



***Pedaliium murex* L.: botany, ethnobotany, phytochemistry, pharmacology, propagation and cultivation of an underutilized plant genetic resource of industrial value**

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Abstract

Pedaliium murex (Pedaliaceae), commonly known as large caltrops in English and bada gokharu in Hindi is an underutilized mucilaginous medicinal herb having multiple uses in traditional system of medicine. It is mainly used to cure reproductive disorders, like impotency in men, nocturnal emissions, gonorrhoea as well as leucorrhoea in women. It is also useful in the treatment of urinary and gastrointestinal tract disorders. The present paper deals with botanical identity, vernacular names, ecology, environmental requirement and growth conditions, origin and geographical distribution, morphological/botanical description, propagation and cultivation, usages as a source of food, mucilage, medicine and biodiesel, important Ayurvedic formulations, phytochemical and pharmacological profile and future prospect.

Keywords: pedaliium murex, bada gokhru, pedaliaceae, reproductive disorders, leafy vegetable, mucilage, biodiesel

Introduction

Genus *Pedaliium* belongs to family Pedaliaceae (Sesame family). According to Stapf 1905^[1], there are four species of *Pedaliium* viz *P. intermedium*, *P. caillaudii*, *P. filiforme* and *P. busseanum* but according to modern databases (The Plant List^[2] and USDA GRIN-Global^[3]), it includes a single species with accepted name *Pedaliium murex* L. whereas *P. microcarpum* Decne., *P. muricatum* Salisb., and *Rogeria microcarpa* Klotzsch are synonyms of *P. murex*. Other names were unable to establish their status either as an accepted species name or as a synonym of any accepted botanical name in modern database and are in unresolved status till date. It is generally known as large caltrops and land caltrops in English, Bada gokhru in Hindi and Gajadaunstraka, Gokshura or Titta-gokshura in Sanskrit. Other vernacular names of *P. murex* are Pilagokhru, enugapalleru, peddapaleru, enugapallerumulla, yenugapalleru (Telugu), annegalu –gida, aneneggilu, doddaneggilu (Kannada), motto ghokru, motherghokharu, hatticharatte, karonathia (Marathi), kadvaghokru, motha ghokru, mothangokharu, mottoghokru, ubbaghokru (Gujarathi), mottoghokru, baraghokhu, motharghokru (Bengali), gokshura, gokara (Oriya), gokrukalan (Punjabi), khasakekabar (Arabic), sulegi (Burmese), Dakhini-gokhru (Rajasthan) Kaxar-marood (Somalia) atineranchi (Singapore), khasakekalan (Persian) Vilyatigokhru, Dakhinigokhru, Brihatgokhru, Peru neranji, Yanai Nerinji, Peru Nerinjietc.

Ecology, environmental requirement and growth condition

P. murex generally grows as a weed at the edges/ open grassland near seashore, up to 500 m altitude. It is a saline soil indicator, and also occurs on sandy and limestone soils. It grows luxuriously in fertile soils and crop land as a weed at 25-30°C temperature. In Western Uttar Pradesh germination starts during the month of June-July and flowering fruiting occurs during September to December.

Geographical distribution

P. murex is native to Africa and Asia (Devanesan *et al.* 2018)^[4]. It is distributed in most of the dry and coastal areas of Africa and Asia. In Africa, it is distributed in nearly all directions of Tropical Africa *i.e.*, Northeast Tropical Africa (Djibouti, Somalia), East Tropical Africa (Kenya, Tanzania), West Tropical Africa (Ghana, Nigeria, Togo), South Tropical Africa (Mozambique) and in western Indian Ocean (Madagascar and Comoros). In Asia the species is distributed in Arabian Peninsula (Yemen) and Indian Subcontinent (India and Sri Lanka) (Fig. 1). In India, it mainly occurs as a weed of waste places in the southern India especially in Deccan Peninsula and Corommandal coasts, and in saline sandy areas along river belts in the Tamil Nadu, Andhra Pradesh, Haryana, Delhi, Rajasthan, Punjab, Gujarat and Madhya Pradesh, Uttar Pradesh etc.

Morphological description

Morphological study of *P. murex* collected from Bahadurpur site (established in 2017 for rehabilitation of degraded sandy soil and conservation of local phytodiversity) of Botany department, Dayalbagh Educational Institute (Deemed to be University), Dayalbagh, Agra shows that it is an annual, diffuse, succulent, mucilaginous herb of about 60-70 cm height (Fig. 2).

Root

Tap root system, 4 to 5 inch long, reddish brown in colour and bear a sweet aroma.

Stem

Stem is of about one cm diameter, much branched, succulent, glandular green in colour having branches spread up to 30 X 30 to 60 X 60 cm east-west and north-south diameter. The main shoot may be prostrate or erect. Phyllotaxy is opposite decussate.



Fig 1: Map showing the geographical distribution of *P. murex* throughout the world

Leaves

Leaves are simple, opposite, ovate, glabrous, alternate, fleshy, estipulate, petiolate and irregular in shape. Leaf length and width varies from 4.0-6.5 cm, and 4.0-5.0 cm respectively. Petiole length varies from 2.7-3.0 cm. Leaf contain prominent midrib, slightly thicker lateral veins, uniformly thick lamina with smooth surface, flat petiole and glandular trichomes are also found on both abaxial and adaxial sides of leaf. Venation is reticulate type with thick and straight veins.

Flowers

Flowers arise on leaf axis. Flowers are pentamerous, gamopetalous, 2.5-3.0 cm long and 1.0-1.5 cm width, yellow in colour with short pedicel. Calyx five, parietal with gamopetalous corolla, five lobes, round, tetradynamous stamens, bicarpellary stigma and four celled ovules.

Fruits

Fruits are 1.5-2.0 cm long, 0.8-1.5 cm diameter in size with pale yellowish to brown colour, indehiscent hard drupe, pyramidal glabrous surface and ovoid, globular in shape with four-ridges, having four spreading spines of 2.0-4.0 mm long at the base; attached with a short curved pedicel and having a terminal apex. Fruit possess 5-12 compartments having single seed in each compartment.

Seeds

Seeds are oblong, black in colour and covered with pappus. Seeds are mucilaginous, odourless and sweet in taste. Average weight of 1000 seeds was estimated to be 151.69 grams.

Ethnobotany and other potential usages

P. murex is a very important source of food, mucilage and medicine. Leaves are used as vegetable (Kirtikar and Basu, 1935) [5]. Various parts of the plant are used for the maintenance of general health and vitality, prevention and treatment of various disease and ailments of human being and domestic animals. The leaves and stems when agitated in cold water turn into tasteless, colourless thick mucilage, which is of high medicinal importance. It is a cheap and effective natural excipient that can be used as an effective alternative for the formulation of pharmaceutical suspensions. It have low rate of sedimentation, high viscosity, slightly basic pH and is easily redispersible (Yeole *et al.* 2010) [6]. An infusion of the stem and leaves is also used in gonorrhoea and dysuria (Kirtikar and Basu, 1935) [5]. It is a medicinal plant used in Ayurveda for the treatment of calculi, spermatorrhoea, amenorrhoea, dysmenorrhoea, inflammation, ulcers, fevers and other disorders. In Ayurveda, it is used as a tonic, aphrodisiac, appetizer, strangury, bladder stone, cough, asthma, pain, heart trouble, piles, leprosy, blood purifier and to cure skin diseases (Chopra *et al.* 1956) [7]. It is a major constituent of Ayurvedic formulations such as Gokhuradiguggul, Gokhurkwith, Gokhuradiawalaha, and Deshnularishta (Sivarajan and Balchandra 1994) [8]. According to Unani system of medicine, it helps to cure gleet, lumbago, stomachache, emmenagogue etc. (Shukla and Khanuja 2004) [9]. Beside Ayurveda and Unani system of medicine various parts of the plant are used as ethno medicine by the indigenous communities for treatment and prevention from various diseases and ailments in various parts of the world (Table 1).

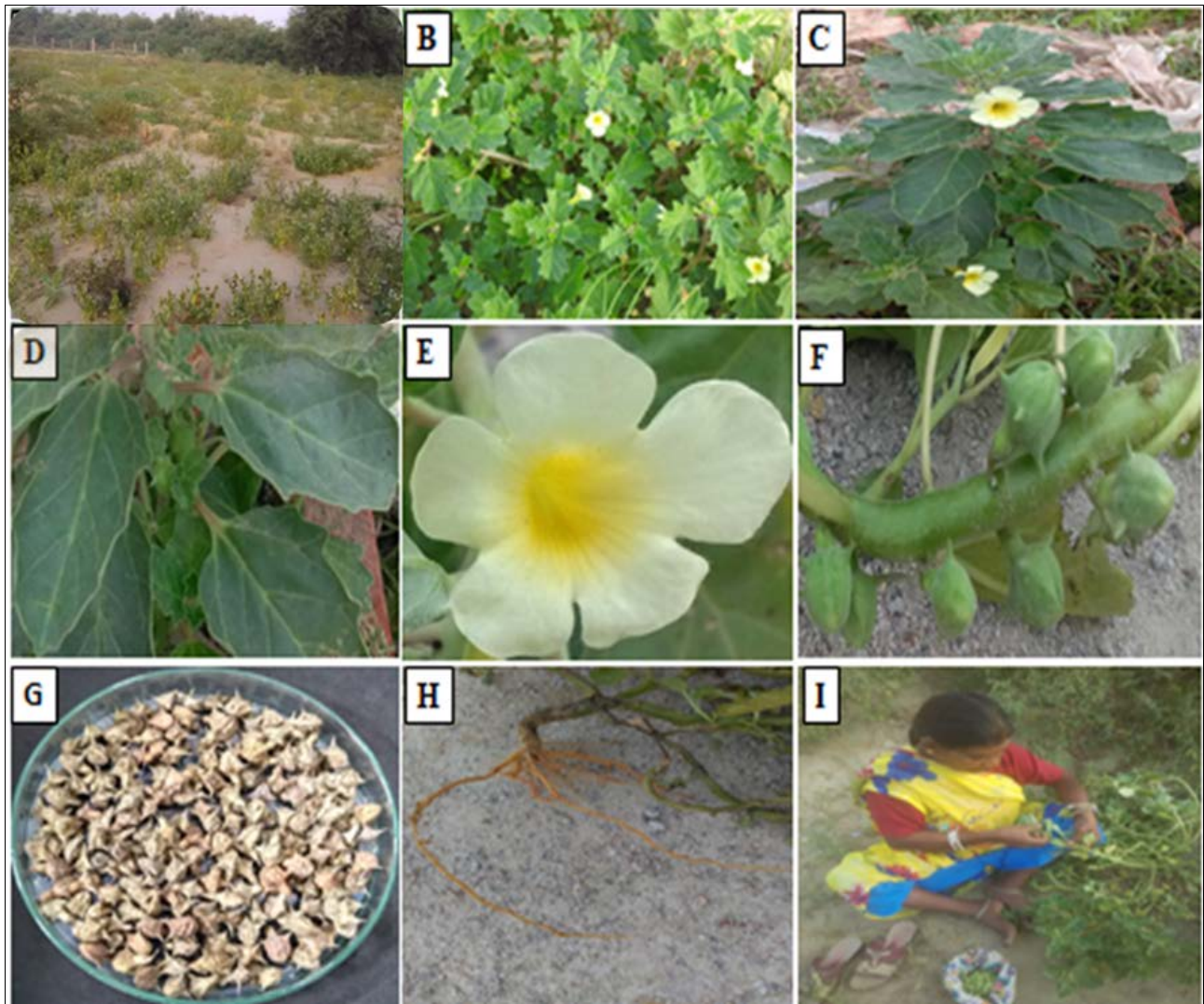


Fig 2: Habit and Morphology of *P. murex* L. (A) Naturally growing plant in field (B) A plant with flowers (C) A flowering twig (D) Leaves with petiole (E) Flower (F) Stem bearing fruits (G) Dried fruits (H) Roots (I) A local women collecting the seeds for medicinal purposes.

Table 1: Ethno medicinal uses of *Pedalium murex* L. in different parts of the world

Plant part	Method of medicine preparation and administration	Region and Local Name	References
Whole Plant	Water boiled with whole plant is fed to animals to help in expel out the placenta after delivery.	Gujarat (Sach gokhru)	Mistry <i>et al.</i> 2003 ^[10]
	Whole plant extract is used as a tonic for health and vigour.	Rajasthan (Dakhini gokhru)	Katewa <i>et al.</i> 2005 ^[11]
	Plant mucilage is administered to livestock for every delivery of young ones.	Tamil Nadu (Anai nerunji)	Ganesan <i>et al.</i> 2006 ^[12]
	The entire plant is macerated and is given for ephemeral fever in cattle for 4 days.	Andhra Pradesh (Yenugu Palleru)	Reddy <i>et al.</i> 1989 ^[13]
	Whole plant is fed to the animal for its cooling effect during summer.	Rajasthan (Dakhini-gokhru)	Galav <i>et al.</i> 2013 ^[14]
	Fresh whole herb is soaked overnight in water. The sticky infusion mixed with cane sugar is taken daily once to cure painful urination, excess urination, haematuria, etc. An infusion is a remedy for dysuria.	Gujarat (Ubbu-gokhru)	Punjani 2010 ^[15]
	Plant infusion is given for common fever	Uttar Pradesh (Bara gokhru)	Ali 1998 ^[16]
	Fine powder or paste is mixed with butter milk and given to drunk to reduce body heat in animals and plants are given as a fodder or soaked in water and this medicated water is given to drink to reduce the exposure to diseases in animals.	Rajasthan (Gokhru Bada)	Upadhyay <i>et al.</i> 2011 ^[17]
Aerial Part	The plant twig is dipped in water seven to ten times and this water is taken orally to cure dysentery. Crushed plant is soaked in water, filtered in next morning, mixed with sugar candy and seed powder of black pepper and taken as refrigerant as well as skin diseases.	Rajasthan (Bada gokhru)	Upadhyay <i>et al.</i> 2010 ^[18]
	Plant is used to cure male fertility disorders.	Haryana (Vilyati gokhru)	Panghal <i>et al.</i> 2010 ^[19]
	Aerial part of the plant is stirred in cup of water, to make oil appearance	Tamil Nadu (Anaineringi)	Nazar <i>et al.</i>

	preparation; taken orally once a day up to one week for the treatment of hyperacidity.		2008 ^[20]
	Stem and leaves are soaked and stirred in milk for few minutes until the milk becomes thick and is taken internally to treat diabetes, urinary irritations, uterine and puerperal diseases and local ulcers.	Tamil Nadu (Yanai Nerunji)	Vimalanathan <i>et al.</i> 2009 ^[21]
Leaves	Leaves mixed with garlic are made into paste and administered orally for leucorrhoea.	Andhra Pradesh (Yenugu Palleru)	Reddy <i>et al.</i> 1989 ^[22]
	Decoction prepared from the plant with leaves of <i>Azadirachta indica</i> is taken internally to treat fever.	Tamil Nadu (Anai Nerunji)	Bose <i>et al.</i> 2014 ^[23]
	Paste prepared from the leaves, ginger and common salt is used to cure tympany.	Tamil Nadu (Peru nerunji)	Jeeva <i>et al.</i> 2006 ^[24]
	Leaf decoction is used to cure diabetes.	Tamil Nadu (Yanai Nerinji)	Bose <i>et al.</i> 2014 ^[23]
	8-10 fresh leaves are boiled in half litre of water, the water becomes mucilaginous. Half cup of this water is taken once a day for seven days to cure gonorrhoea by the tribals.	Rajasthan (Gokhru, Halvi gokhru)	Jain <i>et al.</i> 2004 ^[25]
	Leaves and stem are soaked & stirred in milk for few minutes until the milk becomes thick and is taken internally to treat diabetes, urinary irritations, uterine and puerperal diseases and local ulcers.	Tamil Nadu (Peru Nerunji)	Vimalanathan <i>et al.</i> 2004 ^[21]
	Leaves soaked in water for twelve hours are crushed with sugar candy and cardamon, given to women suffering from leucorrhoea.	Rajasthan (Bada Gokhru)	Upadhyay <i>et al.</i> 2010 ^[18]
	Leaf maceration is drunk for aspermatogonia.	Andhra Pradesh (Yenugu Palleru)	Reddy <i>et al.</i> 1988 ^[13]
Fruits	Decoction of fruits is used for continuance of urine & other complaints of urinary system.	Rajasthan (Dakhini-gokhru)	Katwa <i>et al.</i> 2005 ^[11]
	Fruit powder is mixed with powdered sugar and ghee is taken for the treatment of leucorrhoea.	Haryana (Bara gokhru)	Yadav <i>et al.</i> 2006 ^[26]
	Fruits are used to cure spermatorrhoea, urinary problems, nocturnal emission, impotency and tonic.	Rajasthan (Bara gokhru)	Mohammed <i>et al.</i> 2004 ^[27]
	A pinch of shade dried fruit powder is taken regularly for two weeks with honey for impotence.	Tamil Nadu (Anai Nerunji)	Bose <i>et al.</i> 2014 ^[23]
	Fruits are used to cure fertility problems by taking two spoonful of fruit powder mixed with the leaf juice of <i>Cleome viscosa</i> is administered from the fifth day of menstrual cycles before going to sleep daily once for 7 days.	Andhra Pradesh (Enugu palleru)	Panduranga <i>et al.</i> 2011 ^[28]
	Two spoons of fruit powder mixed with <i>Cleome viscosa</i> L. leaf juice from the fifth day of menses before bed for seven days for fertility.	Tamil Nadu (Yanai Nerinji, Peru Nerinji)	Bose <i>et al.</i> 2014 ^[23]
	An extract of three fruits of gokhru and approx. 25 g of babool (<i>Acacia nilotica</i> L.) leaves mixed with sugar are given twice a day for a week in case of venereal diseases.	Madhya Pradesh (Gokhru)	Anis <i>et al.</i> 2000 ^[29]
	Powder of fruits with roots of <i>Capparis sepiaria</i> , <i>Bombax ceiba</i> and <i>Chlorophyton</i> are taken orally with water as a cooling agent and also used as a tonic.	Rajasthan (Bada Gokhru)	Upadhyay <i>et al.</i> 2010 ^[18]
Seeds	Laddus (a type of sweet) is prepared from the seeds are given to patients suffering from joint pain, lumbago and for better health.	Rajasthan (Dakhini-gokhru)	Katwa <i>et al.</i> 2005
Roots	The roots are powdered and mixed with cold water; the patient is bathed in the mixture once a day for 3 days to cure allergic infections.	Somalia (Kaxar-marood)	Anis <i>et al.</i> 1992 ^[29]
	Root paste made into small pellets and 2-3 pellets given daily with boiled cow milk for increasing vigour in men	Tamil Nadu (Yanai Nerinji or Peru Nerinji)	Bose <i>et al.</i> 2014 ^[23]

P. murex is also used for the biological synthesis nanoparticles. Biosynthesis of gold nanoparticle using cold and hot extract of *P. murex* showed that both the extracts produced nanoparticles in the range of 180-200nm. The biosynthesized AgNPs were found to have a potent antibacterial activity against *E. coli*, *K. pneumonia*, *B. subtilis*, *S. aureus*, etc. Ceramic SrO/CeO₂ mixed oxide NPs biosynthesised from leaves of *P. murex* shows high antibacterial activity against *S. aureus* (G+) and *E. coli* (G-) bacteria and high antioxidant activity (Peter *et al.* 2014; Anandalakshmi *et al.*, 2015; Pandiyan *et al.* 2019) ^[30, 31, 32]. Due to presence of high lipid content in areal parts *P. murex* can be used for biodiesel production (Shivprakash *et al.* 2019) ^[33]. Due to high commercial demand (more than 100 MT/year) in India, the species may be in threat and needs to be conserving properly (Gowthami 2021) ^[34].

Phytochemical and pharmacological profile

Phytochemical and pharmacological profile of the plant is studied well and documented in scientific literatures. *P. murex* is a rich source of various triterpenoids, fatty acids, steroids, flavonoids, tannins, saponins, vitamins, proteins, sugars, vanillin, ursolic acid.

It contains higher concentrations of steroids and sterols, and moderate concentrations of flavanoids, phenols, glycosides, alkaloids, proteins, terpenes, carbohydrates, gums and mucilage (Patel *et al.*, 2011)^[35]. It has been reported that steroidal components found in the plants possess fertility potentiating properties, and they have been found to be useful in the treatment of impotence (Das *et al.* 1966; Subramanian and Nair 1972; Rastogi *et al.* 1982; Zafar *et al.* 1989; Bhakuni *et al.* 1992; Vedavathy *et al.* 1997; Srinivasrao *et al.* 1999; Suganthi 2000; Venkatarathina *et al.* 2005; Kapoor *et al.* 2006; Rajashekar *et al.* 2012; Ananth 2018) ^[36-47].

Pharmacological profile of the *P. murex* is also well explored and documented. Various parts of the plant exhibit antimicrobial activity (moderate activity), anti-inflammatory, anti-nephrolithic, anti-hyperlipidemia, antioxidant, antiulcer, anti-pyretic; aphrodisiac, hepatoprotective, nephroprotective, increases testosterone properties (Balamurugan *et al.*, 2010; Srinivas *et al.*, 2011; Siva *et al.* 2012; Ananth 2018; Rathur 2019; Madhvan *et al.* 2020; Ramadevi *et al.* 2020; Abirami *et al.* 2021) ^[48-54]

Propagation and cultivation

Plant is propagated by seeds in nature, but the germination requirement of seed and information regarding dormancy and viability period of the seeds are not known. There is no information regarding cultivation practices, requirement of nutrients and irrigation. Germination of seed without any seed treatment from the seeds collected from Bahadurpur site before one year was unsuccessful in soil as well as by filter paper method; however plant was propagated successfully by stem cuttings.

An experiment was carried out in the month of October, 2019 in the Department of Botany, Dayalbagh Educational Institute, Agra (27°13'45.57"N and 78°09'45"E). About 4-5 inches long and one cm thick stem cuttings were collected from natural vegetation with the help of a sharp sterilized knife. Leaves from the cutting were trimmed, and 6 cuttings were planted in four replicate in pots containing a potting mixture of farm yard manure and sandy soil in a ratio of 1:3. The average environmental condition at that time in the month of October (post monsoon month) with temperature ranges of average high was 29.4°C (85°F) in day time and an average low of 20°C (68°F) during night and average relative humidity was near to about 40%. Sprouting started in 4th day after transplantation (DAT) and all the cuttings were sprouted in seven days. The number of sprouts' increases with time (Fig. 3)

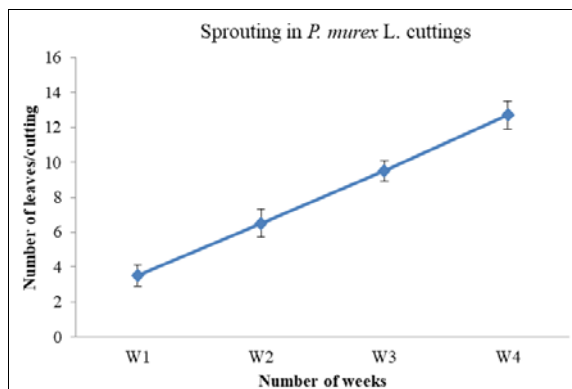


Fig 3: Sprouting in *P. murex* L cuttings

Conclusion and future perspectives:

On the basis of multidimensional potential of *P. murex* it is concluded that the species is underutilized and used for the healthcare management only by the practitioners of Ayurveda, Unani, and folklore system of medicines. The plant has industrial value and hard and prickly fruits are traded as raw medicine in Indian herbal mandies and used by Ayurvedic medicines manufacturers for the medicinal preparations. Due to edible nature of leaves as green vegetable and high mucilage and lipid content (to be used for industrial production) the plant may have high demand in near future. As the plant is collected from natural resources and seeds are collected for selling in local market/vendors the species should be properly conserved and domesticated. Studies for the development of suitable agrotechnology for commercial cultivation of *P. murex* should be conducted to utilize full potential of this species for human welfare.

Declarations

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Conflicts of interest/Competing interests

Authors have no competing interests

Availability of data and material

All data and materials are available in the Department of Botany, Dayalbagh Educational Institute, Agra.

Code availability

Not applicable

Ethics approval

Not applicable

Consent to participate

Not applicable

Consent for publication

All the authors have given their full consent for the publication of the Manuscript in the Journal

References

1. Stapf O. Flora of tropical Africa. R Bot Gard Kew,1905:4(2):538
2. The Plant List <http://www.theplantlist.org/> accessed on 18/06/21
3. USDA GRIN-Global <https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomydetail?id=431293#distro> accessed on 18/06/21
4. Devanesan AA, Zipora T, Smilin BAG, Deviram G, Thilagar S. Phytochemical and pharmacological status of indigenous medicinal plant *Pedalium murex* L.—A review. *Biomedicine & Pharmacotherapy*,2018;103:1456-1463.
5. Kirtikar KR, Basu BD. Indian Medicinal Plants, Lalit Mohan Publication, Allahabad, 1935, 2.
6. Yeole NB, Sandhya P, Chandhan PS, Bhujbal PS. Evaluation of *Malva sylvestris* and *P. murex* mucilage as suspending agent. *Int J Pharm Tech Res*,2010;2:385-389.
7. Chopra RN, Nayar SL, Chopra IC. Glossary of Indian medicinal plants, 1st edn. National Institute of Science Communication (C.S.I.R), New Delhi,1956:20:330.
8. Sivarajan VV, Balachandran I. Ayurvedic drugs and their plant sources. Oxford and IBH publishing, 1994: 570.
9. Shukla YN, Khanuja SPS. Chemical, pharmacological and botanical studies on *Pedalium murex*. *J Med Aromat Plant Science*,2004;26:64–69
10. Mistry N, Silori CS, Gupta L, Dixit AM. Indigenous knowledge on animal healthcare practices in district Kachhh, Gujarat. *Indian Journal of Traditional Knowledge*,2003;2(3):240-254.
11. Katewa SS and Galav P K. Traditional herbal medicines from Shekhawati region of Rajasthan. *Indian Journal of Traditional Knowledge*,2005;4(3):237-245
12. Ganesan S, Venkateshan G, Banumathy N. Medicinal plants used by ethnic group Thottianaickans of Semmalai hills (reserved forest), Tiruchirappalli district, Tamil Nadu. *Indian Journal of Traditional Knowledge*,2006;5(2):245-252.
13. Reddy MB, Reddy KR, Reddy MN. A Survey of Medicinal Plants of Chenchu Tribes of Andhra Pradesh, India. *Int. J. Crude Drug Res*,1988;26(4):189-196
14. Galav P, Jain A, Katewa SS. Traditional veterinary medicines used by livestock owners of Rajasthan, India. *Indian Journal of Traditional Knowledge*,2013;12(1):47-55.
15. Punjani BL. Herbal folk medicines used for urinary complaints in tribal pockets of Northeast Gujarat. *Indian Journal of Traditional Knowledge*,2010;9(1):126-130
16. Ali ZA. Folk veterinary medicine in Moradabad District Uttar Pradesh, India. *Fitoterapia*,1998;70:340-347.
17. Upadhyay B, Singh KP, Kumar A. Ethno-veterinary uses and informants consensus factor of medicinal plants of Sariska region, Rajasthan, India. *Journal of Ethnopharmacology*,2011;133:14–25
18. Upadhyay B, Parveen, Dhaker AK, Kumar A. Ethnomedicinal and ethnopharmaco-statistical studies of Eastern Rajasthan, India. *Journal of Ethnopharmacology*,2010;129:64–86
19. Panghal M, Arya V, Yadav S, Kumar S, Yadav JP. Indigenous knowledge of medicinal plants used by Saperas

- community of Khetawas, Jhajjar District, Haryana, India. *Journal of Ethnobiology and Ethnomedicine*,2010:6(4):2-11.
20. Nazar S, Ravikumar S, Williams G.P. Ethnopharmacological Survey of Medicinal Plants along the Southwest Coast of India. *Journal of Herbs, Spices & Medicinal Plants*,2008:14(3-4):219-239.
 21. Vimalanathan S, Ignacimuthu S, Hudson JB. Medicinal plants of Tamil Nadu (Southern India) are a rich source of antiviral activities. *Pharmaceutical Biology*,2009:47(5):422-429
 22. Reddy KR, Sudarsanam G, Gopala Rao P. Plant Drugs of Chittoor District, Andhra Pradesh, India. *Int. J. Crude Drug Res*,1989:27(1):41-54
 23. Bose MFJ, S Aron& P Mehalingam. An Ethnobotanical Study of Medicinal Plants used by the *Paliyars*aboriginal community in Virudhunagar district, Tamil Nadu, India. *Indian Journal of Traditional Knowledge*,2014:13(3):613-618.
 24. Jeeva S, Kiruba S, Mishra BP, Venugopal N, Dhas SSM, Regini GS, *et al.* Weeds of Kanyakumari district and their value in rural life. *Indian Journal of Traditional Knowledge*,2006:5(4):501-509
 25. Jain A, Katewa SS, Chaudhary BL, Galav Praveen. Folk herbal medicines used in birth control and sexual diseases by tribals of southern Rajasthan. *India Journal of Ethnopharmacology*,2004:90:171-177.
 26. Yadav J, Kumar S, Siwach P. Folk medicine used in gynecological and other related problems by rural population of Haryana. *Indian Journal of Traditional Knowledge*,2006:5(3):323-326.
 27. Mohammed S, Kaseri PK, Shukla JK. Unexploited plants of potential medicinal value from the Indian Thar desert. *Natural Product Radiance*,2004:3(2):69-74.
 28. Panduranga RM, S Prasanthi Reddi STVV. Medicinal plants in Folk medicine for Women's diseases in use by *Konda Reddis*. *Indian Journal of Traditional Knowledge*,2011:10(3):563-567.
 29. Anis Mohammad, Sharma M.P and Iqbal M. Herbal Ethnomedicine of the Gwalior Forest Division in Madhya Pradesh, India. *Pharmaceutical Biology*,2000:38(4):241-253.
 30. Peter J, Backialakshmi M, Karpagavinayagam P, Vedhi C. Green synthesis and characterization of colloidal AuNPs for optical properties. *J. Adv. Chem. Sci.*,2015:1(1)1-5.
 31. Anandalakshmi A, Venugobal J, Ramasamy V. Characterization of Silver nanoparticles by green synthesis method using *Pedalium murex* leaf extract and their antibacterial activity. *Appl Nanosi*,2015:6:399-408.
 32. Pandiyan N, Murugesana B, Sonamuthub J, Samayananc S, Mahalingam S. [BMIM] PF6 ionic liquid mediated green synthesis of ceramic SrO/CeO₂ nanostructure using *Pedalium murex* leaf extract and their antioxidant and antibacterial activities *Ceramics International*.2019:45:12138-12148.
 33. Sivaprakash G, Mohanrasu K, Ravindran B, Chung WJ, Arun A, Al Farraj DA, *et al.* Integrated approach: Al₂O₃-CaO Nanocatalytic biodiesel production and antibacterial potential silver nanoparticle synthesis from *Pedalium murex* extract, *Journal of King Saud University-Science*, 2019. <https://doi.org/10.1016/j.jksus.2019.12.004>
 34. Gowthami R, Sharma N, Pandey R, Agrawal A. Status and consolidated list of threatened medicinal plants of India. *Genet Resour Crop Evol*,2021:68:2235-2263.(. <https://doi.org/10.1007/s10722-021-01199-0>
 35. Patel DK, Laloo D, Kumar R, Hemalatha S. *Pedalium murex* Linn.: An overview of its phytopharmacological aspects . *Asian Pacific Journal of Tropical Medicine*,2011:748-755.
 36. Das VSR, Rao KN, Rao JVS Phenolic acid in some members of Pedaliaceae. *CurrSci*,1966:35:160.
 37. Subramanian SS, Nair AGR. Flavonoids of the leaves of *Pedalium murex*. *Phytochemistry*,1972:11:464-465.
 38. Rastogi JN, Sharma OD, Loiwal SD. Amino acids in certain medicinal plants. *Bull Pure Appl Sci*,1982:1(1):11-12.
 39. Zafar R, Gupta M. Flavone from stem and fruit of *Pedalium murex*. *Indian Drugs*,1989:27(3):202.
 40. Bhakuni RS, Shukla YN, Thakur RS. Flavonoids and other constituents from *Pedalium murex* Linn. *Phytochemistry*,1992:31(8):2917-2918.
 41. Vedhavathy S, Mrudula V, Sudhakar A. Tribal medicine of Chittoor District, A.P., Tirupati. *Herbal Folklore Research Center*: 1997.
 42. Srinivasrao M, Raman GV, Srinivasrao G, Venkateswarlu B, Efficacy of Botanicals against gram pod borer *Helicoverpa armigera* (Hub), *Pestology*,1999:23(1):18-22.
 43. Suganthi M. Efficacy of different plant protection options on the oviposition preference of gram pod borer *Helicoverpa armigera* (Hubner) in chickpea, *Indian J Plant Prot*,2000:28(1):61-63.
 44. Venkatarathina KT, Muthusamy VA, Ramanathan S. Evaluation of the petroleum ether extracts of *Pedalium murex* against Japanese Encephalitis vector culex *Tritanorhynchus*, *antiseptic*,2005:102:335-336.
 45. Kapoor BBS, Gaur R. Evaluation of ascorbic acid from some herbal plants of Shekawati region of Rajasthan, *J Phytol Res*,2006:19(2):297-298.
 46. Rajashekar V, Rao EU, Srinivas P. Biological activities and medicinal properties of Gokhru (*Pedalium murex* L.).*Asian Pac J Trop Biomed*,2012:2(7):581-585.
 47. Ananth DA, Tietel Z, Aseervatham GSB, Garlapati D, Sivasudha T. Phytochemical and pharmacological status of indigenous medicinal plant *Pedalium murex* L.—A review *Biomedicine & Pharmacotherapy*,2018:103:1456-1463.
 48. Balamurugan G, Muralidharan P, Polapala S. Aphrodisiac activity and curative effects of *P. murex* against ethanol-induced infertility in male rats, *Turk Biol*, 2005, 153-163.
 49. Srinivas P, Venkateswarulu L, Kumar ACH. "Antioxidant activity of *Pedalium murex* fruits in carbon tetra chloride-induced hepatopathy in rats." *Int J Pharma Bio Sciences*,2011:2:622-628.
 50. Siva V, Bose NJJ, Mehalingam P, Thirupathi T. Evaluation of Antipyretic Activity of *Pedalium murex* Against Brewer's Yeast-Induced Pyrexia in Rats. *Journal of Ornamental and Horticultural Plants*,2012:2:131-137.
 51. Rathur, R. Evaluation of anti-bacterial activity of *Pedalium murex* L. M Sc. Dissertation, 2019 submitted to Dayalbagh Educational Institute (Deemed to be University, Agra).
 52. Madhvan SA, Vinotha P, Uma V, Mahadevi M. Anticancer activity of *Pedalium murex* methanolic leaves extract against A549 Human lung cancer cell line. *Asean Journal of Advances in Research*,2020:5:33-40.
 53. Ramadevi S, Kaleeswaran B, Ilavenil S. Effect of traditionally used herb *Pedalium murex* L. and its active compound pedalin on urease expression – For the management of kidney stone *Pedalium murex* L. *Saudi Journal of Biological Sciences*, 2019. <https://doi.org/10.1016/j.sjbs.2020.01.014>
 54. Abirami S, Jabesta J, Renitta RE, Anand DA, Samrot AV. Antimicrobial activity of flower extracts against wounds pathogen and fungi. *Current Research in green and sustainable chemistry*,2021:4:100076.