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Parkinsonia aculeata: A Phytopharmacological Review

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Abstract: Since the ancient period plants have been utilized by human beings as medicinal agents on the basis of ethnomedical background. Later on, these speculations were transformed into a scientific basis as a single drug agents. Basic sciences working on plants, serves to use, the obtained natural products as new bioactive pharmaceutical prototypes. The search for phytomedicines that are safe and affordable is still on-going. *Parkinsonia aculeata* is one such a large spinous shrub or a small tree found in the warmer parts of America and Mexico. This species has been introduced and become naturalized in India. It is a well known medicinal shrub for its beneficial effects as antipyretic, antimalarial, diaphoretic and abortifacient. The phytochemistry of the leaves, flowers and stems of *P. aculeata* has revealed the presence of glycosides, glycerides, flavonoids, reducing sugars, sterols and traces of minerals. Studies indicate that it possess various pharmacological activities. The present review aims to showcase phytochemical and pharmacological properties of *Parkinsonia aculeata*.

Key words: *Parkinsonia aculeata*, Fabaceae, C-glycosides, antioxidant, antidiabetic

INTRODUCTION

Medicinal plants have been a major source in the maintenance of health, as well as in the prevention, diagnosis, improvement or treatment of physical and mental illness. They are moving from fringe to main stream use with a greater number of people seeking remedies and health approaches free from side effects caused by synthetic chemicals. The world's one-fourth population i.e., 1.42 billion people, are dependent on traditional medicines for the treatment of various ailments. Especially in some Asian countries more than 80% of people depend on plant based traditional medicine for primary health care (WHO, 1998). The World Health Organization launched its comprehensive traditional medicine strategy in 2002 to promote safe, effective and affordable traditional medicine (WHO, 2000, 2002). An innovative research effort to define the advantages of traditional systems of medicine with respect to their safety and efficacy could result in a better utilization of these complementary systems of medicine.

In response to the global need for scientific information on medicinal plants, the present review compiles all relevant information on the biological and chemical aspects of *P. aculeata*. The tree is a spiny and fast growing living hedge which is used as barrier for livestock and also a well known medicinal shrub. This multipurpose tree belongs to the family Fabaceae (bean family), native to tropical America, extending from Mexico to South America. It has been introduced and is widely cultivated in Florida, Israel, Jamaica, South Africa, Uganda and India (DNR, 1998; PIER, 2000; Wagner *et al*., 1999). In India it is now completely naturalized in all dry regions, particularly in western parts. Plantations of this species are also being raised in the arid and semi-arid tracts of western Uttar Pradesh, Rajasthan and Gujarat (Rajagopalan, 1991). It is commonly called as Mexican PaloVerde, Jerusalem thorn and Jellybean tree (Correll and Johnston, 1970).

BOTANICAL DESCRIPTION

P. aculeata is a small, spiny deciduous tree (Fig. 1a) grows upto 4-10 m high with a short and often crooked trunk up to 40 cm in diameter. It is often branching near the ground with a very open crown of spreading branches and very thin drooping foliage. It remains green throughout the year and appears leafless after leaflets fall.

The bark (Fig. 1d) is smooth and yellow-green or blue-green and the branches and twigs are often the same colour. Twigs are slender and slightly zigzag in shape; finely hairy when young, often have paired short spines (stipules) that may remain on the branches and trunk in groups of three or singly and remaining at nodes, including 2 short spines.

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Fig. 1 (a-e): Parkinsonia aculeata Tree and its different parts; (a) Tree, (b) Flowers, (c) trunk of tree showing bark, (d) stem and twig and (e) leaves

Leaves (Fig. 1e) are specialized and are in alternate order. They consist of 1 or 2 pairs of 1-2 cm long spiny ended axis. They are yellow-green in colour at drooping side axes. Strips or streamers are 20-30 cm long and 3 mm broad, flat and slightly thickened. Each strip contains 20-30 pairs of thin, oblong, green, small leaflets of 3-5 mm long. They resemble a blade of grass and continue functioning as leaves after leaflets fall.

A flower cluster is 7.5-20 cm long at leaf bases and remains unbranched. Flowers (Fig. 1b) are irregular and slightly pea shaped fragrant, showy, golden yellow in colour. Flowers consisting calyx, a short tube with 5 narrow yellow-brown lobes turned back and corolla of 5 nearly round petals 10-13 mm long, yellow tinged with orange and hairy at base. Their upper petal is slightly larger, red spotted and exhibit turning with withering. A flower consists of 10 green stamens with brown anthers, reddish tinged hairy pistil and a single celled ovary.

Pods are linear, torulose, striated, dehiscent, 5 to 15 cm long and constricted between the oblong dark brown seeds which are 0.90 cm long pointed.

Seeds are 1-5 in number, beanlike and oblong in shape, 1 cm long, dark brown in colour (Fournier, 2004; Wagner *et al*., 1999).

TRADITIONAL USES

Leaf, fruit and stem decoctions are taken orally to treat fever, malaria and as an abortifacient. Flower and leaf extractions in alcohol are applied as a poultice to treat rheumatism (Orwa *et al*., 2009).

PHYTOCHEMISTRY

Leaves of the plant have been reported to contain C-glycosylflavones like orientin, iso-orientin, vitexin and

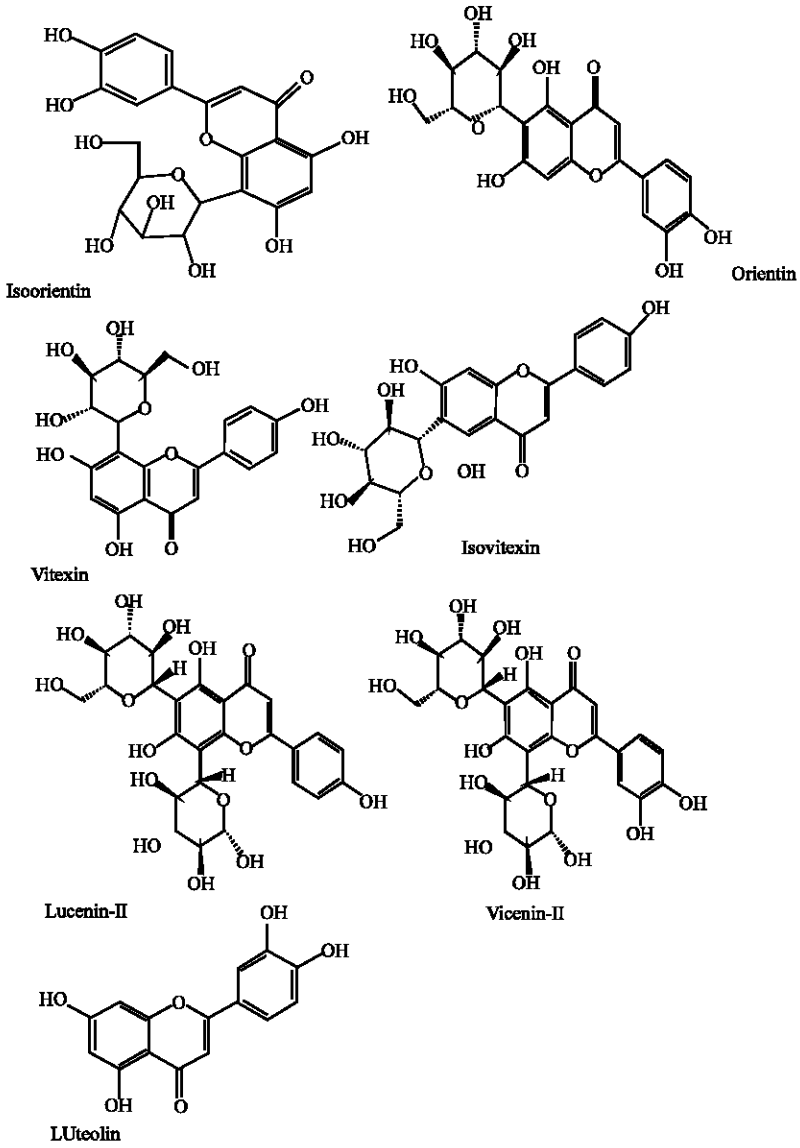

Fig. 2: Chemical constituents of *P.aculeata*

iso-vitexin. Orientin is present in the laevorotatory form (Besson *et al*., 1980). The other constituents reported in leaves of *P. aculeata* are C-glycosides; Epi-orientin, a C-glycoside of luteolin which resembles orientin in composition; Parkinsonin-A, a C-glucoside of 5-O-methyl-luteolin which is closely related to orientin and Parkinsonin-B, a C-glucoside of 5,7-di-O-methyl luteolin which has stereochemistry related to epi-orientin (Bhatia *et al*., 1966). Flavone C-glycoside luteolin which is structurally elucidated as 7, 4'-dimethyl ether 6-C-glucoside has also been isolated from the leaf extract of *P. aculeata* collected from Egypt. From the same extract few of the known compounds (Fig. 2) Orientin, iso-orientin, vitexin, iso-vitexin, lucenin-II, vicenin-II, diosmetin 6-C-β-glucoside, apigenin, luteolin, kaempferol and chrysoeriol were identified by standard procedures and were reported by El-Sayed *et al*. (1991). Also extensive studies on the leaves reported that a new flavanone with epoxy-isopentyl moiety named as Parkintin has been isolated from the methanol soluble part of the leaves (Ali *et al*., 2005).

Stems of *Parkinsonia aculeata* yielded compounds like glycerol β-butanoate α α'-dipentanoate, β-sitosterol, glycerol β-heptanoate κ-octanoate, β-sitosteryl-β-D-glucoside and sucrose (Meera *et al*., 1999).

P. aculeata seed oil contain a high amount of polyunsaturated fatty acids (Sharma *et al*., 2009). Aqueous and alkaline extraction of the milled endosperms of *P. aculeata* yielded four galactomannan fractions with viscous galactomannas and mannose: galactose ratios of 3.1:1; 3.7:1; 4.9:1 and 6.1:1, respectively. Structural studies of these fractions showed a linear backbone of β (1>4) linked d-mannose units, to which single α (1>6)-linked d-galactose was attached (Tewari *et al*., 2005; Garros-Rosa *et al*., 2006). N-Acylamino acid aminoacylase enzyme was found present within cotyledons and embryo of the seeds of *P. aculeata* (Lugay and Aronson, 1969).

Good amount of all the minerals like Ca, Mg, Na, K, P, Cu, Fe, Mn and Zn except Na and K were isolated from the leaves and twigs of *P. aculeata* (Ramirez *et al*., 2006).

Few rotenoids like rotenone, elliptone and deguelin were identified and isolated from various parts of *P. aculeata* and their recovery has been found maximum as per the order: Root>stem>leaves>pods>seed (Kamal and Mathur, 2007).

PHARMACOLOGICAL PROPERTIES

Many pharmacological studies have been reported for the different extracts and phytochemical constituents of *P. aculeata*. A summary of the reported biological activities is described below also given in Table 1.

Antibacterial activity: Hexane and methanol extracts of *P. aculeata* was found to be active against various bacteria: *Bacillus cereus*, *Escherichia coli*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Shigella boydii*, *Staphylococcus aureus* and fungi *Pseudallescheria boydii*, *Candida albicans*, *Aspergillus niger*, *Microsporum canis*, *Trichophyton simii* and *Macrophomina phaseolina* at a concentration of 400 μg mL^{-1} (Ali *et al*., 1999). In another study, crude ethyl alcohol, petroleum ether and chloroform extracts of the leaves of *P. aculeata* were found to inhibit *Pseudomonas aeruginosa*, *Streprococcus faecalis* *Staphylococcus aureus*, *Escherichia coli* and *Salmonella typhimurium* and *Klebsiella* sp. Minimum Inhibitory Concentrations (MIC) of the crude extracts were determined for the above organisms ranged between 35 and 50 mg mL^{-1} and the Minimum Bactericidal Concentration (MBC) ranged between 45 and 60 mg mL^{-1}. Earlier reports suggested that plants containing phenolic compounds like tannins and non-toxic glycosides that can get hydrolyzed to release phenolics are toxic to microbial pathogens. Therefore, the principle active compounds detected may be responsible for the antibacterial activity of the tested organisms (Kamba and Hassan, 2010).

Antidiabetic activity: Water Soluble Fraction (WSF) of aerial parts (leaves and flowers) of the *P. aculeata* was investigated for antidiabetic activity in alloxan induced diabetic rats. Oral administration of WSF at a dose of 125 or 250 mg kg^{-1} for 16 days was found to exhibit a significant reduction in serum and urinary glucose, urinary urea, total cholesterol, HDL-cholesterol and triglycerides in diabetic rats and also showed improvement in hepatic glycogen and a decrease in food and water intake. In addition a significantly positive signs in the weight of skeletal muscles (soleus and extensor digitorum longus) and improvement in kidneys was also observed (Leite *et al*., 2007). Hydroethanolic extract of aerial parts of *P. aculeata* (HEPA) at a dose of 125 or

Table 1: Constituents and uses of different parts of *Parkinsonia aculeata*

Part of the plant	Traditional use	Reported constituents	Reported activates
Leaf	Decoction used to treat fever, malaria and abortifacient. Alcoholic extract as poultice used to treat rheumatism	C-glycosylflavones: orientin, iso-orientin, vitexin and iso-vitexin. C-glycosides: epi-orientin, parkinsonin-A, parkinsonin-B. Luteolin, apigenin, lucenin-II, vicenin-II, diosmetin 6-C-β-glucoside kaempferol and chrysoeriol. Flavanone: parkintin. Minerals: Ca, Mg, Na, K, P, Cu, Fe, Mn and Zn. Rotenoids: rotenone, elliptone and deguelin.	Antibacterial Antidiabetic Antioxidant Hepatoprotective Antimalarial activities
Stem	Decoction used to treat fever, malaria and abortifacient.	Glycerol β-butanoate α α'-dipentanoate, β-sitosterol, glycerol β-heptanoate κ-octanoate, β-sitosteryl-β-D-glucoside and sucrose. Rotenoids: rotenone, elliptone and deguelin.	Antispermatogenic activity
Fruit	Decoction used to treat fever, malaria and abortifacient.		
Flower	Alcoholic extract as poultice used to treat rheumatism.		Antidiabetic and Anti-malarial activity
Seed		Polyunsaturated fatty acids, *N*-Acylamino acid aminoacylase enzyme. Rotenoids: rotenone, elliptone and deguelin.	
Root		Rotenoids: rotenone, elliptone and deguelin.	Amoebicidal activity

250 mg kg^{-1} for 16 days showed similar effect as WSF but did not present any improvement in cholesterol and HDL-cholesterol levels in diabetic, as well as normal in rats. Therefore HEPA treatment was considered to have a relevant hypotriglyceridemic effect in both the groups. Earlier reports indicated the beneficial effects of glycosylated flavonoids like orientin, isoorientin, vitexin and isovitexin, produced in diabetes. In this context, probably the glycosylated flavonoids found in the HEPA extract might have produced its antidiabetic properties (Leite *et al*., 2010).

Antioxidant activity: The antioxidant activity of the 70% hydroalcoholic extract of *Parkinsonia aculeata* was evaluated *in vitro* by various experimental parameters such as DPPH radical scavenging activity, nitric oxide scavenging, β-carotene-linoleic acid module system, hydroxyl radical scavenging activity and lipid peroxidation. The extract successfully reduced ferric ions and its total phenolic content was determined (Mruthunjaya and Hukkeri, 2008).

Antirabies activity: The pharmacognostical data on *P. aculeata* and its use as an antirabies agent based on folklore and along with clinical data involving voluntary subjects have been reported by Trivedi (1975).

Amoebicidal activity: Different concentrations of isolated rotenoids, 1000, 500, 250, 125, 62 and 31 μg mL^{-1} from roots were subjected to *in vitro* anti-amoebic activity along with standard rotenone and also derris resin of the same concentrations for different time intervals (24, 48 and 72 h) in the concentration range 31 to 1000 μg mL^{-1}. Anti amoebic activity at the concentration of 500 μg mL^{-1} of extract was found equivalent to that of anti amoebic activity of standard at 250 μg mL^{-1} concentration (Kamal and Mathur, 2007).

Hepatoprotective activity: *P. aculeata* leaves extract posses potent hepatoprotective activity against carbon tetrachloride (CCl_4). The 50% ethanolic extract of leaves at doses of 100, 200 and 300 mg kg^{-1} showed potent hepatoprotective activity in a dose dependent manner. Results suggested that the leaf extracts of this plant have potential therapeutic and preventive efficacies, probably due to its antioxidative effect (Hassan *et al*., 2008).

Antispermatogenic activity: Ethanolic extract of stem bark of *P. aculeata* was administered in male rats at doses of 50, 100 and 200 mg kg^{-1} per day for 60 days. The body weights were not affected but the weights of reproductive organ decreased. Suppression of cauda epididymal sperm count and motility was observed. Fertility was decreased to 100% in extract-treated rats. The microscopic testicular cell count that is primary and secondary spermatocytes was reduced significantly. A significant decline was also noticed in seminiferous tubular diameter and differential count of Leydig cells. No change in the blood and serum profile, however, testosterone level of serum was declined. The concentration of testicular cholesterol was elevated whereas protein, sialic acid, glycogen and fructose content were reduced significantly. These results suggested that extract has an antispermatogenic effect in male rats (Gupta *et al*., 2007).

Antimalarial activity: Crude extract of aerial parts (leaves and flowers) of *P. aculeata* was evaluated against malaria. Different extracts viz. n-hexane, dichloromethane, ethyl acetate and methanol extracts were screened for Schizontocidal activities using a standard *in vitro* assay with 3D7 *Plasmodium falciparum* strain and results were expressed in IC_{50}. Among all the extracts n-hexane extract showed IC_{50} 24.5±2.9 μg mL^{-1} and exhibited moderate activity (Ramalhete *et al*., 2008).

Others (effect of heavy metals on growth): In two different studies conducted separately, it was found that *P. aculeata* resisted the effects of heavy metals like cobalt, zinc lead, chromium and cadmium on germination, seedling growth, dry biomass accumulation and phenolic contents germination compared to another tree *Pennisetum americanum*. In one study, Cobalt and zinc reduced the final germination of both the trees greatly at higher concentrations. But the germination reduction was markedly higher in *Pennisetum* compared to *Parkinsonia*. It was reported that the *Parkinsonia* exhibited some degree of tolerance against heavy metals in terms of germination, root and shoot growth and dry biomass accumulation (Shaukat *et al*., 1999).

In another study, chromium and cadmium were applied as chloride while lead was used both as nitrate and chloride. Cadmium, chromium and lead salts in both the test species at concentrations of 50 ppm or more, reduced the germination which was markedly higher in *Pennisetum americanum* compared to *Parkinsonia aculeata*. Lead chloride inhibited germination more severely than did lead nitrate. Both root and shoot growth were also reported to be significantly reduced by Cd, Cr and $PbCl_2$. Phenolic contents were substantially elevated in both the test species following treatment with heavy metals particularly at higher concentrations (200 and 400 ppm). *Parkinsonia aculeata* was less affected in terms of germination, root and shoot growth and dry matter accumulation as compared to *Pennisetum americanum* (El-Nahry and Khashaba, 2006).

CONCLUSION

The plant *P. aculeata* has been widely used in various traditional system of medicine. It is used since centuries as an antipyretic, diaphoretic and abortifacient. Recent research carried out indicated its other uses such as antibacterial, hepatoprotective, antifertility and anti-diabetic. The plant is also an important source of various types of compounds with diverse chemical structures. However, very little study has been done on the chemical constituents of the plant. So, there is a wide scope for investigation of more activities from the compounds isolated from the plant. Also since it was reported that the species can grow in presence of heavy metals, *P. aculeata* can be cultivated in polluted areas where it can resist heavy metals toxicities.

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