



# IJPPR

INTERNATIONAL JOURNAL OF PHARMACY & PHARMACEUTICAL RESEARCH  
An official Publication of Human Journals

ISSN 2349-7203




Human Journals

**Research Article**

October 2016 Vol.:7, Issue:3


© All rights are reserved by MS Latha et al.

## Traditional and Therapeutic Importance of *Rotula aquatica* Lour.: An Overview



**IJPPR**  
INTERNATIONAL JOURNAL OF PHARMACY & PHARMACEUTICAL RESEARCH  
An official Publication of Human Journals

ISSN 2349-7203



**A.Vysakh<sup>a</sup>, Nair R Raji<sup>a</sup>, MS Latha<sup>a,\*</sup>, Mathew Jyothis<sup>a</sup>**

<sup>a</sup> School of Biosciences, Mahatma Gandhi University,  
Priyadarshini Hills, Kottayam, Kerala, India.

**Submission:** 30 September 2016  
**Accepted:** 5 October 2016  
**Published:** 25 October 2016

**Keywords:** *Rotula aquatica* Lour; Kidney stone; Anti-inflammatory; Antioxidant; Anthelmintic

### ABSTRACT

*Rotula aquatica* Lour. is a rare rheophyte belonging to the family Boraginaceae. The plant is a member of lotic ecosystem of streams in India. *Rotula aquatica* Lour. is also called as pashanbhed; it is widely distributed in India, Sri Lanka, tropical south-eastern Asia and Latin America. The plant is rich in compounds such as Baunerol, steroid, alkaloid, and rhabdiol and allantoin. The medicinal values of plant lie in its component phytochemicals such as alkaloids, flavonoid, phenolic compounds and other nutrients like amino acid and proteins. The pashanbhed is a mandatory component of many ayurvedic drug preparations and is an important traditional medicine for kidney and bladder stones and uterine diseases. The tribal communities in India use this plant for treating skin diseases, ulcers and urinary disorders. In ayurveda, *R. aquatica* has been reported to be used for diabetes, treatment of piles, venereal disease, cancer etc. *Rotula aquatica* Lour. exhibited anthelmintic activity, cardiogenic activity, antimitotic activity and antirolithiatic activity, antioxidant activity and anti-inflammatory action. Anti-inflammatory and anti-oxidant activity of *Rotula aquatica* Lour. promise its role as a potent anti-inflammatory drug. A systemic research is needed to produce a nutraceuticals drug from *Rotula aquatica* Lour. for treating various health problem of humankind. This review is focused upon the various bioactivities of the plant *Rotula aquatica* Lour.



HUMAN JOURNALS

[www.ijppr.humanjournals.com](http://www.ijppr.humanjournals.com)

## 1. INTRODUCTION

People around the world have practiced herbal system of medicine since historical times and have its roots in civilization of the world. For centuries people have been trying to alleviate and treat disease with different plant extracts and formulations without or with minimal adverse effects(1). Plant-based remedies formed the basis of primary health care system(2). In most of the traditional systems of medicine remedies are taken from plants(3). Drugs of natural origin (including herbal medicine) have always been accepted as the choice of treatment by over 80% of the world's population(4). The common ailments like cough, cold, fever, diabetes are treated by using herbal infusions, decoctions, tinctures, churns etc (5, 6). Medicinal plants are rich in wide variety of chemicals. These chemical may contribute some biological effect in disease management and therapy. So they can be screened for such effect and must be scientifically proven for their efficacy and safety parameters. An extensive research in ethnopharmacology has taken place throughout the world. The plant *R. aquatica* was traditionally well known due to its large number of pharmacological action and medicinal uses.

*Rotula aquatica* Lour. is a member of the family Boraginaceae which is represented by about 100 genera and 2000 species. The plant is scattered throughout Peninsular and Western Ghats of India in the sandy and rocky beds of streams and rivers and are occasionally submerged in floods. It is also distributed in Sri Lanka, China, tropical southeastern Asia, Africa, Brazil and Latin America. The plant has been a mandatory component of many Ayurvedic drug preparations since historical times. It is widely used as an important traditional medicine for kidney and bladder stones. *Rotula aquatica* Lour. contain baurenol, steroid, alkaloid and rhabdiol (7). The root and tuber are bitter, astringent, diuretic and also useful in treating coughs, dysuria, heart diseases, fever, blood disorders, poisonings, ulcers and uterine diseases. The root of *Rotula aquatica* Lour. is also used as a laxative, and used in treatment of piles and venereal disease. The plant also has remarkable hypoglycemic, antidiabetic and hypolipidemic activity. Scientific studies on the plant focus on its antimutagenic(8), antibacterial(9), urolithiatic(10)(11), anthelmintic(12), antidiarrhoeal(13), analgesic, anti-inflammatory, antipyretic(14), psychoactive(15) and antioxidant(16) properties. In India, especially in the states of Kerala and Karnataka, *R. aquatica* is one of the most extensively used medicinal plants in the Ayurvedic system to dissolve urinary calculi and kidney stones.(17)

## 2. MATERIALS AND METHODS

This review was written after searching several databases, including Pub Med, Web of Science, Elsevier Science Direct, Springer, Scopus, Google search; for papers published up to August 2016. The searches were performed using the following keywords/phrases: *Rotula aquatica* Lour. , Traditional knowledge,

*Rotula aquatica* Lour. and anti-inflammatory action, *Rotula aquatica* Lour. and anti-cancer, *Rotula aquatica* Lour. and anthelmintic activity, *Rotula aquatica* Lour. and antiurolithiatic, Cardiotonic activity, Antimitotic activity, *Rotula aquatica* Lour. and antidiarrheal effect. Antioxidant activity of *Rotula aquatica* Lour. The references of these articles were scrutinized for relevant articles.

### 3. RESULT AND DISCUSSION

#### 3.1 Traditional knowledge

Around the world various local communities possess knowledge, innovations and peculiar practices developed from experience gained over centuries and adapted to the local culture and environment, such knowledge is categorized as traditional knowledge. The areas rich in biodiversity are also an abode of diverse ethnic groups possessing a valuable reservoir of indigenous knowledge system (IKS) acquired and developed over a long period of time (18). A large number of plants used in indigenous practices have been discovered through ethnobotanical studies (19). The ethnobotanical and ethnomedicinal studies have great significance in the collection of traditional knowledge, preparation of recorded data and in conservation of endangered medicinal plant species(20). The traditional medicinal knowledge of plants and their use by indigenous culture are not only useful for conservation of cultural tradition, but also for community health care and drug development in the present and future(21). The tribal population still depends on wild resources for their daily needs. The tribals have developed their own traditional ways of diagnosis to treat various ailments by trial and error method(22). They utilize numerous plants and their various parts *viz.*, roots, leaves, stems and rhizome for various ethnomedicinal practices. About the three-fourths of the biologically active plant-derived compounds have been discovered from researchers on folk and ethnomedicinal uses. Such ethnobotanical information serves as a base for new compounds with active principles of phytochemical, pharmacological and clinical research.

The Malapandram tribes in achenkovil forest of Kollam district in Kerala use *Rotula aquatica* Lour. root for treating skin disease. Ground root boiled in milk is taken internally on an empty stomach for one week against body heating and prickles(23). The Malamalasar tribes of Parambikulam wildlife sanctuary in Kerala use the decoction of *Rotula aquatica* Lour. for treating urinary disorders(24). The *Kattunayakans* tribes of Nilambure forests, Malappuram district of Kerala reveals that there are about 90 potential medicinal plant species spreading over 47 families were utilized by these tribes to cure various ailments. They use *Rotula aquatica* Lour. root decoction for treating stomach ulcers(25).

### 3.2 Phytochemistry of *Rotula aquatica* Lour.

Phenols and flavonoids are the important natural bioactive secondary metabolites in plants. These compounds are widely used all over the world to treat various diseases due to its biological properties like antioxidant, anti-carcinogen, anti-aging, protection from cardiovascular, immune/autoimmune diseases and brain dysfunctions viz. Parkinson's, Alzheimer's, Huntington's diseases, etc(26,27). Phytochemical investigation conducted on petroleum ether extract and alcoholic extracts of *Rotula aquatica* Lour. shows the presence of alkaloids and flavone glycosides(28). Phenolic and flavonoid compounds were present in methanolic extract of this plant. Presence of alkaloids was observed in aqueous extracts of leaf, stem, root and methanol extract of root. Flavonoids were observed in methanol and aqueous extracts of leaf, root, petroleum ether and chloroform extracts of stem. Phenols and saponins were present in methanol and aqueous extracts of leaf, root and also aqueous extract of stem(29). Tannins and terpenoids were present in methanol and aqueous extract of leaf, stem and root. Anthraquinones were found in all the extracts. Petroleum ether and chloroform extracts of leaf, stem and root were tested positive for anthocyanin. Chloroform, methanol and aqueous extracts of leaf, stem and root showed the presence of proteins and carbohydrates. Various in-vitro antioxidant studies proved the capability of the plant to scavenge the free radical ions (30). The free radical scavenging activity of the plant can be attributed to the secondary metabolites present in it and hence, it can be used as an effective remedy for oxidative stress-mediated diseases.

### 3.3 Anti-urolithiasis effect

Renal stone formation (Urolithiasis) is a recurrent disorder predominant in males. Since the time of Hippocrates (31), urolithiasis has been a matter of concern for clinicians all over the world. In the traditional system of medicine, many remedies have been employed to treat urinary stones and most of them were taken from plants. This type of medicine was proved to be useful though the rationale behind their use is not well established through systematic pharmacological and clinical studies except for some composite herbal drugs(31). The treatment is costly and poses some serious side effects. Hence, the search for antilithiatic drugs from natural sources has assumed greater importance. Many Indian plants have been proved to be useful as antilithiatic agents. They are highly effective with fewer side effects and are also inexpensive. Hence; many Indian plants are subjected to systematic evaluation for possible antilithiatic effects(32). A study conducted by Gilhotra et al.(33) stated that administration of the *Rotula aquatica* Lour. extracts to rats with ethylene glycol induced lithiasis prevented the growth of urinary stones. This evidence supported the folklore claim regarding the antilithiatic activity of the plant. The mechanism underlying this effect is still unknown but is apparently related to diuresis and lowering of

urinary concentrations of stone forming constituents. The protective effect of the plant against oxalate-induced lipid peroxidation may be contributory to the recovery of renal damage(33). The study of Prashanthi et al(34) proves the in-vitro antiurolithiatic activity of *Rotula aquatica* Lour. The trend of dose-dependent dissolution of stone was reported with increasing the concentration of extract. The diuretic property attributed to the plant can be inferred from the in-vitro antiurolithiatic dissolution study. The HPLC and TLC studies have evidenced that the aqueous extract contains many constituents which are also responsible for its property of “Paashanabheda- the stone breaker”.

### **3.4 Anti-diarrhoeal effect**

Diarrhea is a major health problem especially for children under the age of 5 and up to 17% of children admitted in the pediatric ward die of diarrhea. Worldwide distribution of diarrhea accounts for more than 5-8 million deaths each year in infants and children below 5 years old mostly in developing countries(35). Diarrhea is the outcome of an imbalance between the absorptive and secretory mechanisms in the intestinal tract of an organism. This results in excessive loss of fluid and electrolytes in feces(36). A variety of factors such as consumption of contaminated food/water leads to diarrhea. In developing countries where diarrhea is hyper-endemic with parasitism, the disease is considered to be a major problem.

Antidiarrhoeal effect of *Rotula aquatica* Lour. was evaluated by Sunder et al. (37) using castor oil induced diarrhea, charcoal meal test and PGE2 induced diarrhea models. The result of their study showed that alcoholic extract of *Rotula aquatica* Lour. have significant effect in reduction of gastrointestinal motility, inhibition of prostaglandin synthesis etc. The alcoholic extract of *Rotula aquatica* Lour. was found to be rich in alkaloids and flavonoids, which may account for its potent antidiarrhoeal activity (37).

### **3.5 Anti-inflammatory effect**

Inflammation is a complex biological response characterized by tissue edema, pain, leukocyte infiltration etc(38). It is a type of defensive mechanism of the body adopted to avoid pathogen, irritants, antigens etc and to maintain homeostasis. Many complex events and mediators are involved in the inflammatory reaction. Most of the diseases are accompanied by cascade of inflammatory reactions(39). Inflammation occurs through a cascade of reactions that leads to noticeable physiological effects such as edema, leukocyte infiltration and formation of granuloma(40).

Hemalatha et al(41) conducted a study for evaluating the anti-inflammatory activity of petroleum ether, ethyl acetate and ethanolic extracts of the whole plant of *Rotula aquatica* Lour. on acute inflammation

and sub-acute inflammation in animal models. The result of their study revealed that petroleum ether and ethyl acetate extracts of whole plant at a dose of 200 mg/kg possessed significant anti-inflammatory activity in experimental animals. The efficacy of aqueous extract of *Rotula aquatica* Lour. roots were investigated by Mengi et al. (42) for its anti-inflammatory potential in acute and chronic inflammatory conditions in rats. The IL-6 levels in crystal-induced inflammation were also determined in their study. The result revealed the efficiency of extract at a dose of 200 mg kg<sup>-1</sup> also effectively inhibited IL-6 levels. *R. aquatica* to have a potentially beneficial effect in relieving inflammation and providing a platform for the development of plant drugs for inflammatory diseases. According to studies conducted by Manish et al(14), the alcoholic extract of *Rotula aquatica* Lour. root at a dose of 200 mg/kg body weight has shown significant analgesic, antipyretic and anti-inflammatory activity. *Rotula aquatica* Lour. whole plant possesses anti-inflammatory effects in both acute and sub-acute inflammatory conditions and this may be possible to explain use of plant in traditional medicine. The significant anti-inflammatory action may be attributed to the phytoconstituents presents in it. These studies offered a scientific proof to the traditional use of *R. aquatica* as anti-inflammatory agent.

### 3.6 Anti-diabetic effect

Diabetes mellitus is a syndrome characterized by chronic hyperglycemia and relative insulin deficiency, resistance, or both. It has already affected more than 120 million people worldwide. According to an estimate, 220 million people will be affected by the year 2020(43). Hence, there is an urgent need to search for new drugs to manage this metabolic disorder. India is well known for its diverse reserve of natural resources with a rich history of traditional medicine(44). Recent times, most of the currently available drugs have been derived from plant and plant sources. Plants have always been an exemplary source of drug in many systems of medicine. The available ethnobotanical information accounts for about 800 plants that may possess anti-diabetic potential(45). Management of hyperlipidemia or hyperglycemia with minimal side effect in clinical experience and relatively low cost is still a challenge to the medical system(46).

Tulliballi et al(47) conducted a study to evaluate antidiabetic activity on methanolic extracts of *Rotula aquatica* Lour. roots in Streptozotocin-induced diabetic rats. The methanolic extracts of *Rotula aquatica* Lour. roots showed good activity at a dose of 400 mg/kg body weight in experimental diabetic rats. Ashwini et al (48) investigated the antidiabetic and hypoglycemic effect of aqueous extract in normal and Streptozotocin-induced diabetic rats respectively. The serum lipid profile was also examined during their study. The data obtained from their study showed that the aqueous extract of *Rotula aquatica* Lour. has a remarkable antidiabetic, hypoglycemic and hypolipidemic effect. The antidiabetic activity of this plant is



probably due to the presence of bioactive compounds like triterpenoids and tannins and may be a candidate for the development of potent phytomedicine for diabetes.

### 3.7 Antibacterial effect

Urinary tract infections associated with kidney stones is common in nephrolithiasis and vice-versa. Hence as a step ahead, the in-vitro screening of *Rotula aquatica* Lour. for its antibacterial property was carried out against three Gram +ve bacteria viz., *Bacillus subtilis*, *Bacillus cereus*, *Staphylococcus aureus* and four Gram-ve strains viz., *Pseudomonas aeruginosa*, *Salmonella abony* (*Salmonella enterica* subsp *enterica*), *Klebsella pneumonia*, *Escherichia coli*(9). Among the organisms- Gram +ve - *Bacillus cereus* and Gram-ve *Salmonella abony*, *Klebsella pneumoniae*, *Pseudomonas aeruginosa* were found to be susceptible to aqueous extract. Jamuna et al(49) studied antibacterial activity of methanolic extract of *Rotula aquatica* Lour. against food-related bacteria like *Escherichia coli* and *Salmonella typhi*. As the plant possesses significant antibacterial property, they could find a potential application in pharmaceutical and food industries as a supplement for treatment of urolithiasis, urinary tract infections and also as a natural preservative(9).

### 3.8 Anticancer effect

Cancer is a class of disease in which group of cells display division beyond the normal limits. Nearly all cancers are caused by abnormalities in the genetic material of the transformed cells. The abnormality may be due to the effect of carcinogens such as tobacco smoke, chemicals, radiation, viruses, free radicals etc(50). The cytotoxic effect of plant polyphenols is shown to be mediated through apoptosis. Considering the ability of these natural polyphenols especially the tannins to absorb proteins and metal ions, there is a possibility that they can elicit apoptosis signals through various receptors or proteins(51). The studies of Patila et al. using *Rotula aquatica* Lour. extracts on three pancreatic cancer cell lines HPAF-II, BxPC-3, and CAPAN-2. Extract of *R. aquatica* was found to be extremely effective in the prevention of cell proliferation of the pancreatic cancer cell lines(8).

### 3.9 Anthelmintic effect

Helminth infections are among the most widespread infections in humans. The majorities of infections due to helminths occur in tropical regions and cause enormous hazard to health. The infection may be alleviated in the prevalence of anemia, pneumonia, eosinophilia and undernourishment(52). Parasitic diseases cause ruthless morbidity affecting principally population in endemic areas. The gastrointestinal helminths becomes resistant to currently available anthelmintic drugs and pose problems in the treatment

of helminth diseases. Hence, there is an increasing demand towards natural anthelmintic compound(53). Sunder et al. studied anthelmintic effect of aqueous extract of *Rotula aquatica* Lour. on adult earthworms *pheretima posthuma*. Dose-dependent activity was observed in different concentration reveals potent anthelmintic effect of aqueous extract of *Rotula aquatica* Lour. (54). Abhishek et al and Singh et al also reported anthelmintic activity of the roots of *Rotula aquatica* Lour. (55,56) Anthelmintic potential of leaves and bark of *Rotula aquatica* Lour. was reported by Sarika et al(57) and Lakshmi et al(12) respectively , indicating that *Rotula aquatica* Lour. may be a source of novel anthelmintic drug.

#### 4 CONCLUSION

In the indigenous system of medicine prevalent in India, *Rotula aquatica* Lour. is a controversial drug and is a widely distributed shrub commonly found in the sandy soils and rocky beds of streams and rivers throughout India. The plant has been reported to be used for diabetes, treatment of piles, venereal disease, cancer and also exhibited anthelmintic activity, cardiotoxic activity, antimutagenic activity, antiuro lithiatic activity, antioxidant activity and anti-inflammatory action. This systemic review tried to open up the various health care abilities of different extract of *Rotula aquatica* Lour. We have also focused on revealing the potential role of *Rotula aquatica* Lour. in Ayurveda and tribal medicine. A complete and useful research is needed to reveal the bioactive compound that responsible for various biological activities of *Rotula aquatica* Lour.

#### Source of support

NIL

#### Conflicts of interest

None declared.

#### Acknowledgement

Financial assistance in the form of JRF, from CSIR, Government of India, to A. Vysakh is gratefully acknowledged.

#### REFERENCES

1. Mitchell RN CR. In: Robinsons basic pathology. 7th ed. Harcourt Pvt Ltd (India); New Delhi; 2003. 33-34 p.
2. Dash GK, Mishra B, Panda A, Patro CP GS. Anthelmintic activity of *Evolvulus nummularius*. Indian journal of natural product. 2003;19(3):24–5.
3. Ruth AH, Carol MP CP. Disorders of Renal system. In: Pathophysiology: Concepts of Altered Health States. 2009. p. 799.
4. WHO | Traditional medicine [Internet]. WHO. World Health Organization; 2004.



<http://www.who.int/mediacentre/factsheets/fs134/en/index.html>

5. Singh R, Singh MK, Chandra LR, Bhat D, Arora MS, Nailwal T P V. In vitro Antioxidant and free radical scavenging activity of *Macrotyloma uniflorum* (Gahat dal) from Kumauni region. *International Journal of Fundamental & Applied Sciences*. 2012;1(1):9–11.
6. Middha SK, Mittal Y, Ushal T, Kumar D, Srinivasan R, Vashisth L, et al. Phyto-mellitus: A phyto-chemical database for diabetes. *Bioinformation [Internet]*. Biomedical Informatics Publishing Group; 2009;4(2):78–9.
7. Singh S, Rai AK, Sharma P, Barshiliya Y. Comparative study of Anthelmintic activity between aqueous extract of *Areva Lanata* and *Rotula aquatica* Lour. *Asian Journal of Pharmacy and Life Science*. 2011;1(3):2231–4423.
8. Patil S, Narayanan S, Eibl G, Jolly CI. Evaluation of antimetabolic activity of *Rotula aquatica* (Lour): A traditional herb used in treatment of cancer. *Indian Journal of Experimental Biology*. 2004 ;42(9):893–9.
9. Prashanthi P, Anitha S, Shashidhara S. Studies on the antibacterial activity of the aqueous extract of the roots of *Rotula aquatica* ( *R . aquatica* ) Lour. *International Journal of Fundamental and Applied Sciences*. 2012;1(4):87–90.
10. Raut AA, Sunder S, Sarkar S, Pandita NS, Vaidya ADB. Preliminary study on crystal dissolution activity of *Rotula aquatica*, *Commiphora wightii* and *Boerhaavia diffusa* extracts. *Fitoterapia*. 2008;79(7–8):544–7.
11. Reddy, G.B.S KKS. An experimental evaluation of root of *Rotula aquatica* for anti urolithiatic activity in albino rats. *Indian Drugs*. 2000;30(8):398–404.
12. Lakshmi VK, Triveni KB, Anitha S SS. In-vitro Anthelmintic activity of *Rotula aquatica* Lour bark. *Pharma Science Monitor*. 2012;3(4):2332–9.
13. Singh S, Ak R, Sharma P, Barshiliya Y, Sihare M, Negi A. Antidiarrhoeal activity of *Rotula aquatica* in rats. *Asian Pacific Journal of Tropical Biomedicine* *Asian Pacific Journal of Tropical Biomedicine*. 2012;175–277.
14. Manish Kumar Gupta, Kenganora Mruthunjaya, Laxmi Saini, Shiv Kumar Garg, A Agrawal SG. Analgesic, anti-inflammatory and antipyretic activity of *Rotula aquatica* Lour root. *Inventi Rapid: Planta Activa*. 2011;
15. Nayar TS, Kumar ESA, Pushpangadan P. *Rotula aquatica*, Boraginaceae--first report on its psychoactive property. *Economic botany*. 1999;53(1):115–7.
16. Patil S, Jolly CI, Narayanan S. Free radical scavenging activity of *Acacia catechu* and *Rotula aquatica*: Implications in cancer therapy. *Indian Drugs*. 2003;40(6):328–32.
17. Sivarajan VV BI. *Ayurvedic Drugs and Their Plant Sources*. Oxford and IBH Publishing Co. Pvt. Ltd; 1994. 358-359 p.
18. Das AK, Shukla SP. Biodiversity and indigenous knowledge system. In: *Current Science*. 2007. p. 275–6.
19. Senthilkumar M, Gurumoorthi P, Janardhanan K. Antibacterial potential of some plants used by tribals in Maruthamalai hills, Tamil Nadu. *Natural Product Radiance* Vol. 4(1):27–34.
20. Prakash JW, Anpin Raja RD, Asbin Anderson N, Christudas W, Regini GS, Bensar K, Rajeev R, Kiruba S, Jeeva S DS. Ethnomedicinal plants used by Kani tribes of Agasthiyarmalai biosphere reserve, Southern Western Ghats. *Indian Journal of Traditional Knowledge*. 2008;7(3):410–3.
21. Gazzaneo LRS, de Lucena RFP, de Albuquerque UP. Knowledge and use of medicinal plants by local specialists in an region of Atlantic Forest in the state of Pernambuco (Northeastern Brazil). *Journal of ethnobiology and ethnomedicine*. *BioMed Central*; 2005;1(9).
22. Rajith N, Navas M, Thaha AM, Manju M, Anish N, Rajasekharan S, et al. A study on traditional mother care plants of rural communities of South Kerala. *Indian Journal of Traditional Knowledge*. 2010;9(1):203–8.
23. Ps U, George S, Tushar K, Balachandran I. Ethnomedicine of Malapandaram tribes of Achenkovil forest of Kollam district, Kerala. *Indian Journal of Traditional Knowledge*. 2007;6(4):569–73.
24. Yesodharan K, Sujana KA. Ethnomedicinal knowledge among Malamalar tribe of Parambikulam wildlife sanctuary, Kerala. *Indian Journal of Traditional Knowledge*. 2007;6(3):481–5.
25. Haridas R, Thomas B. Ethnomedicinal knowledge of tribe-kattunayakans in nilambur forests of malappuram district, kerala, india. *International Journal of Phytotherapy*. 2015;5(2):76–85.
26. Lai H, Singh NP. Oral artemisinin prevents and delays the development of 7,12-dimethylbenz[a]anthracene (DMBA)-induced breast cancer in the rat. *Cancer Letters*. 2006;231(1):43–8.
27. Sun J, Chu Y-F, Wu X, Liu RH. Antioxidant and antiproliferative activities of common fruits. *Journal of agricultural and food chemistry*. 2002; 50(25):7449–54.
28. Vijayakumari B. Evaluation of enzymatic and non-enzymatic antioxidant potential of *Rotula aquatica* Lour. *BioMedRx*. 2013;11(55):442–4.
29. B. Vijayakumari,V. Sasikala SRR. Preliminary phytochemical screening of the various extracts of *Rotula aquatica* Lour . *World Journal of Pharmacy and Pharmaceutical Sciences*. 2013;2(6):6371–80.
30. Pallavi M, Ramesh CK, Krishna V, Channakeshava GH, Jamuna KS. Total Phenolics and Antioxidant Potentials of *Rotula aquatica* Lour. *Journal of Applied Pharmaceutical Science*. 2016;6(4):169–74.
31. Aggarwal A, Singla SK, Tandon C. Urolithiasis: Phytotherapy as an adjunct therapy. *Indian Journal of*

Experimental Biology. 2014. p. 103–11.

32. Christina AJM, Najumadeen NAH, Kumar SV, Manikandan N, Tobin GC, Venkataraman S, et al. Antilithiatic Effect of *Melia azedarach*. on Ethylene Glycol–Induced Nephrolithiasis in Rats. *Pharmaceutical Biology*. 2008;44(6):480–5.

33. Umesh Kr G, Ajm C. Effect of *Rotula aquatica* Lour. on ethylene-glycol induced urolithiasis in rats. *Int J Drug Dev & Res*. 2011;3(1):273–80.

34. Prashanthi P, Anitha S, Shashidhara S. Effect of *rotula aquatica* lour. on experimental kidney stones. *International Journal of Pharmacognosy and Phytochemical Research*. 2015;7(6):1142–6.

35. Saralaya MG, Patel P, Patel M, Roy SP, Patel AN. Antidiarrheal Activity of Methanolic Extract of *Moringa oleifera* Lam Roots in Experimental Animal Models. *International Journal of Pharmaceutical Research*. 2010;2(2):36–9.

36. Ezenwali M, Njoku O, Okoli C. Studies on the anti-diarrheal properties of seed extract of *Monodora tenuifolia*. *International Journal of Applied Research in Natural Products*. 2009;2(4):20–6.

37. Singh S, Rai AK, Sharma P, Barshiliya Y, Sihare M, Negi A. Antidiarrhoeal activity of *Rotula aquatica* in rats. *Asian Pacific Journal of Tropical Biomedicine*. 2012;2(1 SUPPL.):175–7.

38. Vittalrao AM, Shanbhag T, Meena Kumari K, Bairy KL, Shenoy S. Evaluation of antiinflammatory and analgesic activities of alcoholic extract of *Kaempferia galanga* in rats. *Indian Journal of Physiology and Pharmacology*. 2011;55(1):13–24.

39. Vickerstaff JM BL. Type I hyper-sensitivity: atopic allergy. In *Understanding Allergy Sensitivity and Immunity: A Comprehensive Guide*. New Brunswick: Rutgers University Press; 1990. 126-136 p.

40. Coussens LM, Werb Z. Inflammation and cancer. *Nature*. 2002;420(6917):860–7.

41. Kamurthy H, Nampally S, Dontha S. Anti-inflammatory Activity of *Rotula aquatica* Lour . In Albino Rats. *International Journal of Pharmaceutical Sciences and Drug Research*. 2014;6(1):48–51.

42. Mengi SA, Bakshi VJ. Evaluation of the aqueous extract of *Rotula aquatica* roots in acute and chronic inflammatory conditions in rats. *Pharmaceutical Biology*. 2009;47(6):491–5.

43. Kumar P C. *Diabetic Mellitus and other disorders of Metabolism*. Clinical Medicine. 5th ed. 2002. 1069 p.

44. Sharma B, Viswanath G, Salunke R, Roy P. Effects of flavonoid-rich extract from seeds of *Eugenia jambolana* (L.) on carbohydrate and lipid metabolism in diabetic mice. *Food Chemistry*. 2008;110(3):697–705.

45. Grover JK, Yadav S, Vats V. Medicinal plants of India with anti-diabetic potential. *Journal of Ethnopharmacology*. 2002;81(1):81–100.

46. Sun JE, Ao ZH, Lu ZM, Xu HY, Zhang XM, Dou WF, et al. Antihyperglycemic and antilipidperoxidative effects of dry matter of culture broth of *Inonotus obliquus* in submerged culture on normal and alloxan-diabetes mice. *Journal of Ethnopharmacology*. 2008;118(1):7–13.

47. Shyam T, Ganapaty S, Balakrishnaiah P. Antidiabetic Activity of *Rotula aquatica* Lour Roots in Streptozotocin Induced Diabetic Rats. *American Journal of Phytomedicine and Clinical Therapeutics*. 2013;1(7):530–5.

48. Ashwini CS, Pramod HJ, Abhishek Kumar Rai, Geet P Asnani MP. Antidiabetic activity of aqueous extract of *Rotula aquatica* lour. roots in streptozotocin-induced diabetic rats. *Journal of Pharmaceutical and Scientific Innovation*. 2012;1(3):14–7.

49. Aswathanarayan JB, Vittal RR. In vitro evaluation of antioxidant and antibacterial activities of *Rotula aquatica* and *Ancistrocladus heyneanus*. *Journal of Pharmacy Research*. 2013;6(2):313–7.

50. SV Nwafor, PA Akah CO. Potentials of Plant Products as Anticancer Agents. *Journal of natural remedies*. 2001;1(2):75–88.

51. Taraphdar AK, Roy M, Bhattacharya RK. Natural products as inducers of apoptosis: Implication for cancer therapy and prevention. *Current science*. 2001;80(11):1387–96.

52. Sollman T. Anthelmintics: their efficiency as tested on earthworms. *J Pharmacol Exp Ther*. American Society for Pharmacology and Experimental Therapeutics; 1918;12(3):129–70.

53. Shivkar YM, Kumar VL. Anthelmintic Activity of Latex of *Calotropis procera*. *Pharmaceutical Biology*. 2003;41(4):263–5.

54. Singh S, Rai AK, Sharma P, Barshiliya Y. Evaluation of aqueous extract of *Rotula aquatica* Lour for In vitro Anthelmintic Activity. *Journal of Advanced Pharmacy Education & Research*. 2011;188(2):184–8.

55. Abhishek B, Mamta K, Singh V. Anthelmintic activity of the roots of *Rotula aquatica* Lour . *International journal of Phytopharmacy research*. 2010;1(1):34–7.

56. Lanata A, Aquatica R, Singh LS, Rai AK, Sharma P, Barshiliya Y. Comparative study of Anthelmintic activity between aqueous extract of. *Asian Journal of Pharmacy and Life Science*. 2011;1(3):2231–4423.

57. Zade S, Priya B, Chaskar A, Bagmar UR, Talole BB, Lunkad AS. In-vitro screening of anthelmintic potential of leaves of *Rotula aquatica* lour. *BioMedRx*. 2013;1(5):516–9.

**Table 1: Summary of studies on *Rotula aquatica* Lour.**

Study	Plant parts	Biological action reported	Reference	
Antibacterial	Whole plant	Free radical scavenging activity Antibacterial activity	(49)	
Anti bacterial	Roots	Antibacterial activity	(9)	
Anticancer	Whole plant	Anti-mitotic activity Antioxidant activity	(8) (16)	
Anti-diabetic	Roots	Hypoglycemic effect Antidiabetic effect Hypolipidemic effect Antihyperglycemic activity	(48)(47)	
Anthelmintic	Roots	Anthelmintic activity	(54) (7)(55)	
	Bark	Anthelmintic activity	(12)	
	Leaf	Anthelmintic activity	(57)	
Anti-inflammatory	Roots	Anti-inflammatory Antioxidant activity Antipyretic activity Analgesic activity	(42)(14)	
		Whole plant	Anti-inflammatory	(41)
		Whole plant	Antidiarrhoeal	(37)
Urolithiasis	Roots	Antilithiatic activity	(34) (33)	