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Anti Inflammatory Activity of Musa Sapientum and Its Mediated Copper Nanoparticles- An *In Vitro* Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: Musa sapientum commonly known as 'banana' is widely used in Indian folk medicine for the treatment of diabetes mellitus. Copper nanoparticles demonstrate a very strong catalytic activity, a property that can be attributed to their large catalytic surface area. The copper nanoparticles (Cu NPs) have been a strong focus on applications to health-related processes due to its antibacterial properties and antifungal activity in addition to their catalytic, optical, and electrical properties. The aim of the study is to check the anti-inflammatory activity of musa sapientum and its and it's mediated copper nanoparticles.
Materials and Methods: 1g of musa sapientum was weighed aseptically and then dissolved in 100ml of distilled water. Then the solution is boiled for about 5 minutes at a temperature of about 60-80 degree celsius and then allowed to cool down followed by filtration of extract and then copper nanoparticles were synthesised and anti inflammatory activity was done.
Results: It has been identified that, in 10µL concentration, the percentage of inhibition was noted as 43.5%, 20µL concentration shows 47.5% of inhibition, 30µL shows 83.6%, 40µL shows 85.4%

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and 50µL concentration shows 85.8% of inhibition which results in good anti inflammatory activity observed from 10 to 50µL concentration. From the study it can be clearly seen that a concentration dependent increase in the anti inflammatory activity was evident in copper nanoparticles and the standard in this study.

Conclusion : It has been concluded that the copper nanoparticles synthesised using the extract of musa sapientum have shown better anti-inflammatory activities.

Keywords: Copper nanoparticles; green synthesis; anti-inflammatory activities; musa sapientum; nanotechnology.

1. INTRODUCTION

Copper nanoparticles (CuNPs) have recently been brought into a kind of special attention because of their low-cost and novel optical, catalytic, mechanical, electrical and thermal conduction properties, which are different from that of their bulk metals. Copper nanoparticles of size about 20–80 nm have been formed by irradiating copper salts by gamma rays, using poly N-vinyl pyrrolidone and poly vinyl alcohol as capping agents [1]. Copper nanoparticles were synthesised mainly by simple and eco-friendly green route. The synthesized nanoparticles were subjected to structural, morphological, optical and antimicrobial studies [2]. Musa sapientum which is also known as banana, commonly grown in South India for its fruits, stem, flowers, roots and leaves. Various parts of Musa sapientum which belong to the family Musaceae have been used for various medicinal purposes including the treatment of diabetes mellitus. Musa sapientum could be known to have high-quality and cheap sources of carbohydrates and minerals for livestock.

Many parts of Musa sapientum are used as drugs, food supplements and cosmetics. The banana peel is also used as an astringent in foot care and it has been observed that the unripened fruit of banana is effective to treat diarrhea and the ripened fruit of banana is used as tonic usually. This has been traditionally used in Thai medicines [3]. The seed of musa sapientum was shown to exhibit good antibacterial activity when tested against E.coli, Shigella, and Pseudomonas. Some banana extracts show antidiarrheal properties by their antimicrobial activities [4]. Banana is one of the many fruits that is well consumed in many countries having lots of benefits on health, however there is less evidence regarding physical performance, oxidative stress, metabolic, lipid, and pro-inflammatory cytokines in humans [5].

The peel of banana also shows a better prospects for the improved adsorption of anionic and cationic species. Musa sapientum can have comparable biosorption capacity for copper, lead, zinc and nickel metal ions along with some types of biosorbent materials which are considered to act as antiinflammatory agents in future [6]. Inflammation plays an important role in various diseases with some high prevalence within populations such as rheumatoid arthritis, asthma and atherosclerosis [7,8]. Inflammation is a condition which can be divided as either acute or chronic inflammation. Acute inflammation can be considered as the initial response of the body to some harmful stimuli. In chronic inflammation, the inflammatory response is out of proportion resulting in damage to the body [9]. An inflammatory activity involves some macrophages, neutrophils that are known to secrete different mediators that are responsible for the initiation, progression, persistence, regulation, and eventual resolution of the acute state of inflammation [10]. The aim of this study is to check the anti-inflammatory activity of musa sapientum and its mediated copper nanoparticles.

2. MATERIALS AND METHODS

2.1 Preparation of the Extract

1 g of musa was weighed aseptically and then dissolved in 100ml of distilled water. Then the solution was boiled for about 5 minutes at a temperature of about 60-80 degree Celsius and then allowed to cool down followed by filtration of extract (Fig. 1).

2.2 Synthesis of Nanoparticles

The copper solution was prepared by dissolving 20 millimolar of copper sulphate in 80ml of distilled water followed by 20ml of plant extract. Then the mixture was placed in the shaker for the synthesis and then allowed to mix for about 1 hour then the first reading was taken using a UV spectrometer and noted down and then again the extract was placed in the shaker for 1hr and the second set of readings were taken (Fig. 2).

2.3 Anti Inflammatory Activity

The anti-inflammatory activity for musa sapientum was tested by the following convention proposed by Muzushima and Kabayashi with specific alterations. 0.05 mL of musa sapientum extract 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. These samples were incubated at room temperature for 20 min and then heated at 55 °C in a water bath for 30 min. 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 following equation.

% inhibition= Absorbance of control- Absorbance of sample×100/ Absorbance of control

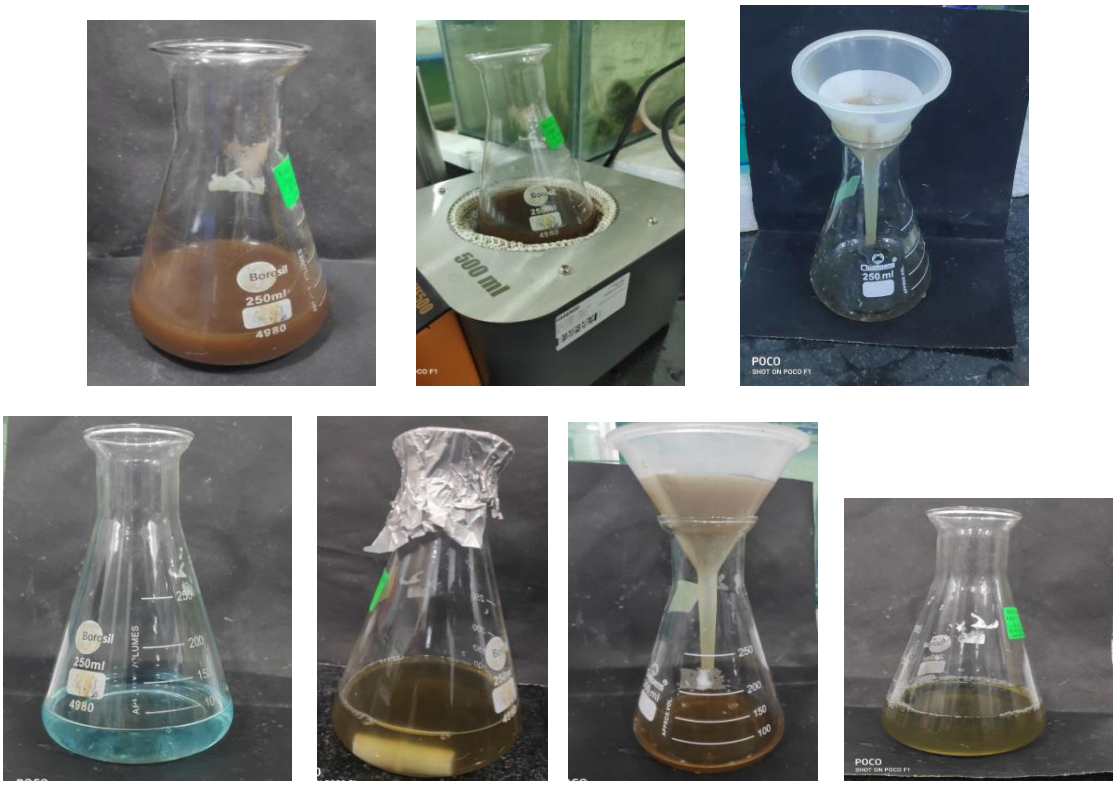

Fig. 1. The pictures show the preparation of musa sapientum plant extract and the sequence of colour changes

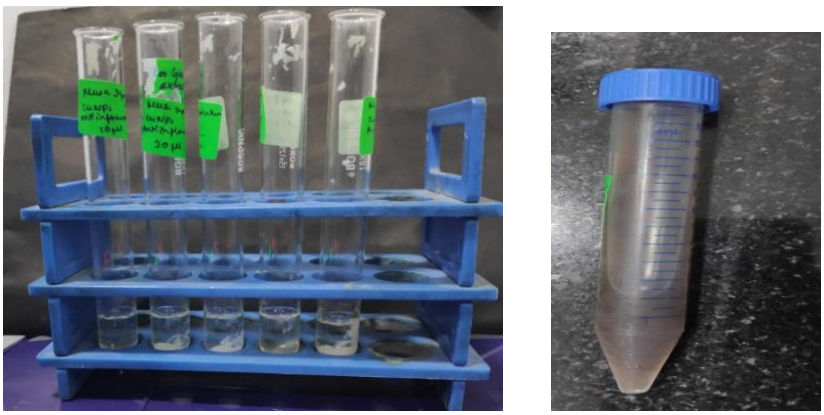

Fig. 2. The pictures showing the preparation of copper nanoparticles and the collection of pellets of copper nanoparticles after incubation

3. RESULTS

The study was done to find the anti-inflammatory activity of musa sapientum and its mediated copper nanoparticles. Descriptive statistics was used. It has been identified that, in 10 µL concentration, the percentage of inhibition was noted as 43.5%, 20 µL concentration shows 47.5% of inhibition, 30 µL shows 83.6%, 40 µL shows 85.4% and 50 µL concentration shows 85.8% of inhibition which results in good anti inflammatory activity observed from 10 to 50 µL concentration. The standard value of 10 µL concentration shows 50.8%, 20 µL shows 57.8%, 30 µL shows 67.6%, 40µL shows 77.9% and 50 µL shows 89.6% which also gradually increases as the concentration increases. It was described in the Table 1 and Fig. 3 bar chart below.

4. DISCUSSION

Our team has extensive knowledge and research experience that has translated into high quality publications [11-30]. Banana peel acts as a complex biological material and is an important by-product of several cottage and major hospitality industries. It contains chemically cellulose, hemicelluloses, lignin and simple sugars. Due to its availability and value, it is capable as an ideal substrate for microbial processes for production of valued-added products. Several efforts have been made to produce protein enriched animal ration, industrial enzymes, citric acid and other industrially viable products. Plantain banana has been shown to possess anti-inflammatory and the ulcer healing activity. The drug obtained from plantain sources promoting healing of ulcer could have effect on wound healing also. The plantain flowers for instance have been used in treating ulcers, dysentery and its extracts have shown antihyperglycemic activity . The peel possesses both antifungal, anti-denaturation and antibiotic properties. Previous study stated that methanolic extract of the banana leaves showed antioxidant and antibacterial activity. The banana extract showed hemagglutination inhibition activities and hydrogen peroxide induced hemolysis inhibition activity of human red blood cells . Bar graph (Fig. 4) depicts the anti-inflammatory activity of musa sapientum and its association with copper mediated nanoparticles. It is seen that a nearly maximum percentage of inhibition (86%) was observed and 83% of inhibition was seen in copper nanoparticles which shows good anti-inflammatory activity with copper mediated nanoparticles.

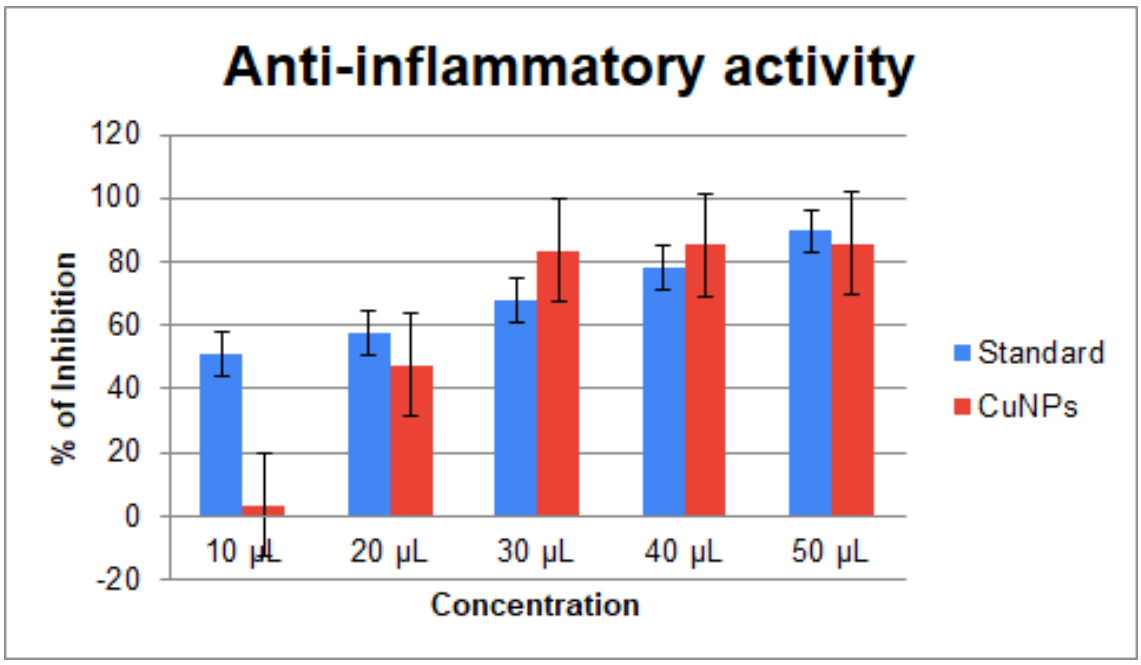

Fig. 3. Bar graph showing the anti-inflammatory activity of musa sapientum and its mediated copper nanoparticles. X axis represents the concentration in µL and Y axis represents the % of inhibition. Blue represents standard value and Red represents CuNps. It has been observed that nearly 86% of inhibition was seen in standard concentrations of 50µL and 83% of inhibition was seen in copper nanoparticles. This concludes that musa sapientum exhibits better anti-inflammatory properties with mediated copper nanoparticles

Table 1. Table representing readings of anti inflammatory activity of musa sapientum and its copper nanoparticles

Concentration	Standard	CuNPs
10µl	50.8	43.5
20µl	57.8	47.5
30µl	67.6	83.6
40µl	77.9	85.4
50µl	89.6	85.8

Previous studies stated that the aqueous extract of both fresh ripe and dry ripe banana peel of Musa sapientum could be considered as a good antimicrobial agent for urinary tract isolates alongside with the synthetic medicines. It was observed that different bioactive constituents of the banana peels were soluble based on the polarity of the individual solvents. Extracts of musa sapientum had the highest total phenolic content and showed a good correlation with their antioxidant activity [31].

The ripe and unripe peels from fresh bananas obtained from a decoction method should be further investigated for the development of some health products. In antiinflammatory study, the water extract of fresh ripe peel exhibited the most potent NO-inhibitory activity. However, this extract possessed low total phenolic content and low antioxidant activity. Accordingly, the present study supports the Thai Traditional Medicine use of Musa sapientum Linn. peel for treatment of inflammatory-related diseases [32]. This study is limited upto the anti-inflammatory activity of musa sapientum in copper nanoparticles. Many researchers have concluded the best results of using musa sapientum, especially peels as it has good anti inflammatory activity, antimicrobial and so on [33]. The future scope of this study can be taken to identify different activities on musa sapientum along with copper nanoparticles and other nanoparticles.

5. CONCLUSION

From this study, it has been concluded that musa sapientum exhibits a better anti-inflammatory activity with mediated copper nanoparticles [34-47]. This can be used for further investigations in employing them as less biotoxic alternatives to already existing chemically synthesised biomaterials.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Shende S, Ingle AP, Gade A, Rai M. Green synthesis of copper nanoparticles by Citrus medica Linn. (Idilimbu) juice and its antimicrobial activity. World J Microbiol Biotechnol [Internet]. 2015;31(6):865–73. Available:http://dx.doi.org/10.1007/s11274-015-1840-3
2. Rajesh KM, Ajitha B, Reddy YAK, Suneetha Y, Reddy PS. Assisted green synthesis of copper nanoparticles using Syzygium aromaticum bud extract: Physical, optical and antimicrobial properties. Optik [Internet]. 2018;154:593–600. Available:https://www.sciencedirect.com/science/article/pii/S0030402617312871
3. Phuaklee P, Ruangnoo S, Itharat A. Anti-inflammatory and antioxidant activities of extracts from Musa sapientum peel. J Med Assoc Thai [Internet]. 2012;95(Suppl 1):S142–6. Available:https://www.ncbi.nlm.nih.gov/pubmed/23964457

4. Hossain MS, Alam MB, Asadujjaman M, Zahan R, Islam MM, Mazumder MEH, et al. Antidiarrheal, Antioxidant and Antimicrobial Activities of the Musa sapientum Seed. Avicenna J Med Biotechnol [Internet]. 2011;3(2):95–105. Available:https://www.ncbi.nlm.nih.gov/pubmed/23407989
5. Leelarungrayub J, Parameyong A, Eungpinichpong W, Klaphajone J. Effects of banana (Musa Sapientum Linn) consumption for physical strength, metabolic response, oxidative stress, lipid profiles, and Interleukin-23 in healthy men: a preliminary study. Open Sports Sci J [Internet]. 2017;10(1). Available:https://benthamopen.com/ABSTRACT/TOSSJ-10-151
6. Muhammad AA, Ismail Y, Others. Study of banana peel (Musa sapientum) as a cationic biosorbent. Am Eurasian J Agric Environ Sci [Internet]. 2010;8(1):7–17. Available:https://www.cabdirect.org/cabdirect/abstract/20103243191
7. Ahmad F, Khan RA, Rasheed S, Others. Study of analgesic and anti-inflammatory activity from plant extracts of Lactuca scariola and Artemisia absinthium. Journal of Islamic Academy of Sciences [Internet]. 1992;5(2):111–4. Available:https://www.journalagent.com/ias/pdfs/IAS_5_2_111_114.pdf
8. Khalid W, Vargheese SS, Lakshmanan R, Sankari M, Jayakumar ND. Role of endothelin-1 in periodontal diseases: A structured review. Indian J Dent Res [Internet]. 2016;27(3):323–33. Available:http://dx.doi.org/10.4103/0970-9290.186247
9. Kavarthapu A, Thamaraiselvan M. Assessing the variation in course and position of inferior alveolar nerve among south Indian population: A cone beam computed tomographic study. Indian J Dent Res [Internet]. 2018;29(4):405–9. Available:http://dx.doi.org/10.4103/ijdr.IJDR_418_17
10. Oguntibeju OO. Medicinal plants with anti-inflammatory activities from selected countries and regions of Africa. J Inflamm Res [Internet]. 2018;11:307–17. Available:http://dx.doi.org/10.2147/JIR.S167789
11. Ramesh A, Varghese S, Jayakumar ND, Malaiappan S. Comparative estimation of sulfiredoxin levels between chronic periodontitis and healthy patients - A case-control study. J Periodontol [Internet]. 2018 Oct;89(10):1241–8. Available:http://dx.doi.org/10.1002/JPER.17-0445
12. Paramasivam A, Priyadharsini JV, Raghunandhakumar S, Elumalai P. A novel COVID-19 and its effects on cardiovascular disease. Hypertens Res [Internet]. 2020;43(7):729–30. Available:http://dx.doi.org/10.1038/s41440-020-0461-x
13. S G, T G, K V, Faleh A A, Sukumaran A, P N S. Development of 3D scaffolds using nanochitosan/silk-fibroin/hyaluronic acid biomaterials for tissue engineering applications. Int J Biol Macromol [Internet]. 2018;120(Pt A):876–85. Available:http://dx.doi.org/10.1016/j.ijbiomac.2018.08.149
14. Del Fabbro M, Karanxha L, Panda S, Bucchi C, Nadathur Doraiswamy J, Sankari M, et al. Autologous platelet concentrates for treating periodontal infrabony defects. Cochrane Database Syst Rev [Internet]. 2018;11:CD011423. Available:http://dx.doi.org/10.1002/14651858.CD011423.pub2
15. Paramasivam A, Vijayashree Priyadharsini J. MitomiRs: new emerging microRNAs in mitochondrial dysfunction and cardiovascular disease. Hypertens Res. 2020;43(8):851–3. Available:http://dx.doi.org/10.1038/s41440-020-0423-3
16. Jayaseelan VP, Arumugam P. Dissecting the theranostic potential of exosomes in autoimmune disorders. Cell Mol Immunol [Internet]. 2019;16(12):935–6. Available:http://dx.doi.org/10.1038/s41423-019-0310-5
17. Vellappally S, Al Kheraif AA, Divakar DD, Basavarajappa S, Anil S, Fouad H. Tooth implant prosthesis using ultra low power and low cost crystalline carbon bio-tooth sensor with hybridized data acquisition algorithm. Comput Commun. 2019;148:176–84. Available:https://www.sciencedirect.com/science/article/pii/S0140366419307017
18. Vellappally S, Al Kheraif AA, Anil S, Assery MK, Kumar KA, Divakar DD. Analyzing Relationship between Patient and Doctor in Public Dental Health using Particle Memetic Multivariable Logistic Regression

Analysis Approach (MLRA2). J Med Syst [Internet]. 2018;42(10):183. Available:http://dx.doi.org/10.1007/s10916-018-1037-z

19. 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 [Internet]. 2019 Apr;83(4):445–50. Available:http://dx.doi.org/10.21815/JDE.019.054
20. Venkatesan J, Singh SK, Anil S, Kim S-K, Shim MS. Preparation, Characterization and Biological Applications of Biosynthesized Silver Nanoparticles with Chitosan-Fucoidan Coating. Molecules [Internet]. 2018;23(6). Available:http://dx.doi.org/10.3390/molecules23061429
21. Alsubait SA, Al Ajlan R, Mitwalli H, Aburaisi N, Mahmood A, Muthurangan M, et al. Cytotoxicity of Different Concentrations of Three Root Canal Sealers on Human Mesenchymal Stem Cells. Biomolecules [Internet]. 2018 Aug 1;8(3). Available:http://dx.doi.org/10.3390/biom8030068
22. Venkatesan J, Rekha PD, Anil S, Bhatnagar I, Sudha PN, Dechsakulwatana C, et al. Hydroxyapatite from Cuttlefish Bone: Isolation, Characterizations, and Applications. Biotechnol Bioprocess Eng [Internet]. 2018;23(4):383–93. Available:https://doi.org/10.1007/s12257-018-0169-9
23. Vellappally S, Al Kheraif AA, Anil S, Wahba AA. IoT medical tooth mounted sensor for monitoring teeth and food level using bacterial optimization along with adaptive deep learning neural network. Measurement [Internet]. 2019;135:672–7. Available:https://www.sciencedirect.com/science/article/pii/S0263224118311333
24. PradeepKumar AR, Shemesh H, Nivedhitha MS, Hashir MMJ, Arockiam S, Uma Maheswari TN, et al. Diagnosis of Vertical Root Fractures by Cone-beam Computed Tomography in Root-filled Teeth with Confirmation by Direct Visualization: A Systematic Review and Meta-Analysis. J Endod [Internet]. 2021 Aug;47(8):1198–214. Available:http://dx.doi.org/10.1016/j.joen.2021.04.022
25. R H, Ramani P, Tilakaratne WM, Sukumaran G, Ramasubramanian A, Krishnan RP. Critical appraisal of different triggering pathways for the pathobiology of pemphigus vulgaris-A review. Oral Dis [Internet]; 2021. Available:http://dx.doi.org/10.1111/odi.13937
26. Ezhilarasan D, Lakshmi T, Subha M, Deepak Nallasamy V, Raghunandhakumar S. The ambiguous role of sirtuins in head and neck squamous cell carcinoma. Oral Dis [Internet]; 2021. Available:http://dx.doi.org/10.1111/odi.13798
27. Sarode SC, Gondivkar S, Sarode GS, Gadbail A, Yuwanati M. Hybrid oral potentially malignant disorder: A neglected fact in oral submucous fibrosis. Oral Oncol [Internet]. 2021;105390. Available:http://dx.doi.org/10.1016/j.oraloncology.2021.105390
28. Kavarthapu A, Gurumoorthy K. Linking chronic periodontitis and oral cancer: A review. Oral Oncol [Internet]. 2021;105375. Available:http://dx.doi.org/10.1016/j.oraloncology.2021.105375
29. Vellappally S, Abdullah Al-Kheraif A, Anil S, Basavarajappa S, Hassanein AS. Maintaining patient oral health by using a xeno-genetic spiking neural network. J Ambient Intell Humaniz Comput [Internet]; 2018. Available:https://doi.org/10.1007/s12652-018-1166-8
30. Aldhuwayhi S, Mallineni SK, Sakhamuri S, Thakare AA, Mallineni S, Sajja R, et al. Covid-19 Knowledge and Perceptions Among Dental Specialists: A Cross-Sectional Online Questionnaire Survey. Risk Manag Healthc Policy [Internet]. 2021;14:2851–61. Available:http://dx.doi.org/10.2147/RMHP.S306880
31. A natural flavonoid present in unripe plantain banana pulp (Musa sapientum L. var. paradisiaca) protects the gastric mucosa from aspirin-induced erosions. J Ethnopharmacol. 1999; 65(3):283–8.. [cited 2021 Aug 25]; Available:http://dx.doi.org/10.1016/S0378-8741(99)00005-7
32. Yang CP, Fujita S, Ashrafuzzaman M, Nakamura N, Hayashi N. Purification and characterization of polyphenol oxidase from banana (*Musa sapientum* L.) pulp. J

Agric Food Chem [Internet]. 2000;48(7): 2732–5.
Available:http://dx.doi.org/10.1021/jf991037+

33. Augustine A, Geethalakshmi S, Vazhacharickal PJ, Sreejith PE, Sabu M. RAPD, Antimicrobial and Anticancer Activity of Musa Varieties in Kerala [Internet]. Prem Jose;
Available:https://play.google.com/store/books/details?id=qMH0DwAAQBAJ

34. Danda AK. Comparison of a single noncompression miniplate versus 2 noncompression miniplates in the treatment of mandibular angle fractures: a prospective, randomized clinical trial. J Oral Maxillofac Surg [Internet]. 2010;68(7): 1565–7.
Available:http://dx.doi.org/10.1016/j.joms.2010.01.011

35. Robert R, Justin Raj C, Krishnan S, Jerome Das S. Growth, theoretical and optical studies on potassium dihydrogen phosphate (KDP) single crystals by modified Sankaranarayanan–Ramasamy (mSR) method [Internet]. Physica B: Condensed Matter. 2010;405:20–4.
Available:http://dx.doi.org/10.1016/j.physb.2009.08.015

36. Krishnan V, Lakshmi T. Bioglass: A novel biocompatible innovation. J Adv Pharm Technol Res [Internet]. 2013;4(2):78–83.
Available:http://dx.doi.org/10.4103/2231-4040.111523

37. Soh CL, Narayanan V. Quality of life assessment in patients with dentofacial deformity undergoing orthognathic surgery—A systematic review. International Journal of Oral and Maxillofacial Surgery. 2013;42:974–80.
Available:http://dx.doi.org/10.1016/j.ijom.2013.03.023

38. Lekha L, Kanmani Raja K, Rajagopal G, Easwaramoorthy D. Schiff base complexes of rare earth metal ions: Synthesis, characterization and catalytic activity for the oxidation of aniline and substituted anilines. Journal of Organometallic Chemistry. 2014;753:72–80.
Available:http://dx.doi.org/10.1016/j.jorganchem.2013.12.014

39. Dhinesh B, Isaac JoshuaRamesh Lalvani J, Parthasarathy M, Annamalai K. An assessment on performance, emission and combustion characteristics of single cylinder diesel engine powered by Cymbopogon flexuosus biofuel [Internet]. Energy Conversion and Management. 2016;117:466–74.
Available:http://dx.doi.org/10.1016/j.enconman.2016.03.049

40. PradeepKumar AR, Shemesh H, Jothilatha S, Vijayabharathi R, Jayalakshmi S, Kishen A. Diagnosis of Vertical Root Fractures in Restored Endodontically Treated Teeth: A Time-dependent Retrospective Cohort Study. J Endod [Internet]. 2016;42(8):1175–80.
Available:http://dx.doi.org/10.1016/j.joen.2016.04.012

41. Vijayakumar GNS, Nixon Samuel Vijayakumar G, Devashankar S, Rathnakumari M, Sureshkumar P. Synthesis of electrospun ZnO/CuO nanocomposite fibers and their dielectric and non-linear optic studies. Journal of Alloys and Compounds. 2010;507:225–9.
Available:http://dx.doi.org/10.1016/j.jallcom.2010.07.161

42. Kavitha M, Subramanian R, Narayanan R, Udhayabanu V. Solution combustion synthesis and characterization of strontium substituted hydroxyapatite nanocrystals. Powder Technology. 2014;253:129–37.
Available:http://dx.doi.org/10.1016/j.powtec.2013.10.045

43. Sahu D, Kannan GM, Vijayaraghavan R. Size-Dependent Effect of Zinc Oxide on Toxicity and Inflammatory Potential of Human Monocytes. Journal of Toxicology and Environmental Health, Part A. 2014; 77:177–91.
Available:http://dx.doi.org/10.1080/15287394.2013.853224

44. Neelakantan P, Cheng CQ, Mohanraj R, Sriraman P, Subbarao C, Sharma S. Antibiofilm activity of three irrigation protocols activated by ultrasonic, diode laser or Er: YAG laserin vitro [Internet]. International Endodontic Journal. 2015; 48:602–10.
Available:http://dx.doi.org/10.1111/iej.12354

45. Lekha L, Kanmani Raja K, Rajagopal G, Easwaramoorthy D. Synthesis, spectroscopic characterization and antibacterial studies of lanthanide(III) Schiff base complexes containing N, O donor atoms. Journal of Molecular Structure. 2014; 1056-1057:307–13.
Available:http://dx.doi.org/10.1016/j.molstruc.2013.10.014

46. Gopalakannan S, Senthilvelan T, Ranganathan S. Modeling and Optimization of EDM Process Parameters on Machining of Al 7075-B4C MMC Using RSM. Procedia Engineering. 2012;38: 685–90.
Available:http://dx.doi.org/10.1016/j.proeng.2012.06.086

47. Parthasarathy M, Isaac JoshuaRamesh Lalvani J, Dhinesh B, Annamalai K. Effect of hydrogen on ethanol-biodiesel blend on performance and emission characteristics of a direct injection diesel engine. Ecotoxicol Environ Saf. 2016;134(Pt 2):433–9.
Available:http://dx.doi.org/10.1016/j.ecoenv.2015.11.005

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