A Review on Phytochemicals and Pharmacological Activities of the medicinal plant *Drynaria quercifolia*

Mudavath Ravi Naik [1], Praveen Thaggikuppe Krishnamurthy[1*]

[1]*Department of Pharmacology, JSS College of Pharmacy, JSS Academy of Higher Education and Research, Ooty, The Nilgiris, Tamil Nadu, India.*

Corresponding author:Dr. Praveen Thaggikuppe Krishnamurthy

praveentk7812@gmail.com, praveentk@jssuni.edu.in

Abstract

Drynaria quercifolia (DQ) also known as oak leaf plant, is epiphytic therapeutic greenery. The DQ rhizome and leaves are significantly used to promote health. The plant is a member of the polypodiaceae family and is widely used by traditional communities around the world to treat a variety of ailments based on their traditional uses. Phytoconstituents isolated from the plant include friedelin, epifriedelinol, β-sitosterol, β-amyrin, 3,4-dihydroxybenzoic acid, β-sitosterol 3-β-D-glucopyranoside, naringin, naringenin and acetyl lupeol. The plant is used as an analgesic, anti-inflammatory, anti-arthritic, anti-fertility, antimicrobial, anthelmintic, antipyretic, antidiabetic, antihyperlipidemic, thrombolytic, antiurolithiatic, antiulcer, antifungal, antihelmintic, cytotoxic and mosquito repellent. Compounds isolated from the plant that are responsible for the pharmacological activities. So far, the review has provided phytochemical and pharmacological action of the plant.

Key words*:* *Drynaria quercifolia*, Polypodiaceae, Phytoconstituents, Epiphytic, Oak leaf.

1. Introduction

Natural plants are rich in secondary metabolites and are considered primary sources in medicine, having been used for a long time to treat a variety of diseases. The lead compound isolated from the medicinal plant has more beneficial effects in treating various ailments while having fewer side effects than synthetic chemical compounds. Plants have a high medicinal value in the treatment of life-threatening diseases such as cancer. Plant medicines are used by approximately 80% of global residents to treat routine health problems. Aspirin, atropine, morphine, codeine, taxol, vincristine, quinine, reserpine, colchicine, digitalis, and Physostigmine are examples of modern medicines derived from natural products. Plants contain a high concentration of antioxidants, which inhibit free radicals, causing the disease **(Rasool Hassan 2012; Akerele 1993; Lai and Lim , 2011)**. DQ is an epiphytic fern with a small root system that is attached to its host plant (Figure 1). It is also known as oak leaf fern or basket fern. It is a member of the Pteridophyta family Polypodiaceae. The minerals and

nutrients derived by the epiphytic plant are derived from the external environment as debris accumulated around it **(Vikas et al., 2016)**. Pteridophytes comprised 305 genera and over 10,000 species worldwide, with India accounting for around 191 genera and over 1000 species **(Joseph and Thomas, 2015)**. DQ mostly distributed in India, Bangladesh, Malaysia, Southeast Asia, New Guinea, Southern China, the Philippines, Pakistan, North America, Sri Lanka, Indonesia, and Australia (**Janarthan et al., 2016; Ranil and Pushpa Kumara, 2008; Sivaraj et al., 2018)**. It thrives in open areas and at low elevations **(Neel et al., 2018)**. DQ consist of dimorphic fronds (Leaves) which includes sterile nest fronds and fertile foliage fronds. Sterile fronds are small and concave with no sori and that turn brown with age. Fertile foliage fronds are large, pinnatifid and bear sori at the basal surfaces. In between the secondary veins, the sori are either dispersed or aligned in two regular chains. The nest fronds resemble oak leaves, thus the common name (Oak leaf fern) **(Rajesh et al., 2016)**. DQR creeping, long, fleshy, up to 2 cm thick, densely clothed with scales and roots (Figure 1) **(Singh)**.

Figure 1: (a & b) DQ leaves (c & d) DQ rhizome

Table 1: DQ plant profile

Taxonomy		**Vernacular name**	
Kingdom	Plantae	English	Oak leaf fern
Division	Pteridophyta	Tamil	Mudavattukal
Class	Polyppodiopsida/pteridopsida	Sanskrit	Aswakatri
Order	Polypodiales	Malayalam	Matipanna, pannakizhangu, pannikizhangu
Family	Polypodiaceae	Kannada	Hanuma hastha, hanuma paada
Subfamily	Polypodiaceae	Hindi	Asvakatri, Katikapan, basingh.
Genus	Drynaria		
Species	Quercifolia		

Table 2: Traditional uses of DQ

Traditional uses	Reference
1. To reduce Typhoid and hectic fever 2. To treat tuberculosis and asthma 3. To treat Jaundice 4. Relieve head ache 5. To reduce throat infection 6. To control Phthisis 7. Poultice for swelling 8. Bowel inflammation 9. Skin diseases 10. In treatment of Syphilis 11. Restore sinews, muscles and bones 12. Relieve body pain and knee pain 13. Treat intestinal worm and abdominal pain 14. Treat urinary problem and spermatorrhoea 15. To reduce Rheumatic pain 16. To treat Cholera 17. Treating Osteodynia and dentagia 18. To restore hair growth	**Pawar et al., 2017; Sen and Ghosh, 2011; Hedge et al., 2006; Das et al., 2009; Alam 1992; Ueda et al., 2002; Tran et al., 2015**

Table 3: The pharmacological activity of DQ

Name of the biological Activity	**Preclinical method**	**Reference**
Cytotoxicity	Brine shrimp lethality bioassay	**Khan et al., 2012; Mohanta et al., 2013a**
Antioxidant	DPPH radical scavenging assay	**Beknal AK et al.,2010**
	DPPH radical scavenging activity	**Jinu et al., 2014**
	Hydroxyl radical scavenging activity	
	Nitric oxide scavenging activity	
	Hydrogen peroxide activity	
	ABTS radical scavenging activity	
	DPPH radical scavenging assay	**Amoroso 2017**
	DPPH scavenging activity	**Sivaraj et al., 2018**
	ABTS scavenging activity	
	Nitric oxide radical scavenging activity	
	Hydroxyl radical scavenging activity	
	Ferric reducing power activity Phosphomolybdenum reduction assay	
	Reducing power activity.	**Das et al., 2014a**
	Superoxide anion radical scavenging	
	DPPH free radical scavenging activity	
	DPPH assay	**Mohanta et al., 2013a**
	Total antioxidant activity	**Prasana and Chitra, 2015b**
	Reducing power assay	
	Nitric oxide scavenging assay	
	Hydrogen peroxide radical	

	scavenging	
Antimicrobial	Agar well diffusion method	**Anamika et al., 2015; Prasana et al., 2014.**
	Agar well diffusion and disc diffusion method	**Padhy and Dash, 2015**
	Disc diffusion method	**Seena and Valsamma 2018; Khan et al., 2007a; Shokeen et al., 2005; Mithraja et al., 2012; Khan et al., 2012.**
	Kirby-Bauer's/disc-diffusion method	**Rajesh et al., 2017**
Anti-inflammatory	Carrageenan-induced paw oedema	**Das et al., 2014a; Janaranjani et al., 2014; Anuja et al., 2014b.**
	HRBC membrane stabilization method	**Prasana and Chitra, 2015c.**
	Histamine-induced paw edema and cotton pellet granuloma formation in rats.	**Anuja et al., 2014b.**
	Albumin denaturation, membrane stabilization, and COX-1 and COX-2 inhibition assay.	**Das et al., 2014a.**
Analgesic	Acetic acid writhing inhibition, radiant heat tail-flick	**Anuja et al., 2014b; Mohanta et al., 2013b.**
	Formalin test in mice, capsaicin-induced paw licking in mice, and hot plate test in mice.	**Anuja et al., 2014b.**
	Capsaicin-induced nociception, glutamate-induced nociception, tail-flick and tail immersion methods.	**Anuja et al., 2014a.**
Antidiabetic &	Alpha-amylase inhibition assay and	**Prasana et al., 2019.**

hypolipidemic	glucose uptake assay	
	Oral glucose tolerance test	**Rajimol et al., 2013**
Antifibrotic	Cytotoxicity assay (MTT)	**Desai et al., 2019**
Antipyretic	Yeast induced hyperpyrexia in rats	**Janaranjani et al., 2014**
Antidematophytic	Agar dilution and disc diffusion methods.	**Neja and Deokule; 2009**
Antidiarrhoeal	Castor oil-induced diarrhea, GIT motility test, and castor oil-induced enteropooling	**Padhy et al., 2016**
Hepatoprotective	MTT assay	**Devika and Prasana, 2016; Kamboj and Kalia, 2013**
Antifertility	Ex-vivo assay for uterine contractile activity, Determination of abortifacient activity. Determination of anti-implantation activity	**Das et al., 2014b**

2. Phytoconstituents

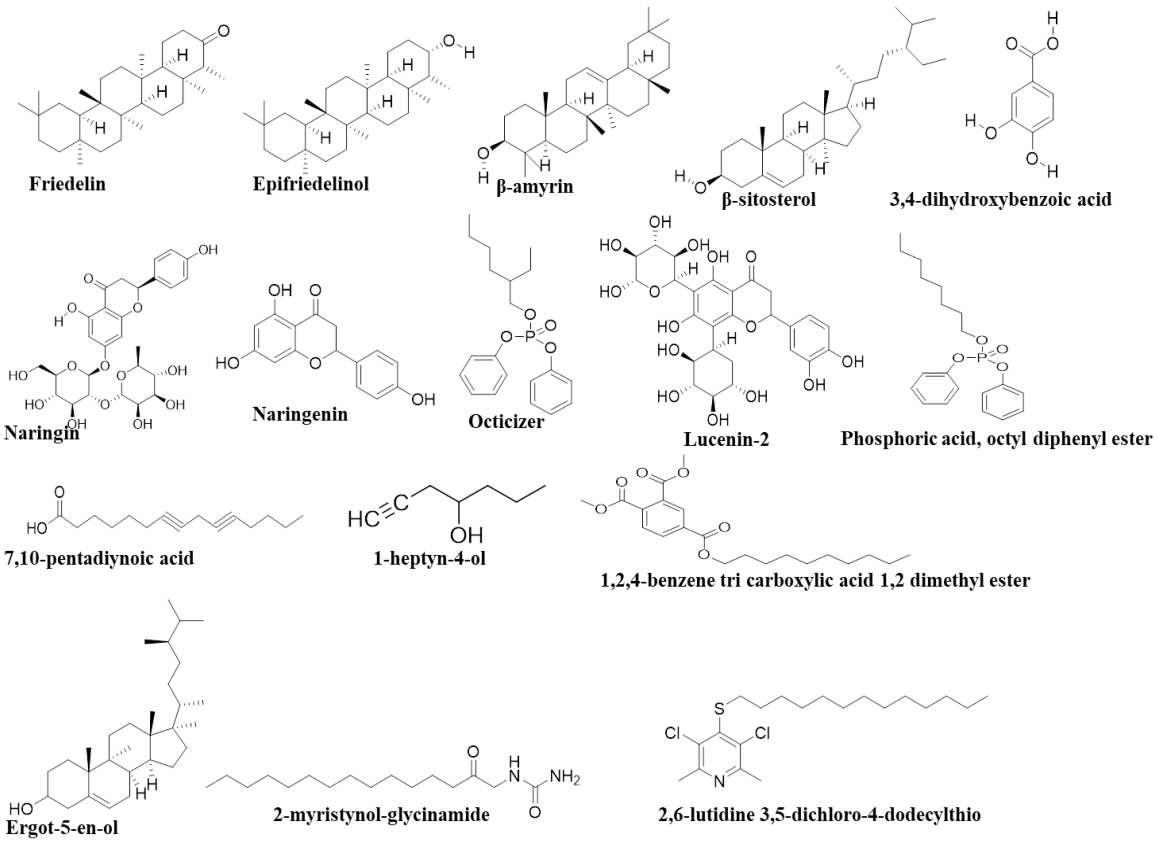

Figure 2

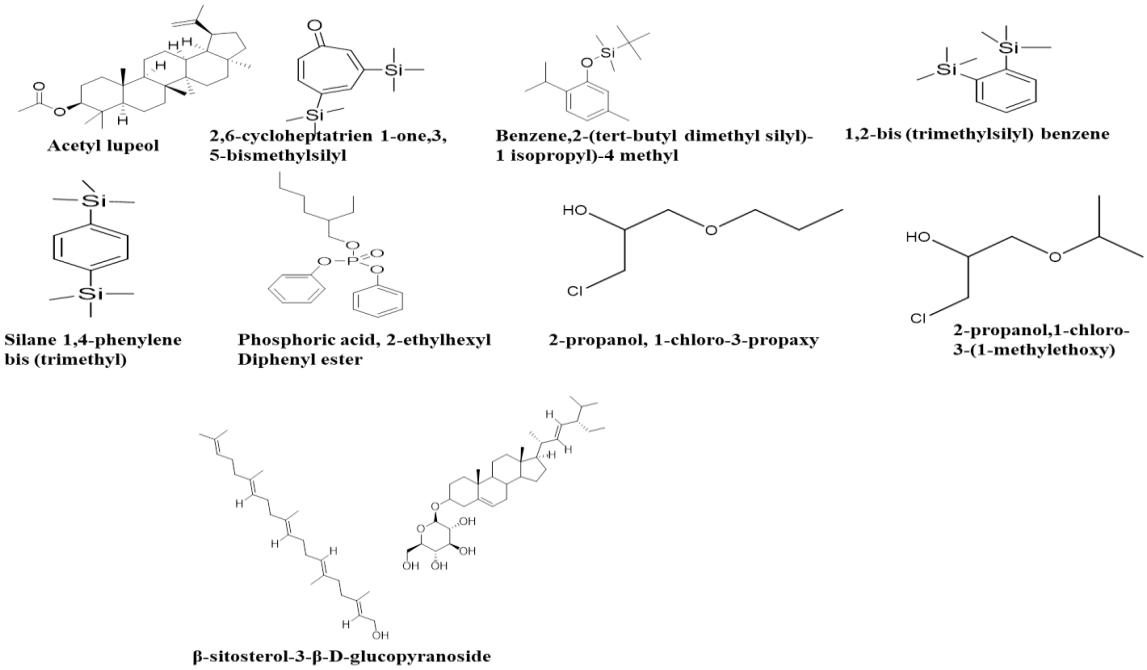

Figure 3

Figure 2 & 3: Reported phytoconstituents of DQ

Phytochemicals such as carbohydrates, saponins, tannins, flavonoids, sterols, terpenoids and proteins and free amino acids were reported in the ethylacetate extract of DQR. HPLC analysis revealed the presence of 1.6% of naringin and 0.15% of naringenin in ethylacetate extract of the DQR **(Anuja et al., 2014a; Janarthan et al., 2016)**. Ethanol extract of DQR detected the phytochemicals like carbohydrates, saponins, tannins, flavonoids, proteins and free amino acids, sterols, terpenoids, phenols, quinones, coumarins and cardiac glycosides. 0.53% of naringenin was confirmed by HPLC analysis method **(Anuja et al., 2014a; Janarthan et al., 2016; Rajesh et al., 2017; Pargavi and Siva Kumar 2014)**. Petroleum ether extract of DQR reported optimistic phytoconstituents such as sterols, terpenoids, cardiac glycosides, tannins, proteins and amino acids, carbohydrates, phenols, coumarins, saponins and fixed oils and fats **(Janarthan et al., 2016; Rajesh et al., 2017; Kowar et al., 2010; Pargavi and Siva Kumar 2014; Prasana and Chitra 2015)**. Phytochemicals including sterols, terpenoids, alkaloids, glycosides and tannins were detected in chloroform extract of DQR **(Janarthan et al., 2016; Kowar et al., 2010)**. Aqueous extract of DQR revealed positive test against phytochemicals such as carbohydrates, saponins, tannins, flavonoids, proteins and amino acids, cardiac glycosides, quinones, phenol, alkaloids and gums and mucilages respectively in the extract **(Janarthan et al., 2016; Rajesh et al., 2017; Kowar et al., 2010)**. Phytoconstituents named as alkaloids, glycosides, phytosterols, tannins, carbohydrates, saponins, proteins and amino acids, phenol, flavonoids, coumarins, terpenoids, cholinergic acid and fixed oils and fats were detected in the methanolic extract of DQR. Chemical compounds such as alkanes, alkenes, amines, carboxylic acid, denaturated amines, alkenes, alkanes and alkynes were recorded at peak value of 1447, 815, 3436, 1722, 2360, 1626, 2917 and 2125 by FT-IR spectrum. Ultra violet- visible displayed peak at 279 and 214 nm with absorption of 2.60 and 0.92 respectively for methanolic extract. The phytochemicals, alkaloids, carbohydrates, saponins, phenols and flavonoids were detected in the methanolic extract of DQ leaves (DQL) **(Kowar et al., 2010; Pargavi and Siva Kumar 2014; Prasana and Anuradha, 2016; Runa et al., 2013; Prasana and Chitra, 2015)**. The physicochemical investigation of Total ash value, water soluble ash value, and acid insoluble ash value, extractive value of water and alcohol extractive value of DQR and fronds ranged as 8.37-9.93%, 4.13-6.93%, 3.48-4.49%, 7.78-13.94% and 4.13-9.87%. The sulphated ash and moisture content found to be 5 and 3% respectively. As the plant rich in phytochemicals, DQ may responsible in treating various health affecting diseases **(Selvi et al., 2016; Kowar et al., 2010; Vikas et al., 2016)**.

Table 4: Phytochemistry of DQ

Name of the phytochemical	**Part of the plant**	**Type of extract**	**Reference**
1. Friedelin 2. Epifriedelinol 3. β-amyrin 4. β-sitosterol 5. β-sitosterol 3-β-D-glucopyranoside 6. Naringin 7. Naringenin	DQR	Methanol	**Ramesh et al., 2001; Prasana et al., 2019**
1. 3,4-dihydroxybenzoic acid 2. Acetyl lupeol	DQR	Ethanol	**Khan et al., 2007a**
1. 2,4,6-cycloheptatrien-1-one,3,5-bistrimethylsilyl 2. 1,2-bis(trimethylsilyl) benzene 3. 2-propanol, 1-chloro-3-(1-methylethoxy)- 4. Silane,1,4-phenylene bis[trimethyl) 5. 2,6-lutidine 3,5-dicholoro-4-dodecylthio- 6. 1-heptyn-4-ol 7. 2-propanol,1-chloro-3-propoxy- 8. 6-amino-5-cyano-4-(3-iodophenyl)-2methyl-4H-pyron-3-carboxylic acid ethyl ester 9. 2-myristynol-glycinamide 10. Benzene,2-(tert-butyldimethyl silyl)-1isopropyl)-4-methy 11. 1,2,4-benzene tri carboxylic acid, 1,2dimethyl ester	DQR	Ethanol	**Nithin et al., 2020**
1. Tetrahydroisovelleral 2. 7, 10, pentadecadiynoic acid	Whole plant	Methanol	**Rajesh et al., 2016**

3. Phosphoric Acid, octyl diphenyl ester 4. Octicizer 5. Phosphoric acid, 2-ethylhexyl diphenyl ester 6. Quercetin 7, 3', 4' Trimethoxy 7. 1, 30-Triacotanediol 8. Ergost-5-en-3-ol, (3a´- 9. Lucenin 2			

3. Pharmacological activities of DQ

3.1. Antimicrobial activity

Rajesh et al., reported the antibacterial properties of DQ against scale rots in pythons by collecting wound swabs from Reticulated Python (Python reticulates) and Indian Rock Python (Python molurus) and cultured in appropriate media. By using the standard biochemical procedure, the isolated bacterium was identified as E. coli (G-ve) and Staphylococcus aureus (G+ve). The Kirby-Bauer/disc-diffusion method was used to screen antibiotic susceptibility against isolated bacterial strains using nine antibiotics. The test confirms that the strains were resistant to all six antibiotics and sensitive to the antibiotics enrofloxacin, ciprofloxacin, and gentamicin used in the study. The antibacterial activity was determined using the agar-well diffusion method and solvent extracts such as petroleum ether, ethanol, and aqueous. Petroleum ether extract inhibited E. coli and S. aureus the least, while ethanolic extract inhibited them the most (24.667 and 28.667). The control linezolid 30g/ml and imipenem 10g/ml were found to have a similar zone of inhibition against the isolated bacterial strains **(Rajesh et al., 2017)**. K.K Seena et al., reported the antifungal and antibacterial properties of aqueous and acetone extracts of DQL and DQR. The disc diffusion method was used to demonstrate antibacterial activity against Vibrio cholera, and the amended potato dextrose agar medium was used to demonstrate antifungal activity against Aspergillus sp. The acetone extract of the DQR demonstrated greater antibacterial activity than the DQL extract, inducing a 3 cm diameter zone of inhibition. The antifungal activity of DQR acetone extract showed significant activity than that of DQL acetone extract. In both cases, the DQL acetone extract was less active than the DQR extract. In both cases, aqueous extract lacked antibacterial and antifungal activity **(Seena and Valsamma, 2018)**. Another study found that isolated acetyl lupeol and 3, 4-dihydroxybenzoic acid from DQR had

antibacterial activity against six gram-ve and four G+ve bacteria using the disc diffusion method and the serial dilution technique. When compared to kanamycin as a positive control, the compound 3.4-dihydroxybenzoic acid demonstrated potent antibacterial activity against the tested bacterial strains. The presence of antibacterial activity was indicated by the MIC value of 3,4-dihydroxybenzoic acid, which was found to be 8-64 g/ml. Antibacterial activity of isolated acetyl lupeol against the tested bacterial strains was insignificant **(Khan A et al., 2007a)**. Rajan Padhy et al., used agar well diffusion and disc diffusion to test the antibacterial activity of a methanolic extract of DQR against both G-ve and G+ve bacterial strains in vitro and in vivo. G+ve bacterial strains such as staphylococcus aureus MTCC 96, S. epidermidis (CI), B. subtilis MTTC 121, and S. pyrogens were sensitive to DQR in both methods, whereas S. pneumonia was resistant. S. flexineri MTCC 1457 was discovered to be resistant to the extract. In G-ve bacterial strains, all of the tested strains were found to be sensitive to methanolic extract of DQR. The test compound's MIC value ranged from 0.62 mg/ml to 1.25 mg/ml. In vitro methanolic extract inhibited more than in vivo methanolic DQR extract. The study looked for phytochemicals like flavonoids, phenols, saponins, tannins, sterols, and carbohydrates. Saponins were found to be responsible for a wide range of antibacterial activity **(Padhy and Dash, 2015)**. Using the agar well diffusion method, an Ethylacetate extract of the tuber and DQL of DQ was tested for antimicrobial activity against Candia albicans and multidrug bacterial strains S. aureus, E. coli pGLO, E. coli pUC19, Staphylococcus saprophyticus, and E. coli DH-5. The tuber extract at 100g/ml demonstrated microbial activity against all strains, but not against Staphylococcus aureus. The DQL extract 100 mg/ml demonstrated microbial activity of strains, but it failed to demonstrate a positive test against E. coli (pUC19) and staphylococcus aureus. The tuber extract at 10 mg/ml did not show any activity, but the DQL extract showed positive results against strains such as Candia Albicans, E. coli (DH-5), and Staphylococcus saprophyticus. The inhibition zone of diameter (451) mm is observed for 100 mg/ml DQL extracts against Staphylococcus saprophyticus and E. coli (DH-5). The results showed that the DQL extract was highly active against the microorganisms tested. When compared to DQL extract, tuber extract at 100 mg/ml demonstrated broad-spectrum activity **(Anamika et al., 2015)**. The disc diffusion method was used to test the antimicrobial activity of the DQR, fertile and infertile leaves of DQ against clinically isolated 24 Neisseria gonorrhoeae and six Neisseria gonorrhoeae strains of WHO [WHO-C, G, L, O, B, F] and the results were compared with penicillin and ciprofloxacin. Penicillin resistance was found in 14 clinical isolates [1-11, 15-20, and 23] as well as WHO strains of WHO-O and WHO-L. Ciprofloxacin was resistant to all isolates as

well as WHO-L. DQ parts tested negative for resistance to clinical isolates and WHO strains. When compared to penicillin, the parts such as fertile and infertile leaves and DQR were susceptible to 7, 8 and 10 clinical isolates among the 24 and WHO strains of WHO-O and WHO-L, respectively. Clinical isolates such as 1-3, 5-11, 18, 23 and 1-3, 5-11, 18, 22 and 23 were found to be susceptible to infertile and fertile leaves. When compared to ciprofloxacin, the DQR showed high sensitivity to clinical isolates 1-11, 18 and 23 and all parts showed high sensitivity to WHO-L strain **(Shokeen et al., 2005)**. Using the disc diffusion method, extracts such as acetone, benzene, chloroform, water, ethanol and petroleum ether were tested for antibacterial activity against isolated urinary tract infecting (UTI) bacteria. Acetone had the highest antibacterial activity against gramme +ve bacteria, Streptococcus pyogenes and Enterococcus faecalis, with maximum zones of inhibition of 22 mm and 8 mm, respectively. The inhibition zone of ethanol extract against Pseudomonas aeuruginosa, a G-ve bacteria, was reported to be seven millimetres. The antibiotic amikacin had a zone of inhibition of 23 mm against Streptococcus pyogenes **(Mithraja et al.,2012)**. The inhibition zone of ethanol extract against Pseudomonas aeuruginosa, a G-ve bacterium, was reported to be seven millimetres. The antibiotic amikacin had a zone of inhibition of 23 mm against Streptococcus pyogenes **(Prasana et al., 2014)**. Using the disc diffusion method, the researchers tested the antibacterial activity of petroleum ether extract, chloroform extract and Ethylacetate extract of DQR against four G+ve and six G-ve bacteria. The extracts at 150 mg/disc demonstrated less antibacterial activity than the standard kanamycin at 50 mg/disc. The chloroform and Ethylacetate extracts were more active than the petroleum ether extract. The extracts' MIC ranged from 16 to 64 µg/ml, respectively **(Khan et al., 2012)**.

3.2. Cytotoxicity

The cytotoxic activity of petroleum ether, chloroform, Ethylacetate, and ampicillin trihydrate extracts against brine shrimp nauplii was investigated using the brine shrimp lethality bioassay method. According to the study, as the concentration of the sample increases, the death of the nauplii increases respectively. The extracts' and standard's LC_{50} values were 22, 16.5, 16.5 and 11.7µg/ml, respectively. The cytotoxicity of chloroform and Ethylacetate extracts was found to be greater than that of petroleum ether extract. All of the extracts had lower toxicity and higher LC_{50} values than the standard ampicillin trihydrate **(Khan et al., 2012)**. Another study used brine shrimp lethality bioassay to assess the cytotoxic activity of carbon tetrachloride soluble fraction, Ethylacetate, petroleum ether and aqueous fractions of DQR against brine shrimp nauplii. Carbon tetrachloride was the most cytotoxic of the

fractions, with an LC_{50} value of 30.31µg/ml. The $LC5_0$ values for aqueous fractions, Ethylacetate and petroleum ether were 41,041.30 µg/ml, 569.39 µg/ml and 2,380 µg/ml respectively. Vincristine sulfate's LC_{50} value has been reported to be 0.544 µg/ml **(Mohanta et al.,2013a)**.

3.3. Antioxidant

The antioxidant activity of was evaluated solvent extracts DQR of chloroform, petroleum ether, methanol and aqueous using DPPH radical scavenging activity and ferric reducing antioxidant power (FRAP) assay model. Among the extracts, the methanolic extract showed potent antioxidant activity (94.37%) at a concentration of 500 ppm (>90%) when correlated with the standard α-tocopherol (500 ppm (86.27) **(Beknal et al., 2010)**. DQR methanolic extract was tested for antioxidant activity using DPPH radical scavenging activity, hydrogen peroxide (H2O2), nitric oxide (NO), hydroxyl ion radical (OH), and ABTS scavenging assays. By assay methods, DQR extract demonstrated significant scavenging activity than standard butyl hydroxyl toluene (BHT) **(Jinu et al., 2014)**. The antioxidant activity of a methanolic extract of DQR and fronds was determined using a DPPH radical scavenging assay. Scavenging activity of DQR and fronds was found to be 26.19 2.20 and 21.94 1.49 percent, respectively. Using TLC, the phytochemical screening revealed alkaloids, saponins, terpenoids, phenolics, anthraquinones, and tannins. The total phenolic content (TPC) of methanol extracts of DQR and frond was found to be between 37 and 100 µg GAE/g and the total flavonoid content (TFC) of methanolic extract of DQR was reported to be 36.74 2.17 µg QE/g, with no flavonoids detected in methanolic frond extract **(Amoroso, 2017).** The aqueous tuber extract of DQ demonstrated potent DPPH, Nitric oxide, ABTS and hydroxyl radical scavenging activity with IC_{50} values of 105.78, 57.07, 27.32 and 26.54 µg/ml, respectively. At a concentration of 120µg/ml, the Fe3+ reducing power assay and the phosphomolybdenum reduction assay revealed an increase in radical reduction of 0.58±0.40 and 0.44±0.80, respectively when compared to the standard ascorbic acid. As the concentration of the extract increases, so does its antioxidant property. The total phenolic and flavonoid content of GAE was found to be 4.2951.23 µg/ml and QE was found to be 24.5640.86 µg/ml **(Sivaraj et al., 2018)**. DQ aqueous extract (AEDQ) and methanolic extract (MEDQ) demonstrated antioxidant activity via DPPH radical scavenging activity, superoxide radicals, and reducing power activity. The IC_{50} value of MEDQ's in vitro antioxidant activity was given as 53.6, 42.9 and 49.8µg respectively and the IC_{50} value of AEDQ was given as 66.2, 67.2 and 41.05 µg. Standard ascorbic acid had IC_{50} values of 12.39 µg, 7.6µg and 4.3µg

respectively. The methanolic extract of DQ had a higher total phenolic content of 95.972 µg/GAE and a higher total flavonoid content of 81.03 µg/QE **(Das et al., 2014a)**. The various fractions such as Ethylacetate, aqueous, petroleum ether, and carbon tetrachloride soluble fraction were tested antioxidant activity using DPPH free radical scavenging method. IC50 value of the fractions was found to be 38.25 µg/ml, 124.39 µg/ml, 161.68 µg/ml and 62.9868 µg/ml respectively. The highest scavenging activity was resulted by the Ethylacetate soluble fraction and carbon tetrachloride fraction. The IC_{50} value of standard butyl hydroxyl toluene (BHT) was found to be 35.52 µg/ml. The Ethylacetate soluble fraction's antioxidant activity was close to the standard butyl hydroxyl toluene (BHT) **(Mohanta et al.,2013a)**. Chaity et al. revealed the aqueous fraction and crude methanol extract of DQR and fertile foliage fronds of DQ showed significant scavenging property against DPPH, ABTS, FRAP assay and hydrogen peroxide assay respectively. The aqueous fraction resulted potent scavenging activity than the crude methanolic extract of both the plant parts **(Chaity et al., 2016)**. In vitro antioxidant activity of methanolic extract of DQR was performed using different in vitro models such as total antioxidant capacity, reducing power assay, nitric oxide scavenging and hydrogen peroxide radical scavenging activity. The activity was tested using 100, 200 and 300 µg/ml of doses respectively as compared with the standard ascorbic acid. The extract at 300 µg/ml showed potent activity against in vitro models found to be 54.88 ± 0.17, 58.07 ± 1.97, 62.77 ± 0.58 and 44.09 ± 1.03% and the standard ascorbic acid at 300 µg/ml reported to be 54.53 ± 0.57, 62.80 ± 2.02, 54.60 ± 0.45 and 57.87 ± 0.71 respective to the models used in the study. Among the in vitro models, nitric oxide showed the highest antioxidant activity. The IC_{50} values of methanolic extract of in vitro model were found to be 230, 230, 180 and 240 µg/ml respectively **(Prasana and Chitra, 2014b)**.

3.4. Anti-inflammatory activity

Janaranjani B *et al.*, screened the anti-inflammatory activity of ethanolic extract of DQR against carrageenan-induced paw oedema rats using various concentrations (100, 200 & 500 mg/kg) of extract. The extract at 500 mg/kg showed a higher (58%) percentage of paw oedema inhibition than the standard drug dexamethasone (40%). The inhibition of paw oedema by extract at 100 and 200 mg/kg was 21% and 33% respectively **(Janarajani et al., 2014)**. Fertile fronds (FF) of DQ were evaluated for their Anti-oedematous activity by using ethanolic extract against histamine-induced paw oedema rats, carrageenan-induced, and also by cotton pellet granuloma formation in rats. The extract at 500 mg/kg dose showed a greater reduction of carrageenan-induced and histamine-induced paw oedema in rats (71.76% &

66.67%). Test results were compared with the standard indomethacin 10 mg/kg (88.24% & 68.89%) respectively in both cases. FF on oral administration reduces both dry weight and wet weight of granuloma tissue. The dose at 500 mg/kg showed inhibition of both the exudative phase (53.2%) and the proliferative phase (60.18%) of inflammation **(Anuja et al., 2014b)**. *In vitro* and *in vivo* anti-inflammatory property of water and methanol extract of DQR was reported against the albumin denaturation, carrageenan-induced paw oedema and membrane-stabilizing methods. The extracts inhibited paw oedema in a dose-dependent manner (100 & 150 mg/kg) and inhibited the COX-1 and COX-2, protein denaturation and hemolysis at 100 mg/ml. The methanolic extract showed potent activity than the water extract **(Das et al., 2014a)**. Methanolic extract of DQR exhibited *in vitro* anti-inflammatory activity in a dose-dependent manner for both test extract and the standard diclofenac (100, 200 & 300 mcg) against human red blood cell (HRBC) membrane stabilization method. The percentage of membrane stabilization of test extract and diclofenac was reported 33.64%, 34.14%, 34.94% & 35.52%, 39.09%, 41.62% respectively 100, 200 & 300 mcg. Maximum activity was reported at 300 mcg in both the plant extract and standard diclofenac **(Prasana and Chitra, 2015c)**.

3.5. Analgesic activity

Ethanolic extract of fertile fronds (FF) of DQ showed potent analgesic activity in a dose-dependent manner of 100, 200 and 30 mg/kg respectively. Notably, FF reduced acute and delayed phases of capsaicin-induced nociception, acetic acid-induced writhinia, formalin-induced pain and hot plate test in mice. The activity was compared with standard drugs aspirin (100mg/kg) sodium salicylate (100 mg/kg) and morphine (7.5 mg/kg) respectively **(Anuja et al., 2014b)**. Milon C Mohanta et al., studied the anti-nociceptive activity of crude methanolic extract and various solvent-soluble fractions of DQR by radiant heat tail-flick and acetic acid-induced writhing inhibition methods in swiss albino mice. Aqueous soluble fraction and carbon tetrachloride fraction (400 mg/kg) of crude methanol extract, revealed the potent anti-nociceptive activity of 40.99%, 45.64% and 34.9% of acetic acid-induced writhing inhibition in peripheral anti-nociceptive method when compared with that of standard diclofenac 51.68% of writhing inhibition. In the radiant heat tail-flick method of central anti-nociceptive, the crude methanolic extract (400 mg/kg), petroleum ether fraction (400 mg/kg) and carbon tetrachloride fraction (400 mg/kg) reported better analgesic activity of 63.92%, 64.92% and 51.4% increase in the reaction time respectively at 1 hour after administration of sample and increase in reaction time was observed with standard morphine

(75%). At 90-minute methanolic crude extract and petroleum ether fraction (400 mg/kg) showed extension of tail-flick time by 34.49% and 36.10% and standard morphine reported as 37.94%, respectively **(Mohanta et al., 2013b)**. The study evaluated the anti-nociceptive property of hexane extract (HDQ), crude ethanol extract and Ethylacetate extract (EDQ) of the DQR against swiss albino mice and wistar albino rats using glutamate-induced nociception, tail immersion, capsaicin-induced nociception and tail-flick methods. The extracts DQ (100, 200 & 300 mg/kg), HDQ (50, 100 & 200 mg/kg) and EDQ (25, 50 & 100 mg/kg) showed dose-dependent inhibition of nociception against methods compared with standard morphine (7.5 mg/kg) respectively **(Anuja et al., 2014a)**.

3.6. Pesticidal and pest repellency

Pesticidal & pest repellency activity of DQR was tested for protecting the stored seeds & flour-based items in tropical and subtropical regions against Tribolium castaneum. The study reported that the chloroform soluble fraction of ethanol displayed notable pesticide and pest repellency activity. Ethylacetate, petroleum ether, methanol soluble fractions did not show the pesticide and pest repellency activity against the Tribolium castaneum. The isolated 3, 4-dihydroxy benzoic acid from Ethylacetate fraction showed negative activity against the tested organism **(Khan et al., 2014)**.

3.7. Antidiarrhoeal activity

Rajan padhy et al., study confirmed the anti-diarrhoeal activity of methanol extract of DQR (MEDQ) castor oil inducing diarrhea along with gastrointestinal motility and enteropooling in albino rats. The DQR methanol extract showed dose-dependent reduction action against castor oil-induced diarrhea at 100 mg/kg and 200 mg/kg (61.89 & 66.25%). The standard drug Loperamide (5 mg/kg) inhibited in the range of 83.1% respectively. The extract reduced the charcoal distance travelled in dose manner 100 mg/kg (36.08%) and 200 mg/kg (54.88%) and the standard drug Loperamide (5 mg/kg) showed a 72.74% decrease of charcoal meal travel through the gastrointestinal tract by using gastrointestinal motility test. The percentage decrease of enteropooling by MEDQ of both the doses (100 & 200 mg/kg) as 57.69 and 66.92% w/w and Loperamide (5 mg/kg) inhibited 74.61% when induced by castor oil. The study concluded that flavonoids and glycosides, saponins, reducing sugars, tannins, and tannic acids in the extract were responsible for the activity **(Padhy et al., 2016)**.

3.8. Anthelmintic activity

Gauri kaustubh Kulkarni et al., reported the anthelmintic property of DQL and DQR by using mature earthworms and piperazine citrate as a standard. Alcoholic extract of DQL and DQR showed an increase in the period of paralysis and death of the worm at doses 2.5, 5, 10, 25 and 50 mg/ml compared with the standard piperazine citrate (10 mg/ml). The test extracts showed high significant anthelmintic activity than the standard **(Kulkarini et al., 2010**). Various doses (10, 20, 30, 40 & 50 µg/ml) of methanolic extract of DQL demonstrated the anthelmintic activity using adult earthworms (Pherentima Posthuma). The activity was determined by parameters such as time of paralysis and time of death worms. The test extracts compared with the standard drug albendazole (15µg/ml). The activity was increased as the concentration of the extract increased. The paralysis and death time of the earthworms by extract reported as 6-23.87 and 53.67-127.67 minutes respectively. The time paralysis and death time of earthworms by standard albendazole reported 35.33 minutes and 71.33 minutes respectively for the worm's death. The extract showed potent anthelmintic activity than the standard drug **(Ali et al., 2013)**.

3.9. Antidiabetic and hypolipidemic activity

G. Prasana et al., evaluated *in vitro* antidiabetic study of methanol extract of DQR. The activity was determined by assay methods such as alpha-amylase and glucose uptake assay. L6 rat myogenic cells were subjected to the glucose uptake assay. The inhibition of alpha-amylase was significantly increased as the extract's concentration increases (25, 50 & 100 µg/ml). The percentage inhibition reported by the concentrations 40.1±2.6, 65.7±4.11 and 79.8±3.5 in a concentration-dependent manner. Standard metformin (0.1µg/ml) reported 85.07±7.6% of inhibition. The standard metformin (0.1µg/ml) in glucose uptake assay increased the glucose uptake level of 7.07±0.30 and 4.81±0.31 in the presence or absence of insulin. Plant extract in the presence of insulin elevated the glucose uptake to 6.13±0.28, 6.23±0.19, 6.39±0.54 and 6.73±0.41, and in the absence of insulin, it resulted as 5.02±0.32, 4.98±0.27, 4.06±0.16 and 3.14±0.21 at concentrations of 5.0, 10, 20 and 40 µg/ml respectively. The standard drug showed potent activity than the extract. The plant DQR extract showed significant antidiabetic activity by preventing hyperglycemia and controlling lipid metabolism **(Prasana et al., 2019)**. Oral administration of ethanol extract and chloroform extract of DQR at 400 mg/kg and glibenclamide 5mg/kg lowered the blood sugar level and increased rats' body mass compared to diabetic control rats. Respectively the test extracts and standard drug reversed the lipid profile levels than the control group.

Additionally, the study is also confirmed by the histopathological examination of the pancreas **(Rajimol et al., 2014)**.

3.10. Antifibrotic activity

Karishma desai et al., reported the antifibrotic activity of DQ methanolic extract on oral submucous fibrosis. The study revealed that the methanolic extract of DQ significantly reduces the cell viability of the Human buccal mucosa fibrosis (HBSF) in a dose-dependent manner (100-400 µg/ml) when compared with chymotrypsin, the drug used for submucous fibrosis **(Desai et al., 2019)**. Another study reported the anti-fibrotic property of crude extract and fractions of Ethylacetate (EDQ), hexane (HDQ) and butanol (BDQ) using different doses (25, 50 & 100 µg/ml) against the isolated rat hepatocytes and RAW 264.7 cells. Ethylacetate fraction at 100 µg/ml showed potent *in vitro* activity than HDQ and BDQ compared with standard drugs silymarin and diclofenac sodium (100 µg/ml). *In vivo* oral administration of EDQ (100 µg/ml) gradually increased catalase (CAT), superoxide dismutase (SOD), Nrf2 levels of CCl_4 induced rats. Decreased amount of malondialdehyde (MDA), iNOS, COX-2, and TNF-α, was observed when compared to CCl4 treated animals. Histology and immune histochemistry results reported that the animals treated with EDQ (100 µg/ml) and silymarin (100 µg/ml) revealed minor fibrotic changes, lack of pseudolobulization and reduction in TIMP-1, α- SMA and collagen deposition and elevated the levels of Nrf2 r **(Anuja et al., 2018)**.

3.11. Antipyretic activity

The Ethylacetate and petroleum ether fractions of ethanol extract of DQR at 80 mg/kg showed potent antipyretic activity when compared with the standard aspirin (10 mg/kg) after 3 hours of elevated body temperature (0.5 ml/kg b.w of boiled milk administered through intraperitoneal (I.P). Both the fractions reported significant activity by lowering the body temperature **(Khan et al., 2007b)**. The antipyretic activity of methanol extract of DQR at doses 100, 250 and 500 mg/kg were tested against rats induced subcutaneously with brewer yeast suspension at a dose of 10 ml/kg (which increases the rectal temperature). The extract at 500 mg/kg revealed a significant reduction of rectal temperature than 100, 250 mg/kg and standard paracetamol 200 mg/kg at a time interval of 3 hours respectively **(Janaranjani et al., 2014)**.

3.12. Thrombolytic activity

The aqueous soluble fraction (AQSF) and petroleum ether soluble fraction (PESF) of methanolic DQL showed significant thrombolytic activity (34.38 and 34.27%) when compared with the standard streptokinase (41.05%) and negative control distilled water (3.31%) of clot lysis **(Ramjan et al., 2014)**.

3.13. Membrane stabilizing

Chaity et al., performed membrane stabilizing activity of crude methanolic extract and fractions of DQR and DQL respectively. The crude methanol extract of the DQR showed potent membrane stabilizing activity than the DQL. The moderate membrane stabilizing was showed by petroleum ether fraction of both the parts used in the study **(Chaity et al., 2016)**.

3.14. Anti dermatophytic activity

The study evaluated the antidermatophytic activity of various solvent extracts of DQR against different pathogenic fungi using disc diffusion and agar dilution methods. Among the extracts, di-ethyl ether with semi-polarity gave a transparent zone of inhibition towards the pathogenic fungi. The highest zone of inhibition was seen against Trichophyton mentagrophytes (25 mm diameter). The presence of triterpenes and coumarins DQR may responsible for the antidermatophytic activity of DQR solvent **(Nejad and Deokule, 2009)**.

3.15. Mosquito repellent activity

The extracts, such as petroleum ether (PET), methanol (MET), dichloromethane (DCM) and aqueous extract (AQ), studied for mosquito repellent activity against the adult mosquito species Culex quinquefaciatus and Aedes aegypti. The activity increases as the concentration of the extracts increases. Aqueous extract at 500 ppm of concentration showed a massive reduction of the larva population than PET, MET and DCM. PET at a concentration of 160 mg resulted in the 'Knock down' effect within 20 minutes **(Marathe et al., 2011)**.

3.16. Cataractostatic activity

Cataractostatic activity of ethylacetate and methanol extracts of DQ tuber evaluated against formation of lens cataracts in isolated goat lens by using photographic evaluation and quantitative catarostatic analysis. The ethylacetate extract showed better activity in inhibition of cataract formation than that of methanolic extract of DQ tuber. Ethylacetate extract inhibited the cataract formation in a dose-dependent manner. The study claimed that ethylacetate extract at 80 µg/ml has shown 100% inhibitory activity in cataract formation and also may prevent diabetic cataract **(Chowdhury et al., 2017)**.

3.17. Hepatoprotective

The methanolic extract of DQR showed significant hepatoprotective activity by increasing the percentage of cell viability and decreasing the levels of MDA, SGOT & SGPT, and also by increasing the levels of GSH and protein in hepatocytes in a dose dependent manner (100, 250, 500 mg/ml) **(Devika and Prasana, 2016)**. The hepatoprotective activity of DQ fronds of hydroalcoholic extract and its fractions and isolated compound (Dq-4) from ethylacetate (EA) fraction were evaluated by *in vivo* and *in vitro* methods. *In vivo* results reported that the hydrochloric extract (400 & 200 mg/kg) and ethylacetate (EA) fraction (74.55 mg/kg) exhibited significant hepatoprotective activity by gradually reducing the level of total bilirubin, hepatic enzymes (ALP, ALT & AST) and improved albumin and serum total protein levels and also increasing and decreasing the levels of GSH and TBARS against toxic CCl4 (1 ml/kg) induced animals. *In vitro* hepatoprotection of HepG2 cells against CCl4 (1%) induced toxicity was performed using the MTT reduction test and trypan blue technique. Isolated compound Dq-4 at a dose level of 50µg/ml showed the highest protection of cell viability against CCl4 (1%) induced cells. The hydrochloric extract and EA fraction at a dose level of 100 µg/ml reported the cell protection **(Kamboj and Kalia, 2013)**.

3.18. Urolithiasis

Urolithiasis activity was investigated by using different solvent extracts of DQR against 0.2% ethylene glycol aqueous induced male wister rats. The activity was performed by treating with extracts of DQR and spironolactone and cystone for 10 days at a dose of 25 mg/kg body weight. The alcohol and water extracts of DQR and cystone & spironolactone increased the volume of urine output and reduced the kidney weight than the diseased control group and also decreased the level of GAO and LDH enzymes which responsible for conversion of glycolate to oxalate which results in urolithiasis. Further, histopathology studies reported that alcohol and water extracts of DQR and cystone and spironolactone gradually decreased the accumulation of calcium oxalate crystals respectively. Chloroform and petroleum ether extract showed negative results towards the activity tested. By all these estimations, it is concluded that alcoholic and water extract of DQR showed significant activity and helpful in treating renal calculosis **(Soodam and Beknal, 2012)**.

3.19. Neuropharmacological activity

Alam khan et al., investigated the neuropharmacological activity of the DQR against the light-dark test effect of nikethamide-induced toxicity, diazepam-induced sleep and forced swimming test. Ethanol extract of ethylacetate and petroleum ether soluble fraction at doses

of 50,100 and 200 mg/kg body weight were administered intraperitonially for albino mice. Both the fractions have increased the duration of diazepam-induced sleep. The fractions were slowed down the time to cause death in mice compared to nikethamide (at high dose causes animal death) **(Khan et al., 2009)**.

3.20. Antiarthritic activity

S. Saravanan et al., demonstrated antiarthritic activity of DQR water extract against adjuvant-induced arthritic female wrister rats. The study concluded that the standard indomethacin (2 mg/kg) and test extract (200 &100 mg/kg) gradually lowered paw thickness and elevated body weight compared to the arthritic animals. The parameters such as plasma protein-bound carbohydrates, liver lysosomal enzymes, ROS, urinary degradative collagen levels, plasma and lysosomal enzymes in neutrophils and pro-inflammatory cytokines [TNF-α AND IL-1β] predominantly lowered by standard indomethacin and also by DQR water extract in a dose dependent manner compared with control and adjuvant-induced arthritic animals. The test extract improved the degree of anti-inflammatory cytokine IL-10 when compared to arthritic animals **(Saravanan et al., 2013)**.

3.21. Toxicity study

Rajan et al., reported the acute and sub-acute toxicity studies of methanolic extract of DQR using wistar albino rats and swiss albino mice respectively. The edge dose of 2000 mg/kg of methanolic extract was induced to swiss albino mice and kept under observation for 7 days. In the acute toxicity model, a daily dose of 1g/kg body weight of methanolic extract was administered to wistar albino rats for 28 days respectively. The study reported that DQ methanolic extract as a safe drug for use and 2000 mg/kg body weight dose resulted ALD_{50} under the Globally Harmonized classification system (GHS) category 5 safe dose, as per OECD guideline 423 (Annexure 2d) as there was no mortality in samples during Acute toxicity studies. There were no significant marked changes observed in haematological parameters during sub-acute toxicity tests **(Padhy et al., 2017)**.

3.22. Antifertility

Banani das et al., reported the anti-fertility activity of DQR solvent extracts of like petroleum ether, ethylacetate, acetone and methanol against female wister albino rats. Among the tested extracts the methanolic extracts at dose of 200 mg/kg showed significant anti-implantation and abortifacient activity by changes in implantation sites' mechanism changed hormone

levels, and rise in uterine muscle contraction when compared with the control animals **(Das et al., 2014b)**.

4. Conclusion

This review reports the traditional uses, phytoconstituents and pharmacological properties of DQ. The presence of numerous bioactive compounds in the plant provided the greater eye-opening activity against various life-threatening ailments. The plant demonstrated potent *in vitro* and *in vivo* activity against diseases such as analgesic, anti-fertility, antimicrobial, anthelmintic, antipyretic, anti-inflammatory, antidiabetic, hypolipidemic, thrombolytic, antioxidants, antiarthritic, urolithiatic, cytotoxic, mosquito repellent, antiulcer, antidermatophytic, anti-arthritis, pest, and pest repellency among others. In the future, more experimental animal studies and clinical trials on isolated plant compounds should be conducted in the development of new drugs in medicine.

Acknowledgement

The authors would like to thank the All-India Council of Technical Education-National Doctoral Fellowship (AICTE-NDF), Government of India, New Delhi, for supporting the project through AICTE-NDF. Also, the authors would like to thank Department of Science and Technology- Found for Improvement of Science and Technology Infrastructure in Universities and Higher Educational Institutions (DST-FIST), New Delhi, for their infrastructure support to their department.

Funding

This work was supported by the All-India Council of Technical Education-National Doctoral Fellowship (AICTE-NDF), Government of India, New Delhi, by providing funding through the project NDF (App 64879).

References

Akerele O. Nature's medicinal bounty: don't throw it away. In World health forum 1993; 14 (4): 390-395 1993.

Alam MK. Medical ethnobotany of the Marma tribe of Bangladesh. Economic Botany. 1992 Jul 1:330-5.

Ali R, Hossain M, Runa JF. Assessment of anthelmintic potential of Averrhoa bilimbi, Clerodendrum viscosum and DQ: as an alternative source for anthelmintics. Research Journal of Pharmacognosy and Phytochemistry. 2013;5(4):178-81.

Amoroso VB. Phytochemical screening, antioxidant and anti-inflammatory activities of the three fern (polypodiaceae) species in Bukidnon, Philippines. Bull. Env. Pharmacol. Life Sci. 2017 Feb 3;6:28-33.

Anamika WJ, Chowdhury MK, Nahid MA, Rouf AS, Uddin MA. Chemical and biological potentialities of the Ethylacetate extracts of DQ tuber and DQL. Dhaka University Journal of Biological Sciences. 2015 Jun 30;24(2):147-52

Anuja GI, Latha PG, Shine VJ, Suja SR, Rajasekharan S. Evaluation of DQ, a Medicinal Pteridophyte for Anti-nociceptive, Anti-allergic, Antilipidperoxidative Properties and Detection of Heavy Metal Content. Am J Exp Biol. 2014a;1(2):85-102.

Anuja GI, Latha PG, Shine VJ, Suja SR, Shikha P, Satheesh Kumar K, Rajasekharan S. Antioedematous and analgesic properties of fertile fronds of DQ. International Scholarly Research Notices. 2014b.

Anuja GI, Shine VJ, Latha PG, Suja SR. Protective effect of Ethylacetate fraction of DQ against CCl4 induced rat liver fibrosis via Nrf2/ARE and NFκB signalling pathway. Journal of ethnopharmacology. 2018 Apr 24;216:79-88.

Beknal AK, Korwar PG, Halkai MA, Kulkarni U, Patil BS, Soodam SR. Phytochemical investigation and antioxidant activity study of DQ Linn. DQR. Int J Curr Pharmaceut Res. 2010;4:36-9.

Chaity FR, Khatun M, Rahman MS. In vitro membrane stabilizing, thrombolytic and antioxidant potentials of DQ L., a remedial plant of the Garo tribal people of Bangladesh. BMC complementary and alternative medicine. 2016 Dec;16(1):1-9.

Chowdhury MM, Hossain MJ, Uddin MA. Cataractostatic Activity of DQ Tuber Extract. Bioresearch Communications-(BRC). 2017;3(2):411-4.

Das B, Choudhury MD, Dey A, Talukdar AD, Nongalleima KH, Deb L. Antioxidant and anti-inflammatory activity of aqueous and methanolic extracts of DQR part of DQ (L.) J. Smith. Int J Pharm Pharm Sci. 2014a;6(6):43-9.

Das B, Dey A, Talukdar AD, Nongalleima K, Choudhury MD, Deb L. Antifertility efficacy of DQ (L.) J. Smith on female Wister albino rats. Journal of ethnopharmacology. 2014b Apr 28;153(2):424-9.

Das HB, Majumdar K, Datta BK, Ray D, Ethnobotanical uses of some plants by Tripuriand Reang tribes of Tripura. Nat Prod Rad 2009; 8: 172180.

Desai K, Priya VV, Gayathri R. Effect of antifibrotic activity of DQ on oral submucous fibrosis. Drug Invention Today. 2019 Oct 15;12(10).

Devika V, Prasanna G. In vitro hepatoprotective activity of Drynaria quercifilia L. DQR. World Journal of Pharmacy and Pharmaceutical Sciences. 2016;5(1):512-21.

Hegde S, Menon VK, Noronha R, D'Souza L. Callus culture and an unconventional pattern of sporophyte regeneration in DQ—A medicinal fern. In Vitro Cellular & Developmental Biology-Plant. 2006 Nov 1;42(6):508-13.

Janaranjani B, Prasanna G, Chitra M. Antiinflammatory and antipyretic activities of DQR in rats. Int. J. Pharm. Sci. Rev. Res. 2014;13:57-61.

Janarthan L, Karthikeyan V, Balakrishna B. R, Jayakar B, Senthilkumar K. L, Anandharaj G. Pharmaconostical standardization and phytochemical profile of DQR of DQ (Linn) J. Smith. European journal of biomedical and pharmaceutical sciences. 2016;3(8):278-287.

Jinu U, Tha. Thayumanavan, Thakur Balwant Singh, JM, Sasikumar. In vitro Antioxidant capacity of the Fern, DQ (L) SM., DQR extract. International Journal of Pharmacy and Pharmaceutical Sciences 2014; 6(7): 413-416.

Joseph MJ, Thomas B. Chasmophytic pteridophytes in Urumbikkara Hills of Idukki District, Kerala, India. International Journal of Research and Review, ISSN. 2015:2349-9788.

Kamboj P, Kalia AN. Hepatoprotective Effect of DQ fronds hydroalcoholic extract and isolated constituent against CCl4-induced hepatocellular damage. Journal of Pharmaceutical Research International. 2013 May 18:563-78.

Khan A, Haque E, Rahman M, Mosaddik A, Rahman M, Sultana N. Isolation of antibacterial constituent from DQR of DQ and its sub-acute toxicological studies. DARU Journal of Pharmaceutical Sciences. 2007a;15(4):205-11.

Khan A, Haque E, Mukhlesur Rahman M, Mosaddik A, Abdul Alim Al-Bari M, Rahman M. Antipyretic activity of DQR of DQ. in rabbit. Pharmaceutical biology. 2007b Jan 1;45(4):312-5.

Khan A, Haque E, Rahman BM, Rahman M. Neuropharmacological Effect of the DQR of DQ in Mice. (2009): 23-27

Khan A, Haque E, Rahman M, Nessa F. Antibacterial activity and cytotoxicity of DQRs of Dryneria quercifolia. Journal of Medicinal Plants Research. 2012 Apr 9;6(13):2576-80.

Khan A, Islam MH, Islam ME, Al-Bari MA, Parvin MS, Sayeed MA, Islam MN, Haque ME. Pesticidal and pest repellency activities of DQRs of DQ (J. Smith) against Tribolium castaneum (Herbst). Biological research. 2014 Dec 1;47(1):51

Korwar PG, Beknal AK, Patil BS, Halkai MA, Kulkarni U, Hariprasanna RC, Soodam SR. A study on phytochemical investigation of DQ Linn DQR. Int. J. Pharm. Sci. Res.(IJPSR). 2010;1(12):148-58.

Kulkarni GK, Kadolkar RV, Maisale AB. Anthelmintic activity of DQ (L.) J. Smith. J Pharm Res. 2010 May;3(5):975-7

Lai H, Lim Y. Evaluation of antioxidant activities of the methanolic extracts of selected ferns in Malaysia. International Journal of Environmental Science and Development. 2011 Dec 1;2(6):442.

Marathe RR, Jadhav MD, Gore S, Joshi S, Thatte V, Rathod LR. Utilization of DQ (L.) J. Smith as a mosquito repellent. Science Research Reporter. 2011;1(3):159-6O3.

Mithraja MJ, Irudayaraj V, Kiruba S, Jeeva S. Antibacterial efficacy of DQ (L.) J. Smith (Polypodiaceae) against clinically isolated urinary tract pathogens. Asian Pacific Journal of Tropical Biomedicine. 2012 Jan 1;2(1):S131-5.

Mohanta MC, Dey A, Rahman SM, Chowdhury RS. Evaluation of Antioxidant, Cytotoxic and Anti-microbial Properties of DQ. Int Res J Pharm. 2013a;4(7):46-8.

Mohanta MC, Ganguly A, Begum F, Rahman SA. Evaluation of anti-nociceptive properties of DQR in Swiss-albino mice. Journal of Pharmacy Research. 2013b;8:41-4.

Neel RS, Pardeshi VN, Bhuktar AS. Fern flora of Maharashtra. BIOINFOLET-A Quarterly Journal of Life Sciences. 2018;15(2):114-22.

Nejad BS, Deokule SS. Anti-dermatophytic activity of DQ (L.) J. Smith. Jundishapur Journal of Microbiology. 2009;2(1):25

Nithin MK, Veeramani G, Sivakrishnan S. Phytochemical screening and GC-MS Analysis of DQR of DQ. Research Journal of Pharmacy and Technology. 2020;13(5):2266-8.

Padhy R, Patro SK, Jena M, Dash SK. Toxicity evaluation of methanolic DQR extracts obtained from DQ (Linn.) J. Smith in experimental animals.

Padhy RA, Dash SK. Antibacterial evaluation of methanolic DQR extract from an in vivo and in vitro grown Pteridophyte, DQ (Linn.) J. Smith. Asian Jour Pharm and Clin Res. 2015;8(4):130-8.

Padhy R, Patro SK, Dash SK, Sasmal D. Evaluation of Anti-Diarrheal Activity of Methanolic DQR Extract of DQ (Linn.) J. Smith in Albino Rats. 2016.

Pargavi B, Sivakumar T. Phytochemical screening and antimicrobial activity of DQ (L.) J. Smith. International Journal of Current Research in Chemistry and Pharmaceutical Sciences. 2014;1(5):68-73.

Pawar V, Chandrashekar KT, Mishra R, Tripathi V, Tripathi K. DQ Plant Extract as A Bone Regenerative Material in The Treatment of Periodontal Intrabony Defects: Clinical and Radiographic Assessment. IOSR Journal of Dental and Medical Sciences (IOSR-JDMS).2017 March;16 (3):93-99.

Prasanna G, Chitra M, Suvitha N. In vitro antimicrobial activity of DQ L. DQR. Asian J Bioc Pharmac Res. 2014;4:342-9.

Prasanna G, Chitra M. Phytochemical screening and GC-MS Analysis of DQR. American Journal of Advanced Drug Delivery. 2015a;3(1):72-8.

Prasanna G, Chitra M. In vitro antioxidant activity of DQ L. DQR. International Journal of Pharmaceutical Sciences and Research. 2015b Jul 1;6(7):3061

Prasanna G, Chitra M. In vitro anti-inflammatory activity of DQR. Research Journal of Pharmacognosy and Phytochemistry. 2015c;7(1):6-8.

Prasanna G, Anuradha R. Ultraviolet - Visible and Fourier Transform-Infrared Spectroscopic studies on DQ L. DQR. Asian J Pharm Clin Res 2016; 9(3): 85-88.

Prasanna G, Devi R, Ishwarya G. In vitro evaluation of antidiabetic and cytotoxicity potentials of the DQR extract of DQ (l.) j. smith. in vitro. 2019;12(11).

Rajesh KD, Subramanian V, Panneerselvam A, Rajesh NV, Jeyathilakan N. GC-MS analysis of secondary metabolites from the whole plant methanolic extract of *DQ* (l) j. smith (polypodiaceae). journal of advanced applied scientific research. 2016 apr 21;1(3):84-9.

Rajesh NV, Subramani A, Devi RK. Antibacterial activity of DQ (L.) J. Smith and Dryopteris cochleata (Buch. Ham. ex. D. Don) against scale rot in pythons. Annals of Phytomedicine. 2017 Jan 1;6(1):148-54.

Rajimol EK, Mohammed SP, Latheef N, Sriganesan P. Evaluation of antidiabetic and hypolipidemic potential of DQ Linn DQR in streptozotocin induced diabetic rats. Int J Pharm Sci Rev Res. 2014;25(1):118-24.

Ramesh N, Viswanathan MB, Saraswathy A, Balakrishna K, Brindha P, Lakshmanaperumalsamy P. Phytochemical and antimicrobial studies on DQ. Fitoterapia. 2001 Dec 1;72(8):934-6.

Ramjan A, Hossain M, Runa JF, Md H, Mahmodul I. Evaluation of thrombolytic potential of three medicinal plants available in Bangladesh, as a potent source of thrombolytic compounds. Avicenna journal of phytomedicine. 2014 Nov;4(6):430.

Ranil, R.H.G., Pushpakumara, D.K.N.G., Occurrence of Drynaria sparsisora (Desv.) T. Moore, in the lower Hantana area, Sri Lanka. J Natn Sci Foundation Sri Lanka 2008;36:331334

Rasool Hassan BA. Medicinal plants (importance and uses). Pharmaceut Anal Acta. 2012;3(10):2153-435.

Runa JF, Hossain M, Hasanuzzaman M, Ali MR. Investigation of Phenolic Profiles, Cytotoxic Potential and Phytochemical Screening of Different Extracts of DQ J. Smith (Leaves). Advanced pharmaceutical bulletin. 2013 Dec;3(2):465.

Saravanan S, Mu theeswaran S, Saravanan M, Chellappandian M, Paulraj MG, Raj MK, Ignacimuthu S, Duraipandiyan V. Ameliorative effect of DQ (L.) J. Sm., an ethnomedicinal plant, in arthritic animals. Food and chemical toxicology. 2013 Jan 1;51:356-63

Seena K. K, Valsamma V. T. Antimicrobial studies on DQ (L.) J. Sm. DQL and DQR extract. International Journal of Pharmacy and Biological Sciences. 2018; 8(4):826-830.

Selvi BP, Prasanna G, Anuradha R. Physicochemical and phytochemical analysis of the DQR of DQ L. International journal of phytopharmacy research. 2016;7(1):18-22.

Sen A, Ghosh PD. A note on the ethnobotanical studies of some pteridophytes in Assam. Indian Journal of Traditional Knowledge.2011 April; 10(2). 292-295.

Shokeen P, Ray K, Bala M, Tandon V. Preliminary studies on activity of Ocimum sanctum, DQ, and Annona squamosa against Neisseria gonorrhoeae. Sexually transmitted diseases. 2005 Feb 1;32(2):106-11.

Singh SY. Spore morphological studies on two Drynoid Ferns of Manipur, India.

Sivaraj C, Aashinya Y, Sripriya R, Arumugam P. Antioxidant Activities and Thin Layer Chromatographic Analysis of Aqueous Extract of Tubers of DQ (L). J. Sm. Free Radicals & Antioxidants. 2018 Jan 1;8(1).

Soodam S, Beknal AK. Effects of Boerhaavia diffusa roots and DQR extracts on urolithiatic rats. J Pharm Res. 2012;5(5):2846-51.

Tran TV, Malainer C, Schwaiger S, Hung T, Atanasov AG, Heiss EH, Dirsch VM, Stuppner H. Screening of Vietnamese medicinal plants for NF-κB signaling inhibitors: assessing the activity of flavonoids from the stem bark of Oroxylum indicum. Journal of ethnopharmacology. 2015 Jan 15;159:36-42.

Ueda JY, Tezuka Y, Banskota AH, Le Tran Q, Tran QK, Harimaya Y, Saiki I, Kadota S. Antiproliferative activity of Vietnamese medicinal plants. Biological and Pharmaceutical Bulletin. 2002;25(6):753-60.

Vikas V. Vaidya, Saurabh H. Patil, Deepal D. Ghadge, Hardik R. Shah. Physicochemical standardization and metal analysis of DQ (L.) J. Sm. 2016;5(6):2140-2148.