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An updated Review on Phytochemical and Pharmacological Studies of *Adenanthera pavonina* Linn

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Abstract

Adenanthera pavonina is a well-known holistic medicinal plant in South Asian countries. Processed seeds of *A. pavonina* served as a nutrient-rich food. The title plant is used in traditional medicine for the treatment of various diseases such as rheumatism, skin burns and ulcer. Investigations into the pharmacological properties of this plant manifested a wide spectrum of bioactivities including anticancer, anti-malarial, anti-viral activities. Both crude extracts and isolated monomeric compounds exhibit a broad spectrum of pharmacology. Adenovin is a novel peptide isolated from *A. pavonina* seeds that provide trypsin-inhibition activity. This review aims to highlight the reported phytochemical and pharmacological studies of *A. pavonina* to explore its pharmaceutical applications.

Keywords: *Adenanthera pavonina,* redwood tree, seed oil, red seeds, trypsin

Introduction

Adenanthera pavonina is known as "Red wood tree" is a large deciduous tree that belongs to the Fabaceae family [1, 2]. This plant is endemic to Asia and widely distributed in Malasiya, Western and Eastern Africa, Pacific and Carribbean islands. *A. pavonina* is a holy and devotional plant in the South Indian Province of India. The red seeds of *A. pavonina* are placed near the entrance to the Guruvayoor temple's sanctum, Kerala, State of India. It is believed that the child who places his hands within the seeds and ploughs through the seeds is cured of all diseases. Different parts of *A. pavonina* [Figure 1] were utilized in the Ayurveda medicine system [3] *A. pavonina* L. barks and leaves are utilized as astringent, anthelmintic and aphrodisiac. The barks are utilized to treat colonorrhea, ulcers, pharngopathy, gout and rheumatism. Emetic nature of the roots was reported. In Indian folk medicine, its seeds are useful in balancing vata and pitta conditions. Powdered seeds are used to treat boils, inflammation, blood disorders, arthritis, rheumatism, cholera, paralysis, epilepsy, convulsion and indigestion [4, 5]. The seeds are used for ornamental purposes and raw seeds are inedible. Boiled or roasted seeds are non-toxic [6]. Phytochemical investigations have identified several secondary metabolites such as cardiac glycosides, tannins, saponins, alkaloids and flavonoids, steroids. *A. pavonina* is reported to exhibit a broad spectrum of biological activities including antimicrobial, anti-malarial, antioxidant, antiviral, anti-diarrheal, anti-diabetic, anti-inflammation, blood cholesterol-lowering activity [7, 8]. This review comprehensively presents the information on ethnopharmacology, phytochemistry and pharmacological activities of the medicinally valuable plant *A. pavonina.*

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(a) Whole plant (b) Leaves (c) Seeds (d) Bark

Figure 1: *Adenanthera pavonina* plant

Phytochemistry

Compounds isolated from A. pavonina: The pure bioactive pyridine derivative compound was separated from the ethanolic extract of *A. pavonina* stem bark [9]. Isolation and structure identification of aliphatic compound and a stigmastanone steroid derivative compounds with two known compounds from dichloromethane soluble portion of *A. pavonina* stem bark was reported by Ara et al. [10]. Flavonoid and triterpenoid type compounds and benzoin were separated from stem bark methanolic extract. Structure confirmation of the pure compounds was extensively studied by various spectroscopic methods [11]. The presence of methyl oleanolate and methyl echinoacysiate in the roots of *A. pavonina* has been reported [12, 13]. Bioactive flavonoid glycosides and flavonoids were isolated from the *A. pavonina* leaves and their cytotoxicity along with antioxidant potential was reported [14]. The existence of stigmasterol glucoside in *A. pavonina* leaves and seeds were reported by Nigam et al. [15]. A new lactone named pavonin was purified and characterized from the aerial parts of *A. pavonina* [16, 17]. Previously a reported compound from various parts of A. *pavonina* was shown in Figure 2.

Chemical composition of A. pavonina Seed oil: Chemical components of essential oils extracted from leaves and fruits of *A. pavonina* have been investigated by GC-MS analysis. The presence of 27 compounds was identified. Monoterpene and sesquiterpene hydrocarbons were the major components of leaves and fruits respectively [18]. Physiochemical and spectroscopic analysis of *A. pavonina* seed oil was assessed by Ajani et al. Preliminary screening of seed oil evidenced that the secondary metabolites, saponin, alkaloid, and terpenoids were present [19]. Nutrient value, screening for minerals, lipid, carbohydrate and amino acid profiles, analysis of primary metabolites and fatty acids were reported. Linoleic acid and oleic acids are the major constituents of fatty acids. The presence of stigmasterol in seed oil was confirmed by GC-MS analysis [20, 21, 22]. Emulsification of oil obtained from *A. pavonina* seed and emulsion properties of seed oil were evaluated [23, 24].

Nutritional components in A. pavonina seeds: A new kind of plant milk was isolated from seeds of *A. pavonina*. The physicochemical nature, nutritive value and biological effects of the seed milk were analyzed and the results were compared with that of soybean milk. Daily intake of seed milk responsible for critical decrease [$P < 0.05$] in acetyl cholinesterase action in the liver, digestive tract, heart and kidney. The seed milk offers promising valuable impacts for patients with neurological illnesses, supporting for health because of its high protein and mineral content [25]. Nutrient and anti-nutrient values of *A. pavonina* seeds based on processing methods were investigated. Boiling and roasting methods enrich the nutrients like protein, carbohydrates etc. and reduce the toxicity of antinutrients such as tannins, saponins, phytates, lectins [6]. Nutrient properties of roasted seeds of *A. pavonina* and their primary and secondary metabolite, mineral profiles were screened. This study evaluated the role of *A. pavonina* to minimize the negative effects of obesity. Results prove that *A. pavonina* is a rich source of

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nutrients and also reduces the negative consequences of obesity [26].

Pharmacological properties of *A. pavonina*

Antimicrobial activity: The efficacy of hexane and ethanolic extract of *A. pavonina* leaves and pure compound against some clinically isolated pathogens was evaluated using Diffusion analysis and micro-dilution technology. *A. pavonina* exhibits good bacteria inhibition activity against the tested pathogens [27]. Stem bark extracts of n-hexane, chloroform, ethyl acetate and ethanol solvents were screened for their inhibition potential against selected microbes. Ethyl acetate extract shows excellent antimicrobial potential. The isolated compounds were subjected to antibacterial test against three kinds of bacteria, findings of this study revealed that its activity was better than the mother extract [28]. A similar study reports the considerable antibacterial and antifungal activity of *A. pavonina* leaf methanol extract against selected microbe strains [29]. Water extract of *A. pavonina* seeds and four other plant seeds exhibit significant growth inhibition activity against the tested micro-organisms [30]. Antimicrobial properties of petroleum ether, dichloromethane, ethyl acetate and methanol extracts of *A. pavonina* barks were screened towards both Gram-positive and Gram-negative bacteria and fungi by the Disc diffusion method. Methanol extracts exhibit significant activity because of the presence of a higher concentration of bioactive compounds [31]. The antibacterial effect of ethanol and aqueous bark extracts of *A. pavonina* were evaluated against the selected microbes [32]. Chloroform, ethyl acetate and ethanol extracts from leaves of *A. pavonina* exhibit antibacterial and antifungal potential against the screened microbes [33]. Antibacterial efficacy of leaf, seed, stem and wood extracts in chloroform solvent were evaluated against Gram-positive and Gram-negative bacterial strains by different evaluation methods. Seed extract exhibits maximum inhibition potential towards bacterial strains [34]. Peptide *Ap*Def1 extracted from *A. pavonina* seeds was screened for antifungal property and the sequence of amino acids in the peptide was also reported. *Ap*Def1 exhibit considerable fungicidal activity [35].

Blood pressure-lowering effect: The antihypertensive potential of the methanolic extract obtained from seeds of *A. pavonina* was tested in a rat model. The histopathological assessment confirmed that the extract does not produce any injuries in liver, kidneys and even testes. Results had shown that *A. pavonina* exhibits considerable anti-hypertensive potential [36].

Blood cholesterol-reducing effect: Safety of methanol extract of *A. pavonina* seeds towards the blood cholesterol-reducing potential in selected rat models were evaluated. This study revealed that *A. pavonina* exhibit significantly reduced blood cholesterol levels and did not show any adverse side effects on the animal model [37]

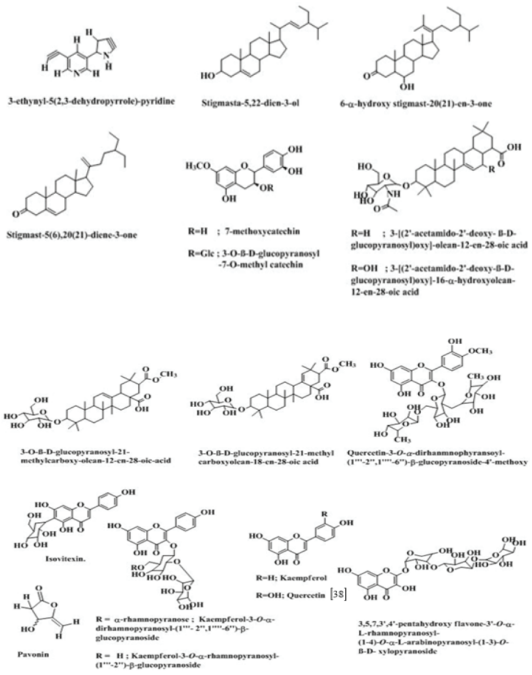

Figure 2: Compounds isolated from *Adenanthera pavonina*

Anti-diabetic activity: Water extract of *A. pavonina* seeds were evaluated for their effect on reducing diabetic kidney disease in streptozotocin-induced diabetic rat models. *A. pavonina* considerably minimize diabetic nephropathy by changing the level of serum albumin, creatinine and urea etc. [39].

Antiviral activity: *In vivo* antiviral effect of a sulphated polysaccharide isolated from the endosperm decoction of *A. pavonina* against selected strains of herpes virus were reported by Rechenchoski et al. *A. pavonina* polysaccharide exhibit good activity by reducing the development of skin lesions [40]. Antiviral potential of sulphated polysaccharide isolated from *A. pavonina* seeds in type 1 poliovirus [PV-1] in cultured HEp-2 cells. The complete inhibition of Poliovirus replication was discovered when sulphated polysaccharide treatment was corresponding with viral infection at all tested dosage [41].

Anti-malarial activity: Effect of 98 % methanol extract of *A. pavonina* seeds against *Plasmodium berghei* was tested in parasitized rats. Crude seed extract at 800 mg/kg dosage exhibit better antimalarial action 92.11 % compared to the standard drug 88.73%. The extract of *A. pavonina* seeds in methanol solvent showed remarkable activity against malarial parasites [42].

Anti-inflammation studies: *In vivo* effect of petroleum ether, dichloromethane, ethyl acetate and methanol extracts of *A. pavonina* barks were evaluated in inflammation-induced rat models. *A. pavonina* extract exhibits dose-dependent anti-inflammation activity [43]. The anti-inflammation effect of methanol and water extracts of *A. pavonina* seeds in animal models and their mechanism of action was assessed by different methods. Results revealed that *A. pavonina* shows a potent effect on inflammation [44]. *A. Pavonina* seed methanol extract was evaluated for inflammation potential against the carrageenan-induced rat models [45].

Anti-diarrheal activity: *A. pavonina* bark methanol extract was screened for antidiarrheal potency in diarrhea-induced animal models. The methanolic bark extract has been greatly reduced the aggregate of wet fecal mass in dose-dependent activity [46].

Toxicity studies: Acute toxicity of methanol extract of *A. pavonina* bark was tested using animal models. The LD_{50} estimation of the tested extract was discovered to be 1453.44 mg/kg. Results of the study established the safety of *A. pavonina* bark extract [46].

Analgesic activity: The analgesic effect of petroleum ether, dichloromethane, ethyl acetate and methanol extracts of *A. pavonina* barks were investigated in pain-induced animal models. Dichloromethane extract shows higher analgesic properties which might be the presence of steroids that suppress the synthesis of prostaglandins [31].

Hepatoprotective activity: The methanolic extract of *A. pavonina* leaves was assessed for hepatoprotective activity in hepatosis-induced rat models by various estimation methods. Results revealed that *A. pavonina* exhibits considerable activity against induced hepatosis [47].

Antioxidant activity: DPPH radical scavenging potential of petroleum ether, dichloromethane, ethylacetate, and methanol extracts of *A. pavonina* barks were reported by Arzumand Ara et al. Ethylacetate and methanol extract shows higher activity than the standard which might be the presence of flavonoids and tannins [31]. Another study reports the significant *in vitro* DPPH radical scavenging activity of 98 % methanol extract of *A. pavonina* seeds in malaria-infected rat models [42]. The antioxidant property of *A. pavonina and Thespesia populnea* decoction were screened by various assays. The findings suggested that the decoction exhibits good antioxidant activity [48].

Anti-emetic activity: Emesis control potential of A. pavonina leaf and three other plant extracts were investigated in emesis induced four days old male chicks. Results revealed that *A. Pavonina* exhibit lower anti-emetic activity [49].

Anti-cancer activity: Different cell lines were used to assess the Anti-proliferative and Cytotoxic effect of *A. pavonina* and *Thespesia populnea* leaf decoction. Results explained that the decoction reduces the cancer threat by inducing apoptosis [50]. Cytotoxicity assessment of *A. pavonina* leaf extract in chloroform, ethyl acetate, acetone, methanol and ethanol solvents were tested in HCT116, NCIH460, U251 and MCF7 cell lines. Chloroform extract showed high activity against MCF7 cell lines [51].

Antinoceceptive activity: The central and peripheral antinoceceptive effect of *A. pavonina* leaf extract in ethanol solvent was screened by using different analysis methods and the action mechanism of extracts toward the tested animals was also reported. *A. Pavonina* exhibits a significant dose-dependent antinoceceptive effect [52].

Amylase-inhibition activity: Amylase inhibitor isolated from *A. pavonina* seed reduces both salivary amylase and the development of streptococcus. The findings show that *A. pavonina* is a powerful inhibitor of mammalian amylases and recommends its efficacy in diabetes treatment [53]. Crude methanol extract of *A. pavonina* leaves and its ethyl acetate fractions were evaluated for *in vitro* antioxidant and α-amylase inhibition study on 3,5-dinitrosalicylic acid method. Methanolic extract exhibit the remarkable activity of α-amylase inhibition [54].

Trypsin inhibitors: Peptide Adenovin, a trypsin inhibitor isolated from the *A. pavonina* and its structural features and antimicrobial activity of the novel peptide were investigated [55]. Isolation and purification of ApKTI, a Kunitz trypsin inhibitor from *A. pavonina* seeds and their effect against the moth *Plodia interpunctella* in larval stage were screened. ApKTI exhibits significant insecticidal properties [56]. A kind of trypsin inhibitor ApTI isolated from *A. Pavonina* seeds and their insecticidal property against *Anagasta kuehniella* and *Callosobruchus maculates* were reported [57, 58]. The mechanism of ApKTI against serine and cysteine protease enzymes was studied by Migliolo et al. [59]. Insect control potential of ApTI against *Anticarsia gemmatalis* larvae was evaluated [60]. The amino acid sequence of different trypsin inhibitors and the identification of their active sites were investigated by Richardson et al. [61]. Larvicidal activity of a trypsin and chymotrypsin inhibitor from *A. pavonina* seeds against the larvae of *Aedes aegypti* dengue vector were reported [62]. Anti-diabetic activity and structural characterization of a biopolymer, galactomannan separated from *A. pavonina* seeds were evaluated. The study's findings revealed that galactomannan exhibit considerable anti-diabetic activity in the tested diabetes-induced animal models [63].

Natural dyes from A. pavonina seeds: Natural dye anthocyanin was extracted from *A. pavonina* seeds by different solvent extraction methods. Quantitative and qualitative analysis, antioxidant potential and toxicity profile of the isolated natural pigment were investigated using standard methods [64].

Polymer isolation: Galactomannan is a natural polymer isolated from the endosperm of *A. pavonina* seeds. This kind of neutral polymer had a broad spectrum of biomedical applications. The impact of crosslinking glutaraldehyde with Galactomannan and its sensitivity to p^H of the medium was evaluated [65]. Galactomannan isolation, spectral analysis and *in vitro* free radical scavenging activity were reported by Melo et al. [66].

Bio adsorption analysis: *A. pavonina* leaves were used as a bio adsorbent for the removal of heavy metal lead. The study reports the effects of size, pH, the concentration of the bio adsorbent. The effectiveness of biosorption was evaluated by Freundlich, Langmuir and Temkin isotherm methods. Results found that *A. pavonina* was a good bio adsorbent for the removal of lead [67].

Conclusion

In this review, we have summarized the research outcome made in past and present years on the

various aspects of *A. pavonina* covering botany, distribution, traditional medicine and devotional importance, processing benefits, phytochemistry and pharmacology. This review will serve as a database for future research on *A. pavonina.*

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Conflict of Interest

Authors have no conflict of interest

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