was the major component in the extract. Palmitic acid is reported to be an antioxidant, a nematicide, and a pesticide,[9] while phytol is said to be cancer preventive. Other antioxidants present were tetradecanoic acid; hexadecanoic acid; heptadecanoic acid; 2, 6, 10, 15, 19, 23-hexa methyl; and gamma-tocopherol.[14]

Priya and Nethaji have investigated the preliminary phytochemical screening of the leaves and bark of *D. virginiana* belonging to family *Ebenaceae*. The dried leaves and bark of the plant were subjected to successive Soxhlet extraction by continuous hot percolation method using organic solvents of increasing polarity such as ethanol. Both the extracts were subjected to qualitative phytochemical screening. The phytochemical analysis of the *D. virginiana* extracts showed the presence of tannins, alkaloids, flavonoids, and phenolic compounds. Tannins have been found to form irreversible complex with proline-rich protein synthesis. The results showed that the plants hold tremendous promise in providing the variable secondary metabolites and mineral supply that could enhance the curative process of ill health.[15]

Diospyros kaki

The chemical constituents present in *D. kaki* are betunalic acid, flavonoids, fibers, minerals, vitamins, cartenoids, mucilage, pectin, tannins, kaempferol-3 glucoside, quercetine-3 glucoside, Vitamin C, and shibuol.[16]

Diospyros chloroxylon

Ali *et al.* have reported the isolation of the binaphthaquinones, diospyrin, and (-) isodiospyrin from the wood of *D. chloroxylon*. On chromatography of the crude chloroform extract of the wood on a silica gel column with chloroform-benzene (4:1), 7-methyl juglone, diospyrin, diospyrin-iso-diospyrin mixture, and diospyrin-xylospyrin mixture were eluted.[17]

Thomas *et al.* have done comparative preliminary study on the phytochemistry of acetone, methanol, ethanol, and aqueous extracts of the leaves of *D. chloroxylon* of family *Ebenaceae* using specific color reaction tests. Phytochemical studies indicated that the leaf contain a broad spectrum of secondary metabolites such as carbohydrates, cardiac glycosides, alkaloids, flavonoids, tannins, amino acids and proteins, and saponins. The results obtained showed that acetone was the best extractive solvent. The acetone extracts of the leaf have shown positive results for carbohydrates, cardiac glycosides, terpenoids, alkaloids, phenols, tannins, and saponins. However, flavonoids, quinines, fixed

Table 5: MIC values of pathogenic fungi

Fungus	MIC
Candida albicans (MTCC 227)	160
Candida tropicalis (ATCC 6258)	160
Candida krusei (ATCC 750)	160
Cryptococcus neoformans (ITCC 1672)	320
Sporothrix schenckii (ITCC 2317)	630
Fusarium oxysporum (ITCC 4998)	630
*Trichophyton mentegrophytes*7 (ITCC3572)	320
Microsporon gypseum (ITCC 5277)	320
Aspergillus flavus (ITCC 5290)	320
Aspergillus fumigatus (ITCC 4880)	630
Rhizomucor pusillus (ITCC W-14)	1250
Phialophora verrucosa (MCCL 32006)	1250
Curvularia lunatus (ITCC 5248)	1250
Pseudallescheria boydii (MCCL W-48)	2500

MIC=Minimum inhibitory concentration

oils, and fats are absent in all the four extracts. The presence of these metabolites suggests great potential for the *D. chloroxylon* plant as a source of useful phytomedicines. For instance, the presence of tannins could also shows that it is an astringent that helps in wound healing and antiparasitic. Tannins bind to proline-rich proteins and interfere with the protein synthesis.[18]

CONCLUSION

Diospyros genus plants grown majorly in the tropical areas, found to have many folklore uses mainly in the treatment of diarrhea, for decreasing the increased cholesterol level, improve cognitive function used for inflammatory disorders, but very few scientific evidence is available in relating to these three plants of the present review. With this review, it will be helpful for researchers to prove scientific evidence of the folklore uses.[19]

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Conflicts of interest

There are no conflicts of interest.

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