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Review Article

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Carya illinoinensis: Ethnobotany, Phytochemistry and Pharmacology- A Review

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Abstract The plant *Carya illinoinensis* belongs to the Juglandaceae family and is native of the south of the United States and north of Mexico, but are also cultivated in other regions of the world, such as South America, Australia, North Africa, Palestine, China, India, France, Spain and North Africa. Traditionally it has been used for the treatment of various ailments such as inflammation, rheumatism, jaundice and malaria. Following various folk claims for cure numerous diseases, efforts have been made by researcher to verify the efficacy of the plant through scientific biological screenings. The plant contains saponins, alkaloids, steroids, tannins, flavonoids and triterpenoids are the main phytoconstituents. A scrutiny of literature revealed some notable pharmacological activities like anti-diabetic, anti-tumor, antioxidant, anti-microbial, antihyperlipidemic activities. The present review is an attempt to highlight the various ethanobotanical and traditional uses as well as phytochemical and pharmacological reports on *Carya illinoinensis*.

Keywords *Carya illinoinensis*, ethnobotany, phytochemistry, pharmacological activities

Introduction

Natural products are being increasingly recognized as potential sources of new drug leads. The use of plant remedies in the prevention and treatment of illness has a history as long as that of mankind. The demand for herbal medicines has continued to grow since 1980s. Patients are taking charge of their own health and exploring treatment alternatives. They have easy access to online health information, which increases frequency of the use of herbal medicines. According to a report of World Health Organization, more than 80% of world's populations depend on traditional medicine for their primary health care needs [1, 2]. Traditional medicines have long provided front-line pharmacotherapy for many millions of people worldwide. Although their application is often viewed with skepticism by the Western medical establishment, medicinal extracts used in ancient medical traditions such as

Ayurveda on the Indian subcontinent and traditional Chinese medicine are a rich source of therapeutic leads for the pharmaceutical industry. The use of medicinal plant therapies to treat chronic illness, including rheumatoid arthritis (RA) and inflammatory bowel disease (IBD), is thus widespread and on the rise [3]. Plants may also be an important source of biologically active natural products and could be considered a promising avenue for the discovery of new drugs due to easy access and relatively low cost [4]. Current treatments for the chronic inflammation involved in diseases such as arthritis, autoimmune disorders, cancer, dementia, diabetes, neurodegeneration, and vascular diseases are not definitive because of potential adverse events and a lack of efficacy. Whitehouse has recently reviewed and considered the problem of the serious concomitant side effects of powerful anti-inflammatory drugs modelled upon the principal human glucocorticoid hormone, cortisol. The use of anti-inflammatory steroids has limitations particularly with high dosage and prolonged use [4]. In this context, the identification of substances that can promote the resolution of inflammation in a way that is homeostatic, modulatory, efficient, and well-tolerated by the body is of fundamental importance. Therefore the potential plants need to be explored for new drug development. This review aims at reviewing the traditional uses, phytochemical profiles and therapeutic potential of various parts of *Carya illinoinensis*, which has been used in traditional practice for many years. *Carya illinoinensis* (Pecans) are tree nuts that are native to the southern United States and northern Mexico but are also cultivated in other regions of the world, such as South America, Australia, North Africa, Palestine, China, India, France, Spain and North Africa [5].

Botanical description of *Carya illinoinensis*

The *Carya* genus comprises several species and is commercially cultivated in North America and East Asia for over 500 years. It has been has been reported to possess the highest antioxidant capacity and the highest phenolic content among the common fruits and vegetables [6, 7]. *C. illinoensis* is one of the best-known pecan hickories. It is also called sweet pecan nuts. *C. illinoensis* is a native, medium to large sized deciduous tree ranging from 100-140 feet [8].

- **Leaf**

Leaves are odd-pinnately compound, with generally 7 to 17 leaflets. The leaflets are lanceolate or lanceolate-oblong in shape, curved to one side, and coarsely serrated along their margins. The leaflets have asymmetric bases and elongated tips [9]. Their upper surfaces are yellowish green to dark green and glabrous, while their lower surfaces are pale green and glabrous to sparsely pubescent (Figure 1.1).

Figure 1.1: Exomorphic features of leaves of Carya illinoinensis

- **Bark**

The *C. illinoensis* has gray bark that becomes reddish brown with age and rough-textured; it has shallow irregular furrows and flattened ridges with barely discernible shapes. The bark of large branches is similar to trunk bark [10] (Figure 1.2).

Figure 2.2: Exomorphic features of trunk bark of Carya illinoinensis

- **Flowers**

Flowers are monoecious; are pollinated by the wind and both male and female flowers are on the same tree. The male flowers are in hanging catkins and the female flowers in terminal spikes. Both male and female flowers are green in color, with individual flowers about 1/8″ in size. Flowers are incomplete, and both sexes lack petals and sepals. The males are basically groups of anthers subtended by bracts, and the females are merely an ovary with large, feathery stigma at the distal end, having almost no length of style in between (Figure 1.3).

Figure 1.3: Exomorphic features of flowers of Carya illinoinensis

- **Fruit**

The fruit is technically a drupe, dark brown in color and covered with yellow scales. The husk is thin and brittle. The husk often persists on the branch into the winter after dropping the nut [12]. The nut is thin shelled with a reddish-brown color and pointed at both ends. Crack open the nut to get at the delicious, oily, nutrient-rich kernels (Figure 1.4).

Figure 1.4: Exomorphic features of fruits of Carya illinoinensis

Ethanobotanical uses

C. illinoinensis was used by the Comanche as a treatment for ringworm. They would pulverize the leaves and rubbed them on the infected part of the ringworm. The Kiowa would consume a decoction made from the bark of pecan for tuberculosis [13]. *C. illinoinensis* are an excellent source of vitamin-E, especially rich in gamma-tocopherol; provide about 25 g per 100 g. Vitamin E is a powerful lipid soluble antioxidant, required for maintaining the integrity of cell membrane of mucus membranes and skin by protecting it from harmful oxygen-free radicals. The nuts are very rich sources of several important B-complex groups of vitamins such as riboflavin, niacin, thiamin, pantothenic acid, vitamin B-6, and folates. Together, these vitamins work as co-factors for the enzyme

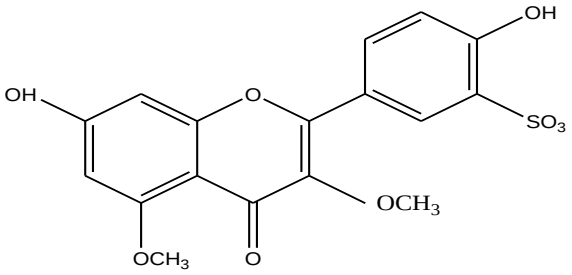
metabolism inside the human body. The nuts are also rich source of minerals like manganese, potassium, calcium, iron, magnesium, zinc, and selenium [14-17].

Other uses

The *C. illinoinensis* trees produce edible nuts that have a high percentage of fat and are used extensively in candies and cookies [18, 19]. These nuts are sweet and delicious and are often added to bread, cake, and ice cream. The oil from the rejected nuts is used for cooking and cosmetics. Milk can be made from the seed and is used to thicken soups and season corn cakes [20]. The leaves are said to be used as a tea. The wood has occasionally been used for flooring, furniture, cabinetry, paneling, and agriculture implements.

Phytochemistry

- *C. illinoinensis* are rich in unsaturated lipids and their regular consumption can improve the serum lipid profile and the antioxidant status [21]**.**
- Domínguez-Avila *et al.,* 2013 reported that presence of mono- and polyunsaturated fatty acids, phytosterols, tocopherols and other micronutrient in the oil of *C. illinoinensis* [22]**.**
- Two new flavonol methyl ether: caryatin-3` sulfate **(1)** and caryatin-3` methyl ether-7-O--D-glucoside **(2)** were isolated the n-butanol fraction of bark of *C. illinoinensis* along with five known phenolics compounds from its ethyl acetate fraction [23].
- In previous study reported the presence of high concentration of bioactive compounds, including ellagic **(3)**, gallic acids **(4)**, catechin **(5)**, epicatechin **(6)**, hydrolysable and condensed tannins in non-lipid fraction of *C. illinoinensis* were identified [24].
- In study carried out by Leon, 1964 and his group reported the presence of capric, lauric, myristic, palmitic, stearic, arachidic, oleic, linoleic, and linolenic acids along with a crystalline acidic substance was identified as 3, 4-dihydroxybenzoic acid in the saponified portions of lyophilized aqueous extract of *C. illinoinensis* [25].



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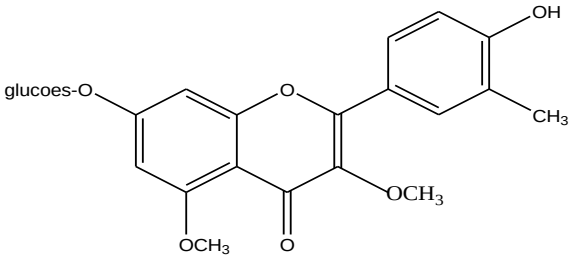

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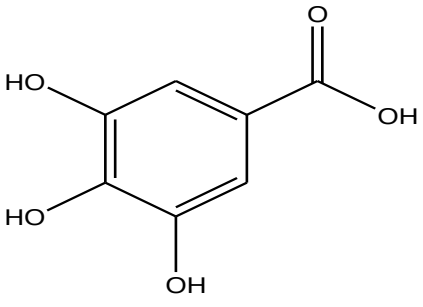

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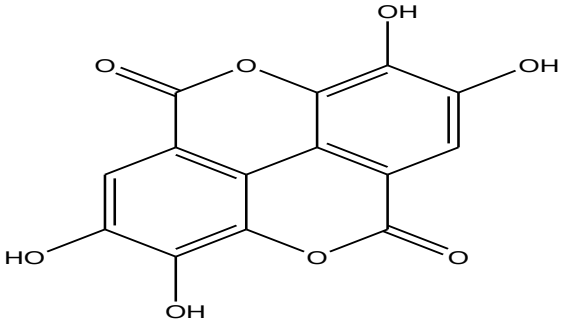

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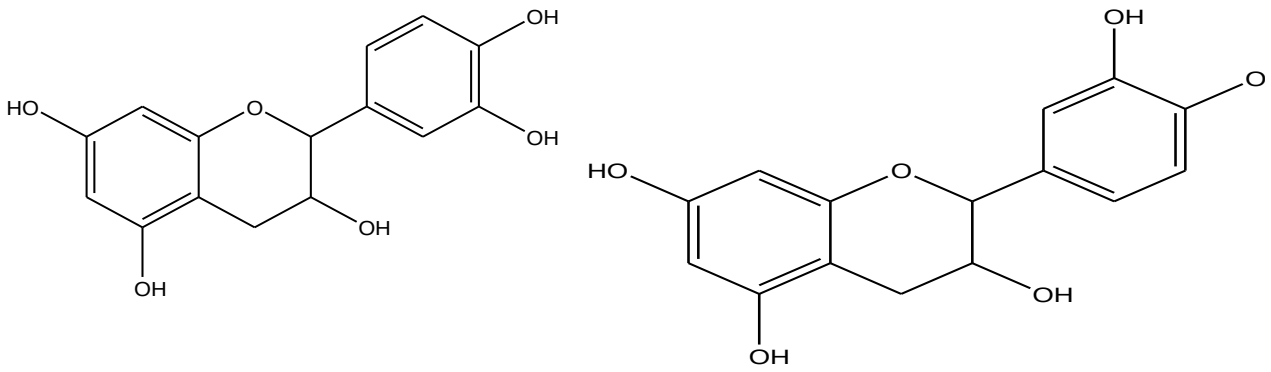

(5) **(6)**

Figure 2: Structures of selected some phytoconstituents previously isolated from C. illinoinensis. Caryatin-3` sulfate (1) caryatin-3` methyl ether-7-O--D-glucoside (2) gallic acid (3) ellagic acid (4) catechin (5) and epicatechin (6)

Pharmacological screening of *C. illinoinensis*

Following are the folk and traditional uses of the plant; it has been investigated scientifically in animal models to validate the potential of the plant in cure of variety of ailments.

- **Anti-diabetic activity**

Hossam *et al.,* 2011 carried out hypoglycemic activity of isolated two new flavonol methyl ether: caryatin-3` sulfate and caryatin-3` methyl ether-7-O-D-glucoside from the n-butanol fraction of bark of *C. illinoinensis* along with five known phenolics compounds. All the isolated compounds exhibited significant hypoglycaemic and antioxidant activities [26].

- **Antimicrobial activity**

Sabrina *et al.*, 2016 screened anti-microbial property of aqueous extract of *C. illinoinensis against pathogenic bacteria Listeria monocytogenes, Salmonella Enteritidis, Staphylococcus aureus, Bacillus cereus, Aeromonas hydrophila and Pseudomonas aeruginosa*. The aqueous extract *C. illinoinensis* exhibited potent anti-microbial activity against above six pathogenic bacteria [26].

- **Antioxidant activity**

- The investigation of the total phenolic and condensed tannin contents of *C. illinoinensis* nut shell infusion and the antioxidant activity of the infusion was evaluated through ABTS (2,2′-azino-di-(3-ethylbenzthiazoline sulfonic acid), DPPH (2,2-diphenyl-1-picrylhydrazyl) and β-carotene/linoleic acid systems. The shell presented high fiber content (48% ± 0.06), the total phenolic content ranged from 116 to 167 mg GAE/g and the condensed tannin content was between 35 and 48 mg CE/g. The antioxidant activity varied from 1112 and 1763 μmol TEAC/g in the ABTS system. In the DPPH method, the antioxidant activity was from 305 to 488 mg TEAC/g (30 minutes reaction) and from 482 to 683 mg TEAC/g (24 h reaction). The oxidation inhibition percentage obtained in the β-carotene/linoleic acid system varied from 70 to 96%. The results indicated the high phenolic content and significant antioxidant activity of Pecan nut shell infusion [27].
- In a study carried out by Prado et al., 2009b the total phenolic and condensed tannin contents of different *C. illinoinensis* kernel cake extracts (ether, acetone, alcohol and distilled water) their antioxidant activities were evaluated through ABTS, DPPH and β- carotene/linoleic acid systems. Their findings revealed that the kernel of *C. illinoinensis* species might be a potentially antioxidant activity due to high content of condensed tannins [28].
- Mao et al., 2011 investigated the antioxidant activities of methanol extracts from four species of *Carya genus* were compared by various antioxidant assays, including the reducing power, DPPH radical scavenging activity and the superoxide anion scavenging activity. The reducing power of extracts from *C.*

dabieshanensis, C. cathayensis, C. hunanensis and C. illinoensis were 0.246, 0.237, 0.22 and 0.073 at the concentration of 0.50 mg/ml, respectively. Among the four species, *C. dabieshanensis* possessed the highest antioxidant activity, while *C. illinoensis* was the lowest. The antioxidant activity of methanolic extracts of four *Carya* species may be attributed to the phytoconstituents present, such as phytosterol, tannins and high content of phenolic components [29].

- **Antihyperlipidemic activity**

  Domínguez-Avila *et al.*, 2015 studied the lipid lowering activity of *C. illinoinensis* nut extracts in rats using high fat diet induced hyperlipidemic models. Administered high-fat (HF) diets to male Wistar rats, supplementing them with pecan oil (HF + PO), pecan polyphenols (HF + PP) or whole pecans (HF + WP), and analyzed the effects of each fraction. The HF diet increased the serum leptin and total cholesterol (TC) with respect to the control levels. The HF +WP diet prevented hyperleptinemia and decreased the TC compared with the control. The HF +WP diet up regulated the hepatic expression of apolipoprotein B and LDL receptor mRNAs with respect to the HF levels. The HF + PO diet reduced the level of triacylglycerols compared with the control. The HF+PP diet stimulated the hepatic expression of liver X receptor alpha mRNA. The HF+WP diet increased the activities of hepatic catalase, glutathione peroxidase and glutathione S transferase compared with the control, and decreased the degree of lipid peroxidation compared with the HF diet. The most bioactive diet was the WP diet. The lipid lowering activity of the aqueous nut extracts of *C. illinoinensis* may be attributed to the phytoconstituents present, such as phytosterol, tannins and high content of phenolic components [30].

Conclusion

In recent years, ethnobotanical and traditional uses of natural compounds, especially of plant origin received much attention as they are well tested for their efficacy and generally believed to be safe for human use. The obviously deserve scrutiny on modern scientific lines such as phytochemical investigation, biological evaluation on experimental animal models and toxicity studies, investigation of molecular mechanism of action of isolated phytoprinciple and their clinical trials. It is a best classical approach in search of new lead molecules for managements of various diseases. Through screening of literature available on *C. illinoinensis* depicted the fact that it is a popular remedies among the various ethnic groups, vaidyas, Hakim and Ayurvedic practioners for cure of variety of ailments. Following traditional and folk claims, little efforts have been made by researchers to explore the therapeutic potential of this plant. It is interesting to note that the earlier scientific investigation on this plant *C. illinoinensis* reveals that analgesic, anti-tumor, antioxidant, antimicrobial, hypoglycemic and free radical scavenging, properties tested with crude extracts. However naturally occurring terpenoids, flavonoids, steroids and alkaloids, are unique phytoconstitiuents of the genous *C. illinoinensis*. But there is no scientific evidence has been demonstrated against the effect of this phytoconstitiuents enriched fraction for their biological potentials. In future study, the isolated phytoprinciples from *C. illinoinensis* need to be evaluated in scientific manner using specific experimental animal models and clinical trials to understand the molecular mechanism of action, in search of lead molecules from natural resources.

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