Annals of R.S.C.B., ISSN: 1583-6258, Vol. 25, Issue 6, 2021, Pages. 1584-1593
Received 25 April 2021; Accepted 08 May 2021.

Antimicrobial activity of silver nanoparticles synthesised using Solanum Xanthocarpum extract against oral microbes

Running title:Antimicrobial activity of Solanum Xanthocarpum induced silver nanoparticles

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ABSTRACT

Introduction

In the branch of nanotechnology, the synthesis of nanoparticles and their development play a significant role because of their wide applications. They are used as antimicrobial agents and prevent the development of multidrug resistant bacteria.All parts of Solanum xanthocarpum plant, including the stem, flowers, fruits and roots have proved to have medicinal properties.

Aim

This study aimed to evaluate antimicrobial activity of silver nanoparticles synthesised using Solanum Xanthocarpum extract against oral microbes.

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Materials and Methods

For this study about 25 grams of dried fruit powder of Solanum Xanthocarpum was mixed with 250 ml of water, placed in a rotating shaker at room temperature for 48 hours,filtered, air dried in room temperature and stored at 4 degree C. 25 ml of plant filtrate was added into 225 ml of aqueous solution of 1mM silver nitrate for reduction of silver nitrate into Ag+ ions and kept at room temperature for 24 hours in a rotating shaker at 28degree C.

Results

Solanum xanthocarpum induced with silver nanoparticles showed good antibacterial activity against oral pathogens.

Conclusion

The use of fruits for the synthesis of silver nanoparticles has many advantages such as, ease with which the process can be scaled up, economic viability and to obtain smaller particle size.

Clinical Significance

The capability of other plant parts such as fruit and root as a capping and reducing agent is not tested and not well defined.In the present study, it was found that fruits were a good source for the synthesis of silver nanoparticles.

Keywords

Antimicrobial Activity; Silver nanoparticles;Solanum xanthocarpum;Oral microbes

INTRODUCTION

Nanotechnology occupies tremendous applications in diverse fields such as chemistry, cosmetics, catalysis, energy, plasmonics, opto-electronics and medicine. In the branch of nanotechnology, the synthesis of nanoparticles and their development play a significant role because of their wide applications.

Nanoparticles are used as antimicrobial agents and they are highly effective and acquire huge attention as they satisfy the requirements where antibiotics fail to prevent the development of Multi-Drug Resistant (MDR) mutants. Many studies have explained the advantages of introducing a material with better properties, including the use of nanotechnology to fabricate antimicrobial agents.

Plant mediated biological synthesis of silver nanoparticles is of importance due to its ecofriendliness and its simplicity.Biosynthesis of silver nanoparticles from plants such as Euporbia hirtaki,(Elumalai et al. 2010) Svensonia hyderabadrensis,(Rao and Savithramma 2011) Trianthena decandre,(Geethalakshmi and Sarada 2010) Shorea tumbuggaia (Venkateswarlu et al. 2010) have been reported previously.

Solanum Xanthocarpum of the Family Solanaceae is a prickly, perennial, diffuse, patch forming herb, flowering and fruiting throughout the year and it is most commonly found in Southeast Asia, Malaysia, and in all districts of Tamil Nadu, India. (K. M. Mathew 1983)This plant is also known as Yellow berried nightshade/ Indian nightshade ,Other names of the plant include Kandangathiri/ Kantakari ,Kateli/ Berkateli.(Pandey 2004) All parts of the plant, including the stem, flowers, fruits and roots have medicinal properties. In India, entire dried plant is used for treating diseases like leprosy, dropsy and cough.(Prempeh and Mensah-Attipoe 2008)

Pharmacological activities of the plant include antibacterial,antifungal, antinociceptive,antioxidant,hypoglycemic and larvicidal properties.(Samiei et al. 2013)According to a study that was done by Pandey et al ,seed fumes of this

plant were useful in the relieving tooth pain and pain from gingival swellings and also useful in treatment of fever, rheumatism, pneumonia and other respiratory troubles.(Sheeba 1970)

Previously our team has a rich experience in working on various research projects across multiple disciplines (L. Govindaraju and Gurunathan 2017; A. Christabel et al. 2016; Soh and Narayanan 2013; Mehta et al. 2019; Ezhilarasan, Apoorva, and Ashok Vardhan 2019; Campeau et al. 2014; Kumar and S 2016; S. L. Christabel 2015; Kumar and Rahman 2017; Sridharan, Ramani, and Patankar 2017; Ramesh et al. 2016; Thamaraiselvan et al. 2015; Thangaraj et al. 2016; Ponnulakshmi et al. 2019; "Fluoride, Fluoridated Toothpaste Efficacy and Its Safety in Children - Review" 2018) Now the growing trend in this area motivated us to pursue this project.

This study aimed to evaluate antimicrobial activity of silver nanoparticles synthesised using Solanum Xanthocarpum extract against oral microbes.

MATERIALS AND METHODS

Collection of pathogens

The pathogens used for antimicrobial activity were collected from Tamil Nadu, India. The pathogens used for the study were E.fecalis,Candida Albicans,S.Mutans,S.Aureus.

Collection of plant materials

Fruit of Solanum xanthocarpum was collected from Tamilnadu, India. The collected plant materials were brought to the laboratory for plant extraction and for synthesis of silver nanoparticles.

Processing of plant materials

The fruit of Solanum Xanthocarpum was collected and washed thoroughly.The fruit was then cut into smaller pieces for quick drying. Cleaned fruits were shade dried for 10-15 days and the dried plant materials were crushed into fine powder with the help of an electric grinder. The fine powder obtained was stored in an airtight container at room temperature.

Preparation of Solanum xanthocarpum fruit extract

For preparation of Solanum Xanthocarpum fruit extract,25 grams of dried fruit powder was mixed with 250 ml of distilled water. The solution was stirred for proper mixing. Then the solution was placed in a rotating shaker (100rpm) at room temperature for 48 hours. After incubation, the extract was filtered in Whatman No: 1 filter paper. Finally the filtrate was allowed to air dry at room temperature and dried powder was stored at 4 degree C until it was used.

Synthesis of silver nanoparticles from fruit extract

25 ml of solanum xanthocarpum filtrate was added into 225 ml of aqueous solution of 1mM of silver nitrate for the reduction of silver nitrate into silver ions and kept at room temperature for 24 hours in a rotating shaker at a temperature 28degree C. The solution was kept in the dark to avoid other biological changes.By this process silver nanoparticles were produced by the reduction of silver ions to metallic silver. Silver nanoparticles were determined by the change in colour of the reaction mixture.

Analysis of silver nanoparticles in Solanum Xanthocarpum fruit extract

UV-vis Spectrophotometer analysis

UV-vis spectrophotometer was used for the Spectrophotometer analysis. The reduction of Ag+ ions was monitored by measuring the UV-vis spectrum of the reaction medium. The wavelength of the spectrophotometer was taken between 300-550 nm. 2.5 ml of plant filtrate extracts and 22.5 ml of water was prepared as blank for UV-vis Spectrophotometer analysis.

Antibacterial activity

The Muller Hinton agar plates and Rose Bengal agar plates were swabbed with bacterial pathogens and filled with 10-50µl (200-1000µg) of plant extract. The plates were incubated at a temperature of 37OC for 48 hours and after

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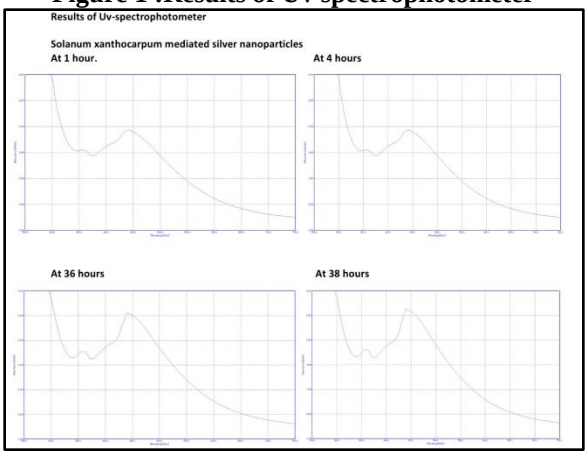
the incubation period, the diameters of zone of inhibition produced by the sample with different organisms in different plates were measured and was recorded.

RESULTS AND DISCUSSION

Analysis of silver nanoparticles in plant extract

Reduction of silver ions to silver nanoparticles were analysed by observing the colour change and UV-Vis spectroscopy.(Figure 1 and Figure 2)

Figure 1 :Results of Uv spectrophotometer



Colour change

The synthesized silver nanoparticles were confirmed by naked observation. Production of silver nanoparticles takes place by the reduction of silver ions during exposure to the plant followed by color change. Within 2 hours the silver ions gets reduced and it exhibits colourless to dark reddish brown colour.This colour change is due to the Surface Plasmon Resonance (SPR) phenomenon.(Figure 2)

Figure 2 :Colour change observed before and after addition of silver nanoparticles.

UV-VIS Spectra analysis

Wavelength between 400-450nm the formation of silver nanoparticles reach the peak maximum.The specific characteristic peak for silver nanoparticles was due to the SPR.The UV-Visible spectrum shows the formation of silver nanoparticles of aqueous fruit extract as the peak maxima in 440 nm.This is characteristic to silver nanoparticles and the broadening of peak indicated that the particles were polydispersed.(Figure 3)

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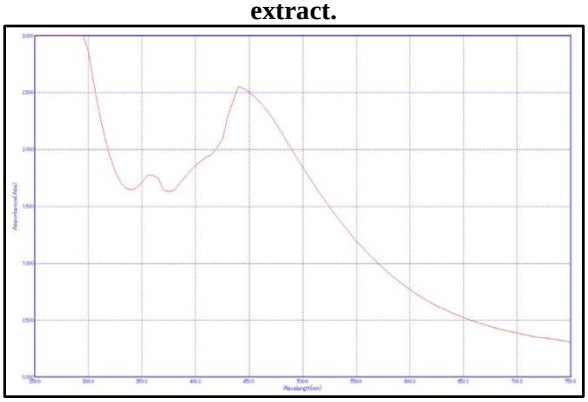
Figure 3:UV-vis spectrograph of Ag nanoparticle synthesized from Solanum xanthocarpum aqueous fruit extract.



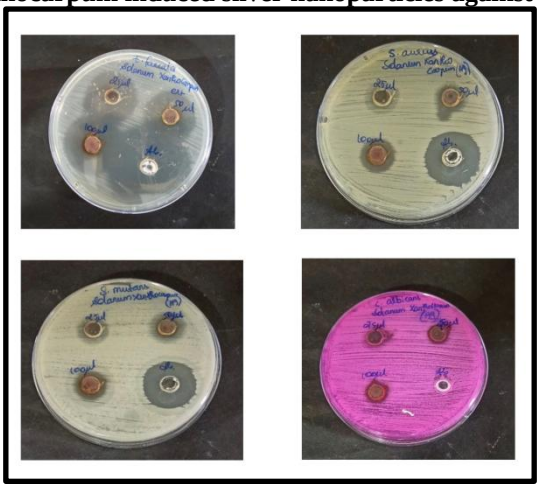
Antibacterial activity of aqueous fruit extract of Solanum xanthocarpum induced with silver nanoparticles against pathogens.

The activity was limited in Candida albicans spp (14 mm). The best activity was found in E.feacalis(35 mm),followed by S.mutans (23mm), and S.aureus sp. (20 mm) in 100 µg concentration. (Figure 4)(Figure 5)

Figure 4: Zone of inhibition against various oral pathogens.

Organisms	Concentration	Concentration	Concentration	Concentration
	25 ul	50 ul	100 ul	AB
S.Mutans	16	19	23	24
Candida Albicans	13	15	14	12
S.Aureus	16	18	20	25
E.fecalis	29	31	35	45

Figure 5:Solanum Xanthocarpum induced silver nanoparticles against various oral pathogens.



The synthesis of nanoparticles is now emerging field because of its eco friendly route.(Chen, Lin, and Ma 2003; Ingle et al. 2008)In the present study, Ag nanoparticles from aqueous extract of fruits of Solanum xanthocarpum were studied.Ankanna et al (Ankanna et al. 2010)say by the aqueous extract it gives colour change from colourless to dark yellowish brown in colour. In the present study, the extract changed its colour from colourless to dark reddish brown.The formation of Ag nanoparticles was confirmed by UV-Vis spectral analysis. According to a study

done by Govindaraju et al., (K. Govindaraju et al. 2010) had explained the same family Solanaceae and it was found that the plant Solanum torvum got a maximum peak at around 434 nm.The study done by Udayakumar et al., reported (Udayakumar et al. 2003) that the leaf extract of Solanum xanthocarpum inhibits Klebsiella pneumoniae (18mm) and E.coli (7mm) in 100 µl concentrations.According to the study done by Satyavani et al., (Ramanathan, Satyavani, and Gurudeeban 2011) suggested that leaf aqueous extract of silver nanoparticles of Citrullus colocynthis showed maximum activity against E. coli, B. subtilis, P. aeruginosa and Streptococcus pyogenes but it showed no activity against P. mirabilis, Salmonella enteritis and Staphylococcus aureus.One of the main reasons for endodontic failure is the presence of some species of bacteria inside the root canal system such as Enterococcus faecalis. These bacteria are more resistant to disinfection agents, causing a persistent intra-radicular or extra-radicular infection.(Alghamdi and Shakir 2020) E. faecalis has the capacity for growing as a biofilm on root canal walls without synergistic support from other bacteria,has high resistance to antimicrobial agents and is a very resistance pathogen to root canal treatment.(Estrela et al. 2008; Sassone et al. 2008)It possesses many survival mechanisms to live in unfavorable conditions, such as to grow an environment with low oxygen, at high pH, at a wide range of temperatures between 10° and 60°, at high salinity or in a poorly nutrient environment.(Pinheiro et al. 2003; Rôças, Siqueira, and Santos 2004; Jhajharia et al. 2015; Narayanan and Vaishnavi 2010).

Our institution is passionate about high quality evidence based research and has excelled in various fields (Jayaseelan Vijayashree Priyadharsini 2019; Pc, Marimuthu, and Devadoss 2018; Ramesh et al. 2018; Ramadurai et al. 2019; Sridharan et al. 2019; Ezhilarasan, Apoorva, and Ashok Vardhan 2019; M. G. Mathew et al. 2020; Samuel 2021; R et al. 2020; Chandrasekar et al. 2020; J. Vijayashree Priyadharsini, Smiline Girija, and Paramasivam 2018)

In this current study Solanum Xanthocarpum induced with silver nanoparticles showed excellent antimicrobial activity.Highest antimicrobial activity was seen against Enterococcus faecalis.The activity was limited in Candida albicans spp (14 mm). The best activity was found in E.feacalis(35 mm),followed by S.mutans (23mm), and S.aureus sp. (20 mm) in 100 µg concentration.

CONCLUSION

Herbal medicine is gaining growing interest because of its cost effective and echo friendliness.The reduction of the metal ions through plant extracts leading to the formation of silver nanoparticles has been explained before but the capability of parts of the plant such as fruits as a capping and reducing agent has not been explained in previous studies. In the present study, we found that fruits were a good source for the synthesis of silver nanoparticles. It has many advantages such as, ease with which the process can be scaled up, economic viability and to obtain smaller particle size. This study demonstrated the antimicrobial activity
of using biologically synthesized silver nanoparticles against various oral pathogens.The preparation of silver nanoparticle by using Solanum xanthocarpum extracts has excellent antimicrobial activity against Enterococcus faecalis.Hence this technology can be applied in therapeutics.

Acknowledgement
With Sincere gratitude,we acknowledge the staff members of the department of Conservative Dentistry and Endodontics, Saveetha Dental College and study participants for their extended support towards the completion of research.

Financial Support and Sponsorship
Nil

Conflicts of Interest
There are no conflicts of interest.

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