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Review Article

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IXORA L. - AN OVERVIEW

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ABSTRACT

Rubiaceae is a large family of about 500 genera and 6000 species, of which 489 species are found in India. Most of them are tropical trees and shrubs. A few members are herbs growing in temperature climates. This family is represented in India by 77 genera and 286 species of which as many as 124 species and 11 varieties *i.e.* approximately 48% are endemic to peninsular India. Different classes of chemical constituents include alkaloids, anthraquinones, phenolic derivatives; catechins, di and triterpenoids, iridoid glycosides etc. are present in these family members. The second subfamily, Ixoroideae includes a large genus *Ixora*. Theyare popular ornamental plants grown in the tropics for their beautiful inflorescences which are different shades of white, yellow, orange, pink and red. In general the classification and identification of species and cultivars in this genus has been very difficult.This review provides information regarding the works undertaken in different aspects of various species of *Ixora*.

KEYWORDS: Ixoroideae, endemic.

INTRODUCTION

Ixora is a well- defined genus of sub-shrubs; shrubs and small trees comprising about 400 taxa (Willis, 1966), which are largely pan tropical in distribution with the greatest diversity of species occurring in the South east Asian region (Fosberg and Sachet, 1989). It belongs to the second subfamily, Ixoroideae of family Rubiaceae. Hooker (1880) has reported 37 species from the Indian sub-continent, and Gamble (1921) has recorded 17 species as occurring in south India. *Ixora* are grown in Indian gardens, on account of their brilliantly coloured flowers and dark green hand some foliage (Bor and Raizada, 1982; Husain and Paul, 1988). Van Rheeda states in Hortus Malabaricus that the flowers of this genus are offered to the God (Bor and Raizada, 1982). Various species of *Ixora* are used as a medicine in Ayurveda, Folk, Siddha and Unani systems of medicine (Udayan and Indira Balachandran, 2009). This review encompasses information on population studies, pharmacognosy, pharmacological studies, phytochemistry, molecular and micropropagation studies of various species of *Ixora*.

a. Population Studies

There is a great worldwide interest in the study of rare, endangered and threatened plants these days, because of the chances of them becoming extinct due to various reasons. In Kerala, five species of *Ixora* are endemic to the Western Ghats (Nayar *et al*., 2006). One among them is *Ixora johnsonii* Hook. f. It was described by Joseph Dalton Hooker in 1880 based on a single collection of Rev. Johnson made in 1865 from Wennamala, Cochin, Kerala. This plant was rediscovered by Dan *et al.* (1997); Binu (1999) in Pathanamthitta district; and Prasanthkumar and Sujanapal (2008) in Kottayam district. Population density/ distribution analysis was done by Usha *et al* (2012 & 2013) in Kottayam and Pathanamthitta districts of Kerala and established its conservation status.

b. Pharmacognostical studies.

Sl. No.	*Ixora* species	Pharmacognosy in Plant parts	Reference
1	Four taxa of *Ixora* - *I. barbata, I. fulgens, I. javonica* and *I. coccinea*	Wood anatomy	Sharma (1970).
2	All Ixoroideae	Fibre tracheids	Koek–Noorman (1972).
3	*I. andamensis, I. monticola* and *I. squalierei*	Giant stomata with long radiating striae	Husain and Paul (1985).
4	*I. coccinea, I. coccinea* var. *lutea, I. chinensis, I. rosea, I. williamsii, I. macrothyrsa, I. andamensis, I. javanica, I. cuneifolia, I. pubirama, I. roxburghii, I. tigriomustax, I. monticola, I. subsessilis, I. goalparensis, I. longibracteata, I. polyantha, I. captuliflora, I. finlaysoniana, I. multibracteata, I. johnsonii, I. saulierei, I. malabarica, I. leucantha, I. leucantha var.malabaria, I. barbata, I. hymenophylla, I. katchalensis, I. elongata, I. arborea, I. brachiata, I. brunnescens, I. notoiana, I. calycina , I. undulate, I. thwaitterii, I. grandifolia , I. grandifolia var.rosella and var . kurzeana*	Leaf anatomy - in connection with the epidermis	Husain and Paul (1989).
5	*I. coccinea*	Root anatomy	Sudhakaran Nair (2001).
6	*I. brunnescens*	Bark and wood anatomy	Jayakumar (2003).
7	*I. coccinea*	Standardization of the leaves	Vadivu *et al*. (2009).
8	*I. johnsonii*	Pharmacognostical standardization -leaves	Usha *et al* (2012)

c. Phytochemical studies

Sl. No.	*Ixora* species	Plant parts	Chemical compounds and activity	Reference
1	*I. coccinea*	Root bark	A liquid acid free from glycerides-the lower homologue Δ^{9-11-} Octadecadienoic acid (CH_3-$(CH_2)_5$- CH =CH- CH=CH-$(CH_2)_7$ -COOH)	Kartha and Menon (1943).
2	*I. coccinea*	Bark	Mannitol	Kartha and Menon (1943).
3	*I. coccinea*	Flowers	Hydrolysable neutral principle	Varghese (1956).
4	*I. parviflora*	Roots	D- Mannitol	Anjaneyulu *et al*. (1965).
5	*I. coccinea*	Root bark	Free higher fatty acids	Kartha (1967).
6	*I. parviflora*	Leaves	Alcohols - ixoral and β –sitosterol	Ali and Kapadia (1968).
7	*I. chinensis*	Leaves	Triterpenoids –lupeol and betulin; sterols – β –sitosterol and stigmasterol	Hui and Ho (1968).
8	*I. coccinea*	Flowers and stem bark	D- Mannitol	Subramonian and Nair (1971).
9	*I. parviflora*	Roots, stem bark, leaves and flowers	D- Mannitol	Subramonian and Nair (1971).
10	*I. coccinea*	Leaves	Flavonoids –rutin	Subramonian and Nair (1971).
11	*I. coccinea*	Flowers	Flavo-flavonoids cyanidin-3- rutinoside and leucocyanidin glycoside	Subramonian and Nair (1971).
12	*I. arborea*	Leaves and flowers	Flavonoids - rutin and kaempferol -3-rutinoside	Subramanian and Nair (1971).

13	*I. parviflora*	Stem bark	β –sitosterol	Sastry (1974).
14	*I. undulata*	Bark	Tannins and flavonoids	Saxena (1975).
15	*I. coccinea*	Flowers	A yellow coloring matter related to quercetin, astringent principle (a wax) and a neutral crystalline substance (M.P. 257^0 C)	Nadkarni (1976).
16	*I. arborea* and *I. nigricans*	Whole plant excluding root	Tannins	Atal *et al*. (1978).
17	*I. arborea*	Seed oil	Capric (1%), lauric (3.1%), myristic (4.7%), palmitic (11.4%), stearic (11.9%), arachidic (2.9 %), behenic (2 %), oleic (18.7 %), and linoleic (44 %) acid.	Daulatabad and Ankalagi (1982).
18	*I. arborea*	Stem	Flavone glycoside chrysin: 5-0-β-D – xylopyranoside	Chauhan *et al.* (1984).
19	*I.coccinea*	Flowers	A mixture of monoglycosides - cyanidin and delphinidin	Rastogi and Mehrotra (1991).
20	*I. javanica*	Flower	Ferulic acid and its regionmers 3 – hydroxyl -4 – methoxy cinnamic acid	Nair *et al*. (1991).
21	*I. coccinea*	Whole plant	Triterpenoid – Ursolic Acid	Panlilio *et al.* (1992).
22	*I. coccinea*	Root	Saturated and unsaturated fatty acids	Padmaja *et al*. (1993).
23	*I. coccinea*	Leaves	Lupeol	Reena *et al*. (1994).
24	*I. coccinea*	Leaves	Triterpenoid –lupeol	Zachariah *et al.* (1994).
25	*I. coccinea*	Root	Biochemical effects	Sudhakaran and Nair (2001).
26	*I. coccinea*	Dried flowers	New cycloartenol esters.	Ragasa *et al.* (2004).
27	*I. coccinea*	Flower	*In-vitro* free radical scavenging activity-DPPH assay	Saha *et al.* (2008).
28	*I. brachiata*	Bark	Antioxidant- study	Poojari *et al*. (2009).
29	*I. arborea*	-	Phytochemical and biological investigations	Aktar *et al*. (2009).
30	*I. lutea*	Leaves and stem	Phytochemical and biological investigations	Sultana *et al*. (2009).
31	*I. coccinea*	Leaves	A-type proanthocyanidin trimer and other constituents and antioxidants.	Idowu *et al*. (2010).
33	*I. johnsonii*	Leaves, stem and root.	Chemical Profile- Pri & Sec. metabolites, TLC, HPTLC, GC-MS & Antioxidant studies. Flavonoids in all parts.	Usha (2012).

d. Antimicrobial studies

Sl. No	***Ixora* species**	**Plant parts**	**Microbial activity**	**Reference**
1	*I. coccinea*	Roots	*Helminthosporium sativum*	Bhatnagar *et al*. (1961).
2	*I. arborea*	Whole plant excluding root.	Antiviral activity - Ranikhet virus	Bhakuni *et al*. (1971).
3	*I. parviflora*	Stem bark	Antiviral properties against potato virus -X.	Singh and Singh (1972).
4	*I. polyantha*	Aerial portion	Interferon like activity against *vaccinea* virus	Babbar *et al*. (1982).
5	*I. coccinea*	Pollen	Antifungal activity- inhibition of fungal spore germination of *Helminthosporium oryzae.*	Tripathi *et al.* (1982).
6	*I. coccinea*	Leaves and flowers	Antimicrobial principles	Vijaya Kumari *et al*. (1987) and Panikkar (1987).
7	*I. coccinea*	Flower oil	Bacteria -*Bacillus subtilis, Salmonella richmani*, *S. stanley* and the fungus *Aspergillus flavum.*	Yadav (1989).

8	*I.coccinea*	Whole plant	Antimutagenic activity against carcinogen, 4_nitroquinoline in two *Bacillus subtilis* strains, namely H_{17}^{-} Rec $^{+}$ and M_{45}^{-} Rec.	Panlilio *et al*. (1992).
9	*I. coccinea*	Flower	Antimicrobial properties	Latha *et al*. (1995).
10	*I. coccinea*	Root	Antibacterial activity - *S. aureus, B. subtilis, E. coli* and *K. pneumonia*. Antifungal activity – *Aspergillus niger, A.flavus, Microsporum gypseum* and *Candida albicans*	Sudhakaran Nair (2001).
11	*I. coccinea*	Leaves	Antimicrobial activity- gram negative and gram positive bacteria.	Annapurna *et al*. (2003).
12	*I. coccinea*	Dried leaves, fresh leaves and flowers	Antimicrobial activity- gram negative and gram positive bacteria. -*Staphylococcus aureus, Escherichia coli* and *Klebsiella pneumoniae*.	Jayashree and Maneemegalai (2008).
13	*I. brachiata*	Bark	Anti-bacterial property against *Staphylococcus* spp.	Poojari *et al.* (2009).
14	*I. brachiata*	Leaf and Root	Antidermatophytic activity- dermatophytes *viz. Microsporum, Trichophyton* and *Epidermophyton*	Sadeghi-Nejad and Deokule (2009).
15	*I. coccinea*	Fresh leaves	Gram-negative bacteria- *E.coli, Pseudomonas aeruginosa, Salmonella typhi* Gram-positive bacteria- *Staphylococcus aureus*	Mukesh Chandra Sharma and Smita Sharma (2010).
16	*I. coccinea*	Leaves	Antibacterial properties	Idowu *et al*. (2010).
17	*I. coccinea*	Leaves	Fungai disease by *Pseudocercospora ixoricola* causing leaf spots	Alves and Barreto (2010).
18	*Ixora* spp.	Leaves and flowers	Antimicrobial activity- gram negative and gram positive bacteria.	Yoga Latha *et al*. (2012).
19	*I. johnsonii*	Root	Antimicrobial activity- gram negative and gram positive human bacteria.	Usha *et al* (2013)

e. Pharmacological Studies

Sl. No	*Ixora* species	Plant parts	Pharmacological screening	Reference
1	*I. nigricans*	Whole plant excluding root.	Antisplasmodic activity in isolate guinea pig ileum and CNS depressant effects and antagonism of amphetamine hyper activity in mice.	Bhakuni *et al*. (1971).
2	*I.brachiata*	Whole plant excluding root	Diuretic activity in rats	Dhar *et al*. (1974).
3	*I. coccinea*	Whole plant excluding root	CNS depressant activity and semen-coagulant effect in mice	Dhawan *et al*. (1977).
4	*I. arborea*	Whole plant excluding root	Antispasmodic effect on isolated guinea pig ileum, hypotension in cat/dog and CNS depressant effect in mice.	Dhawan *et al*. (1977).
5	*I.undulate*	Whole plant	Diuretic activity in rats and anticancer activity against P.388 lymphocytic leukemia in mice.	Dhawan *et al*. (1980).

6	*I. polyantha*	Whole plant excluding root	Effect on isolated guinea pig ileum, CVS and CNS in albino mice.	Aswal *et al.* (1984).
7	*I. coccinea*	Flowers	Anticancer activity	Panikkar *et al*. (1985).
8	*I. coccinea*	Ayurvedic oil with *I. coccinea* plant	Anticancer activity	Panikkar *et al*. (1986).
9	*I. coccinea*	Flowers	Cytotoxic to ascetic tumor cells and cells in culture	Vijaya Kumari *et al.* (1987); Panikkar (1987).
10	*I. coccinea*	Root, stem and leaves	Cytotoxic principles	Vijaya Kumari *et al.* (1987); Panikkar (1987).
11	*I. javanica*	Flower	Topical application inhibited growth and delayed the onset of Papilloma formation in mice (100mg /kg body weight).	Nair *et al.* (1991).
12	*I. javanica*	Flower	Antitumor activity-oral administration inhibit growth of subcutaneously injected 20 – methyl cholanthrene (MCA) induced soft tissue fibrosarcomas	Nair *et al.* (1991).
13	*I. coccinea*	Root	Anti-inflammatory activity in formalin induced acute paw oedema in rats	Seethadevi *et al.* (1991).
14	*I. coccinea*	Root	Anti-inflammatory activity in carrageenan induced paw oedema in albino rats	Padmaja *et al.* (1993).
15	*I. coccinea*	Leaves	Anti-inflammatory and anti-mitotic activities	Reena *et al.* (1994).
16	*I. coccinea*	Leaves	Anti-inflammatory activity in carrageenen induced paw oedema and antimitotic activity	Zachariah *et al.* (1994).
17	*I. coccinea*	Flower	Cytotoxic and antitumor principles.	Latha and Panikkar **(**1998).
18	*I. coccinea*	Flower	Modulatory effects on cyclophosphamide—induced toxicity in mice.	Latha and Panikkar **(**1999).
19	*I. coccinea*	Flowers	Dead space wound healing in rat.	Nayak *et al*. (1999)**.**
20	*I. coccinea*	Flower	Chemoprotective effect on cisplatin induced toxicity in mice.	Latha and Panikkar **(**2001)**.**
21	*I. coccinea*	Root	Anti-inflammatory activity	Sudhakaran Nair (2001).
22	*I. cibdela* var. *puberula* and *I. stricta.*	Leaves	Cytotoxic activity against human cervix carcinoma (KB-3-1) cell line.	Tanamatayarat *et al.* (2003).
23	*I. coccinea*	Leaves	Anti-inflammatory activity in rat	Ratnasooriya *et al*. (2005).
24	*I. coccinea*	Leaves	Antinociceptive action.	Ratnasooriya *et al*. (2005a).
25	*I. coccinea*	Fresh leaf	Anti-ulcer activity.	Arunachalam *et al*. (2008).
26	*I. brachiata*	Leaf and root	Antidermatophytic activities	Sadeghi-Nejad, B. and Deokule**, S.S. (**2009**).**
27	*I. coccinea*	Leaves	Antidiarrhoeal activity against castor oil induced model in rats.	Yasmeen *et al.* (2010).
28	*I. coccinea*	Flower	Antidiarrheal activity in rat.	Maniyar *et al.* (2010).
29	*I. coccinea* and *I. finlaysoniana*	Leaves	*In vitro* cytotoxicity study.	Liza Mary (2011).
30	*I. coccinea*	Root	Anthelmintic activity	Surana *et al.* (2011).
31	*I. johnsonii*	Root	Wound healing activity in rat.	Usha (2012)

f) Molecular studies

Sl.No.	*Ixora* species	Molecular studies	Reference
1	*Ixora* spp. (cultivars)	Investigate the efficient genomic DNA extraction protocol and genetic analysis	Rajaseger *et al*. (1997).
2	*Ixora* spp.	Study the usefulness of RAPD markers to assist in analysing different varieties, populations and mutant cultivars.	Rajaseger *et al*. (1999).
3	*I. coccinea* (atavistic mutant cultivar)	Phenotypic alteration.	Rajaseger *et al*. (1999).
4	*I. coccinea* and *I. duffii*	Identified the morphoforms by using RAPD marker.	Jayasree (2009).
5	*I. johnsonii*	Protein profile and random amplified polymorphic DNA (RAPD) analysis.	Usha (2012).

g. Micropropagation studies

Sl.No.	*Ixora* species	Tissue culture	Reference
1	Woody ornamental *I. coccinea*	Mass propagation.	Lakshmanan *et al*. (1977).
2	*I. singaporensis*	Large scale multiplication through micropropagation.	Malathy and Pai (1998).
3	*I. coccinea* cv superking	Simple and efficient micropropogation protocol.	Saifullah khan *et al*. (2004).
4	*I. parviflora*	Tissue culture study	Thakur and Kumar (2009).
5	*I. coccinea* and *I. finlaysoniana*	Improvement of secondary metabolites by elicitors, hairy root culture and somatic hybridization.	Liza Mary (2011).
6	*I. johnsonii*	*In vitro* multiplication using leaf explant.	Usha *et al* (2015)

CONCLUSION

Ixora is a well known large genus belongs to the family Rubiaceae. Although the distributions of most of the species are common, yet less number of researches has been carried out in this genus. Traditional uses of most of the species of *Ixora* are unproved scientifically.This review is an effort to compile all available information and research data on this plant.This study will be helpful for the researchers to explore the knowledge about various other species of *Ixora*.

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