ABSTRACT

Peperomia pellucida (L.) Kunth is a herb belonging to the family Piperaceae. In this review, an extensive literature survey was carried out to compile information available on medicinal uses, phytochemistry and pharmacological properties of P. pellucida. The plant is used as food, flavoring agent and as medicine. The plant is used as medicine for treating various ailments or disorders such as asthma, rheumatism, wound, fever, stomach problems, kidney infection, hemorrhoid pain, joint pain, hypertension, diarrhea, snake bite and measles. The plant contains phytochemical groups such as alkaloids, flavonoids, saponins, terpenoids, steroids and glycosides. Compounds such as dill apiol, phytol, stigmasterol, sitosterol, secolignans, tetrahydrofuran lignans, highly methoxylated dihydronaphthalenone, peperomins, sesamin and isoswertisin have been identified in the plant. Studies have shown that the plant exhibited several pharmacological activities such as antimicrobial, antioxidant, anti-angiogenic, anti-inflammatory, analgesic, antipyretic, neuropharmacological, anti-cancer, enzyme inhibitor, antiallergic, hypotensive, immunostimulatory, fracture healing and antidiabetic activities which support the traditional use of the plant. Purified chemicals from the plant have also shown to exhibit certain pharmacological activities such as antiulcer, anticancer and antimicrobial activity. By this extensive literature review, it can be concluded that P. pellucida can be utilized as a promising candidate for developing newer drugs with potent pharmacological activities.

Keywords: Peperomia pellucida (L.) Kunth, Ethnomedicine, Traditional medicine, Phytochemical, Pharmacological activities

INTRODUCTION

Throughout the world, especially developing and under-developing countries, plants have been exploited as medicine to meet primary healthcare needs. It is estimated that vast majority of population relies on medicinal plants for therapy against several diseases or disorders. Traditional medicinal practitioners utilize plants, either singly or in certain formulations, to treat ailments. Non-availability (especially for people from remote areas) and high cost of modern drugs limits their use by people from economically poor background. Nowadays, medicinal plants are used routinely in urban settings in daily healthcare and as medication against ailments. Many indigenous medicinal systems such as Ayurveda, Siddha and Unani utilize several plant species. Besides, plants provide many drugs limits their use by people from economically poor background. Nowadays, medicinal plants are used routinely in urban settings in daily healthcare and as medication against ailments. Many indigenous medicinal systems such as Ayurveda, Siddha and Unani utilize several plant species. Besides, plants provide many

The genus Peperomia Ruiz and Pavon belongs to the family Piperaceae. The genus is the second largest genus in piperaceae and includes plants that are annual or perennial, usually succulent herbs and often epiphytic. The genus encompasses a number of species found distributed in tropical and subtropical regions worldwide. The species of Peperomia are characterized by bisexual flowers (male and female flowers in the same plant), usually minute, sessile (sunk in rachis) in spike inflorescence and lateral or terminal stigma which is usually penicillate. The genus is often considered as one of the most species rich genera of angiosperms [7-10]. Peperomia pellucida (L.) Kunth (fig. 1) belonging to the family Piperaceae is commonly known by names such as pepper elder, rat ear and shining bush. The plant is native to South America and is found distributed in various countries in the world including India. The plant is very common during rainy season and usually grows in clumps in loose and humid soils and is found in shaded, damp habitats. The plant occurs more or less throughout the year in wet places. It is characterized by succulent stems, fleshy and heart shaped leaves, and tiny dot like seeds attached to fruiting spikes. It is called neeru kaddi gida in Kannada. The plant is known to be edible and is considered to possess cooling property [8, 10, 11]. In the present review, we presented updated information (up to 2017) concerned with the ethnomedical uses, phytochemical composition and pharmacological properties of P. pellucida. An extensive literature survey on various aspects of the plant was carried out by referring flora, journals, and various search engines including Google scholar, Science Direct and Pubmed.

Plant description

P. pellucida is a slender herb (reaching 30-50 cm in length) with straight and succulent stem and is cosmopolitan in distribution. Leaves are opposite and alternate, up to 2.5x2 cm, ovate-deltoid, obtuse to acute at apex. Leaves are thin, fleshy, smooth, membranous when dry, 5-7 nerved from the base. Petiole is up to 1.5 cm long. Spikes are terminal and leaf-opposed, up to 5 cm long. Flowering occurs more or less throughout year. Fruits are ribbed and reticulate, minute in size and almost dry [8, 10].

Fig. 1: Peperomia pellucida (L.) Kunth (photograph by prashith kekuda).
Ethnobotanical uses of *P. pellucida*

The plant *P. pellucida* is used ethnobotanically as medicine, food and flavoring agent in various parts of the world. Aerial parts, young shoots, leaves and whole plant are used in the form of decoctions, juice, paste etc. to treat several diseases such as fever, cold, cough, viral diseases, rheumatic pain, asthma, vaginal infections and kidney infections. The Sumu (Ulwa) of southeastern Nicaragua and southern Miskitu uses *P. pellucida* against bites and stings (snakes, scorpions and insects), infections, venereal diseases and female disorders [12]. The plant is used as human food and medicine in Luang Prabang, Lao People’s Democratic Republic [13]. In Lombok, Indonesia, the plant is used to treat fever [14]. In North-Kamrup district, Assam, India, the plant paste is applied externally to reduce pimples and white spots of the body [15]. In Trinidad and Tobago, the plant is used for cooling [16]. The whole plant is used in the treatment of measles in Ogun state, Nigeria [17]. Juice made from leaves and roots are used to treat athletes foot, decoction prepared from leaves is used in the treatment of hemorrhoid pain and kidney infection in Rondônia, Western Amazon, Brazil [18]. In Nigeria, the whole plant is used in haemorrhoids, hypertension, convulsion and bone fracture [19]. The whole plant is boiled and used to treat kidney infection and to lower hypertension in Mindanao, Philippines [20]. Table 1 depicts ethnobotanical (medicinal and non-medicinal) uses of *P. pellucida* in various parts of the world.

### Table 1: Ethnobotanical uses of *P. pellucida* in various parts of the world

<table>
<thead>
<tr>
<th>Region</th>
<th>Part used</th>
<th>Uses</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malappuram district, Kerala, India</td>
<td>Whole plant</td>
<td>Decoction prepared from whole plant is taken internally for treating rheumatism</td>
<td>Chithra and Geetha [21]</td>
</tr>
<tr>
<td>Barpeta district, Assam, India</td>
<td>Plant juice, leaf paste</td>
<td>Plant juice is used in stomach problems, leaf paste is applied on cuts and wounds.</td>
<td>Kaliita et al. [22]</td>
</tr>
<tr>
<td>East Sepik, Papua New Guinea</td>
<td>Leaves, whole plant</td>
<td>Leaves are used as antidepressant and in the treatment of pimples.</td>
<td>Koch et al. [23]</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Aerial parts</td>
<td>Dizziness, headache, fever, stomachache</td>
<td>Waty et al. [24]</td>
</tr>
<tr>
<td>Greater Khulna division, Bangladesh</td>
<td>Whole plant</td>
<td>Whole plant is used in the treatment of diarrhea.</td>
<td>Rahmatullah et al. [25]</td>
</tr>
<tr>
<td>Bagerhat district, Bangladesh</td>
<td>-</td>
<td>Tribal community uses plant for medicinal purposes</td>
<td>Mollick et al. [26]</td>
</tr>
<tr>
<td>Tinsukia district, Assam, India</td>
<td>Whole plant</td>
<td>Paste made from the whole plant is applied on burns for quick relief.</td>
<td>Buragohain [27]</td>
</tr>
<tr>
<td>Assam, India</td>
<td>Young shoots</td>
<td>Young shoots are used as flavoring agents.</td>
<td>Bharali et al. [28]</td>
</tr>
<tr>
<td>Morigaon district, Assam, India</td>
<td>Aerial parts</td>
<td>Aerial part of the plant is used to treat stomach pain, joint pain and headache.</td>
<td>Bordoloi et al. [29]</td>
</tr>
<tr>
<td>Jalpaiguri district, West Bengal, India</td>
<td>Whole plant</td>
<td>Paste made from whole plant is used against boils.</td>
<td>Bose [30]</td>
</tr>
<tr>
<td>Kanda community, Bangladesh</td>
<td>Whole plant</td>
<td>Paste made from the whole plant is applied by the sides of the bitten place (poisonous snake, insect or reptile bites).</td>
<td>Rahmatullah et al. [31]</td>
</tr>
<tr>
<td>Saramacca Maroons in Suriname</td>
<td>Whole plant</td>
<td>Used as herbal bath for children for general health promotion and to get rid of evil.</td>
<td>Ruyschaert et al. [32]</td>
</tr>
<tr>
<td>Dominican Republic and New York City (Dominican traditional medicine)</td>
<td>Aerial parts, leaf</td>
<td>Aerial parts are used in the treatment of flu, leaves are used to treat vaginal infections and asthma/chest congestion.</td>
<td>Vandebroek et al. [33]</td>
</tr>
<tr>
<td>Assam, India</td>
<td>Leaves</td>
<td>Leaves are used to treat athletes’ foot and wound.</td>
<td>Uzodimma [34]</td>
</tr>
<tr>
<td>Tristan</td>
<td>Whole plant</td>
<td>Leaves are used in urinary disorder and fever.</td>
<td>Gogoi and Zaman [35]</td>
</tr>
<tr>
<td>Tshopo district, DR Congo</td>
<td>Leaves</td>
<td>Leaves are cooked and used as leafy vegetable.</td>
<td>Termote et al. [36]</td>
</tr>
<tr>
<td>Mouhivazar district, Bangladesh</td>
<td>Leaves, whole plant</td>
<td>Paste made from leaves and whole plant is used in the treatment of fever in children and adults respectively.</td>
<td>Das et al. [37]</td>
</tr>
<tr>
<td>Kamrup district, Assam, India</td>
<td>Leaves and stem</td>
<td>Leaves and stem are used in the treatment of fever.</td>
<td>Bora and Das [38]</td>
</tr>
</tbody>
</table>

### Phytochemical groups identified in *P. pellucida*

<table>
<thead>
<tr>
<th>Plant part</th>
<th>Phytochemical group</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole plant</td>
<td>Tannins, saponins, flavonoids, terpenoids, phytosterols, alkaloids, phenolics</td>
<td>Gini and Jothi [46]</td>
</tr>
<tr>
<td>Leaf</td>
<td>Alkaloids, tannins, saponins, terpenoids, flavonoids, cardiac glycosides</td>
<td>Ojo et al. [47]</td>
</tr>
<tr>
<td>Leaf</td>
<td>Alkaloids, flavonoids, saponins, tannins, steroids, triterpenoids</td>
<td>Majumder and Kumar [48]</td>
</tr>
<tr>
<td>Leaf</td>
<td>Alkaloid, cardiac glycoside, terpene, saponin, tannin</td>
<td>Omotayo and Borokini [49]</td>
</tr>
<tr>
<td>Whole plant</td>
<td>Alkaloids, saponins, tannins, flavonoids, anthraquinones, glycosides</td>
<td>Idris et al. [50]</td>
</tr>
<tr>
<td>Leaf</td>
<td>Alkaloids, tannins, flavonoids, saponins and cardiac glycosides</td>
<td>Abare and Okpalukonyu [51]</td>
</tr>
<tr>
<td>Leaf</td>
<td>Alkaloids, flavonoids</td>
<td>Ibibia [52]</td>
</tr>
<tr>
<td>Stem</td>
<td>Alkaloids, flavonoids, steroids, triterpenoids</td>
<td>Majumder [53]</td>
</tr>
<tr>
<td>Whole plant</td>
<td>Alkaloids, flavonoids, glycosides, saponins</td>
<td>Sheikh et al. [54]</td>
</tr>
<tr>
<td>Leaf</td>
<td>Alkaloids, tannins, saponins</td>
<td>Egwuche et al. [55]</td>
</tr>
<tr>
<td>Aerial parts</td>
<td>Alkaloids, flavonoid, tannins, saponins, steroids, glycosides</td>
<td>Raina and Hassan [56]</td>
</tr>
</tbody>
</table>

**Phytochemistry of *P. pellucida***

Plants produce a range of primary and secondary metabolites. The study of chemical compounds present in plants (phytochemicals) is known as phytochemistry. The therapeutic potential of plants is ascribed to the presence of a wide range of phytochemicals, mainly secondary metabolites. Significant advancements in the technology, mainly chromatographic and spectral analyses, led to the discovery of many types of phytochemicals from plants and the pharmacological studies revealed their potential role. Techniques
such as column chromatography, Thin layer chromatography (TLC), Gas chromatography–mass spectrometry (GC-MS). Fourier-transform infrared spectroscopy (FT-IR) and Nuclear magnetic resonance (NMR) spectroscopic techniques are routinely used to identify phytochemicals present in plants [39-45]. Various researchers have identified phytochemical groups and chemical compounds in leaves and whole plant by standard phytochemical procedures and various analytical techniques.

Table 2 and 3 provides information on various phytochemical groups and chemicals identified in different parts of the plant by standard phytochemical tests and GC-MS analysis respectively.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Compounds identified</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essential oil</td>
<td>Dillapiole, trans-caryophyllene</td>
<td>da Silva et al. [57]</td>
</tr>
<tr>
<td>Leaf extract</td>
<td>phytol, 2-Naphthalenol, Hexadecanoic acid and 9,12-Octadecadienoic acid</td>
<td>Wei et al. [58]</td>
</tr>
<tr>
<td>Essential oil</td>
<td>Dillapiole, myristicine</td>
<td>Francois et al. [59]</td>
</tr>
<tr>
<td>Essential oil</td>
<td>carotol, dillapiole, pygmaein, (E)-caryophyllene, germacrone D, β-elemene, camphor,</td>
<td>Verma et al. [60]</td>
</tr>
<tr>
<td></td>
<td>daucene, apiole, β-bisabolene and bicyclogermacrene</td>
<td></td>
</tr>
<tr>
<td>Whole plant</td>
<td>Apiol, Phytol, n-Hexadecanoic acid, E-2-Tetradecen-1-ol, Stigmasterol, and Sitosterol</td>
<td>Naraynamoorthi et al. [61]</td>
</tr>
<tr>
<td>extract</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Essential oil</td>
<td>γ-gurjunene, 1,10-di-epicubenol, (E)-caryophyllene, dillapiole, carotol, trans-β-guaiene</td>
<td>de Oliveira et al. [62]</td>
</tr>
<tr>
<td>Essential oil</td>
<td>Phytol, α-terpineol, β-caryophyllene, d-limonene, linalool</td>
<td>Okoh et al. [63]</td>
</tr>
</tbody>
</table>

Ragasa et al. [39] isolated dill-apiole, aurantiamide acetate and pachypophyllin from leaf extract of *P. pellucida* and elucidated their structure by NMR studies. Pellucidin A, a novel dimeric ArC2 compound, along with dill-apiole has been isolated by Bayma et al. [64] from the aerial parts of *P. pellucida*. The structure of pellucidin A was established by spectral analyses. The study carried out by Xu et al. [65] revealed isolation of compounds such as secolignans, tetrahydrofuran lignans, highly methoxylated dihydro-naphthalenone, peperomins, sesamin and isoswertisin from the whole plant of *P. pellucida*. Khan et al. [66] recovered a xanthone glycoside from leaves of *P. pellucida* and characterized the compound as vitexin by chromatographic and spectral analyses. The study carried out by Ahad et al. [69] revealed a total alkaloid content of 29.59 mg/g piperine in the dichloromethane fraction of plant material. Fig. 2 shows the structure of some of the compounds identified in the plant.

**Fig. 2: Structures of some compounds identified in *P. pellucida* [39, 41, 66, 68]**

**Pharmacological activities of *P. Pellucida***

Many studies have been carried out to investigate pharmacological properties of *P. pellucida*. The plant is reported to exhibit several bioactivities such as hypotensive, immunostimulatory, antioxidant, antimicrobial, analgesic, anti-inflammatory, fracture healing, gastroprotective and antidiabetic activity.

Concise information on pharmacological activities of extracts and purified compounds of *P. pellucida* is discussed below.
Hypotensive activity

Nwekocha et al. [70] evaluated hypotensive activity of aqueous extract from whole plant of *P. pellucida* in rat model. Intravenous administration of extract showed a dose dependent reduction in systolic and diastolic blood pressure, heart rate and mean arterial pressure. It was shown in the study that the extract induces bradycardia and hypotension in normotensive rats via mechanisms that are nitric oxide dependent. The study carried out by Fasola and Adeboye [71] also revealed anti-hypertensive activity of *P. pellucida* in normotensive rats. Intravenous administration of methanol extract resulted in marked decrease in mean arterial blood pressure and heart rate.

Neuropharmacological activity

The study carried out by Khan et al. [72] indicated that the petroleum ether and ethyl acetate fractions of ethanol extract of leaves of *P. pellucida* possess central nervous system depressant effect as the fractions were shown to possess dose dependent effects on duration of diazepam-induced sleep, nikelhamide-induced toxicity, light-dark test and force swimming test.

Immunostimulatory activity

In a study, Lee et al. [73] revealed the potential of leaf extract of *P. pellucida* (mixed with fish pellets) as an immunostimulator in controlling motile aeronomad septicaemia caused by *Aeromonas hydrophila* in *Oreochromis* spp. (red hybrid tilapia). It was observed that the mortality rate was considerably lesser in fishes that were fed with diet which was mixed with leaf extract.

Antimitogenic activity

Ragas et al. [39] evaluated antimitogenic activity of dill-ai pol and pachyphillin isolated from leaf extract of *P. pellucida* by micronucleus test. The compounds were not effective as the study did not indicated significant reduction in micronucleated polychromatic erythrocytes induced by mitomycin C.

Anti-angiogenic activity

The study carried out by Camposano et al. [74] revealed anti-angiogenic activity of methanol extract of *P. pellucida* in terms of inhibition of angiogenesis in chorioallantoic membrane assay. The extract was shown to inhibit angiogenesis with an activity of 26%.

Fracture healing activity

Ngueguim et al. [75] evaluated the potential of ethanol extract of *P. pellucida* on bone regeneration following bone and marrow injury in rats, and determined the mode of action. The extract dose dependently induced bone regeneration at the fracture site and significantly increased mineral deposition. The extract was also found to improve microarchitecture of the regenerating bone. It was shown that the extract accelerates fracture repair via stimulatory effects on osteoblast differentiation and mineralization. Recently, Florence et al. [76] revealed the potential of aqueous extract of *P. pellucida* to accelerate fracture healing in Wistar rats. Radiological tests revealed a dose dependent formation of callus at the level of the fracture gap and was evidenced by formation of a highly dense and compact fibrocartilagenous callus.

Antulcerogenic/gastroprotective activity

Roslida and Aini [77] evaluated gastroprotective (antulcerogenic) activity of ethanolic extract of aerial parts of *P. pellucida* in indomethacin and necrotizing agent induced models in rats. The result revealed that the extract at all doses produced significant inhibition of gastric mucosal damage induced by necrotizing agents and indomethacin. Rojas-Martinez et al. [78] determined gastroprotective activity of solvent extracts and Dillapirole from *P. pellucida*. Dichloromethane extract of leaf and stem displayed marked gastroprotective activity in rats with ethanol induced gastric ulcer. Dillapirole also exhibited marked gastroprotection.

Analgistic activity

Aziba et al. [79] determined analgesic activity of methanol extract of aerial parts of *P. pellucida* by acetic acid induced writhing in mice. It was observed that oral administration of extract (70-210 mg/kg) exhibited a significant analgesic activity in mice. Arrigoni-Blank et al. [80] evaluated analgesic activity of aqueous extract prepared from aerial parts of *P. pellucida* by abdominal writhing and hot plate tests. The extract displayed significant analgesic activity at extract concentration of 400 mg/kg and 100 mg/kg in abdominal writhing and hot plate test respectively. The study carried out by Sheikh et al. [54] revealed analgesic potential of ethyl acetate extract of whole plant by acetic acid induce writhing in mice.

Antipyretic activity

The study carried out by Khan et al. [81] revealed the antipyretic potential of petroleum ether and ethyl acetate soluble fractions of ethanol extract of leaves of *P. pellucida* in boiled milk induced pyrexia in albino rabbits. Administration of solvent fractions at a dose of 80 mg/kg body weight showed a significant reduction in elevated body temperature in albino rabbits.

Anti-inflammatory activity

Arrigoni-Blank et al. [82] evaluated anti-inflammatory activity of aqueous extract of leaves of *P. pellucida* by carrageenan induced paw edema test in rats. It was observed that the extract obtained from plants in all seasons displayed antiedematogenic activity with significant activity observed in phenophases of winter and spring. Arrigoni-Blank et al. [80] evaluated anti-inflammatory activity of aqueous extract prepared from aerial parts of *P. pellucida* by paw edema induced by carrageenan and arachidonic acid. It was observed that oral administration of 200 and 400 mg/kg of the extract showed an anti-inflammatory activity in the carrageenan test, which was based on interference with synthesis of prostaglandin, as confirmed by the arachidonic acid test. The study carried out by Mutet et al. [83] indicates the anti-inflammatory potential of petroleum ether, chloroform and methanol extract of *P. pellucida* in carrageenan induced rat paw edema. Among extracts, petroleum ether extract displayed significant activity when compared to chloroform and methanol extracts.

Antimicrobial activity

Ragas et al. [39] isolated dill-ai pol and pachyphillin from leaf extract of *P. pellucida* and determined their antimicrobial activity. These compounds were selectively effective against *Trichophyton mentagrophytes* while other test microbes were not affected. In a study, Khan and Omoloso [84] screened antimicrobial activity of crude methanolic extract and petrol, dichloromethane, ethyl acetate and butanol fractions of methanolic extract of *P. pellucida*. Crude extract and fractions displayed broad spectrum antibacterial activity. Butanol fraction of crude extract was more active. Patalaks A isolated from leaves of *P. pellucida* was shown to display concentration dependent inhibition of Gram positive and Gram negative bacteria. Patalaks D showed weak activity against *Aspergillus flavus* and *Candida albicans* while A. *niger* and *Rhizopus oryzae* were unaffected [66]. Further details on the antimicrobial potential of *P. pellucida* described by other researchers are shown in table 4.

Antidiabetic activity

Humzah et al. [93] showed that diet containing *P. pellucida* (10% and 20%) possess antidiabetic effect in alloxan-induced diabetes in rats. A considerable reduction in the blood glucose level was observed in the study. The levels of aspartate transaminase (AST), alanine transaminase (ALT) and alkaline phosphatase (ALP) were lesser in rats fed with diet containing *P. pellucida*. Moreover, the concentration of total cholesterol, triglycerides (TG), high-density lipoprotein (HDL) and low-density lipoprotein (LDL) content were also lesser in rats fed with diet containing *P. pellucida*. The levels of superoxide dismutase (SOD), catalase and glutathione were also increased. Sheikh et al. [54] evaluated antidiabetic activity of ethyl acetate extract of whole plant of *P. pellucida* in alloxan-induced diabetic mice. A significant hypoglycemic effect was observed in mice administered with extract. 8.9-dimethoxy ellagic acid, isolated from leaf extract of *P. pellucida*, was evaluated for antidiabetic activity by alloxan-induced hyperglycemic mice [68]. The compound was shown to exhibit 33.74% blood glucose lowering in normoglycemic mouse at 100 mg/kg dose.
Acaricidal activity

In a study, de Oliveira et al. [62] evaluated the activity of the essential oils from leaf and stem against Tetanychus urticae. The study observed that the stem oil was four-fold more toxic than the leaf oil however the activity of essential oils was lower than eugenol, the positive control.

Anticancer/cytotoxic activity

Peperomia E, isolated from whole plant of P. pellucida, was found to exhibit cytotoxicity against cell lines viz. HL-60, MCF-7 and HeLa cell lines [65]. Khan et al. [66] determined cytotoxic activity of Patuliside A, isolated from leaves of P. pellucida, against brine shrimp nauplii. The compound exhibited cytotoxicity with an IC₅₀ value of 18.24 μg/ml and the activity observed was lesser when compared to standard drug. Wei et al. [58] determined cytotoxic potential of methanolic extract of P. pellucida leaf against MCF-7 cell line by 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay. The extract displayed concentration dependent cytotoxicity with an IC₅₀ value of 10.4±0.06 μg/ml. Oloyede et al. [87] screened cytotoxicity of crude methanol extract and fractions such as hexane, ethyl acetate, butanol and aqueous fractions of leaves of P. pellucida by brine shrimp lethality assay. Crude extract, hexane and ethyl acetate fractions were shown to be effective while butanol and aqueous fractions were not effective in causing mortality of brine shrimp larvae.

Antioxidant activity

Mutee et al. [83] determined antiradical activity of chloroform, petroleum ether and methanol extract of P. pellucida by 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay. Methanol extract was shown to display marked scavenging of free radicals when compared to other extracts. Wei et al. [58] screened methanolic extract of P. pellucida leaf for radical scavenging potential by DPPH assay. The extract was shown to display concentration dependent scavenging of radicals but the activity observed was considerably lesser than that of quercetin. Oloyede et al. [87] determined antioxidant potential of crude methanolic extract and hexane, ethyl acetate, butanol and aqueous fractions of leaves of P. pellucida by DPPH scavenging, hydrogen peroxide scavenging and ferric thiocyanate method. Extract and fractions were shown to exhibit marked activity in all methods. The study carried out by Beltran-Benjamin et al. [94] revealed an increase in the levels of antioxidant enzymes viz. superoxide dismutase and catalase on administration of crude methanolic extract of P. pellucida in rats. Phongtongpasuk and Poadang [95] evaluated antioxidant potential of butanol, ethyl acetate and methanol extracts of P. pellucida obtained by maceration and reflux method. Extracts obtained by reflux method displayed marked DPPH scavenging activity and reducing power. Phenolic content was also higher in extracts obtained by reflux method. The study carried out by Okoh et al. [63] showed the antioxidant potential of essential oil of leaf and stem of P. pellucida. The essential oils exhibited concentration dependent scavenging of DPPH. 2,2'-azino-bis(3-ethylbenothiazoline-6-sulphonic acid) (ABTS) and nitric oxide radicals.

Enzyme inhibitory activity

In a study, Ong et al. [96] evaluated porcine pancreatic lipase inhibitory activity of methanolic extract of leaves of P. pellucida and observed lesser potential of leaf extract to cause inhibition of lipase activity when compared to standard. Kurniawan et al. [43] isolated a compound by name 3',4', dihydroxy-3,5-dimethoxy flavone-7-O-β-rhamnose from aerial parts of P. pellucida and evaluated its inhibitory activity against Angiotensin converting enzyme (ACE). The compound was found to inhibit ACE dose dependently with an IC₅₀ value of 7.72 μg/ml. Ethyl acetate fraction was more potent than the compound. The study carried out by Parawansah et al. [97] showed the potential of ethanol extract of leaves of P. pellucida to inhibit the activity of xanthine oxidase. Extract was shown to exhibit inhibition of xanthine oxidase with an IC₅₀ value of 19.5 ppm.

Antisickling activity

Abere and Okpaladumnyagu [51] evaluated antisickling activity of leaves of P. pellucida on the inhibition of sodium metabisulphite-induced sickling of the HbSS red blood cells. Leaf extract was found to significantly inhibit sickling of red cells with maximum inhibition of sickling (57.5%) at 500 mg/ml of the extract.

Anti-osteoeroposis activity

The study carried out by Putri et al. [98] revealed the potential of ethanol extract of P. pellucida (100 mg/kg body weight [b. w]) to prevent osteoporosis in ovariectomized (O VX)-induced osteoporotic rats. At 100 mg/kg concentration, the extract treated rats showed improvement on three-dimensional image of the trabecular bone compared with the O VX-control group. Also, the trabecular cavity formation in 100 mg/kg- extract-treated group was minimal.

Fibrinolytic activity

The study of Ebenezer et al. [99] showed a weaker fibrinolytic activity of P. pellucida extract. The in vitro clot lysis activity was
considerably lesser when compared to extracts from other plants. In another study, Zubair et al. [91] revealed the potential of ethyl acetate, hexane, chloroform and aqueous soluble fractions of *P. pellucida* to cause lysis of clot indicating thrombolytic activity. Marked activity was displayed by ethyl acetate soluble fraction.

**Antidiarrhoeal activity**

The ethanolic extract of *P. pellucida* leaves was evaluated for antidiarrhoeal activity in castor oil-induced diarrhoea in mice. The extract was shown to display concentration dependent anti-diarrhoeal activity [91].

**Hair growth promotion activity**

The study carried out by Kanedi et al. [100] revealed the potential of crude extract of *P. pellucida* in a topical gel formulation to promote hair growth in rabbits dose dependently. The mean hair length increased on increasing the concentration of extract in the gel.

**Proximate and nutritive attributes of *P. Pellucida***

Egwuche et al. [55] evaluated nutritive attributes of *P. pellucida* leaves from Nigeria. The leaves were shown to contain carbohydrates (38.97%), proteins (7.68%), crude fibre (22.35%) and fat (1.08%). The leaves were also shown to contain appreciable quantity of calcium, magnesium, potassium and sodium. The study carried out by Ooi et al. [101] revealed the nutritive composition of *P. pellucida* from Malaysia. The plant was shown to contain an appreciable quantity of carbohydrates (about 45%) and proteins (about 10%) however the lipid content was low (about 3%). The plant is also shown to possess considerable quantity of potassium, calcium, iron and sodium.

**CONCLUSIONS**

The plant *P. pellucida* is a well-known medicinal plant being used ethnomedicinally for treatment of various diseases worldwide. In vitro and in vivo studies have shown many pharmacological activities of the plant which supports the traditional use of the plant. Literature has shown the potential of isolated compounds to exhibit bioactivities such as antimicrobial, antitumour, gastroprotective and anti-diabetic activities. The presence of phytochemicals such as alkaloids, flavonoids, saponins, tannins and glycosides in the plant could be responsible for the pharmacological activities of the plant. The plant *P. pellucida* appears to be suitable for developing drugs that can be used to treat several diseases or disorders. Utilization of the plant in suitable form can be beneficial in terms of promotion of health and disease therapy.

**SOURCES OF SUPPORT**

None

**AUTHORS CONTRIBUTIONS**

Both the authors namely Dr. Prashith Kekuda T. R and Dr. Raghavendra H. I. were involved equally in literature survey, framing contents, writing draft paper and finalizing the review paper.

**CONFLICTS OF INTERESTS**

Authors declared that there are no potential conflicts of interest.

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