Antibacterial Activity of *Lawsonia inermis* : An Overview

Madhushree Das Sarma

Department of Chemistry, Acharya Prafulla Chandra College, New Barrackpore, North 24 Parganas, Pin - 700 131

E-mail: madhushree_dassarma@yahoo.com

Date of Submission: 4th December, 2015 Date of Acceptance: 19th December, 2015

Abstract

aasLawsonia inermis Linn., commonly referred as 'Henna' is a well-known plant, is widely distributed in the tropical countries of North Africa and South East Asia. The plant has been used over centuries for herbal medicinal and cosmetic purposes. Henna is also a pharmacologically important plant with significant *in vitro* and *in vivo* biological activities. Almost a hundred phytochemicals have been identified from different parts of this plant, in which main dyeing principle lawsone, a naphthoquinonoid compound has been linked to many of the biological activities of this plant. This review focuses mainly on the antibacterial activity of the plant vis-à-vis lawsone.

Key words: *Lawsonia inermis*, Lawsone, Antimicrobial activity

1. Introduction

Plants secondary metabolites have proved to be an excellent reservoir of structurally diverse chemical compounds which contribute to the human civilization mainly as drugs, pigments and cosmetics since antiquity[1]. One such plant Lawsonia inermis (Lythraceae) commonly known as 'Henna' is a flowering shrub (Figure 1), has been widely cultivated throughout the tropical and subtropical regions of North Africa, South East Asia and the Middle East for ornamental and medicinal purposes [2]. Over the centuries, paste made from the Henna leaves (Mehndi) has been used by women for colouring their hair, hand and feet, especially at the times of festivals. Even today, henna paste has been popularly used for body art paintings and designs in all over the World[3].

The plant is not only important as the source of potential 'biocolourant' (natural dye), but also played a vital role in the daily lives of some ancient cultures, providing psychological and medicinal benefits. This plant is well documented in traditional Oriental medicinal systems for the treatment of wide range of ailments to cure almost anything from headache to leprosy and other skin disorders[4]. Historically, Henna was applied to the hands and feet to protect against fungal pathogens and to hair to combat lice and dandruff. Other traditional uses include the treatment of rheumatoid arthritis, headache, ulcers, diarrheoa, jaundice, leprosy, fever, spleen enlargement, diabetes etc. Again, it can be used as an astringent, antiseptic and antihemorragic agent and is also known for its hypertensive, cardio inhibitory and sedative effects[4,5].

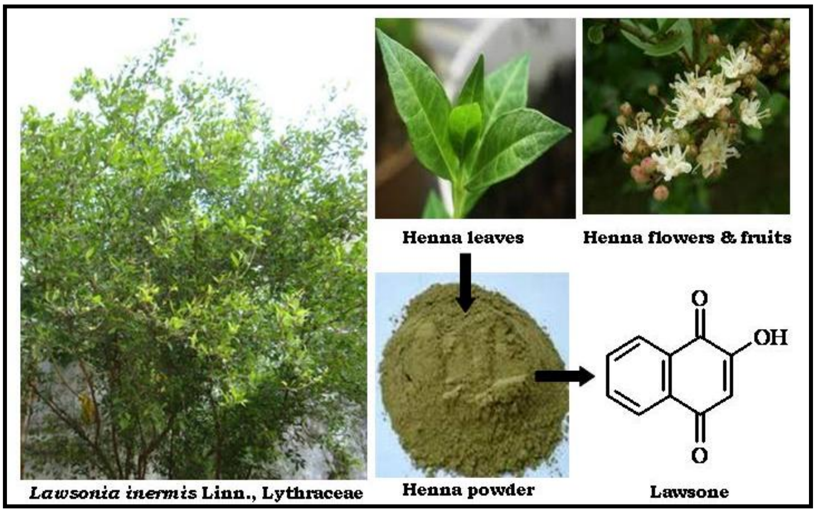

Figure 1: Different parts of Lawsonia inermis (Henna); Structure of Lawsone

Phytochemical screening of different parts of *L. inermis* have shown that a large variety of compounds have been isolated including napthoquinone derivatives, phenolic compounds, terpenoids, sterols, tannins, xanthones, coumarin, fatty acids, amino acids and other volatile constituents. The principal colouring matter of henna is lawsone (2-hydroxy-1,4-napthaquinone, Figure 1), is particularly concentrated in the leaf petioles. It has been found that, dried powdered leaves of henna contain about 0.5-1.5% lawsone. Many of the biological properties displayed by the plant have been attributed to lawsone[6,7]. Beside lawsone, the plant has reported to contain esculetin, fraxetin, isoplumbagin, scopoletin, betulin, betulinic acid, gallic acid, hennadiol, hennatannic acid, lupeol, methyl linolenate, lacoumarin, laxanthone etc[5,6].

Several researchers have reported a wide range of pharmacological activities of *L. inermis* in different *in-vitro* and *in-vivo* test models. Henna leaves, flower, seeds, stem bark, roots have been found to exhibit antimicrobial, antidiabetic, anticancer, anti-inflammatory, antiparasitic, antidermatophytic, antiviral, anti-ulcer, wound healing, immunomodulatory, hepatoprotective, tuberculostatic, antifertility, protein glycation inhibitor properties[5,6,8]. A wide search for novel antibacterial agents is urgently needed due to overcome the growing problem of resistance and the toxicity of the currently available commercial antibiotics[9]. The use of medicinal plants provides an interesting source in the development of potential new drugs for the treatment of various microbial infections[10]. However, a large number of plants with significant ethnomedicinal value remain virtually unexplored in this respect. Various parts of *L. inermis* are known to possess potential antibacterial activity against a wide range of different bacterial strains[11]. In the present paper, some recent information on antibacterial activity of this plant and also its chief dyeing component lawsone, are summarized.

2. Antibacterial Activity

In early 1968, antibacterial studies of henna extracts have been first documented[12], but research still continues since then. By using different solvents, several parts of *L. inermis* have been evaluated against a large variety of human pathogenic bacteria. In most of the cases, leaf extract has been found to show highest inhibitory activity[6,11]. Gull *et al.* reported that aqueous leaf extract has exhibited notable activity against clinical isolates of seven bacteria including four Gram negative (*Escherichia coli, Salmonella typhi, Klebsiella spp., Shigella sonnei*) and three Gram positive (*Bacillus subtilis*, *Staphylococcus aureus*, *Staphylococcus epidermidis*) using disc diffusion method and minimum inhibitory concentration (MIC) was found to be varying from 2.3 - 9.3 mg/mL[13]. Crude extracts of this plant were investivated against eleven bacterial strains and it exhibited strong activity against *Bordetella bronchiseptica*[14]. Solvent polarity plays an important role in antibacterial efficacy. Al-Rubiay and co-workers have investigated the antibacterial effects of aqueous, ethanolic and oily (hexane) extracts of *L .inermis* leaves against four bacterial cultures isolated from various skin diseases by using Agar diffusion dilution method[15]. Alcoholic extract showed lowest MICs against all the tested pathogens compared to other extracts and water extract did not show any notable activity. In another report, different solvent extracts of Henna leaves were shown promising activity against eight reference bacterial strains and two clinically isolated strains[16]. Similar results were obtained by several group of researchers, some recent studies are summarized in Table 1.

Sl. No.	Plant part	Solvent	Bacterial strain	Assay	Remark	Ref
1.	Leaf	EtOH	*S.a* , *P.a.*	AWD	Conc.: 100-500 mg/mL; IZD: 8-18 mm(*S.a.*); 0-11 mm (*P.a.*)	17
2.	Leaf	H_2O, EtOH, MeOH, EtOAc	*E.c.*, *K.p.*, *P.a.*, *P.m.*, *S.ty.*, *V.c.*, *S.a.*	DDM	At 25 mg/mL conc., IZD : 10-26mm; MIC : 34 -71μg/mL Activity order: EtOH>MeOH>H_2O>EtOAc	18
3.	Leaf, Stem, Root	Hexane, $CHCl_3$, MeOH	*A.sp.*, *P.Sp.*, *V.Spp.*	AWD	Conc.: 100 mg/mL (Leaf extract); IZD: 11-21 mm(*A.sp.*); 9-17 mm (*P.sp.*); 10-20 mm (*V.sp.*)	19
4.	Whole plant	MeOH	*S.a.*, *E.c.*, *K.p.*, *P.a.*, *P.m.*	DDM	Conc.: 250, 500, 1000 μg /mL IZD: 13-24 mm(*S.a.*); 12-22 mm (*E.c.*); 9-18 mm (*K.p.*); 12-17 mm (*P.a.*); 10-23 mm (*P.m.*);	20
5.	Stem bark	H_2O	*S.a.*, *E.c.*, *P.a.*	DDM	IZD: 12.5 mm(*S.a.*); 15.6 mm (*E.c.*); 7 mm (*P.a.*) MIC : 45 mg/mL (*S.a.*); 15.6 mg/mL (*E.c.*); 7 mg/mL (*P.a.*)	21
6.	Leaf, Fruits, Flowers	CH_2Cl_2, EtOAc, EtOH	*E.c.*, *P.a.*, *B.s.*, *S.a.*	AWD	Conc.: 40 mg/100 μL (EtOH extract); IZD: 14-25 mm(*E.c.*); 19-26 mm (*P.a.*); 17-26 mm (*B.s.*); 21-26 mm (*B.a.*)	22
7.	Leaf, Seed	EtOH	*S.e.*, *S.a.*, *E.c.*, *P.a.*, *B.sp.*,*K.p.*, *S.s.*,*C.f.*, *V.c.*,	AWD	Conc.: 125 - 500 mg/mL; IZD: 20-28 mm(*S.e.*); 19-25 mm (*S.a.*); 0-15 mm (*E.c.*& *K.p*); 10-18 mm (*S.s.*); 0-18 mm (*P.a.*);15-30 mm (*B.sp.*&*V.c.*);	23

			N.m., H.i., A.h.		0-17 mm (*C.f.)*; 10-26 mm (*N.m.*); 17-25 mm (*H.i.*); 20-30 mm (*A.h.*)	
8.	Whole plant	H_2O, MeOH	*C.sp.,K.sp., E.c., S.p., P.m.,P.a., S.b.,S.s., S.f., S.ty.,S.t.,S.p.*	DDM	IZD: 8.9 – 10.8 mm MIC : 4 -40 μg/mL	24

Table 1: Antibacterial activities of several parts of Henna plant against an array of different pathogens

Abbreviations: AWD = Agar well diffusion; DDM = Disk diffusion method; IZD = Inhibitory zone diameter; MIC = Minimum inhibitory concentration; *A.h. = Aeromonas hydrophila; A.sp. = Aeromonas species; B.s. = Bacillus subtilis;B.sp.= Bacillus species; C.f. = Citrobacter frewndii; C.sp.= Citrobacter species; E.c.= Escherichia coli; H.i.= Haemophilus influenzae; K.p.= Klebsiella pneumoniae;K.sp.= Klebsiella sp.; N.m.= Neisseria meningitides; P.a. = Pseudomonas aeruginosa;P.sp.= Pseudomonas species; P.m.=Proteus mirabilis;S.a.= Staphylococcus aureus;S.b.= Shigella boydii; S.e.= Staphylococcus epidermidis;S.f. = Shigella flexneri; S.p. = Salmonella paratyphi; S.s.= Shigella sonnei; S.t. = Salmonella typhimurium; S. ty.= Salmonella typhi; V.c.= Vibrio cholerae; V.sp.= Vibrio species.*

Lawsone, the main constituent of Henna leaf was found to be responsible for the inhibitory activity of leaf extracts against both gram-positive and gram-negative bacterial strains [5,6,11]. This may be due to the presence of free -OH group in lawsone which has the capability to combine with the carbohydrates and proteins in the bacterial cell wall, and get attached to enzyme sites rendering them inactive[25]. Some synthetic derivatives of lawsone were reported to possess significant antibacterial activity. Chloro and nitro anlogues of lawsone were active against *S. aureus* with MIC value 16 μg/mL and 32 μg/mL, respectively[26]. Naphthothiazoles derived from lawsone showed inhibitory activity against *B. polymyxa*, *B. subtilis* and *P. vulgaris* in dose dependent manner[27].

3. Conclusion

The plant, *Lawsonia inermis* (Henna) is not only a worldwide known cosmetic agent, but it also possesses a broad spectrum of antimicrobial activity against both gram-positive and gram-negative bacterial strains. With the rapidly emerging resistant strains of microorganisms to the already available antibiotics, Henna could be a potential natural source of alternative remedy. Lawsone and some of its derivatives have also exhibited significant antimicrobial activities against selective pathogens. Hence, by using lawsone as ‘lead molecule’, further research in this area might provide novel pharmacophore for the better treatment against various bacterial diseases.

References:

1. G. M. Cragg and D. J. Newman, *Biochim. Biophys. Acta.,* **1830**, 3670, (2013).
2. A. Chatterjee and S. C. Pakrashi, “*The Treatise on Indian Medicinal Plants*”, National Institute of Science Communication CSIR, New Delhi, India, (1997).
3. B. Chengaiah, K. M.Rao, K. M. Kumar, M.Alagusundaram and C. M. Chetty, *Int. J. Pharm. Tech.Res.,* **2**, 144. (2010) (b) R. Siva, *Curr. Sci.,* **92**, 916, (2007) (c) V. G. Mehendale, N. C. Chaudhari, S. N. Shenoy and A. V. Mehendale, *World J. Surg.* **35**, 311, (2011).
4. R. N. Chopra, S. L. Nayar and I. C. Chopra, “*Glossary of Indian Medicinal Plants*”,

National Institute of Science Communication (CSIR), New Delhi, India, (1999).

5. G. Chaudhary, S. Goyal and P. Poonia, *Int. J. Pharm. Sci. Drug Res.*, **2**, 91, (2010) (b) E. Zumrutdal and M. Ozaslam, *Int. J. Pharmacol.*, **8**, 483, (2012).
6. I. K. Makhija, *in www.pharmatutor.org,* Reference ID: PHARMATUTOR-ART-1022 (b) R. B. Semwal, D. K. Semwal, S. Combrinck, C. C. Jones and A. Viljoen, *J. Ethnopharmacol.*, **155**, 80, (2014).
7. M. V. Araujo, P. S. O. Souza, A. C. Queiroz, C. B. B. Matta *et al., Molecules,* **19**, 15180, (2014) (b) L. I. L. Lopez, S. D. N. Flores, S. Y. S. Belmares, A. S. Galindo, *Vitae Revista de la Facultad de Quimica Farmaceutica*., **21**, 248, (2014). (c) S. M. Lee, Y. S. Chen, C. C. Lin, K. H. Chen, *Int. J. Mol. Sci.,* **16**, 1495, (2015).
8. M. Kamal and T. Jawaid, *Int. J. Biomed. Res.*, **1**, 62, (2010) (b) S. B. Amit, N. K. Babsaheb and V. S. Rajkumar, *J. Pharm. Life Sci.,* **2**, 536, (2011) (c) F. E. Babili, A. Valentin and C. Chatelain, *Pharmaceut. Anal. Acta.*, **4**, 203, (2013).
9. M. P. Doyle, G. H. Loneragan, H. M. Scott, and R.S. Singer, *Comprehensive Rev. Food Sci. Food Safety*., **12**, 234, (2013).
10. M. M. Cowan, *Clin. Microbiol.Rev.*, **12**, 564, (1999).
11. H. S. Muhammad and S. Muhammad, *Afr. J. Biotech.*, **4**, 934, (2005) (b) P. D. Babu and R. S. Subhasree, *Acad. J. Plant Sci.*, **2**, 231, (2009) (c) A. H. Kawo and A. M. Kwa, *Int. Res. J. Microbiol.*, **2**, 510, (2011) (d) M. R. Nadjib, B. A. Zahia, B. Mohammed, B. Kebir and C.B. Noureddine, *Am. J. Med.Biol. Res.*, **1**, 16, (2013) (e) A. A. Al-Edany, B. Y. Khudaier, N. N. Jaber, Bas. *J. Vet. Res.*, **12**, 256, (2013).
12. F. Malekzadeh, *Appl. Microbiol.*, **16**, 663, (1968).
13. I. Gull, M.Sohail, M. S. Aslam and M. A. Atar, *Annals Clin. Microbiol. Antimicrob*., **12**, 36, (2012).
14. S. Bonjar, *J. Ethnopharmacol.*, **94**, 301, (2004).
15. K. K. Al-Rubiay, N. N. Jaber, B. H. Al-Mhaawe and L. K. Alrubaiy, *Oman Med.J.,* **23**, 4, (2008).
16. M. M. H. Chowdhury, K. Kubra and S. R. Ahmed, *Res. J. Med. Plant.*, **8**, 187, (2014).
17. T. Santhanamari, P. R. Meenakshi and S. Velayutham, *Asian J. Pharmaceut. Clin. Res.*, **4**, 62, (2011).
18. V. Jothiprakasam, S. Ramesh and S. K. Rajasekharan, *Int. J. Pharm. Pharmaceut. Sci.*, **5**, 219, (2013).
19. K. P. Rayavarapu, D. Kaladhar and S. K. Santosh, *J. Pharm. Biomed. Sci.*, **7**, 1, (2011).
20. P. Arun, K. G. Purushotham, J. J. Johnsy and V. Kumari, *Int. J. Pharm Tech Res.*, **2**, 1178, (2010).
21. G. B. Kavishankar, N. Lakshmidevi and S. M. Murthy, *Int. J. Pharma Bio Sci.*, **2**, 509, (2011).
22. E. C. Jeyaseelan, S. Jenothiny, M. K. Pathmanathan and J. P. Jeyadevan, *Asian. Pac. J. Trop. Biomed.*, **2**, 798. (2012).
23. O. Habbal, S. S. Hasson, A. H. El-Hag, Z. Al-Mahrooqi *et al., Asian. Pac. J. Trop. Biomed.*, **1**, 173, (2011).
24. S. Satish, M. P. Raghavendra, D. C. Mohana and K. A. Raveesha, *Asian J.Microbiol. Biotech. Environ. Sci.*, **11**, 19, (2009).

25. S. B. Harborne and A. Baxter, *“Phytochemical Dictionary. A handbook of bioactive compounds from plants”, Tylor and Francis, London,* (1995).
26. N. M. Rahmoun, Z. B. Atmani, K. Boucherit, M. Benabdallah, D. Villemin and N. C. Braham, *Med. Maladies Infect.*, **42**, 270, (2012).
27. G. Brahmeshwari, M. Surekha, K. Saini, *J. Pharm. Biomed. Sci.*, **14**, 17, (2012).