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RHIZOPORA MUCRONATA (LOOP ROOT MANGROVE) –AN ETHNOMEDICINAL REVIEW

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ABSTRACT

Rhizopora mucronata (Rhizoporaceae) is a mangrove commonly found in the coastal intertidal zones of Indo-pacific and East Africa. It is popularly known as Asiatic mangrove and regionally (Tamil Nadu) as 'peykkanthal'. Mangroves are rapidly growing as a potent source of medicinal wealth which has been successfully proven as a cure for treating various ailments for centuries. Ethnomedicinal use of this halophyte includes Angina, Dysentery, Hematuria and many more. With recent advancements in analytical and clinical studies, it has further been proven for its biological activity such as hepatoprotective, antihyperglycemic, antiviral (HIV), anthelminthic, immunostimulant, anti-inflammatory, analgesic, antitumor and anti-diabetic. Medicinally active phytoconstituents like coumarins, xanthone, squalene, triterpenoids and many other compounds have been isolated and further studies will lead to a discovery novel drug moiety. Inspite of this Red mangrove being placed in the least concern category of the IUCN Red List, lack of a validated database on its medicinal properties and its ecological importance, it is being exploited for varied reasons as in dyeing and logistics industries. This review is a holistic approach to detail every aspects of this loop root mangrove.

KEYWORDS: Mangrove, *Rhizopora mucronata*, Ethnomedicinal, Pharmacological activities.

GENERAL INTRODUCTION

Rhizophora mucronata belongs to family Rhizophoraceae and commonly known as the looproot mangrove, red mangrove and Asiatic mangrove.[1] Mangroves are relatively recent and ephemeral coastal features on a geological time scale. The mangrove forests in the Beran

River Delta of East Kalimantan may be among the oldest mangrove communities in Indonesia.[2] while Rhizophora sp. were recorded to be present 30 million years ago as revealed by the fossils found and analyzed.[3] Mangroves are a product of convergent angiosperm evolution where plants from different families have evolved under similar adaptations that enabled them to colonize and reproduce in tropical intertidal environments of the early Thetys Sea between Laurentia and Gondwanaland[4] The first established angiosperm vegetation type included Avicennia sp., Rhizophora sp. and Hibiscus sp. in both centers of diversity, the western center with West Africa, Atlantic, and Pacific South America and the eastern-center with East Africa to the Western Pacific.[5] Rhizophora species generally grow only on sheltered shores often protected by coral reefs on shallow muddy deposits or on pure coralline or calcerous substrate with minimum water temperatures between 12 ° C and 32 ºC.[6] There are five species groups of *Rhizopora* species recognized under inundation factor of which *Rhizophora mucronata* is Inundated at high tides along stream banks and with its main foliage head still above water.[7] Mangrove trees, with probably the exception of the *Rhizophora* genus, are no halophytes, that is, they do not need salt to grow. Instead, they have developed special adaptation mechanisms to tolerate relatively high salt concentrations with an average of 34.7 ‰ salinity (g salt. 1 kg-1 of water), hence, creating a very specific niche.[8]

Adaptation Mechanisms

Dispersal adaptations: The hypocotyls of *Rhizophora mucronata* will at times reach up to 1 m in length and will fall out of the fruit base and hypocotyls below 1m will be intact with the plant. It is dicotyledonous where the cotyledons are completely fused, with the plumule entrenched in them. They absorb nutrients from the pericarp for the heightening of the hypocotyl.[2] The plumule often sprouts from the fruit and is prominently demarcated by a grove from the hypocotyl. The sustainable seedling can be water-borne over long distances and can make use of opportunities at an earlier stage of development. It can be stated that the embryo development is more or less continuous and the dispersal takes place through seedlings, not seeds. Rhizophora forests develop behind the pioneering species. *R. mucronata* being more tolerant of salt water than *R. apiculata* occurs behind a seaward fringe. The genus Rhizophora is the most prevalent mangrove genus worldwide and it is one of only three genera to be spread over global regions.[7] The average annual carbon sequestration rate for mangroves has been estimated to be 8 tonnes of carbon dioxide (CO_2) equivalent (CO_2e) ha–1 yr–1 (Murray et al. 2011). Worldwide, there are 114 species of true mangroves belonging to

66 genera (Tomlinson 1994). Mangroves grow under extreme environmental and climatic conditions such as high salinity, temperature, and radiation.[8] Asia harbors the largest mangroves in the world; India alone contributes 3% of the global mangrove habitat.

Occurrence: Rhizophora species as a wide geographic range of distribution and are primarily divided into two genetically isolated global regions by two currently effective dispersal barriers, namely the Atlantic east Pacific and Indo West Pacific.[2] In the AEP, two chief Rhizophora taxa dominate, namely R. mangle and R. Racemosa there are also two groupings of taxa in the IWP, including R. apiculata and a sub-group combining R. mucronata and R. stylosa. Taxa in the genus Rhizophora are primarily divided into IWP and AEP groups based on morphological characters, notably the presence/absence of leaf mucro. The total number of species is around five, but there are also comparable wide-ranging hybrids in each region, as well as wide variation in diagnostic morphological characters for the known entities.[3] This combination of factors has created considerable confusion for those wanting to identify the genetic composition of particular mangrove stands. Rhizophora species comprise four distinct groupings of taxa: “mangle” and “racemosa” in the AEP and “mucronata-stylosa” and “apiculata” in the IWP. There are also at least four reported hybrids in the world and there are likely to be more.[6] In the IWP, there are four reported species [*R. mucronata, R. stylosa, R. apiculata,* and *R. mangle* and three hybrids (*R. lamarckii, R. selala and R. annamalai*).

Morphological Description of *Rhizopora mucronata:* An evergreen, medium to a tall tree that may reach 25 to 30 m height. As in the case of Rhizophora apiculata numerous, much-branched, hoop or pile-like stilt roots loop from branches and stems and provide support to trees. These stilt roots also function as above-ground breathing roots. The bark is brown or reddish, smooth and sometimes scaly. Leaves are single, opposite, leathery, broadly elliptic to oblong-elliptic in shape with very distinct black dots on the under surface and tipped with a fine spine (mucor). Leaf stalk is 3 to 5 cm long. The inflorescence is dichotomously branched cyme, four to eight flowered and axillary in position; peduncle is slender, yellow and 2 to 3 cm long.[9]

Table. 1: Summary of chief diagnostic morphological characters (range with median in brackets) of *Rhizophora* taxa in NW Pacific island sites. Blank cells indicate no data (*Bb* mature flower bud,*Fb* mature fruit, *Hb* mature hypocotyl, *L* length, *L1* style length from corolla base, *L2* style length above swollen base, *SW* style width at corolla base, *W* width).[10]

Distinguishing features of *Rhizopora mucronata* from *Rhizopora* species.

Diagnostic characters		*R. apiculata*	*R.* X *lamarckii*	*R. stylosa*	*R. mucronata*
Leaf mucro (mm)	L W	0.8-(2.1)-3.5 0.3-(0.5)-0.6	1.5-(3.3)-5.6 0.3-(0.5)-0.8	2.0-(4.4)-6.7 0.5-(1.0)-2.5	2.7-(5.0)-7.0 0.7-(1.0)
Leaf undersurface		Spots	Spots	Spots	Spots
Inflorescence	Bb	6–11	3–6	2–5	2–3
Position no.	Fb	8–10		4–7	4–5
	Hb	9–13	8–9	4–9	5–10
Bract surface		Corky	Smooth	Smooth	Smooth
Inflorescence joints	No.	(1)-2	1–2	0–4	1–4
Style dimensions (mm)	L1 L2 SW	0.1-(0.6)-1.3 1.5-(2.2)-3.0 2.6-(3.6)-4.8	1.7-(2.7)-3.7 3.2-(4.3)-5.8 3.2-(4.1)-5.4	1.6-(3.4)-5.7 3.0-(4.9)-8.0 2.0-(2.5)-3.0	0.5-(1.3)-2.3 2.5-(3.8)-5.8 2.5-(3.3)-4.2
Petal margin		Glabrous	Slightly hairy	Very hairy	hairy
Petal shape		Linear	Linear-lanceolate	Lanceolate	Lanceolate
Stamen	No.	8-(10)-13	6-(11)-16	6-(7)-8	7-(8)
Calyx lobes	No.	(4)-6	3-(4)	3-(4)	4

PHYSIOLOGICAL DISTINCTION

The photosynthetic characteristics of mangroves are consistent with those of C3 plants photosynthetic biochemistry. Photosynthesis of mangroves is typically saturated at moderate light intensities with photosynthetic rates maximal at leaf temperatures less than 35 °C.[11] Carbondioxide fixation is done by the use of intermediates containing 3 carbon atoms which is converted into glucose (C6H12O6) using light that at most 10% of the salinity of seawater will be found in the sap of the tree.[12] Due to the presence of salt glands on the leaves, the excess of salt can be secreted (Parida and Jha, 2010).Water use efficiency is one outstanding feature of the gas exchange characteristics in mangroves and when compared with other C3 plants grown under similar conditions it is unusually high.[13]

Ecological and Economic Benefits of *Rhizopora mucronata:* Tantamount benefits are being provided by *Rhizophora mucronata* to mankind. In the perspective of natural disasters, *Rhizophora mucronata* act as a protective barrier against storms, hurricanes and tsunamis and soil erosion.[6] It plays a decisive role in the avoidance of coastal erosion. It Counteracts global warming by its high carbon sequestration capacity. It provides protection to natural fish diversity in oceanic water. The extensive root systems provide the breeding place for fish and prawns, as well as the shelter for the juveniles.[7] Economically, Mangroves are considered as a supplier of natural products such as charcoal, wild honey, timber, food and medicinal element.[8] The bark of *R. mucronata* is usually covered with cyanobacteria, sometimes with Begiatoa or sulfur-bacteria). Whereas the roots are usually covered with thick layers of algae including Halimeda and Caulerpa species. Cirripedia, Bryozoa, and Oyster species are also found commonly attached to the roots. Carpet-like algae layers can be found near the average tidal line, including Bostrychia species. The trunk and big branch area of the mangrove trees is abundant with marine organisms like littorinid snails and grapsid crab species, and typical terrestrial organisms like lichens and many insects can be found. The canopy of the mangrove trees is a domain of terrestrial insects, like the weaver ants and in some specific places the very habitat of eminent endemic monkeys, like the proboscis monkey, Nasalis larvatus, living only in some parts of Kalimantan and feeding particularly on Sonneratia leaves or the Macaca pagensis or Mentawai Macaque.[9] They search for crabs and whelks in the mangrove areas of Siberut Island off the Western coast of Sumatra.

Ethnobotanical Attributes: Mangroves have been consistently used in folk medicine for its antiviral, anti-bacterial, anti-diarrheal, antifungal, and antioxidant properties. Its antifouling activity been attributed to betanidine alkaloid (C17H14N2O2) compounds in leaf extract and showed an antifouling activity against barnacles.[14] The methanol extract was active as an antibacterial indicated by the inhibitory rate against A. hydrophila and E. coli.[15] Extraction of *R. mucronata* demonstrated potent anthelmintic activity tested against Indian earthworm Pheretima posthuma.[16] This plant has anti-cholinesterase, antiplasmodial, anti-viral, anti-oxidant, anti-microbial, antinociceptive and anti-hypoglycemic activities. Its bark has been proved to be an effective analgesic and anti-Inflammatory.[17] It has been screened for their anti-viral, anti-bacterial, anti-ulcer, and anti-inflammatory activities. Its leaf is being used in folk medicine for treating diarrhea or gastric motility disorder.[18] Antidiarrheal properties of medicinal plants have been known to relate with the presence of tannins and flavonoid. The barks of *Rhizophora mucronata* have long been used for tanning and dyeing and the leaves are the source of a black or chestnut dye. *R. mucronata* has long been traditionally used for the treatment of elephantiasis, hematoma, hepatitis, ulcers, and febrifuge. The parts of *R. mucronata* showed some antibacterial activity against S. aureus and E. coli. *R. mucronata* extract of leaves exhibited strong inhibitory action against Bacillus subtilis, Staphylococcus aureus, Candida albicans, Escherichia coli, Aspergillus fumigatus and Aspergillus niger and moderate inhibitory action against Pseudomonas aeruginosa and Proteus vulgaris. It is interesting to note that just about all parts showed broad-spectrum antibacterial activity. Its leaf is a natural source for both tannins and flavonoid, but their chemical, biological and pharmacological properties have not yet been determined. The barks of *Rhizophora mucronata* have long been used for tanning and dyeing and the leaves are the source of a black or chestnut dye. Recently scientists are veering in search of effective remedies from mangroves for diseases such as diabetes, asthma, cancer, ulcer, wounds and AIDS.[19]

Table. 2: Traditional uses and chemical constituents and activities of *R. mucronata.*

Botanical name	Traditional use/properties	Tested for	Chemical compounds
R. mucronata	Treatment of hematuria,	Antimicrobial, Antiviral, anti-	Coumarins, squalene, Alkaloids,
	elephantiasis,	HIV, growth	Anthocyanidins,
	haematoma,	hormones test on	Carbohydrates,
	hepatitis, astringent, ulcers	plants, biotoxicity	Terpenoids,
	febrifuge and diarrhoea, (B, FL, FR, L, R)	on fingerlings of Fish,hypreglycemic conditions (B, FL, FR, L, R)	Chlorophyll a, b, a & b, condensed and hydrolysable
			tannins, minerals, flavanoids and saponins (B, L,R, S).

Fig. 1: Rhizophora mucronataa: a. Plant showing leaf b. fruit c. root.

Phtyoremedial Potential of *Rhizopora mucronata:* Mangroves in general play a dominant role in phytoremediation by its ability to trap water borne metals. Phytoremediation capacity of *R. mucronata* varies from metal to metal.[20] As mangroves grow in coastal areas its concentration of metals such as Fe and Mn is very high. BAC (Biological accumulation cooeefficient) would be higher in future because the plant will be stabilized to the environment and grow to the greater extent in contrast to the present environment. Most of the studies have proved that phenomenon regarding the accumulation of Fe and Mn by *R. mucronata* in roots. Mangrove plays an important role in the purification of the eco-environment in river and estuary.[21]

Table. 3: Metallic composition of sediment of Bhitarkanika Mangrove System.

Period	Fe	Cu	Zn	Mn	Na	K	Ca
A	21	1.5	0.7	6.8	363	476	04
B	19	1.5	1.1	7.2	61	331	08
C	32	1.9	1.1	7.1	67	335	02

Table. 4: Metal concentration factor of *R. mucronata.*[20]

Parts	Cu	CD	Ni	Mn	Cr	Zn	Fe	Pb
Leaves	0.030	0.187	0.027	0.109	0.030	0.059	0.010	0.191
S. leaves	0.041	0.178	0.022	0.242	0.018	0.078	0.010	0.350
Bark	0.061	0.250	0.012	0.295	0.020	0.081	0.01	0.369
Root	0.091	0.107	0.021	0.055	0.015	0.047	0.044	0.265
Weighted average	0.056	0.180	0.021	0.175	0.021	0.066	0.018	0.294

Antioxidant Properties of *Rhizophora mucronata:* A free radical is defined as a molecule or a molecular species that contain one or more unpaired electrons which makes it extremely reactive because of the tendency of this electron to become paired at the earliest opportunity. It may occur in living cells due to various environmental factors such as ultraviolet radiation, chemical reactions, and some metabolic processes. Accretion of free radicals initiate dilapidation of biomolecules such as proteins, lipids, carbohydrates, and nucleic acids and are implicated in several diseases such as cardiovascular diseases, aging, cancer, atherosclerosis, Parkinson's disease, Alzheimer's disease, inflammatory diseases.[22] Artificial antioxidants have been shown to possess carcinogenic activity which makes it indispensable for the development of safer antioxidants particularly from natural sources. Plants are the primary source of natural antioxidants in the form of phenolic compounds (phenolic acids, flavonoids, and polyphenols). Most of the anti-inflammatory, digestive, antinecrotic, neuroprotective and hepatoprotective drugs derived from natural origin have been reported to have antioxidant/radical scavenging mechanism as part of their activity. DPPH (1,1‑diphenyl‑2‑picrylhydrazyl) determination of the radical scavenging activity of Methanol extract of *R.mucronata* showed high antioxidant activity equal to that of Ascorbic Acid which was assessed by means of its ability to convert Fe3+ to Fe2+.[23] It also exhibited potent ABTS radical cation scavenging activity in a concentration-dependent manner. Methanol extract showed the highest antioxidant capacity (146.18%) followed by ethanol (123.92%) and ethyl acetate (111.76%). The IC50 values for the DPPH (1,1‑diphenyl‑2‑picrylhydrazyl), Hydrogen Peroxide, Nitric Oxide, FRAP(Ferric reducing antioxidant powers), LPO(lipid peroxidation) and SOD(superoxide dismutase) showed the potential of free radical scavenging activity of *Rhizopora mucronata*.[24]

Table. 5: IC50 values of different solvent extracts of the leaf extracts of *R. mucronata.*

Solvents	IC50 (µg/ml)			
	DPPH	Hydroxyl	ABTS	Superoxide anion
P.ether	23.56	27.12	27.45	29.27
Benzene	21.47	28.56	26.89	28.45
Ethyl acetate	28.55	32.94	29.13	30.47
Methanol	36.17	32.56	34.84	36.47
Ethanol	30.89	29.84	32.46	33.12
Ascorbic acid	31.04	30.47	-	32.14
Trolox			31.47	

Chemical Characterisation of *Rhizopora mucronata* Parts: *R. mucronata* has been broadly explored for its secondary metabolite content and a large number of compounds have been structurally elucidated. Two new coumarins and a new xanthone were identified from the leaves of *Rhizophora mucronata*.[25] Two oleanenes, olean-18(19)-en-3 beta-yl-(3,6-dimethyl- 3E,6Z-dienoate) and (13 alpha)-27-frido-olean-14(15)-en-(17 alpha)-furanyl-3 beta-ol representing a class of rare natural pentacyclic triterpenoids were isolated from the chloroform extract of R. *Mucronata.*[27] Joel and Bhimba opined the presence of squalene (19.19%), n-Hexadecanoic acid (6.59%), phytol (4.74%), 2-cyclohexane-1-one, 4-hydroxy-3,5, (4.20%) and oleic acid (2.88%) in this plant.[28] Benzophenone (16.09%) and 2-(2-ethoxyethoxy) ethanol (7.82%) were identified as predominant constituents of *R. mucronata*.[29] Chromatographic Identification of Two Biologically Important Triterpenoids was done from the Chloroform Extract of *Rhizophora mucronata*. It is attributed with the most diverse phytochemical i.e. alkaloid, tannin, saponin, phenolic, flavonoid, triterpenoid, and glycosides.

Table. 6: Phytochemical content in *Rhizophora Murcatana.*

Phytochemical screening	Parts of Mangrove *Rhizopora mucronata*				
	Leaves	Root	Bark	Fruit	Flower
Alkaloid	++++	++++	++++	+++	++++
Tannin	+	+	++++	++	+++
Saponin	+	+	+++	++	+++
Phenolic	++++	-	++++	++	++
Flavanoid	++++	-	++++	+	++
Terpenoid	++++	-	++++	+	+
Steroid	++	+	-	-	-
Glycosides	++++	+	+++	++	+++

(-) negative; (+) weak positive; (++) positive; (+++) strong positive

Conservation status: Mangrove species are at extreme risk from coastal development and extraction at the extremes of their distribution, and are likely to be contracting in these areas more than in other areas. *R. mucronata* is in the least concern category of IUCN Red List Of Threatened Species ver 3.1(2010).[30] It is also anticipated that changes in climate due to global warming will, in addition, affect these parts of the range. There has been a predicted 20% decline in mangrove areas within its range due to habitat loss or extraction, but not enough to reach any of the threatened category thresholds. Exploring the potential health benefits of the mangrove will further alleviate the influence of this plant in medical research and thus making the conservation of this plant a human mandate.

Threats: Mangroves are particularly threatened by large scale commercial wood-chips operations, fish and prawn pond constructions called tambaks, residential and industrial developments. Ironically, the supply of young shrimps and larvae of the milkfish (Chanos Chanos) for the expanding pond industries come only from mangrove areas. By this means the genetic diversity of the future breeding stock is in danger. In India, the genus Rhizophora has already been reported to be at the verge of extinction.[31] Deforestation and Overgrazing are alarmingly increasing in all terrestrial biomes of the country which is a threat to biodiversity. Without proper protection, the values of the marketable and more important, non-marketable values provided by the mangrove forests in form of shoreline protection, waste filtration, and fish fingerling protection cannot be maintained. Other causative agents include, high population growth rate, increasing poverty among the Indian population and the prevalence of a deficit between the supply and demand of the natural resources.

Conservation Strategies: Emphasis must be given to launch a huge awareness drive on both governmental and community level in order to propagandize awareness among the people about the importance of plants and conservation of the flora. There are no conservation measures specific to this species at present. Continued monitoring and research is recommended and inclusion of the mangrove areas in marine and coastal protected areas will be a substantial measure to conserve this ecological boon. This species is the most preferred species for mangrove restoration.

CONCLUSION

This article is a holistic approach to detail about the indispensable role played by the mangrove(*Rhizopora mucronata*) in the biosphere and the threats posed to it by the mankind and measures to been taken to conserve this ecological boon. Taking into account the ethnomedicinal uses and the veering innovative medicinal approaches stringent measures must be taken to conserve this species. As cited above, meticulous research on the phytochemicals present in this mangrove will lead to innovate a potent biomolecule of interest. owing to its antioxidant properties, it can be therapeutically used for the treatment of the diseases triggered by the free radicals.

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