Summary and Conclusion

5. SUMMARY AND CONCLUSION

Researchers are increasingly turning their attention to natural products and looking for new leads to develop better drugs against viral and microbial infections. Several synthetic antibiotics are employed in the treatment of infections and communicable diseases. The harmful microorganisms can be controlled with drugs and this has resulted in the emergence of multiple drug resistant bacteria and it has created alarming clinical situations in the treatment of infections. Therefore, actions must be taken to reduce the problem, such as, to develop the research of resistance among microorganism and to continue studies to develop new antibiotic and immune modulating compounds with diverse chemical structures and novel mechanisms of action, either synthetic or natural to control pathogenic microorganisms because there has also been an alarming increase in the incidence of new and re-emerging infectious diseases.

Medicinal plants represent a rich source from which antimicrobial agents obtained. The antimicrobial activities of plants may reside in a variety of different compounds. Antimicrobial drugs have caused a dramatic change for the treatment of infectious diseases. Antimicrobial chemotherapy made remarkable advances, resulting in the overly optimistic view that infectious diseases would be conquered in the near future.

The synthesis of a newer class of anti-bacterial and anti-fungal agents is in need of time, especially against drug-resistant fungi and bacteria, such as Gram-positive and Gram-negative strains, which are responsible for a number of serious infections. The search of new antimicrobial agents with reduced toxicity and lower side effects is of continuous process.

The synthesis of nanoparticles is an emerging area of research due to their use in a variety of biological methods. Silver nanoparticles are widely synthesized due to its applications in various fields. Its applications have been seen mostly in products that come in direct contact with humans. Hence, there is a need to develop biological methods for the synthesis of silver nanoparticles.

In the present study, the synthesis of nanoparticles using the methanolic leaf extract of *A. adenophora* was done to optimize the method for the synthesis of silver nanoparticles and to analyse their antimicrobial potential. The bioactive compound eupalitin was subjected to *in silico* studies.

Four different methods like heating at 60°C in a water bath, by microwave, at room temperature and by exposure to sunlight were used to synthesis the nanoparticles. It was found that all the four methods produced the AgNPs efficiently from *A. adenophora* leaf extract. However, exposure to sunlight for 20 minutes was the most quick and efficient method for the synthesis of AgNPs.

The AgNPs synthesized by various methods were subjected to absorption spectrum in both UV and visible range, and the spectra showed a characteristic peak between 400-450nm. The range indicates that synthesis of silver nanoparticles increased on increasing the time of exposure, confirming that the immediate colour change was due to the synthesis of AgNPs.

SEM results provided further insight into the morphology, where the particles were roughly spherical in shape and found to be in aggregates at nanoscale. The FTIR results also confirmed the formation of silver nanoparticles by showing prominent absorption peaks. Thus, in the present study, all the physiochemical characteristics (absorption spectrum, SEM imaging and FTIR analysis) confirmed the nature of the AgNPs synthesized from *A. adenophora* leaf extract.

The bioactivity of the AgNPs was monitored in terms of antimicrobial activity. The results obtained from the experiments conducted in this study showed that the synthesised AgNPs found to have maximum activity against all the pathogenic strains tested to different extent.

Among the bacterial strains, AgNPs were found to have maximum activity against *Staphylococcus aureus, Escherichia coli*, *Pseudomonas aeruginosa, Proteus vulgaris*, and *Salmonella typhi,* while the same was found to be moderately effective against *Shigella flexneri.* and *Klebsiella pneumonia.*

Among the fungal strains, the inhibition activity was seen to a larger extent towards *Aspergillus niger*, *Aspergillus flavus* and *Candida albicans*, and lesser extent was showed against *Rhizopus indicus*, *Aspergillus fumigatus* and *Mucor oryzae*.

Also, it is clearly evident from our *in silico* studies, eupalitin has a good bioavailability a non-toxic compound which can be developed into a drug. The docking results of eupalitin with the target protein dihydrofolate reductase of different bacteria and fungi indicated that eupalitin will easily inhibit the microbes that are responsible for several diseases.

Thus, the present study strongly proves the antimicrobial efficacy of silver nanoparticles synthesised from *A. adenophora* leaf extract, the medicinal value of the eupalitin and scientifically validates it for use as a component of medicinal preparations, to address the infectious disease caused by microorganisms.

Suggestions for future research

The outcome of the present study has opened the way for addressing several other research problems in the current scenario. Some of the suggestions for the future research include the following,

- Other than AgNPs, other metal NPs can be synthesised using leaves of *A. adenophora* and their bioactivity can be compared.
- The cytotoxic effects can be studied using *in vitro* models.
- The anticancer activity of the synthesised nanoparticles can be studied.
- The bioavailability and toxicity of eupalitin can be further determined with animal models.