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A COMPREHENSIVE REVIEW ON- BIOLOGICAL PROPERTIES OF *PITHECELLOBIUM DULCE*

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ABSTRACT

Pithecellobium dulce (Roxb.) has scientific attestation because it contains various phytochemicals and a wide range of biological properties. This plant traditionally has been employed in various regions for the treatment of skin disorders, digestive system, infections, metabolic disease, and inflammatory conditions. The pharmacological studies of medicinal plant *P. dulce* indicate that different parts of the plant, such as leaves, stem, bark, roots, fruits, and seeds, contain various phytochemical constituents like alkaloids, flavonoids, polyphenols, tannins, saponines, and terpenoids that collectively contribute to its biological properties. Several researches and their findings have been revealed remarkable antimicrobial, anti-inflammatory, antioxidant, antidiabetic, wound-healing, analgesic, hepatoprotective, cytotoxic, and immunomodulatory properties, which suggesting its medicinal importance as a promising natural source for future drug development. However, various formulations and extraction procedures for phytochemical compounds, and their experimental models have resulted in an emphasis on standardized. This comprehensive review critically integrates available information on the phyto-active components diversity and biological properties of *P. dulce*. The biological information of phytochemicals is expected to support researches in advanced studies and sustainable development of pharmaceutical products.

Keywords: *Pithecellobium dulce*; Phytochemicals; Medicinal Plant; Biological Properties.

1 INTRODUCTION

The medicinal plant *Pithecellobium dulce* belongs to the family of *Leguminosae*, which are locally called 'Jangaljalebe' and in English 'Manila tamarind'. This plant has a small medium size evergreen, spiny woody plant up to 18 m in height. *P. dulce* is a native of tropical America, and it is also found in India, Southeast Asia, the Caribbean, and other tropical and subtropical regions. It is commonly found along roadsides, field margins, wastelands, and dry deciduous habitats, where it tolerates drought and poor soils. The various parts of the *P. dulce* have long been used in traditional medicine. The bark, leaves, pods, seeds, and roots are widely used for the treatment of diarrhea, stomach disorders, dysentery, fever,

toothache, inflammation, skin diseases, and wound healing [1]. The bark of *P. dulce* has anti-dysentery, febrifuge, and anti-inflammatory properties that help with dermatitis and eye discomfort [9]. The leaves of *P. dulce* can be applied as plasters for pain and venereal sores [3].

2 PHYTOCHEMISTRY OF *P. DULCE*

The ethanolic leaf extract of *P. dulce* has major phytochemicals like alkaloids, cardiac glycosides, tannins, anthraquinones, terpenoids, proteins, and sugar [2]. Bisdesmoside, echino cystic acid, dulcin, acylated triterpenoid saponin, saccharides, triterpenoids, flavonoids, and long-chain aliphatic hydrocarbons are among the phytochemicals found in the leaf and bark of *P. dulce*. β -sitosterol, tannins, oleanolic, and echinocystic acids are also present [5]. The leave extract of *P. dulce* contains afezilin, kaempferol, quercitin, and dulcitol [4]. However, leaves have a bitter taste that contains Vitamin C, saponin, sterols, kaempferol, quercetin, and myricetin [6]. The ethanolic extract of fruit powder of *P. dulce* has various phytochemicals such as 2,5,6-trimethyl 1,3-oxathiane; 2-furan carboxaldehyde-5-(hydroxymethyl); trans-3-methyl-2-N-propylthiophane; D-pinitol; heptacosanoic acid; hexadecanoic acid; tetracosanol; 22-tricosenoic acid; methyl-2-hydroxy icosanoate and stigmasterol [7]. Leaf contains phytochemicals like phytol, anthracene, 9(3butenyl), diisooctyl phthalate, 13-docosenamide, 3,6,9-triethyl 3,6,9, trimethyl formic acid, cyclotetrasiloxane, octamethyl, and 1(+) ascorbic acid 2,6 dihexadecanoate [7].

3 BIOLOGICAL ACTIVITIES OF *P. DULCE*

Pithecellobium dulce is used as a febrifuge, an astringent for dysentery, an anticonvulsant, an antidiabetic, an antiulcer, an abortifacient, and larvicides [4]. Sugumaran et al. [3] have reported that the leaves of *P. dulce* can be used in plasters for pain and venereal sores. However, due to their sweet flavor and range of therapeutic benefits, *P. dulce* fruits are consumed in many parts of India.

Pithecellobium dulce has several biological characteristics, including the following

3.1 Antibacterial activities

The etanolic extract of *P. dulce* has shown a significant inhibitory activity against *Staphylococcus aureus*, *S. pyogenes*, *Klebsidla pneumonia*, and *E. coli*. In a comparative study, the antibacterial activity increased with extract concentration and was comparable to the standard antibiotic gentamicin at higher doses, indicating the therapeutic potential of the plant as a natural anti-bacterial agent [8]. The leaf extract of *P. dulce* has anti-bacterial properties against Gram-positive bacteria. The highest inhibition was noted in the growth of *S. epidermidis*, *P. acne*, and *S. aureus* [7]. The ethanolic root extracts of *P. dulce* produced inhibition zones of approximately 19 mm against *Klebsiella pneumonia*, 15.4 mm against *Acetobacter aceti*, 13 mm against *Enterobacter aerogenes*, and 11 mm against *Staphylococcus aureus*. Whereas, polar solvent extracts were more effective than non-polar extracts, suggesting that polar phytochemicals are primarily responsible for the antibacterial activity [9]. While the methanolic extract was active against *S. aureus*, *K. pneumonia*, and *P. putida*, the ethyl acetate extract of *P. dulce* fruit powder is more effective against *S. epidermis*, *S. aureus*, *K. pneumonia*, *E. faecalis*, *P. putida*, and *P. aeruginosa*. The petroleum extract was only effective against *P. putida*, while the water extract also works against *S. aureus* and *K. pneumonia* [10]. Afzelin (Kaempferol-3-O- α -L-rhamopyranoside) was isolated from *P. dulce* leaves which have antimycobacterial properties [11].

3.2 Antifungal activities

Pithecellobium dulce exhibits promising the antifungal activity due to the flavonoid, tannins, phenolic compounds, triterpenoid, and saponins, which can disrupt fungal cell membranes, interfere with ergosterol biosynthesis in cells, and inhibit fungal growth. The extract of seeds and leaves has shown inhibitory effects against pathogenic fungi such as *Aspergillus fumigates*, *A. niger*, *Botrytis cinerea*, *Candida albicans*, *Rhizopus stolonifer*, and *Penicillium digitatum* [12-15]. The methanolic and aqueous extracts of *P. dulce* seed powder have anti-fungal activities against plant pathogens [16]. The seed powder of *P. dulce* and their aqueous and methanolic extract have fungicidal properties against plant pathogens like *Fusarium oxysporum*, *Botrytis cinerea*, *Penicillium digitatum*, and *Rhizopus stolonifer* [17]. The methanolic leaf extract of *P. dulce* exhibits significant antifungal activity against *Aspergillus niger* [18].

3.3 Antioxidant activities

The fruit extract of *P. dulce* has phenolic contents which are used as anti-oxidantal components. Fruit pericarp has phytochemicals like anthocyanin, and flavanoids which are a major source of polyphenol antioxidant properties. The phenolic components function as good donors of hydrogen, making them potent antioxidants [19]. The aqueous extract of *P. dulce* leaves revealed the phenolic components, including flavonoids, which show a potent free radical scavenging activity [7]. A strong source of antioxidants is acetone and the methanolic extract of *P. dulce* leaf powder [4]. Kumari [12] has investigated that bark, leaf, fruit, and seed extract of *P. dulce* effectively scavenge free radicals and reduce oxidative stress through various mechanisms, like hydrogen atom donation, electron transfer, and inhibition of lipid

peroxidation. Whereas, methanolic and petroleum ether leaf extract of *P. dulce* have anti-oxidant properties such as the superoxide anion and hydroxyl radical and enzyme inhibition [20]. The ethanolic and methanolic extracts generally exhibit stronger antioxidant activity than aqueous extracts due to the presence of higher concentrations of phenolic compounds [21]. The oxidative stress is implicated in the development of chronic diseases such as cardiovascular disorders, diabetes, cancer, and neurodegenerative diseases. The antioxidant properties of *P. dulce* suggest its potential as a source of natural therapeutic agents [22].

3.4 Anti-inflammatory activities

Inflammation is a protective physiological response of the cells; however, its persistence contributes to the development of various chronic disorders. The leaves of *P. dulce* are used as a traditional cure for earaches, leprosy, peptic ulcers, toothaches, and general illnesses. *P. dulce* is a natural anti-inflammatory agent because its bark, and leaves are enriched with phenolic acids, flavonoids, triterpenoids, saponins, and tannins, which are known to regulate inflammatory pathways in the cells. The fruits of the plant also have anti-inflammatory qualities [23]. The pharmacological studies of *P. dulce* bark and leaf extracts alleviate experimentally induced inflammation and pain, supporting the traditional use of the plant in the management of inflammatory conditions [24]. Dasari et al, [11] have reported that *P. dulce* fruits have also been studied for anti-inflammatory activity due to saponin. However, the methanolic, ethanolic, and petroleum ether extract of *P. dulce* leaf shows [25] anti-inflammatory activity. Matta et al, [26] has been demonstrated that methanolic and ethanolic extracts of *P. dulce* effectively suppress protein denaturation and stabilized erythrocyte membranes *in vitro* indicating, their ability to reduce inflammatory responses.

3.5 Cytotoxic activities

The cytotoxic properties of *P. dulce* bark and leaves were evaluated using MTT cell viability against two distinct cancer cell lines, namely hepatocellular carcinoma and colon carcinoma. The lipophilic fractions of *P. dulce* demonstrated notable cytotoxic activity against a colon carcinoma cell line [27]. The aqueous extract of *P. dulce* leaf powder has demonstrated selective toxicity towards human breast adenocarcinoma (MCF-7) cells while exhibiting minimal toxicity to normal mammary epithelial cells. The treated cancer cells showed reduced viability accompanied by activation of apoptotic signaling, including increased expression of p53, Bax, p21, TNF- α , and Fas, together with suppression of anti-apoptotic mediators such as Bcl-2 and NF-kB, indicating apoptosis-mediated cell death rather than nonspecific cytotoxicity [28]. *P. dulce* leaf extracts have cytotoxic potential on breast cancer cells (MCF-7 cell line) at 400mg/ml [28].

3.6 Wound healing activities

Pithecellobium dulce has wound-healing activity due to the presence of bioactive components like tannins, flavonoids, phenolic acid, and other metabolites. In an *in vitro* scratch assay using human skin fibroblast cells, the methanolic leaf extract of *P. dulce* markedly enhanced cell migration and promoted wound closure, achieving approximately 78.8% wound closure within 72 hours [29]. *P. dulce* is traditionally used for the management of skin injuries and emphasized the need for further pharmacological and clinical studies to validate its therapeutic applications [30].

4 CONCLUSION

It is clear from the above review of the literature that the *P. dulce* has attracted considerable scientific interest because it has various phytochemical compositions and a wide spectrum of biological activities. The various part of the plant, particularly the leaves, seeds, fruits, pods, and bark, contain several phytochemicals constituents, including alkaloids, flavonoids, tannins, saponins, phenolic acids, sterols, triterpenoids, and glycosides. These metabolites are considered the principal contributors to the therapeutic potential of the species, and it provides a scientific base for various medicinal applications. The experimental findings have demonstrated that the various extracts of *P. dulce* exhibit noteworthy antibacterial, antifungal, antioxidant, anti-inflammatory, cytotoxic potential, wound-healing properties. Although the current findings are encouraging, further investigations involving isolation of active compounds, elucidation of molecular mechanisms, toxicological evaluation, pharmacokinetic studies, and well-designed clinical trials are essential to establish its safety, efficacy, and therapeutic value in modern medicine.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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