INTERNATIONAL RESEARCH JOURNAL OF PHARMACY
www.irjponline.com
ISSN 2230 – 8407

Research Article

COMPARATIVE ANTIMICROBIAL ACTIVITIES OF NEEM AND CURRY LEAF EXTRACTS AND THEIR SYNERGISTIC EFFECT AGAINST SELECTED PATHOGENIC BACTERIA AND FUNGUS

Raj Mukesh Bhuva *, Yogini Manohar Dixit
Guru Nanak Institute of Research and Development, Guru Nanak Khalsa College, Mumbai, Maharashtra, India
*Corresponding Author Email: rajbhuva98@gmail.com

Article Received on: 29/09/15 Revised on: 27/10/15 Approved for publication: 06/11/15

DOI: 10.7897/2230-8407.0611147

ABSTRACT

There is a growing demand today for naturally derived drugs and medicine in place of synthetic drugs that are more commercially available. Such drugs derived from indigenous plants are effective as they contain potent therapeutically active compounds of the plants that show antimicrobial activity against a variety of pathogens that cause common diseases. Such diseases as periodontitis and oral candidiasis are a growing concern these days. This study was undertaken to investigate the antimicrobial activity of two indigenous Indian plants, *Azadirachta indica* and *Murraya koenigii* and their synergistic effect, if any, against three pathogenic microorganisms associated with oral diseases and one pathogenic bacteria known to be a nosocomial causative agent. Three bacterial species (*Streptococcus mutans, Streptococcus gordonii, Pseudomonas aeruginosa*) and one fungal species (*Candida albicans*) were selected for antimicrobial assays. Both ethanolic and methanolic extracts were prepared from the leaves of the two plant species in addition to an aqueous extract of *A. indica* and an n-hexane extract of *M. koenigii*. Antibacterial and antifungal assay was done using agar well diffusion method under standard culture conditions. Inhibitory activity was observed for all extracts against *P. aeruginosa* while *A. indica* and *M. koenigii* showed ineffectiveness in inhibiting growth of *C. albicans* and *S. mutans* respectively. *C. albicans* and *S. mutans* were selected for study of synergistic effect based on the results of the initial assay, however there was no synergistic activity observed for any combination of extract mixtures.

Key Words: *Azadirachta indica*, *Candida albicans*, *Murraya koenigii*, *Pseudomonas aeruginosa*, *Streptococcus gordonii*, *Streptococcus mutans*, synergistic effect.

INTRODUCTION

The medicinal potential of several plant species against a plethora of pathogenic microorganisms is well documented in literature, with an exponential growth of academic research on the antimicrobial activities of such plants. More importantly, the study of these indigenous species is a commendable way of preserving the Indian medicinal and scientific heritage as well as move towards developing indigenously made herbal medicines for a variety of diseases instead of importing foreign manufactured drugs. Often, these plants have been demonstrated to have more potency than standard drugs, for instance, when Pillai and Santhakumari 1981[1] revealed that nimbidin, derived from neem oil, served as a much more potent anti-inflammatory drug than the standard drug phenylbutazone. Another concern is the increasing resistance of common bacterial strains to standard antibiotics as Clewell 1981[2] discusses how isolated strains of *Streptococcus sp.* have become resistant to erythromycin, chloramphenicol, aminoglycosides and tetracyclines. Indigenous plants with medicinal properties are thus being explored for their potential activity against drug-resistant bacterial strains too, for instance, in the US patent US6599541 B1 (2003) [3] wherein Brindavanam et al disclose a composition for treating resistant bacteria, comprising an extract obtained from *Azadirachta indica* (neem).

The present study focuses on the antimicrobial activity of *Azadirachta indica* and *Murraya koenigii* against 3 bacterial strains namely: *Streptococcus gordonii* MTCC 2695, *Streptococcus mutans* MTCC 497 and *Pseudomonas aeruginosa* MTCC 1688 and 1 fungal strain, namely *Candida albicans*.

Streptococcus gordonii is a gram-positive, mesophilic cocci that grow in short, bead-like chains. They are non-motile, non-sporing and mainly aerobic.[4] It exists as part of the human oral microflora and colonizes the smooth tooth surface, contributing to formation of dental plaque. Upon invading the bloodstream, it may also cause endocarditis.[5] Entenza et al[6] demonstrates the tolerance of the tolerant derivative of *S. gordonii* to penicillin in the penicillin treatment of experimental endocarditis. This demands the need for a potent alternative antibiotic, with *A. indica* serving as a potential candidate since its bark extracts have been shown to inhibit growth of *Streptococcus sanguis*[7], a close relative to *S. gordonii*. Experimentation with curry leaves (*Murraya koenigii*) has shown antimicrobial activity, albeit not very substantive, against *Streptococcus mutans*[8], again a close relative of *S. gordonii* yet no literature was found for antimicrobial activity of *M. koenigii* against *S. gordonii* itself. Hence, strains of *S. gordonii* and *S. mutans* have been selected for this study as their genetic similarity to *S. sanguis* may lead to similar inhibition patterns due to presence of *A. indica*.

Streptococcus mutans is a gram-positive, non-capsulated coccus, about 0.75 m in diameter when grown on a medium with a neutral or alkaline reaction. *S. mutans* is a major pathogenic agent of dental caries[9] and like *S. gordonii*, it has been known to cause infective endocarditis[10] as well as periodontitis and atheroma.[9] Xavier et al (2007) [11] reports the significant activity of *A. indica* against *S. mutans* but even though Prabhakar A.R. et al (2009) [8] shows antibacterial activity of *M. koenigii* against *S. mutans*, it is reported to show poor substantiality.

Pseudomonas aeruginosa is a gram-negative, rod-shaped, asporogenous, and monoflagellated bacterium. It is found in a variety of environmental settings including in hospitals, sourced from

respiratory therapy equipment, antiseptics, soap, sinks, mops, medicines, and physiotherapy and hydrotherapy pools. This is a primary reason why its colonization rates exceed 50% in patients upon hospitalization and most of the infections of *P. aeruginosa* are hospital-acquired. These include nosocomial pneumonia, ventilator-associated pneumonia and urinary tract infections.[12] *P. aeruginosa* has been proved to be resistant to common antibiotics such as kanamycin and ampicillin by Jain et al (2011).[13] Mehrotra et al (2010) has shown the effectiveness of ethanolic extract of *A. indica* in inhibiting growth of *P. aeruginosa*.[14] Mathur et al (2011) has shown activity of *M. koenigii*, especially through its compound 9, 12 octadecadienoic acid, against *P. aeruginosa* although the activity was reported to be only moderate and that too using the ATCC 25619 strain[15], whereas the present study uses the MTCC 1688 strain of *P. aeruginosa*.

Candida albicans is a diploid fungus that grows as both yeast and filamentous cells and is a causal agent of opportunistic oral and genital infection in humans.[16] It is the most common cause of oral candidiasis, an infection that causes white patches on the tongue and other parts of the mouth and the throat. Oral candidiasis occurs due to the overgrowth of the *C. albicans* colonies existing as part of natural human oral flora, especially when the infected's immunological defences have been undermined.[17] Bohora et al (2010) demonstrates the efficacy of ethanolic extract of neem leaf against *C. albicans*, showing greater antifungal activity than the standard irrigant sodium hypochlorite.[18] The aqueous extract of *A. indica* also inhibits growth and colonization of *C. albicans* although at higher concentrations as shown by Polaquini et al (2006).[19] Doddanna et al (2012) has shown that ethanolic extracts of curry leaf are quite effective in their activity against *C. albicans* although the aqueous extract has close to no activity.[20] This is further verified by Disegha et al (2014) where alcoholic extract of *M. koenigii* showed maximum inhibitory effect whereas the cold aqueous extract was the least effective in inhibiting both *C. albicans* and other fungal species.[21] There has been no study yet in literature on the synergistic activity of *M. koenigii* and *A. indica* on *C. albicans*.

Neem, or *Azadirachta indica*, is well known for its numerous pharmacological properties including antibacterial, antifungal, antiulcer, repellent and pesticide among others.[22] These activities arise due to the presence of nimbin ($C_{30}H_{36}O_9$), nimbinene desacetylnimbinase, nimbandial, nimbolide ($C_{27}H_{30}O_7$) and quercentin ($C_{15}H_{10}O_7$) in neem leaves.[23, 24, 25] Hence, not surprisingly, neem leaf extracts have been used to control leprosy, intestinal helminthiasis and respiratory disorders in children[26] and a range of viruses and pathogens including Vaccinia virus, Chikungunya and measles virus[26], both Gram-positive (example: *Staphylococcus sp.*) and Gram-negative (example: *Escherichia coli*) bacteria as well as a host of other bacterial strains such as *Bacillus cerus, Proteus vulgaris, Salmonella typhi, Klebsiella pneumoniae, Shigella dysenterae*. Among fungal strains, neem shows antifungal activity against *Fusarium oxysporum, Aspergillus flavus, Aspergillus fumigates, Aspergillus niger, Candida albicans, Cladosporium sp., Microsporum canis, Microsporum gypseum, Trichophyton rubrum* and *Trichophyton mentagrophytes*.[26] Thus it would be interesting to study the antimicrobial effect of neem against the selected pathogens too, adding to the repertoire of microbial species that are susceptible to inhibition by neem.

Curry-leaf, or *Murraya koenigii*, is native of India, Sri Lanka and other South Asian countries and is distinguished by its sharp smell. It is well known for its antidysentric, antianemic, antiulcer, antidiarrheal, antidiabetic and analgesic properties in addition to its antibacterial and antifungal activities. The leaves are often applied externally as a traditional remedy for burns and skin itches. Among its antibacterial activity, *M. koenigii* significantly inhibits growth of *Staphylococcus epidermidis*, due to the activity of three carbazole alkaloids namely murrayanol ($C_{20}H_{20}O_9$), mahanine ($C_{23}H_{25}NO_2$) and mahanimbine ($C_{23}H_{25}NO$). [27, 28, 29] Common fungal species against which *M. koenigii* shows activity include *Candida albicans*, *Aspergillus niger* and *Trichophyton rubrum*, due to the mono-terpenoids and sesquiterpenoids present in the leaves of *M. koenigii*.[30] The plant is also highly valued for its leaves an important ingredient in an Indian cuisine to promote appetite and digestion.[31]

The present study seeks to study *in vitro* antibacterial activity of *Azadirachta indica* and *Murraya koenigii* against the aforementioned strains of *S. gordonii, S. mutans P. aeruginosa* and *C. albicans* and more importantly, to determine if there exists a synergistic effect upon combining the extracts of the two plants and testing them for antibacterial activity against the 3 bacterial strains and antifungal activity against the fungal strain.

MATERIALS AND METHODS

Collection of plant material

Fresh leaves of *Azadirachta indica* (Family: *Meliaceae*; Common Name: Neem (English)) and *Murraya koenigii* (Family: *Rutaceae*; Common Name: Curry tree (English)) were collected from a local vendor in Matunga (E), Mumbai, India and were authenticated by Dr (Mrs.) A.S. Upadhye at the Agharkar Research Institute, Pune, India.

Preparation of plant extracts

The collected leaves of *A. indica* and *M. koenigii* were kept for slow drying in an oven for 48 hours at a temperature of 60°C. After drying, the leaves were powdered using a mixer and collected and stored in a cool, dry place. For extraction, cold extraction procedure was used[23] albeit modified. 1g of powdered plant material of *A. indica* was added to 10 cm^3 of methanol, ethanol and distilled water while 1g of powdered plant material of *M. koenigii* was added to 10 cm^3 of methanol, ethanol and n-hexane. These solvents were chosen in particular as they have been commonly featured in literature for extraction purposes. Polar solvents like ethanol and methanol were chosen to extract bioactive compounds that are usually polar, while n-hexane was used to extract any non-polar compounds that might show desired activity. They were then placed for extraction in a rotary shaker for 27 hours at a rate of 35 rpm. After extraction, the mixtures were filtered through Whatman no. 1 filter paper and the filtrates were kept in a water bath at 80°C for complete evaporation to obtain dry, pure extracts. The dry extracts were then dissolved in 1 cm^3 of dimethyl sulfoxide (DMSO) and stored in glass vials.

Preparation of cultures

3 bacterial strains were used, namely – *Streptococcus gordonii* MTCC 2695, *Streptococcus mutans* MTCC 497 and *Pseudomonas aeruginosa* MTCC 1688 along with 1 fungal strain namely *Candida albicans*. The bacterial cultures were grown on Luria Bertani broth (LB) slants for 24 hours at 37°C while fungal culture was grown on Sabouraurd's agar slant for 24 hours at room temperature.[32]

Antimicrobial assay

The agar well diffusion technique[33] was used for antibacterial assay of all 4 strains. For the purposes of antibacterial assay, the cultures in actively growing phase were introduced into 20 cm^3 molten butts of sterile Mueller Hinton Agar following which they were poured into Petri plates. In each Petri plate, 5 wells were made using a 7mm-diameter cork borer. 50 microlitres of each extract of *A. indica* was poured into one of the wells while the remaining 2 wells contained 50 microlitres of the standard antibiotic, ciprofloxacin 20 ppm (positive control) and 50 microlitres DMSO (negative control) respectively. The same process was repeated for extracts of *M. koenigii*. For study of synergistic activity, in each well, 25 microlitres of each extract of *A. indica* was mixed with 25 microlitres of each extract of *M. koenigii*

to make a total of 9 combinations. At the end of incubation of 24 hours at 37°C, the diameter of the zones of inhibition was measured. The assay was performed in three independent trials.

RESULTS

The antimicrobial activity of the plant extracts was qualitatively assessed. As seen in Table 1, all 3 extracts of *A. indica* were effective against the pathogenic strains except against *C. albicans* where all 3 extracts failed to inhibit the growth of the fungus. All 3 extracts of *M. koenigii* too were effective in their activities except against *S. mutans*. Across all 4 pathogens and all 3 extracts of both the plant species, the zone of inhibition was similar, falling in the range of 10.0mm – 12.0mm. The exception was activity against *P. aeruginosa* that showed a larger zone of inhibition of 13.0mm – 14.0mm.

In the antibacterial assay, the highest inhibitory effect was shown by the methanolic and ethanolic extract of *M. koenigii* (zone of inhibition = 14.0 ±0.5mm) both against *P. aeruginosa*, while the least activity was shown by the aqueous extract of *A. indica* against *S. mutans* and n-hexane extract of *M. koenigii* against *S. gordonii* (zone of inhibition = 10.0 ±0.5mm). The aqueous extract of *A. indica* showed no activity against *S. gordonii* while none of the extracts of *M. koenigii* showed activity against *S. mutans*.

In the antifungal assay of *C. albicans*, the highest inhibition was demonstrated by the methanolic extract of *M. koenigii* (zone of inhibition = 12.0 ±0.5mm) and the least by the aqueous extract of the same plant species (zone of inhibition = 10.0 ±0.5mm). None of the extracts of *A. indica* were effective against the fungal strain of the present study.

The measured zones of inhibition of the plant extracts were lesser than those of the standard inhibitor ciprofloxacin. However, the presence of a zone of inhibition in the cultures inoculated with the plant extracts indicates the potent antimicrobial activity of these extracts and their potential to be used in herbal antibiotics that are not artificially synthesized.

For synergistic effect, nine combinations were selected from extracts of the two plants. These combinations, as shown in Table 1, were methanol (neem) – hexane (curry leaf), methanol (neem) – methanol (curry leaf), methanol (neem) – ethanol (curry leaf), ethanol (neem) – hexane (curry leaf), ethanol (neem) – methanol (curry leaf), ethanol (neem) – ethanol (curry leaf), distilled water (neem) – hexane (curry leaf), distilled water (neem) – methanol (curry leaf) and distilled water (neem) – ethanol (curry leaf). These combinations were chosen since for the two selected pathogens, *S. mutans* and *C. albicans*, no extract of curry leaf and neem was effective respectively. Hence, it was important to see if any of one plant's extracts would have a synergistic effect with any of the other plant's extract for some activity against the selected pathogens.

Table 1: Antimicrobial activity of various extracts of *A. indica* AND *M. koenigii*

Plant species	Extract solvent	Zone of inhibition/mm (± 0.5mm)			
		S. mutans	*S. gordonii*	*P. aeruginosa*	*C. albicans*
A. indica	Methanol	11.0	11.0	13.0	0.0
	Ethanol	10.5	12.0	12.0	0.0
	Distilled water	10.0	0.0	12.0	0.0
M. koenigii	Methanol	0.0	12.0	14.0	12.0
	Ethanol	0.0	11.0	14.0	11.0
	n-Hexane	0.0	10.0	13.0	10.0
Positive control (Ciprofloxacin)		15.0	24.0	25.0	24.0

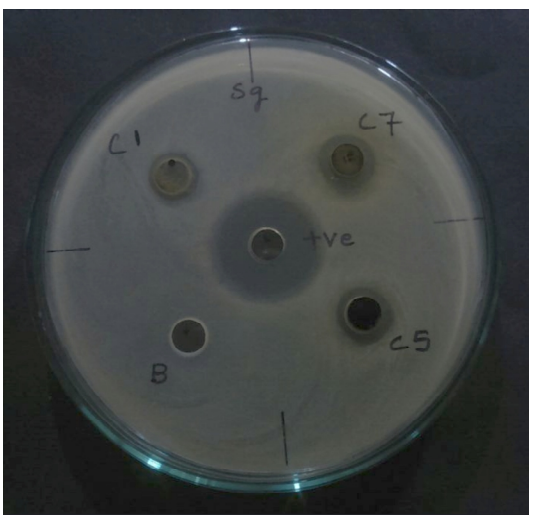

Figure 1: Antibacterial assay of ethanolic, methanolic and hexane extract of *M. koenigii* against *S. gordonii* (C1 = hexane extract; C5 = ethanolic extract; C7 = methanolic extract)

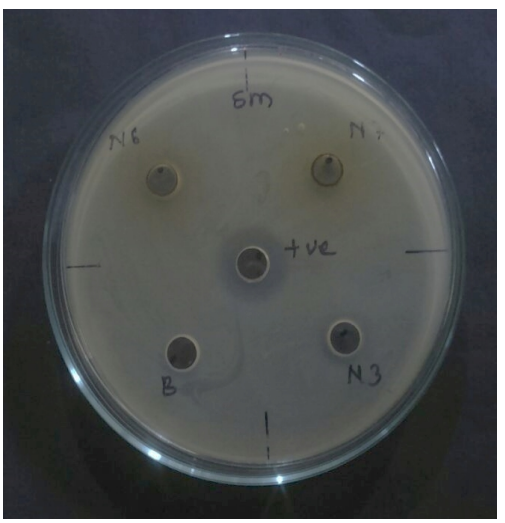

Figure 2: Antibacterial assay of ethanolic, methanolic and aqueous extract of *A. indica* against *S. mutans* (N3 = aqueous extract; N6 = methanolic extract; N7 = ethanolic extract)

DISCUSSION

It has been shown in literature that the antimicrobial activity of both *A. indica* and *M. koenigii* are due to certain pharmacologically active phytochemicals sourced from various parts of the plant. Aslam et al (2009) has confirmed the presence of alkaloids, flavonoids, crude and cardiac glycosides, steroids, triterpenoids, tannic acid and saponins in significant concentrations in the leaf extract of *A. indica*. These are thought to be the active compounds that inhibit bacterial growth, especially against strains of *Streptococcus* genus.[34] The antifungal activity of *A. indica* can be explained from the findings of Pant et al (1986) that show the leaf extract to contain cyclic trisulphide and cyclic tetrasulphide[35] that inhibit fungal growth. As for *M. koenigii*, Mathur et al (2011) not only showed the compound 9,12 octadecadienoic acid to be a potent antimicrobial agent but also confirmed the presence of other active compounds including alkaloids, tannins, saponins and glycosides and with steroids being present prominently.[15]

Further studies need to be done to understand why no synergistic activity exists between the 2 plant extracts. One possible reason could be that the compounds extracted via the selected procedure may have had antagonistic effect instead of synergistic. Another reason could be that the phytochemicals of the 2 plant extracts may have not interacted at all. However, the mixing of extracts meant a smaller quantity of extract dissolved in a larger volume of solvent and thus due to decreased concentration, the individual activities of the phytochemicals may have reduced too.

CONCLUSION

All 3 extracts of *A. indica* and *M. koenigii* showed that they were effective in inhibiting the *in vitro* growth of the pathogenic bacteria *S. gordonii* and *P. aeruginosa* with the exception of aqueous extract of *A. indica* for the former. For the pathogen, *S. mutans*, all 3 extracts of *M. koenigii* were ineffective in antibacterial activity. For the fungal pathogen, *C. albicans*, all 3 extracts of *A. indica* were ineffective. On an average, the highest activity was shown against *P. aeruginosa*. No synergistic effect was observed for any of the different mixtures of the plant extracts against *S. mutans* and *C. albicans*.

ACKNOWLEDGEMENTS

I would like to thank the GNIRD Coordinator, Dr. Sukhjeet Kaur Gujral and all other faculty members of GNIRD who have helped me and supported me during the course of this research. Plant material authentication was done by Dr. (Mrs.) A.S. Upadhye at the Agharkar Research Institute, Pune, India.

REFERENCES

1. Pillai NR, Santhakumari G. Anti-arthritic and anti-inflammatory actions of nimbidin. Planta medica. 1981;49(3):59–63.
2. Clewell D. Plasmids, Drug Resistance, and Gene Transfer in the Genus Streptococcus. Microbiological Reviews [Internet]. 1981 Sep 1 [cited 2015 Oct 10];45(3):409–36.
3. Brindavanam N, Katiyar CK, Narayana D. Composition for treatment of drug resistant bacterial infections and a method of treating drug resistant bacterial infections. US6599541 B1. Jul 29, 2003.
4. Kilian M, Mikkelsen L, Henrichsen J. Taxonomic Study of *Viridans streptococci*: Description of *Streptococcus gordonii* sp. nov. and Emended Descriptions of *Streptococcus sanguis* (White and Niven 1946), *Streptococcus oralis* (Bridge and Sneath 1982), and Streptococcus mitis (Andrewes and Horder 1906) . International Journal Of Systematic Bacteriology [Internet]. 1989 Oct 1 [cited 2015 Oct 14];39(4):471–84.
5. Wells V, Munro C, Sulavik M, Clewell D, Macrina F. Infectivity of a glucan synthesis-defective mutant of *Streptococcus gordonii* (Challis) in a rat endocarditis model. Federation of European Microbiological Societies Microbiology Letter [Internet]. 1993 Sep 1[cited 2015 Oct 16];112(3):301–5.
6. Entenza J, Caldelari I, Glauser M, Francioli P, Moreillon P. Importance of Genotypic and Phenotypic Tolerance in the Treatment of Experimental Endocarditis Due to *Streptococcus gordonii*. The Journal of Infectious Diseases [Internet]. 1997 [cited 2015 Oct 16];175(1):70–6.
7. Wolinksy LE, Mania S, Nachnani S, Ling S. The Inhibiting Effect of Aqueous *Azadirachta indica* (Neem) Extract upon Bacterial Properties Influencing in vitro Plaque Formation. Journal of Dental Research [Internet]. 1996 Feb [cited 2015 Oct 16];75(2):816–22.
8. Prabhakar AR, Ahuja V, Basappa N. Effect of Curry Leaves, Garlic and Tea Tree Oil on *Streptococcus mutans* and Lactobacilli in Children: A Clinical and Microbiological Study. Pesquisa Brasileira em Odontopediatria e Clínica Integrada [Internet]. 2009 Sep [cited 2015 Oct 16];9(3):259–63.
9. Nakano K, Inaba H, Nomura R, Nemoto H, Takeda M et al. Detection of Cariogenic *Streptococcus mutans* in Extirpated Heart Valve and Atheromatous Plaque Specimens. Journal of Clinical Microbiology [Internet]. 2006 Sep [cited 2015 Oct 16];44(9):3313–7.
10. Robbins N, Szilagyi G, Tanowitz H, Luftschein S, Baum S. Infective endocarditis caused by *Streptococcus mutans*. A complication of idiopathic hypertrophic subaortic stenosis. JAMA Internal Medicine [Internet]. 1977 Sep 1[cited 2015 Oct 18];137(9):1171–4.
11. Xavier TF, Vijayalakshmi P. Screening of Antibiotic Resistant Inhibitors from Indian Traditional Medicinal Plants Against *Streptococcus mutans*. Journal of Plant Sciences [Internet]. 2007 [cited 2015 Oct 13];2(3):370–3.
12. Lister P, Wolter D, Hanson N. Antibacterial-Resistant *Pseudomonas aeruginosa*: Clinical Impact and Complex Regulation of Chromosomally Encoded Resistance Mechanisms. Clinical Microbiology Reviews [Internet]. 2009 Oct 1 [cited 2015 Oct 15];22(4):582–610.
13. Jain S, T V, V R, B.C D, Sampath A, K.G S. *et al* Antibiotic Synergy Test: Checkerboard Method on Multidrug Resistant *Pseudomonas aeruginosa*. Int Res J Pharma [Internet]. 2011 Nov 25 [cited 2015 Nov 3];2(12):196–8.
14. Mehrotra S, Srivastava A, Nandi S. Comparative antimicrobial activities of Neem, Amla, Aloe, Assam Tea and Clove extracts against *Vibrio cholerae*, *Staphylococcus aureus* and *Pseudomonas aeruginosa*. Journal of Medicinal Plants Research [Internet]. 2010 Nov 18 [cited 2015 Oct 15];4(22):2393–8.
15. Mathur A, Verma S, Singh S, Prasad G, Dua VK. Investigation of the antimicrobial, antioxidant and anti-inflammatory activity of compound isolated from *Murraya koenigii*. International Journal of Applied Biology and Pharmaceutical Technology [Internet]. 2011 Jan [cited 2015 Oct 18];2(1):470–7.
16. Ryan K, Ray C, editors. Sherris Medical Microbiology. New York. McGraw Hill; 2004.
17. Cannon RD, Holmes AR, Mason AB, Monk BC. Oral Candida: Clearance, Colonization, or Candidiasis. Journal of Dental Research [Internet]. 1995 May [cited 2015 Oct 18];74(5):1152–61.
18. Bohora A, Hegde V, Kokate S. Comparison of the antibacterial efficiency of neem leaf extract and 2% sodium hypochlorite against *E. faecalis*, *C. albicans* and mixed culture - An in vitro study. Endodontology [Internet]. 2013 Dec [cited 2015 Oct 17];25(2):38–45.
19. Polaquini S, Svidzinski T, Kemmelmeier C, Gasparetto A. Effect of aqueous extract from Neem (*Azadirachta indica* A. Juss) on hydrophobicity, biofilm formation and adhesion in composite resin by *Candida albicans*. Archives of Oral Biology [Internet]. 2006 Jun [cited 2015 Oct 17];51(6):482–90.

20. Doddanna S, Patel S, Sundarrao M, Veerabhadrappa R. Antimicrobial activity of plant extracts on *Candida albicans*: An in vitro study. Indian Journal of Dental Research [Internet]. 2013 Jul [cited 2015 Sep 29];24(4):401–5.
21. Disegha G, Izionworu V. Antifungal Activities of Curry Leaf (*Murraya koenigii*) Extract on Some Selected Fungi. Chemistry and Materials Research [Internet]. 2014 [Sonalkar M, Nitave S, Kagalkar. A review on neem plant [Internet]. 2014 Mar 20 [cited 2015 Sep 28];3(4):590–8.
22. Kumar S. Analysis on the Natural Remedies to Cure Dandruff/Skin Disease-causing Fungus- *Malassezia furfur*. Advanced BioTech [Internet]. 2013 Jan [cited 2015 Sep 30];12(7):1–5.
23. National Center for Biotechnology Information. PubChem Compound Database; CID=108058, https://pubchem.ncbi.nlm.nih.gov/compound/108058 [cited 2015 Oct 14]
24. National Center for Biotechnology Information. PubChem Compound Database; CID=100017, https://pubchem.ncbi.nlm.nih.gov/compound/100017 [cited 2015 Oct 14].
25. Asif M. Antimicrobial Potential Of *Azadirachta indica* Against Pathogenic Bacteria And Fungi. Journal of Pharmacognosy and Phytochemistry [Internet]. 2012 Nov [cited 2015 Oct 18];1(4):78–83.
26. National Center for Biotechnology Information. PubChem Compound Database; CID=44258048, https://pubchem.ncbi.nlm.nih.gov/compound/44258048 [cited 2015 Oct 14].
27. National Center for Biotechnology Information. PubChem Compound Database; CID=46229242, https://pubchem.ncbi.nlm.nih.gov/compound/46229242 [cited 2015 Oct 18].
28. National Center for Biotechnology Information. PubChem Compound Database; CID=167963, https://pubchem.ncbi.nlm.nih.gov/compound/167963 [cited 2015 Oct 14]
29. Malwal M, Sarin R. Antimicrobial efficacy of *Murraya koenigii* (Linn.) Spreng. root extracts. Indian Journal of Natural Products and Resources [Internet]. 2011 Mar [cited 2015 Oct 14];2(1):48–51.
30. Handral H, Pandith A, SD S. A review on *Murraya koenigii*: multipotential medicinal plant [Internet]. Asian Journal of Clinical Research. 2012 [cited 2015 Oct 16];5(4):5–14. Available from: http://www.ajpcr.com/Vol5Suppl4/1356.pdf
31. MacWilliams MP, Liao M-K. Luria Broth (LB) and Luria Agar (LA) Media and Their Uses Protocol [Internet]. ASM Microbe Library. 2006 [cited 2015 Oct 20].
32. Perez C, Pauli M, Bazerque P. An antibiotic assay by the agar well diffusion method. Journal of Natural Acta Biologica Et Medica Experimentalis. 1990;15:113–5.
33. Aslam F, Rehman K, Asgar M, Sarwar M. Antibacterial activity of various phytoconstituents of Neem. Pakistan Journal of Agricultural Sciences [Internet]. 2009 [cited 2015 Oct 20];46(3):209–13.
34. Pant N, Garg HS, Madhusudanan KP, Bhakuni DS. Sulfurous compounds from *Azadirachta indica* leaves. Fitoterapia. 1986;57:302–4.

Cite this article as:

Raj Mukesh Bhuva, Yogini Manohar Dixit. Comparative antimicrobial activities of neem and curry leaf extracts and their synergistic effect against selected pathogenic bacteria and fungus. Int. Res. J. Pharm. 2015; 6(11):755-759 http://dx.doi.org/10.7897/2230-8407.0611147

Source of support: Nil, Conflict of interest: None Declared