Journal of Research in Medical and Dental Science
2021, Volume 9, Issue 10, Page No: 70-76

Available Online at: www.jrmds.in
eISSN No.2347-2367: pISSN No.2347-2545

Anti-Inflammatory and Antimicrobial Activity of Silver Nanoparticles Synthesized Using *Piper Longum*

Obuli Ganesh Kishore S[1], R Priyadharshini[1*], S Rajeshkumar[2], Palati Sinduja[1]

[1]Department of Pathology, Saveetha Dental College & Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, India

[2]Department of Pharmacology, Saveetha Dental College & Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, India

ABSTRACT

Background: Piper longum commonly known as long pepper is a traditional medicinal plant that has been used for ages. It was most used to treat respiratory infections, bronchitis, cholera, etc. and could aid in appetite and digestion. Nanoparticles have been employed in the field of medicine due to their ability to target specific cells without damaging the adjacent cells. Nanoparticles were employed as an antimicrobial in bandages whose medicinal properties play a role in wound dressings and antiseptic creams. To comprehend the antimicrobial and anti-inflammatory property of Piper longum, silver nanoparticles were synthesised, and the effects were correlated with their ability to inhibit various microbes in the human body.

Aim: The present study aimed to analyse the antimicrobial and anti-inflammatory activity of silver nanoparticle particles synthesized using Piper longum extract.

Materials and methods: Plant extract-based silver nanoparticles were tested for its anti-inflammatory activity by protein denaturation assay. The standard anti-inflammatory used was diclofenac sodium. To assess the antimicrobial activity, the prepared extract was inoculated in different culture plates containing various microorganisms. The results obtained were collected and statistically analyzed in SPSS software and graphs were obtained.

Results: The silver nanoparticles synthesised using Piper longum showed highest absorbance value at a concentration of 10 microliter (102 nm) when subjected to albumin denaturation assay to check for its anti-inflammatory activity. The maximum percentage of inhibition recorded was 81.1% at 20 microliter concentrations. The zone of inhibition against C. albicans was found to be 8mm, 9mm, 11mm zones at 25, 50, and 100µL and was higher than the standard antifungal agents used. The ANOVA p value was found to be less than 0.05 which indicated statistically significant values.

Conclusion: Silver nanoparticles synthesized using Piper longum extract can act as a potential antifungal agent and anti-inflammatory activity. However, the anti-inflammatory activity of the extract varied with the different concentrations of the extract.

Key words: Anti-inflammatory, antimicrobial, albumin denaturation assay, the zone of inhibition, absorbance, percentage of inhibition, Innovative technique

HOW TO CITE THIS ARTICLE: Obuli Ganesh Kishore S, R Priyadharshini, S Rajeshkumar, Palati Sinduja,Anti-Inflammatory and Antimicrobial Activity of Silver Nanoparticles Synthesized Using *Piper Longum*, J Res Med Dent Sci, 2021, 9(10): 70-76

Corresponding author: R Priyadharshini
e-mail ✉: priyadharshinir.sdc@saveetha.com
Received: 9/9/2021
Accepted: 29/9/2021

INTRODUCTION

Prolonged usage of steroidal and non-steroidal anti-inflammatory drugs are known to be associated with peptic ulcer formation. The search for new anti-inflammatory agents that retain therapeutic efficacy and yet are devoid of these adverse effects should be produced. The uses of medicinal plants for the development of the new drug molecule against bacterial infections show a bright future [1]. A wide variety of medicinal plants used traditionally have not yet been systematically investigated against various microbial pathogens [2].

Piper longum (pippali) also called as Javanese from the *piperaceae* family. *Piper longum* commonly referred to as "long pepper" in India is seen within the tropical and subtropical regions of the planet throughout the Indian subcontinent, Sri Lanka, Middle Eastern countries, and America [3,4]. Piperine is an alkaloid in long pepper for its pungency. It is a rejuvenator and relieves inflammation and pain. It dispels the discomfort in the intestine [5]. Even though there are modern medicines available, herbal medicines have often retained popularity for historical and cultural reasons. Since the usage of those herbal medicines has increased, the problems regarding their

safety, quality, and efficacy in industrialized and developing countries have cropped up [6]. Although there are numerous indications for its use, controlled trials are needed to work out its efficacy [7].

The fruit of long pepper is utilized in palsy, gout, and lumbago. The fruits have a bitter, hot, sharp taste and are tonic to the liver, stomachic, emmenagogue, abortifacient, aphrodisiac, and digestive. They need a pungent pepper-like taste and produce salivation and numbness of the mouth. The fruits and roots are attributed with numerous medicinal uses and should be used for diseases of tracts, cough, bronchitis, asthma etc, as counter-irritant and analgesic when applied locally for pain in muscles and inflammation, as snuff in coma, drowsiness and internally as a carminative [8]. Besides fruits, the roots and thicker parts of the stem are cut and dried and used as a crucial drug within the Ayurvedic and Unani systems.

Natural products with anti-inflammatory activity have been used for a long time as a folk remedy for inflammatory conditions such as fevers, pain, migraine, and arthritis. As the inflammatory basis becomes clearer, there arises a need for various natural food products rich in antioxidants to counteract the diseases arising due to the same [9]. The highest anti-inflammatory potential was observed in chili pepper. Among the selected plants, the plants that improved the secreted cytokine profile were allspice, basil, bay leaves, black pepper, licorice, nutmeg, oregano, sage and thyme. The compounds apigenin, capsaicin, chrysin, diosmetin, kämpferol, luteolin, naringenin, quercetin and resveratrol moderately reduced IL-6 and TNF-alpha secretion [10].

Medicinal plants with antimicrobial, antioxidant, and anti-inflammatory properties have played an important role in the wound healing process. Poly Herbalism results in cheaper medication by reducing the duration of therapy or individual cost for anti-inflammatory and antimicrobial medications. The incidences of new and relapsing infectious disease and antibiotic resistance have greatly increased the susceptibility of delayed healing [11]. A combinatorial synthesis approach can be applied to synthesize the compound which can mimic the natural component present in these medicinal plants with better efficacy [12]. The spices that we Indians use to cook daily have been used for ages for adding flavor and also for the house-hold treatment of infectious diseases. Our team has extensive knowledge and research experience that has translated into high quality publications [13-32]. The aim of the current study is to analyse the Anti-inflammatory and Antimicrobial activity of silver nanoparticles synthesized using *Piper longum*.

MATERIALS AND METHODS

s

Regents and chemical

BSA (Bovine serum albumin) was used as a reagent for the assay. Bovine serum albumin makes up approximately 60% of all proteins in animal serum. It is commonly used in cell culture, particularly when protein supplementation is necessary, and the other components are unwanted.

Preparation of plant extract

The samples were collected by using a randomized sampling method. The plant extract was purchased readymade to hasten the study. 0.5g of *Piper longum* extract was added to 100ml of distilled water and was boiled for 5 minutes at 50 degrees Celsius. The solution was filtered. 1.16g of AgNO3 was added to the extract and was kept in the shaker at 750rpm for half a day. After the complete dissolution of silver. A sample of extracts with different readings in the spectrophotometer were taken in different time intervals. A spectrophotometer is an optical device that can determine the concentration of a compound or particles in a solution or suspension.

Anti-inflammatory activity

The anti-inflammatory activity for silver nanoparticles was tested using an albumin denaturation assay. 0.05 mL of Solanum torvum gel of various fixation (10µL, 20µL, 30µL, 40µL, 50µL) was added to 0.45 mL bovine serum albumin (1% aqueous solution) and the pH of the mixture was acclimated to 6.3 utilizing a modest quantity of 1N hydrochloric acid. Micro pipetting the solutions showed minor errors which was an inconvenience. These samples were incubated at room temperature for 20 minutes and then heated at 55 °C in a water bath for 30 minutes. The samples were cooled, and the absorbance was estimated spectrophotometrically at 660 nm. Diclofenac Sodium was used as the standard. DMSO is utilized as a control. Percentage of protein denaturation was determined utilizing the following equation.

The absorbance of control - Absorbance of sample × 100/ Absorbance of control

Antimicrobial activity

The agar well diffusion method was used to determine the antimicrobial activity of silver nanoparticles using *Piper longum*. Different concentrations of compounds were tested against *Candida albicans, Staphylococcus aureus, Enterococcus faecalis, and Streptococcus mutans*. The fresh suspension of microbes was dispersed on the surface of agar plates. Different concentrations of nanoparticles (50, 100, and 150 microliters) were incorporated into the wells and the plates were incubated at 37 degrees Celsius for 24 hours. The antibiotics and antifungal agents were used as a positive control. Zone of inhibition was recorded in each plate. The study was validated by guides and experts in nano research. Only the zone of growth inhibition was measured while the other criterias of organism with colour change and other activity are excluded.

Statistical analysis

The values obtained from antioxidant and cytotoxic activity assay are entered in excel sheets and correlation analysis was done with IBM SPSS software version 23.

The ANOVA p value was found to be less than 0.05 which indicated statistically significant values.

RESULTS

Antifungal activity

The nano preparation of *Piper longum* plant extract mediated nano formulation showed various percentage of inhibition at different concentration (10µL-50µL) (Table and Figure 1). The nano preparation of *Piper longum* plant extract inhibited *S. mutans, C. albicans, E. faecalis, and S. aureus* at different concentrations (25µL, 50µL, and 100µL)(Figures 2 and Figure 3).

Table 1: The table represents the zone of inhibition of different pathogens at concentrations 25, 50 and 100µL and the zone of inhibition of the standard antibiotic on different pathogens.

Pathogen	25µL	50µL	100µL	Ab
C. albicans	8mm	9mm	11mm	8mm
S. aureus	8mm	8mm	11mm	23mm
E. faecalis	8mm	9mm	7mm	40mm
S. mutans	14mm	13mm	12mm	36mm

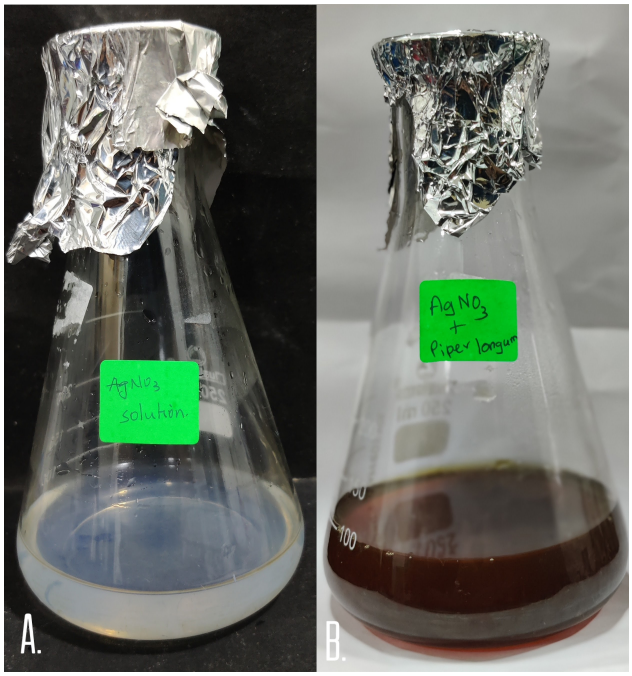

Figure 1: *Piper longum* **mediated silver nanoparticles preparations. A - after dissolving AgNO3 in distilled water. B - after the plant extract was mixed with AgNO3 solution. The characteristic color and property of the prepared extract are observed. There was also a characteristic color change observed after the filtration of the extract.**

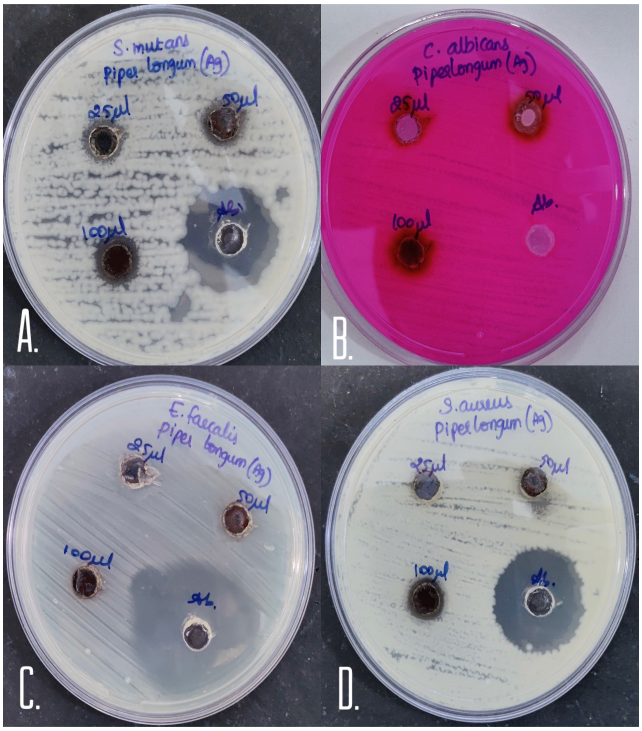

Figure 2: Antimicrobial activity observed in agar plates containing different microorganisms. In plate A, the zone of inhibition of *S. mutans* **was observed at different concentrations (25µL, 50µL, and 100µL). In plate B, the zone of inhibition of** *C. albicans* **at different concentrations was observed. In plate C, the zone of inhibition of** *E. faecalis* **was observed at different concentrations. In plate D, the zone of inhibition of** *S. aureus* **was observed at different concentrations.**

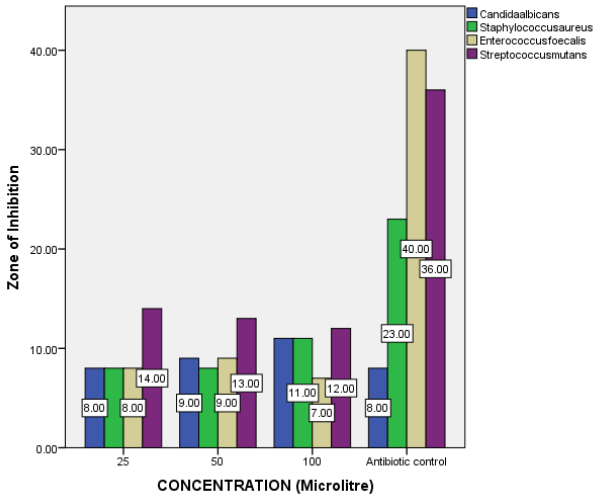

Figure 3: The graph represents the antimicrobial activity of the extract over different microorganisms. X axis showed concentration at varying microlitre. The zone of inhibition was measured as diameter. Y axis represents zone of inhibition of varying microorganisms. *C. albicans* **(blue),** *S. aureus* **(green),** *E. faecalis* **(yellow), and** *S. mutans* **(purple).** *C. albicans* **showed an increased zone of inhibition.**

Anti-Inflammatory

The anti-inflammatory activity is shown in Figures 4 and Figure 5, Table 2.

Table 2: The table is the comparison of the control and the percentage of inhibition with increase in concentration (µL).

Concentration (Microlitre)	Control	Percentage of inhibition
10	65.6	79.9
20	55.4	81.1
30	40.8	80.7
40	34.9	80.9
50	26.4	79.1

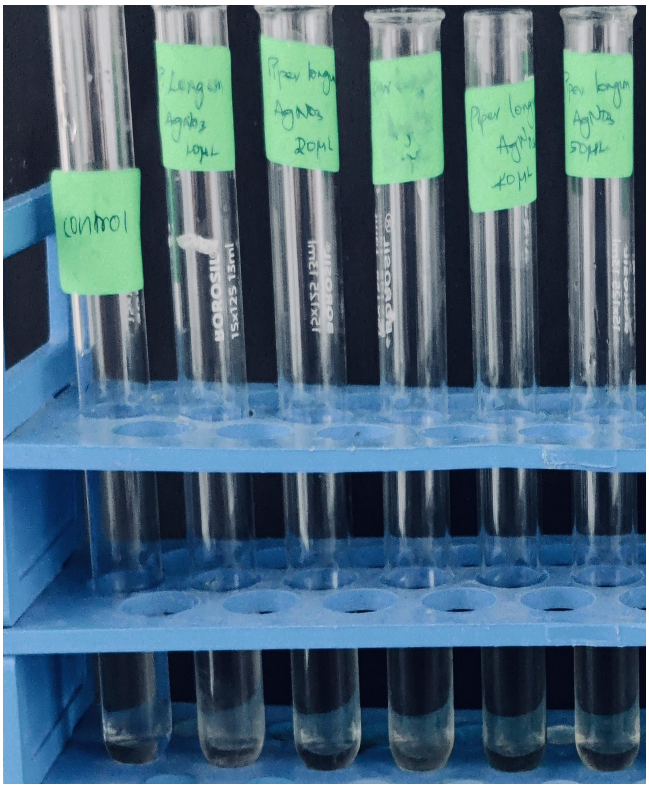

Figure 4: Anti-inflammatory activity assessed using albumin denaturation assay of the reaction mixture at different concentrations compared to a positive control diclofenac sodium.

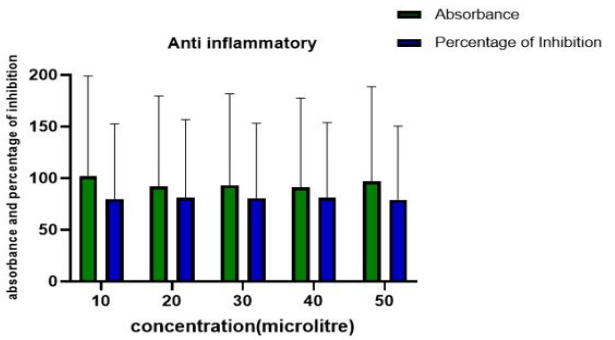

Figure 5: The graph represents the anti inflammatory activity of extract and control with the X axis representing concentration at varying microlitre. Y axis represents the absorbance and percentage of inhibition showing negative correlation with increase in concentration (r=-1) with 26mm at 50microlitre concentration.

DISCUSSION

The study showed that silver nanoparticles synthesized using *Piper longum* extract can act as an anti-inflammatory agent. It was observed from the spectra that the extract at 660 nm had the highest value of absorbance at a concentration of 10 µL which was found to be 0.102, which proved the denaturation of albumin was significant. In a similar study conducted, the zinc oxide nanoparticles synthesized using grape seed extract showed the highest absorbance value at 50µL concentration [12,33]. Hence, agents that can prevent

protein denaturation can be used as an anti-inflammatory agent. The inhibition of protein denaturation by the prepared extract was maximum at 20 µL concentration which was found to be 81.1%. From another similar research conducted, the maximum inhibition of protein denaturation was observed at 20µL concentration which was found to be 79%. The study was on coriander oleoresin-mediated selenium nanoparticles [34]. By comparing with the control which was diclofenac sodium, it showed a 0.087 absorbance value and 81.9% inhibition of protein denaturation at 10 µL concentration. The highest percentage of inhibition of the extract prepared showed a maximum value of 89% at 50µL concentration [35]. From a study conducted, we may understand that silver when compared with any anti-inflammatory agent can yield potent anti-inflammatory activity [36]. Basically the more the protein is denatured the more there will be inflammation. Hence the extent of inflammation can be reduced by inhibiting protein denaturation. From a study conducted, L Theanine mediated silver nanoparticles were close to being apt as an anti-inflammatory agent as it had only a slight decrease compared to the control [37]. At 10µL concentration, the prepared extract showed an absorbance value of 0.102 nm and 79.9% inhibition, at 20 µL concentration, it showed 0.092 nm absorbance value and 81.1% inhibition, at 30 µL the absorbance value was 0.093 nm and the percentage of inhibition was 80.7%. At 40µL and 50µL concentrations, the absorbance values were 0.091nm and 0.097nm respectively and the percentage of inhibition was 80.9% and 79.1% respectively. The absorbance value of the control was 0.087nm and the percentage of inhibition was 81.9%.

The optimized silver nanoparticles were tested for antimicrobial activities in *S.mutans, S.aureus, E. faecalis,* and *C. albicans*. The zone of inhibition was observed for each of the organisms at 25, 50, and 100 µL concentrations. The growth of all cultures in normal conditions showed all the phases of growth, but when they were treated with the synthesized silver nanoparticles there was a reduction in the growth phase. From a study conducted by Soumya Et al. the bacterial cultures showed a bacteriostatic effect on adding the synthesized selenium nanoparticles [37,38]. By comparing the results obtained with a study conducted by Swapna Et al. the silver nanoparticles confirmed antibacterial activity by forming a zone of inhibition against *S. aureus, Lactobacillus species, S. mutans* [39]. The antibacterial activity is mainly due to the penetration of the cations of the nanoparticles penetrating the cell membrane and killing them.

The agar plate containing *S. mutans* culture showed 14mm, 13mm, and 12mm zones of inhibition at 25, 50, and 100 µL concentrations respectively. Whereas the same organism showed a zone of inhibition of 36mm with a standard antibiotic. Similarly, *S. aureus* showed 8, 8, 11mm zones of inhibition at various concentrations whereas the standard antibiotic showed 23mm inhibition. *E. faecalis* showed 8mm, 7mm, and 11mm zones of inhibition at 25, 50, and 100µL concentrations, whereas the standard antibiotic showed a 40mm zone of inhibition. When the fungi *C. albicans* was cultured and the zone of inhibition for the prepared extract was assessed, it showed 8mm, 9mm, 11mm zones at 25, 50, and 100µL concentrations which were higher than the standard antifungal. The standard antifungal showed only an 8mm zone of inhibition. Hence the optimized nanoparticles can be a potent antifungal agent. The antimicrobial activity of silver nanoparticles synthesized using *Piper longum* plant extract can be used as an antimicrobial agent after controlling and regulating the morphology and particle size of synthesized nanoparticles.

In a previous study conducted by Satheesha et al. *S. aureus* was the most sensitive bacteria followed by *E. faecalis* and *S. mutans*. The gram-positive organisms showed a maximum zone of inhibition at 100µL concentration which showed a diameter of 42mm [40]. In the study conducted by Nafeesa et al. the alcoholic extract of tulsi leaves mediated silver nanoparticles were assessed to observe the antifungal activity. The plant extracts mediated Ag nanoparticles showed immense antifungal potential and can be used in the management of fungal infections [41]. Silver nanoparticles were found to be potent inhibitors of *C.albicans* biofilm formation from a study conducted [42]. The mechanism of fungal growth inhibition was not due to the penetration of the cell membrane, it was due to the release of silver ions that infiltrated into the cells leading to the formation of organic compounds present in the cell wall and cytoplasm. The silver nanoparticles hence have proved to have a cytotoxic effect on the fungi *C.albicans*.

The limitation of this study is that during the micropipette of solutions, concentration errors were obtained which were difficult to rectify. Prepared extract was not tested in different concentrations. Different species of *Piper longum* plant were not tested for antimicrobial and anti-inflammatory activities. Comparing the anti-inflammatory effect with different standards other than diclofenac sodium was not done. With further advancements in this study, increased concentrations of the same extract could be used to test different activities, which could lead to the production and manufacturing of natural product-based medicines.

CONCLUSION

Piper longum plant has better anti-inflammatory and antifungal activity as compared to the standard drugs examined. Further development and processing of the extract can lead to the development of a potent anti-inflammatory and antifungal agent. The present study paves way for creating new pathways in the field of natural medicine and can potentially improve the health of the individual by providing natural and safer methods.

ACKNOWLEDGEMENT

The authors are thankful to Saveetha Institute of Medical and Technical Sciences, Saveetha Dental College and

Hospitals, Saveetha University for giving a platform to conduct the study.

CONFLICT OF INTEREST

The authors would like to declare no conflict of interest in the present study.

FUNDING

The present project is supported by Saveetha Dental College and Hospitals, Saveetha University, Saveetha Institute of Medical and Technical Sciences, SARKAV Health Services, Chennai.

REFERENCES

1. Baker JT, Borris RP, Carté B, et al. Natural product drug discovery and development: New perspectives on international collaboration. J Nat Prod 1995; 58:1325–57.
2. Aqil F, Ahmad I. Broad-spectrum antibacterial and antifungal properties of certain traditionally used Indian medicinal plants. World J Microbiol Biotechnol 2003; 19:653–657.
3. Mammen D, Daniel M. A Critical review on the pharmacognosy and chemistry of the fruiting spikes of Piper Longum L. Indian J Applied Res 2011; 4:429–32.
4. Yadav R, Saini H, Kumar D et al. Bioengineering of Piper longum L. extract mediated silver nanoparticles and their potential biomedical applications. Mater Sci Eng C Mater Biol Appl 2019; 104:109984.
5. Kirtikar KR, Basu BD, Cs I. Indian medicinal plants, oriental enterprises. Dehradun 2001; 6:2029–2035.
6. Sharma R, Kumari N, Ashawat MS, et al. Standardization and phytochemical screening analysis for herbal extracts: Zingiber officinalis, Rosc., Curcuma longa Linn., Cinnamonum zeylanicum Nees., Piper longum, Linn., Boerhaavia diffussa Linn. Asian J Pharm Technol 2020; 10:127.
7. Kumar S, Kamboj J, Sharma S. Overview for various aspects of the health benefits of Piper longum linn. fruit. J Acupuncture Meridian Studies 2011; 4:134-40.
8. Huang H, Shan K, Liu J et al. Synthesis, optimization and characterization of silver nanoparticles using the catkin extract of Piper longum for bactericidal effect against food-borne pathogens via conventional and mathematical approaches. Bioorg Chem 2020; 103:104230.
9. Sharma P. Pharmacognostical, physicochemical and phytochemical studies of piper longum linn. fruits. Int J Pharm Educ Res 2019; 1:19–24.
10. Mueller M, Hobiger S, Jungbauer A. Anti-inflammatory activity of extracts from fruits, herbs and spices. Food Chem 2010; 122:987–96.
11. Hetta HF, Kh Meshaal A, Algammal AM, et al. In-vitro Antimicrobial activity of essential oils and spices powder of some medicinal plants against species isolated from raw and processed meat. Infect Drug Resist 2020; 13:4367–78.
12. Arutselvi R, Balasaravanan T, Ponmurugan P, et al. Comparative Studies of anti-microbial activity of turmeric and selected medicinal plant leaf extracts used in indian traditional medicine. J Herbs Spices Med Plants 2012; 18:231–9.
13. Anita R, Paramasivam A, Priyadharsini JV, et al. The m6A readers YTHDF1 and YTHDF3 aberrations associated with metastasis and predict poor prognosis in breast cancer patients. Am J Cancer Res 2020; 10:2546–54.
14. Jayaseelan VP, Paramasivam A. Emerging role of NET inhibitors in cardiovascular diseases. Hypertens Res 2020; 43:1459–61.
15. Sivakumar S, Smiline Girija AS, Vijayashree Priyadharsini J. Evaluation of the inhibitory effect of caffeic acid and gallic acid on tetR and tetM efflux pumps mediating tetracycline resistance in Streptococcus sp., using computational approach. J King Saud University Sci 2020; 32:904–9.
16. Smiline Girija AS. Delineating the immuno-dominant antigenic vaccine peptides against gacs-sensor kinase in acinetobacter baumannii: An in silico investigational approach. Front Microbiol 2020; 11:2078.
17. Iswarya Jaisankar A, Smiline Girija AS, Gunasekaran S, et al. Molecular characterisation of csgA gene among ESBL strains of A. baumannii and targeting with essential oil compounds from Azadirachta indica. J King Saud University Sci 2020; 32:3380–7.
18. Girija ASS. Fox3+ CD25+ CD4+ T-regulatory cells may transform the nCoV's final destiny to CNS! J Med Virol 2020.
19. Jayaseelan VP, Ramesh A, Arumugam P. Breast cancer and DDT: Putative interactions, associated gene alterations, and molecular pathways. Environ Sci Pollut Res Int 2021; 28:27162–73.
20. Arumugam P, George R, Jayaseelan VP. Aberrations of m6A regulators are associated with tumorigenesis and metastasis in head and neck squamous cell carcinoma. Arch Oral Biol 2021; 122:105030.
21. Kumar SP, Girija ASS, Priyadharsini JV. Targeting NM23-H1-mediated inhibition of tumour metastasis in viral hepatitis with bioactive compounds from Ganoderma lucidum: A computational study. Pharma Sci 2020; 82.
22. Girija SA, Priyadharsini JV, Paramasivam A. Prevalence of carbapenem-hydrolyzing OXA-type β-lactamases among Acinetobacter baumannii in patients with severe urinary tract infection. Acta Microbiol Immunol Hung 2019; 67:49–55.

23. Priyadharsini JV, Paramasivam A. Key regulators of viral response in cancer patients. Epigenomics 2021; 13:165–7.
24. Mathivadani V, Smiline AS, Priyadharsini JV. Targeting epstein-barr virus nuclear antigen 1 (EBNA-1) with murraya koengii bio-compounds: An in-silico approach. Acta Virol 2020; 64:93–9.
25. Girija As S, Priyadharsini JV. Prevalence of Acb and non-Acb complex in elderly population with urinary tract infection (UTI). Acta Clin Belg 2021; 76:106–112.
26. Anchana SR, Girija SAS, Gunasekaran S, et al. Detection of csgA gene in carbapenem-resistant Acinetobacter baumannii strains and targeting with Ocimum sanctum biocompounds. Iran J Basic Med Sci 2021; 24:690–8.
27. Girija ASS, Shoba G, Priyadharsini JV. Accessing the T-Cell and B-Cell immuno-dominant peptides from a.baumannii biofilm associated protein (bap) as vaccine candidates: A computational approach. Int J Pept Res Ther 2021; 27:37–45.
28. Arvind P TR, Jain RK. Skeletally anchored forsus fatigue resistant device for correction of class II malocclusions-A systematic review and meta-analysis. Orthod Craniofac Res 2021; 24:52–61.
29. Venugopal A, Vaid N, Bowman SJ. Outstanding, yet redundant? After all, you may be another choluteca bridge. Semin Orthod 2021; 27:53–6.
30. Ramadurai N, Gurunathan D, Samuel AV, et al. Effectiveness of 2% articaine as an anesthetic agent in children: Randomized controlled trial. Clin Oral Investig 2019; 23:3543–50.
31. Varghese SS, Ramesh A, Veeraiyan DN. Blended module-based teaching in biostatistics and research methodology: A retrospective study with postgraduate dental students. J Dent Educ 2019; 83:445–50.
32. Mathew MG, Samuel SR, Soni AJ, et al. Evaluation of adhesion of Streptococcus mutans, plaque accumulation on zirconia and stainless steel crowns, and surrounding gingival inflammation in primary molars: Randomized controlled trial. Clin Oral Investigations 2020; 24:3275–3280.
33. Agarwal H, Shanmugam V. A review on anti-inflammatory activity of green synthesized zinc oxide nanoparticle: Mechanism-based approach. Bioorg Chem 2020; 94:103423.
34. Kishen A, Rajeshkumar S, Preejitha VB. Cynodon dactylon mediated synthesis of selenium nanoparticles and its antimicrobial activity against oral pathogens. Int J Res Pharma Sci 2020; 11:4152–6.
35. Abirami M, Sudharameshwari K. Study on plant extract mediated synthesis of silver nanoparticles using combination of cardiospermum halicacabum and butea monosperma & screening of its antibacterial activity. Int J Pharmacog Phytochem Res 2017; 9:663-6.
36. Jain A, Anitha R, Rajeshkumar S. Anti-inflammatory activity of Silver nanoparticles synthesised using Cumin oil. Res J Pharm Technol 2019; 12:2790.
37. Banerjee P, Satapathy M, Mukhopahayay A, et al. Leaf extract mediated green synthesis of silver nanoparticles from widely available Indian plants: Synthesis, characterization, antimicrobial property and toxicity analysis. Bioresources Bioprocessing 2014; 1.
38. Menon S, Agarwal H, Rajeshkumar S, et al. Investigating the antimicrobial activities of the biosynthesized selenium nanoparticles and its statistical analysis. Bio Nano Sci 2020; 10:122–135.
39. Sreenivasagan S, Subramanian AK. Assessment of antimicrobial activity and cytotoxic effect of green mediated silver nanoparticles and its coating onto mini-implants. Annals Phytomed Int J 2020; 9.
40. S SK, Satheesha KS. In-Vitro antibacterial activity of black tea (camellia sinensis) mediated zinc oxide nanoparticles against oral pathogens. Biosci Biotechnol Res Communications 2020; 13:2077–2080.
41. Khatoon N, Mishra A, Alam H et al. Biosynthesis, characterization, and antifungal activity of the silver nanoparticles against pathogenic candida species. Bio Nano Sci 2015; 5:65–74.
42. Lara HH, Romero-Urbina DG, Pierce C, et al. Effect of silver nanoparticles on Candida albicans biofilms: An ultrastructural study. J Nanobiotechnol 2015; 13:91.