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Phytopharmacological and Biological Exertion of *Spondias pinnata*: (A Review)

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ABSTRACT

Herbal medicines are gaining wide recognition and acceptance due to their versatility in usage as condiments, dietary supplements, therapeutics, flavoring agents, etc. Medicinal herbs are a broad reservoir for biological and pharmacological active bio-compounds exhibiting therapeutic activities and can be implemented to diagnose and manage various disorders and ailments. This review emphasizes on the photo assembly and therapeutic properties of *Spondias pinnata* which is extensively utilized in folklore and traditional medicine. The greater disadvantage of herbal medicine is the scarcity of scientific affirmation of the safety, potency, purity, and dosage of the herbal drug. *Spondias pinnata* demonstrates various pharmacological properties like antihyperglycemic, anti-cancerous, anti-inflammatory, anti-oxidant, anti-microbial, hepatoprotective, etc. which indicates their potential to address numerous maladies. This review concentrates on the pharmacological effectiveness of *Spondias pinnata* to provide substantial evidence from past research in order to insinuate this medicinal herb as a potential drug.

Keywords: Spondias, Phytochemistry, Pharmacological, Bioexertion, Therapeutics.

INTRODUCTION

Mounting medical conditions have significantly increased the consumption demand of food and food items that provide beneficial health effects as they have therapeutic applications in addition to basic nourishment[1]. Increased consumption of fresh produce like fruits and vegetables has been associated with a reduced risk of unabating chronic disorders like malignancies and cancer, heart disease, cataracts, neurological problems and associated cognitive dysfunctions, and immunological abnormality[2,3]. The human body has an essential and ingenuous natural defending process to deal with oxidative stress, however, when reactive oxygen species surpass this defense system, damage to fundamental components such as proteins, DNA, and lipids arises. Natural antioxidants are beneficial to one's wellness since they guard against oxidative stress, complications, and diseases associated with them[4]. Antioxidant characteristics of polyphenols procured from plants have been linked to health aggrandizing and/or the benefits to avert disorders, such as those that could have caused due to microbes or the management of a disease like type 2 diabetes mellitus which have been validated by epidemiological and experimental laboratory research. In the emerging epoch of resistance to antibiotics, herbal and natural treatments can be an attainable and promising replacement to combat infections[5-7]. Because of their nontoxicity and dearth of adverse effects, herbal compounds obtained from plants are becoming incredibly common in healthcare and medicine. According to the World Health Organization, 65-80 percent of people across the globe reckon that using herbal products derived from plants will help them to maintain good health and prevent illness[8].

Hog-plum is a small deciduous tree species with a beneficial nutritional quality like low-cal and high in plant proteins, essential minerals like zinc, plenteous polysaccharides like chitin, fiber, and nutrients. It is also known as 'Ambate' or 'Ambade Kaai' in the Netherlands. This tree has gained spiritual prominence because it is venerated in Nakshathravanam Vana for hasta nakshatra. 2 hydroxy propane and ascorbic acid are both present in substantial amounts[4]. Yellow mombins are usually consumed fresh, pickled, and processed into chutneys and other delicacies, nevertheless, their actual applications are unstructured and unsophisticated. The shelf-life of shining yellow mombins is likewise limited by microbial deterioration and enzymatic browning.

Spondias pinnata (Family – Anacardiaceae), a.k.a *Spondias mangifera* (*Linn. F.*) *Kurz*., is a perennial evergreen to a deciduous tree native to India, and Indian subcontinents like Sri Lanka, and South-Eastern Asia. The Spondias is one of the first genera of the Anacardiaceae family circle, which consists of 70 genera and 600 species. It is predominantly found in the tropics and subtropical areas around the globe, but it may also be found in temperate zones and is maneuvered in traditional medical treatments to treat a variety of ailments. Pharmacological and medicinal research has demonstrated that Spondias does have vegetation, antihyperglycemic, anticancer, cytostatic, antioxidative, impostume protective, antihepatotoxic, light sensitivity, anxiolytic, febrifuge, anti-inflammatory, antiarthritic, antihypertensive, antimicrobial, anti-dementia, antifertility, thrombolytic, and anthelmintic activities due to the wide range of phytoconstituents[9,12-13, 15-17]. Spondias plants contain insoluble phenolic acids like tannins, flavonoids that determine the anti-oxidant property, unsaponifiable sterols, and their precursor molecule triterpenes, toxic saponins, essential oils, amino acids, and carbohydrates. Due to domiciliary usage by residents, *S. pinnata* is in high demand in its natural habitats. Locals utilize this species commercially for fruit and other therapeutic applications on a regular basis. This article defines *S. pinnata*, with an emphasis on ethnobotanical uses[10,11,14].

History

The provenance of *S. pinnata* is enigmatic and confounding due to its extensive cultivation and natural inclinations. Malaysian, Indian, and Indonesian habitat promotes the massive farming of this plant. The genesis of *S. pinnata* is still being researched as it is a disputed conjecture. The whole genetic analysis via DNA examinations has yet to be completed. As a result, it is still described as "naturally occurring" in the numerous region of Bali, Indonesia, and Malaysia. The ecological and topographical aspects of the region where the plant is cultivated determine the traits and attributes of the plant content of the same species. *S. pinnata* was formerly referred to throughout Bali as 'catsjemtsjem' (pronounced 'kecemcem'), which relates to the Balinese condominium. The foremost empirical delineation of the species' subsistence in Bali substantiated that it was either a plant that originated in Bali or in its native geographical dispersal territory. It was most probably introduced to Bali by Majapahit Javanese Hindus who were escaping to the island. The most popular "loloh cemcem," which is typically located in the tourist bour of Penglipuran Bangli, is a classic Bali drink. *S. pinnata* leaves, alternatively known as "cemcem" or "kedondong" in other dialects, is used to make "Loloh cemcem."[4,9,12]

Molecular Characteristics and Exertions

S. pinnata is endemic to the region of Central America and Southern Mexico, and these herbal species have been discovered across both moist and dry settings, encompassing a variety of semideciduous jungles. It is also present in tropical locations, particularly in India's east and northeastern parts. Indian yellow mombins have been found growing in natural habitat or can also be domesticated up to the heights of 1500 meters in India and its subcontinental regions like China, Malaysia, Sri Lanka, the Andaman Islands, Thailand, Myanmar, as well as in the Philippines. In Florida, this variety exists and flourishes in abundance. An enormous amount of work has gone into adapting this variety to the dryland weather of Anand, Gujarat.

This flora is widely documented in India's tropics and mountainous Himalayan highlands, although it is seldom seen in western parts of India, despite flourishing evergreen forests in the western ghats of Karnataka. *S. pinnata* is not widely grown due to high pressure in the natural environment caused by increased demand for local domestic consumption. Because of its hard seed coat, it is unfortified to the ambush by a miscellany of pests, pathogens, and insects, and the seed radical dries quickly, causing a problem with seed germination. The tree thrives infecund, humus-rich soils, but with proper supplements to favor its nourishment. They can also thrive in a range of less fruitful environments. Spondias thrive in climates with definite dry weather. Mature trees are drought tolerant and do not require any additional irrigation. Some irrigation is appropriate for establishing the order of young timber at some point after planting in the primary year[4].

The deciduous trees of *S. pinnata* can be pullated in both old-growth/virgin forests and in secondary forests. *S. pinnata* is conventionally described as "kedondong hutan." Traditional healers have exploited herbs from the genus Spondias, which comprises 18 species, to address a multitude of afflictions. Ornamental trees with ascending burgeoning that can attain a height of 12 to 18 meters are its idiosyncrasy. The tree's bark has a grey to light reddish-brown tint, with uneven fractures, and oozes transparent, gooey, and turpentine sap. The aromatic leaflets are spiraled together. The sour tang of the fronds can be deployed to flavor dishes. Its florets are bisexual, sessile, and are white. It has yellowish, plump fruits, having stiff and craggy seeds with a fibrous covering and a tender, edible core. In a number of countries, this species is intensively cultivated for domiciliary and global trade[12].

Ethnopharmacology

Conventional medicine utilizes Spondias species to treat and manage a wide range of disorders and associated symptoms, notably digestive issues, constipation, diabetes mellitus, a cognitive disorder like dementia, anemic conditions, gastroenteritis, dysentery, and other infestations. Fruits belonging to different species were used to heal a range of diseases. The fruits of *S. pinnata* have been claimed to be consumed by the countryside inhabitants of Bangladesh to strengthen their vision and avoid eye infections, whilst those of *S. tuberosa* are ingested by local inhabitants in Brazil due to their excessive nutritional content[18]. The fruits of *S. mombin*, on the other hand, are exercised as a diuretic in Nigeria. In India, pulverized ripened fruits of *S. pinnata* are applied as a mithridate against poison arrows. The extract of the leaves is slopped into the ears and smeared topically to relieve earache. Gastroenteritis and associated conditions like diarrhea and dysentery are medicated with powdered and dried leaves. The infusion of the stem and the bark is administered in the same way. Fresh and delicate leaf consumed along with raw sugary candy is beneficial in the management of acid reflux while the leaf extracts are effective in treating digestive disorders. The lesions, wounds, and sores are treated with the fruit paste, and the bark prepared into a paste is applied topically to treat sprains and rheumatism while its decoction is used to cure gonorrhea. Anti-scorbutic properties are found in the fruits, leaflets, and bark of *S. pinnata*. Collywobbles and flatus are treated in Mexico with an interpolation of fresh Spondias purpurea leaves Anemia, diarrhea, gastroenteritis, and dermal afflictions are treatable with fresh leaf decoctions, while a concoction of *S. pinnata* leaf is used to relieve symptoms of diarrhea and constipation in Belize, as well as by the populations in Nigeria, Benin, and Togo to enhance cognition[19]. The concentrates of *S.mombin* leaves are frequently used as an abortion-inducing oral contraceptive in Brazil. The leaves are used by traditional practitioners of Southwest Nigeria to medicate diabetes. Germicidal, antimicrobic, and antiviral activities are also present. *S. mombin* gum is used as a therapeutic intervention to oust Cestoda in Belize while in India, it is used to address shortness of breath, chest discomfort, diarrhea, ulceration, dysentery, and dermatitis[20]. In Mexico, anemia, vomiting, diarrhea, and skin diseases are managed with an infusion of *S. purpurea* bark. In India, the bark of *S. pinnata* is often used to ease sore joints as a rubefacient when applied topically. Constipation and dysentery are both treated and prevented using them. To cure gonorrhea and control the menstrual cycle, a solution prepared from the root bark is administered[21].

In ethnomedicine, the entire plant is utilized was effective as antituberculosis medication, while the undeveloped fruits were used as a philter. In India, powdered ripe Spondias pinnata fruits are used as a poison arrow antidote. The tribes of Odisha's Mayurbhanj district were the first to use this fruit as a medicinal agent to treat ailments such as madhumeha, amlapitta, and uttaravaruni. The fruit juice has antiscorbutic properties. The pulp of the fruit is used to treat bilious dyspepsia and to prevent rheumatism[18,21].

Nutrition and Mineral Demand

S. pinnata's drupelet fruit is appreciated in the culinary and nutriceutical sectors for its savor and health benefits, which include limited energy, empowering plant proteins, minerals like Zn, Ca, Fe, chitosan, fibers, and retinol, thiamine, and riboflavin. It has ascorbic acid in an increased range which is equivalent to half the amount present in carbonated water. The plant's greenish fruits are brine-pickled and extensively implemented in food preparations by Assam's Ahum people and other North-eastern Indian tribes, including sauces, preserves, curies, sherbet, and calming drinks[22,23]. The end products of *S. pinnata* are slightly acidic in nature. Carbohydrate and sweet content, acetic acid, and their associated reactions have a substantial effect on the typical desirability of yellow mombin coulis enrichment. This observation was derived from the sauce preparation procedure of *S. pinnata* fruits. Instead of vinegar, sugar had a greater impact on universal acceptability[24].

Table 1: Nutritional potential with the biochemical profile of *S. pinnata*

Parameters	Fruit	Bark	Leaf
Total protein (g%)	17.32	3.21	11.04
Crude fat (g%)	12.23	5.14	4.8
Carbohydrate (g%)	23.54	16.3	68.9
Crude fibres (g%)	42.53	33.9	10.5
Flavonoids (mg%)	710.23	350.5	76.03
Polyphenol (mg%)	634.53	91.47	27.76
Moisture (%)	82.02	23.6	15.13
pH	3.93	-	-
Calcium (mg%)	115	72	10.85
Iodine (mg%)	24	9	-
Iron (mg%)	150	128	0.09
Sodium (mg%)	96	-	0.85
Potassium (mg%)	1.78	3.05	9.50
Copper (mg%)	123	90	-
Aluminium (mg%)	87	58	-
Phosphorous (mg%)	0.68	-	0.24
Riboflavin (mg%)	0.09	-	-
Niacin (mg%)	0.16	-	-
Ascorbic acid (mg%)	87.45	-	59.05
Thiamine (mg%)	1.8	0.8	-
Food energy value (kcal/g)	168.76	-	-

Phytochemical Screening

S. pinnata comprises phenolic constituents, natural antioxidants, and minerals, and has a caloric value of 348 kcal per 100 g. Vitamin c, hydroxyscuccinic acid, calcium, and phosphate ions are predominately present. Its phytochemical investigations revealed the presence of alkaloids, saponins, and tannins. Trihydroxy benzoic acid, 2-hydroxy benzoic acid, 3-caffeoylquinic acid, benzoaric acid, 4-hydroxy cinnamic acid, trolox, meletin, cianidanol, myricetol, alpha-tocopherol, 2-furaldehyde, phytosterol, campesterin, and fatty acids were also identified. Flavones, tannic acid, resins, alkaloids, saponins glycosides, and terpenoids are all extracted from the leaves. According to the preliminary phytochemical findings, the ethyl alcohol extract of *S. pinnata* exhibited the presence of nitrogenous compounds like alkaloids, polysaccharides, flavonoids polyphenol, and triterpenes which are present in gums, steroids, polyphenolic tannoids, resins, and saponin glycosides[4]. Essential oils derived from pulp contains carboxylic acid, esters, alcohol, and aromatic hydrocarbons. It incorporates polyphenols like tannins & flavonoids, sterols, terpenoids, and emulsifying agents like saponins glucoside, essential oils, amino acids, and carbohydrates, which are validated through research investigations. The presence of bioactive compounds like 24-methylene-cycloartanone, tetracosanoic acid, cupreol, and D-glucoside are present in *S. pinnata* which can be exemplified by the findings of phytochemical investigations from various previous research[19]. The phytoconstituents detected in these plants influence the pharmacological properties of *S. pinnata*. Secondary metabolites of plant products encompasses unsaturated sterols, pigmenting component flavonoid, carbohydrates, natural gums that are polysaccharides, lellocitgerinsin gallon, beta-amyrinol, oleanic acid, amino acids such as GLY, CYS, SER, ALA, LEU, sitogluside, 24 methylene cycloartenol, tetracosanoic acid, ellagitosinoic acid, and lellagitosinsin gallon. beta a myrin and oleanic acid are found in the bark, while the fruits include GLY, CYS, SER, ALA, and LEU, as well as tetracosanoic acid and beta sitosterol. Both phenolic and the flavonoid constituents of *Spondias pinnata* is extremely high. Easily hydrolyzing carboxylic esters, alcoholic compounds, and aromatic hydrocarbons with the circular structure are the components of *Essential oil*. The 100 mg extract has a tri-hydro benzoic acid equivalent phenolic content of 91.47 mg/mL and a sophoretin equivalent flavonoid constitutes 350.5 mg/mL. Arabinopyranoside, D-galactopyranoside, and D-galactopyranurnate, beta amyrin, oleanic acid are the carbohydrates present in the fruit in addition to GLY, CYS, SER, ALA, and LEU. The ethyl alcohol extracts of *S. pinnata* fruit exhibited potential antimicrobial properties towards *P. aeruginosa and S. epidermidis* at a concentration of 500 g/disc and significant cytotoxicity properties are displayed at IC_{50} 2.12 g/mL when tested using the disc diffusion method. With an IC_{50} of 147.84 g/mL for human lung cancer and 149.34 g/mL for cancer of mammary glands in humans, a roughly 70% methanolic extract of *S. pinnata* stems bark exhibits cytotoxic effects on the glandular cancerous cells. The extraction of the bark has an antidiabetic activity similar to glibenclamide which is used to treat type 2 diabetes, and the ethyl alcohol extract displays an analgesic effect similar to aspirin *S. pinnata* aqueous preparations and methyl alcohol are bactericidal against Vibrio cholerae, *Salmonella typhimurium*, and *Escherichia* coli. Iron-induced hepatic cytotoxicity can also be mitigated by using a 70 percent methanolic bark extract.[23,25]

Pharmacological features

S. pinnata has been demonstrated to benefit with a spectrum of human ailments. The chloroform extract of *S. pinnata* exhibits anthelminthic properties against earthworms outperforming other extracts w.r.t parasitic infection of worms. Antimicrobial, anti-diabetic, antioxidant, and free radical scavenging activities are all found in *S. pinnata* isolates. *S. pinnata* bark extract was reported to exert an anti-diabetic effect in mice with streptozotocin-induced hyperglycemia at a normal medicational dosage of 1 g/kg BW. Orally ingested concentrations of 200 and 400 milligrams/kg, of the ethyl alcohol extraction of *S. pinnata* bark, exhibits an antipyretic response. Leaves extract from *S. pinnata* offers antiviral and antimicrobial activities. The phenolic chemicals found in the methanol extract of *S. pinnata* leaves are principally accountable for the scavenging of free radicals. Numerous different investigations have demonstrated that *S. pinnata* methanolic extracts have antidiabetic, anticarcinogenic, anti-ulcer, anti-bacterial, antihepatotoxicity, thrombolytic therapies ore clot buster, anti-inflammatory, antiarthritis properties, pain reliever, reduces fever, hypotensive, anti-helminthic, increases diuresis, relieves constipation, cytotoxic, free radical scavenging, anti-hyperlipidemic, anticarcinogenic activities in addition to which they help to manage heart burn, acid reflux, ulcers, etc.

Hypoglycemic effects

A nondiabetic investigation and a glucose tolerance test in mature Wistar rats averaging around 150-200 g of either sex were used to assess *S. pinnata* antidiabetic properties. Methanolic extracts of *S. pinnata* root system at a concentration of 400 mg/kg body mass lowered blood sugar levels following 4 days of therapy in normoglycemic examinations, contrasting to that of the reference standard; glibenclamide, which dropped glucose levels after 60 min of administration. The aqueous extracts at a rate of 400 kg/mg body mass revealed a significant reduction in glucose levels after 4 h of treatment. The trichloromethane extract did not generate any noteworthy or encouraging[9].

During a glucose tolerance test, the aqueous and methanolic extractions drastically lowered blood sugar levels with administrations of 200 and 400mg/kg body mass after 1 h of glucose infusion, however, the chloroform extract had no remarkable influence.[18-19]

Glibenclamide inhibited the spike in blood sugar after alloxanisation by 63.22 percentile after eight hours in anti-diabetic tests, whereas methanolic extract controlled glucose concentration by 53.88 percent. Consequently, the folklore usage of *S. pinnata* roots for controlling blood sugar levels was corroborated by this research.[21]

Antihelmentic property

Multiple glycosides with considerable antiparasitic, preferably anti-helminthic effects can be found in the ethanol extract and acetone extracts of Spondias pinnata barks (Panda B.K. *et al.,*). The effectiveness of different formulations of *S. pinnata* bark over Native Indian earthworms species Pheritima posthuma was evaluated to that of piperazine citrate, which was treated as a reference. The trichloromethane extracts have been reported to be the most effective of all the tested isolates. The acetone and ethanolic extracts of *S. pinnata* were evaluated. Conventional treatments like piperazine citrate and albendazole were used to analyze the outcomes. Pheritima posthuma species were used to assess the antihelmintic activity of the extract in question. The time span taken by the worms to inflict mortality or paralytic disability was considered. Acetone extraction with doses of 50 mg/mL and 100 mg/mL were shown to be fatal around 82 and 54 min, respectively. The ethanolic isolates exhibited concentration-dependent antihelmintic effectiveness in a range of concentrations of 10 mg/mL to 100 mg/mL. The ethyl alcohol isolates were shown to be significantly more efficacious than the dimethyl ketone fraction w.r.t antihelmintic properties[26,27].

Anticancerous characteristics

The trunk of *S. pinnata* possesses anti-carcinogenic effects affirmed by the latest report. A 70% methyl alcohol preparation of *S. pinnata* bark was assayed for anti-carcinogenic properties. In human lung cancer; cell line (A549) and in human mammary gland cancer; cell line (A549) (MCF-7), it was identified to elicit apoptosis. Likewise, A549 and MCF-7 cells were afflicted by the cytotoxic effects exerted by the methanolic extract of Spondias pinnata bark, with IC_{50} values of 147.84 3.74 and 149.34 13.30 g/mL, accordingly. The cytotoxic levels of the normal persons' lung fibroblast cell lines (WI-38) were zero with a corresponding IC_{50} 932.38 84.44 g/mL. The methyl alcohol extract of *S. pinnata* bark appeared beneficial in apoptosis induction among both malignant tumorigenic cell lines, in accordance with the findings confirmed by flow cytometry and confocal microscopic examinations. Interestingly, immunoblotting observations insinuated that an increase in the Bax/Bcl-2 proportion among both the cancerous cell types instigated the initiation of the caspase cascade and, eventually, leads to the degradation of the Poly adeno ribose polymerase complex. *S. pinnata's* antitumor efficacy towards human lung and mammary gland cancerous cells was experimentally verified in this investigation by apoptosis induction via the regulation of Bcl-2 family proteins. The significance of the need for additional studies w.r.t *S.pinnata* with the intention to formulate it as a pharmaceutical anti-cancerous agent has been underlined by this investigation[11,28-29].

Ulcer protective features

The effectiveness of the extraction of anti-inflammatory drug indometacin-instigated ulcers in mature Wistar rats was assessed, using cimetidine as a positive control standard. The ulcerogenic function of indomethacin was suppressed by the ninety percent methanol extraction. To initiate the ulceration, varying concentrations of indomethacin (30, 60, and 100 mg/kg) were administered. Gastric ulcers were found to be uncommon among rats fed with 100-200 mg/kg of bark extract. In a concentration-dependent manner, the orally delivered extract suppressed indomethacin's ulcerogenic action, dropping the overall ulceration indices from 17.7 (control) to 8.7 and 6.7 for the 100mg/kg and 200mg/kg, respectively, yielding the preventive ratios of 50.4 and 62.0, correspondingly[4].

Analgesic effects

The analgesic abilities of Spondias pinnata ethanolic extracts were evaluated via ethanoic acid, formaldehyde testing, and a hot plate technique. The ethyl alcohol extracts of *S. pinnata* exhibited concentration-dependent analgesic effects analogous to the observations of acetylsalicylic acid in the ethanoic acid test and the second phase of the formaldehyde test. The results from this experiment confirm *S. pinnata's* traditional applications, especially as an analgesic.[9]

Anti-microbial properties

S. pinnata methyl alcohol and aqueous extractions were appraised in vitro for antibacterial properties toward *E. coli, Salmonella typhi*, and *Vibrio cholerae* at concentrations of 50 mg, 100 mg, and 150 mg by implementing the cup plate diffusion technique. The standard medications used in the experiment were penicillin and streptomycin. The methyl alcohol extract displayed effective bactericidal properties against *E. coli, Salmonella typhi*, and *Vibrio cholerae*, whilst the extract showed modest antimicrobial properties. Through the cup-plate diffusion technique, methanolic and aqueous extracts of *S. pinnata* barks exhibited antibacterial properties against 3 *Gram-negative* bacterias at a dosage of 50, 100, and milligrams. Penicillin and streptomycin were used as standard medications. The methyl alcohol extraction displayed better bactericidal properties towards *Escherichia coli*, *Vibrio cholera*, and *S. Typhimurium* whereas the aqueous extraction exhibited modest antibacterial activity against *Escherichia coli, Vibrio cholera*, and *S. typhimurium. Antimicrobial properties* of *S. pinnata* resins towards *S. cerevisiae, B. subtilis, E. coli*, *Cronobacter sakazakii*, and *A. baumannii* have also been investigated. The antibacterial properties of the resin exudate preparations *In vitro* were examined using the disc diffusion technique and macro dilution methods. The bacteria *B. Subtilis* was reported to be the most susceptible to resin preparation. *Gram(-)* bacteria and *S. cerevisiae* growth rates were unaltered by the extracts. Antimicrobial action towards the pathogenic infections in fish was reported in *S. pinnata* studies. Simultaneously, ethyl alcohol and chloroform preparations of *S. pinnata* roots demonstrated significant antibacterial properties against *Salmonella Typhi* and *V. cholera*, while the chloroform extraction showed positive antibacterial properties towards *Salmonella typhi* but much lesser impact against *S. aureus* and *V. cholerae*.[30,31]

Anti-diarrhoeal effect

When mature wister rats were administered castor oil-instigated diarrhea, *S. pinnata* was observed to display potential anti-diarrheal effects. By contrasting it to a standardized diphenoxylate HCl (5mg/kg), the activity was observed. Methyl alcohol extract of *S. pinnata* was fed to the animals at dosages of 100 and 200 milligrams/kg. The animals were administered 1 mL of castor oil orally after 60 min of intervention, and the constancy of their stools was analyzed. In castor-oil-induced diarrhea, *S. pinnata* bark extraction (100-200mg/kg, p.o.) potentially lowered the dampness and regularity of excrement. The anticholinergic medication diphenoxylate HCl (5mg/kg, p.o.) had a similar impact. In a one-day in-vivo experiment, dimethyl sulfoxide formulations of the ethyl alcohol crude preparations were implemented against Artemia salina a brine shrimp. The reference in the study was the drug vincristine sulfate, and the trials were conducted in triplicate with the average mean data results were recorded. Following 24 h of exposure, the extract's fatality against brine shrimp was verified. The ethyl alcohol crude extracts were shown to have substantial cytotoxic properties, with LC_{50} values equivalent to 2.120.09 g/mL for the ethanolic crude extract and 0.320.05 g/mL for the drug vincristine sulfate.[4,9]

Hepatoprotective effect

Ethyl ethanoate and methyl alcohol extractions of stem heartwood *S. pinnata* were studied for their hepatoprotective properties in tetrachloromethane-instigated rodents. Serum Glutamatic Pyruvic Transaminase (SGPT), SGOT/ aspartate transaminase (AST0, Alkaline Phosphatase (ALP), and bilirubin were used to evaluate hepatic injury and damage in both untreated and treated cohorts. On rats anguished from tetrachloromethane-instigated toxicity of hepatic cells, oral dosing of the ethyl ethanoate extraction of *S. pinnata* stem heartwood in concentrations of 100, 200, and 400 milligrams/kg dramatically lowered the abnormal SG0T, ALP, SGOT, and total bilirubin concentrations to near-normal values. The hepatoprotective efficacy was supported by histopathological investigation of hepatic tissue samples derived from tetrachloromethane-instigated rodents. In mice administered with ethyl ethanoate and methyl alcohol extractions of *S. pinnata* stem heartwood, the cellular structure of the hepatic cells was retained. This response was comparable to that of Silymarin, an extensively prescribed drug. This characteristic property perhaps could be due to the presence of bioactive flavonoids, which have hepatoprotective properties.[32]

Antioxidant properties

S. pinnata displayed more efficient free radical scavenging properties than ascorbate in an investigation that included fifteen edible fruits native to Nepal. *S. pinnata* preparations had a free radical scavenging efficacy of 16% at 5 g/mL, but ascorbic acid exhibited mere radical scavenging activity of 5%. The antioxidant properties of the methyl alcohol and water preparations were proved to be linked with TPC, with the values (R2) of 0.7189 and 0.7246, respectively representing the correlation coefficient. The scavenging effect of the methanolic extracts pinnata fruit on the ABTS+ free radical was also used to test its antioxidant properties. The samples were prepared with concentrations varying from 0 to 10 g/L. A fraction of every diluted reduction (50 L) was combined with 3 mL of ABTS along with the solution and left undisturbed for 6 min before reading the absorbance at 734 nm with a spectrophotometer. The inhibition percentage, half-maximal inhibitory concentration (IC_{50}), and Trolox equivalent antioxidant capacity (TEAC) is used to represent the antioxidant potential exhibited by the extract. A 70 percent methyl alcohol extraction of *S. pinnata* stems bark was reported to be a significant source of antioxidants in one of the research investigations. The extraction has a TEAC score of 0.78 0.02 and IC_{50} score of 66.54 0.84 g /mL, the extraction is an excellent iron-chelator. In 100 milligram, the plant extract exhibited 3,4,5 trihydroxy benzoic acid-equivalent phenolic concentration of 91.47 0.004 milligram/mL and quercetin-equivalent flavonoid concentration of 350.5 0.004 milligram/mL[30,33].

Anti-arthritic activity

Inflammatory mediators rely heavily on nitric oxide. Bibhabasu *et al.,* reported that the methyl alcohol extractions of *S. pinnata* potentially reduce the production of nitrite ions by interacting directly with oxygen molecules in the reaction involving nitric oxide. The IC_{50} score of the methyl alcohol fractions was 716.32 g/mL, while the well-known 3,4,5 trihydroxy benzoic acid had an IC_{50} score of 876.24 g/mL. *S. pinnata* and benzoic acids had 22.3 and 15.8% scavenging efficiencies, respectively. The extract had higher azoperoxoate radical scavenging activity than the reference standard benzoic acid, which is validated through this investigation[7,31].

Role in chemotherapy of *S. pinnata*

Beena *et al.,* tested for the preventive properties of Spondias pinnata bark extracts at various concentrations after exposing rats to etoposide. A semiauto analyzer was used to assess the levels of alanine and aspartate aminotransferases, and spectrophotometry was used to determine the levels of reduced glutathione, glutathione-S-transferase, total antioxidants, and lipid peroxidation. Between the control, chemotherapeutic, and *S. pinnata* groups, there were changes in parameters. The levels of Thiobarbituric acid-responsive substances that could be retrieved with *S. pinnata* therapeutic interventions increased dramatically, as per the observations. Histopathological studies of *S. pinnata* bark extract intervention might repair intestine sodium-potassium ATPase activity and regular morphology, according to Sudarshan *et al.,*[34]

Toxicity

In wistar mice, severe and subchronic cytotoxicity of *S.pinnata* bark was observed. Astute toxicity assessments from the dermal extractions were seen as alterations in the epidermis, scalp, eye, mucosal membranes, respiratory, and circulatory systems, autonomic nervous system, CNS, somatic nervous system, and behavioral tendencies. Significant acute intoxication manifestations involve trembling, seizures, drooling and vomiting, tiredness, drowsiness, and comatose. Cytotoxic effects were not observed under dosages of 0.25, 0.50, 0.75, 1.00, 1.25, and 2.00 g/kg body weight when given once during the course of 30 min, frequently on the first day, and in the corresponding days for a period of fourteen days. Upon ingestion of *S. pinnata* bark at concentrations of 0.25, 0.50, 0.75, 1.00, 1.25, and 2.00 g/kg body weight, no cytotoxic effect, fatality, illness, or diseases were detected[35]. The bark extract did not impede the development of the mice, and all experimental animals accepted extracts at defined dosage satisfactorily, showing that the extract is suitable for remote delivery. *S. pinnata* was ineffective on the hepatic cells, lungs, colon, pancreatic, or renal cells after a period of 28 days of repeated treatment. The intake of its extraction was ineffective with regard to the appetite of the experimental mice. Aqueous extracts from the bark of *S. pinnata* were considered safe in experimental Wistar rat models up to 2 g/kg body weight. There were no significant observable changes or significant abnormalities or improvements w.r.t hunger, body mass, development, biochemical markers, hematologic parameters, or histopathological abnormalities in body tissue after dosing for a period of 28 days.[36]

Molecular Level Mechanism

Leaves extraction of *Spondias sp*. displays antioxidants and antimicrobial properties and harbors important bioactive compounds such as such as meletin, phytomelin, and benzoaric acid. Antitubercular effectiveness of *S. pinnata* leaves extract towards *Mycobacterium tuberculosis* MDR bacteria was evaluated. In another study, the aqueous component of *S. pinnata* leaf has been found to create protein disruption and phenotypic abnormalities in *Bacillus cereus* cells. The antibacterial properties of *S. pinnata* resins have been evaluated. Its latex kills bugs and fungus by slowing down their metabolism.[4]

The ethyl alcohol extract of *S. pinnata* possesses antibacterial and antifungal properties against *S.aureus, Escherichia coli*, and *P. aeruginosa*, as well as against *Candida albicans* and *A. flavus*. Bioactive phytocompund like flavonoids are identified in the resins exuded by *S. pinnata*, and they have bactericidal capabilities, according to previous research findings. The antimicrobial effect of *S. pinnata* was demonstrated to be mediated by resin and flavonoid. *S. pinnata* resin, on the other hand, is ineffectual against *Gram(-)* bacterial species, Saccharomyces, and fungus, with the exception of *B. subtilis* bacteria. Antioxidant activities are found in *S. pinnata* stem bark extraction, while antimicrobial characteristics are found in *S. pinnata* crude extraction. 4-O-glucoside is the constituent in *S. pinnata* bark extraction that can potentially suppress the production of nitrogen monoxide. Quebrachol, found in the bark of *S. pinnata*, is involved in the action of GSH preservation by reducing the levels of cytokines[9]. GSH levels in the renal and hepatic cells are maintained by taking synthesized glutathione (GSH) molecules. Reactive oxygen species generate oxidative stress, which leads to the destruction of DNA and protein structure, and fat degradation fosters cancerous cells and causes atherosclerosis, hypertension, cardiac diseases, and senescence. When the reactive oxygen species are coupled to electrons from other biomolecules like protein, lipids, and DNA in normal and functional healthy cells, they remain stable very. Every cell in a normally functioning human body requires enzymes like superoxide dismutase (SOD) and catalases, in addition to the antioxidants like vitamin c, vitamin E, and isethione, to defend oneself from the free damage caused by free radicals. Antioxidant supplements are essential in the combat against oxidative.[11]

Nitrogen monoxide oxide accelerates the inflammatory responses. Long-term expression of nitrogen monoxide accords cancer and other inflammatory disorders like type 1 diabetes, neonatal diabetes, sclerosis, osteoarthritis, ulcerative colitis, gastrointestinal disorders, and its continuous generation promotes cytotoxicity and vascular breakdown, which is correlated with septicemia and septic shock. When nitrogen monoxide reacts with superoxide anions, it forms the extremely reactive peroxynitrite radicals, which amplifies its cytotoxicity (ONOO-). The combination of sodium nitrous with oxygen to generate nitrite generates nitrogen monoxide as a byproduct. *S. pinnata* extraction prevents the generation of nitrite ions by competing directly with oxygen in a nitrogen monoxide reaction.[20]

CONCLUSION

Different parts and their constituents of the plant *S. pinnata* have been extensively researched for their therapeutic potential using a variety of experimental screening models and can be inferred from previous research that this plant has potentially been developed into a natural remedy to treat a multitude of ailments and it associated symptoms. Past research findings validated the potential pharmaceutical application of the plant, and this comprehensive data discussed in this review is believed to encourage proper appraisal of the usage of various sections of this plant to design medications. To establish this plant as a potent drug further studies to validate its pharmacological properties and supporting medical trials are required.

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