RESEARCH
www.commprac.com
ISSN 1462 2815

ANTI-DIABETIC ACTIVITY OF SILVER NANOPARTICLES (AgNPs) SYNTHESIZED USING ACAI BERRY FRUIT EXTRACT

Pradeep Veerappan [1], Sangeetha S [2]*, Taniya M [3], M Sundaram K [4] and Lavanya Prathap [5]

[1,2,3,4,5] Department of Anatomy, Saveetha Dental College and Hospital,
Saveetha Institute of Medical and Technical Science (SIMATS),
Saveetha University, Poonamalle High Road, Velappanchavadi, Chennai.
*Corresponding Author Email: sangeethas.sdc@saveetha.com

DOI: 10.5281/zenodo.10964576

Abstract

INTRODUCTION: In this research we report the natural synthesis of silver nanoparticles (AgNPs) using the *Acai berry* fruit extract. Silver nanoparticles are usually formed from AgNO3 which is reduced to colloidal Ag in the presence of a reducing agent. *Acai berry* (Euterpe *oleracea)* is a species of palm tree (*Arecaceae*) cultivated mostly for its fruit. **MATERIALS AND METHODS:** *Acai berry* fruit was taken and powdered as an extract; 0.12 ml of the acai berry fruit extract was mixed with 100 ml of AgNO3 solution. With the help of heating mantle, it was heated and collected. Colour change from white to dark brown confirms the presence of AgNPs. **RESULTS:** When our extract is compared to a standard drug of diabetes, our extract exhibited same level of inhibition of the two enzymes: alpha amylase & alpha glucosidase. As those two enzymes are significantly responsible for the conversion of complex polysaccharides into glucose and thereby increasing the blood sugar level, inhibition of the two enzymes is necessary in control of diabetes. With increasing concentration of extract the % of inhibition increases furthermore. **CONCLUSION:** We conclude that with the inhibition of two enzymes, blood glucose level can be maintained and people can get rid of diabetes, hyperglycaemia through plant extract mediated nanoparticles. The AgNPs produced from *Acai berry* fruit extract were found to be the best medicine for the treatment of diabetes.

Keywords: *Acai Berry,* Alpha Amylase, Alpha Glucosidase, Diabetes, Hyperglycaemia, Silver Nanoparticles.

INTRODUCTION

Due to its ease of use and environmental friendliness, biological synthesis, also known as green synthesis, is a natural method of creating silver nanoparticles that has gained popularity in recent years. The current study's objective was to create Acai berry fruit-mediated silver nanoparticles and assess their potential anti-diabetic properties. (Kumaresan et al., 2022). The species is found primarily in swamps, backwaters, and floodplains in Brazil's eastern Amazon region. Acai palms are tall, thin trees that can reach heights of over 25 m (82 ft) and have pinnate leaves that can reach lengths of up to 3 m (9.8 ft). The fruit is little, oblong, and purple in hue. Around the 18th century, the fruit evolved into a staple food (a food that is frequently consumed) in some or specific regions. Aça: An Extraordinary Antioxidant-Rich Palm Fruit, no date) was only recently consumed in urban areas as a health food. This coincided with the rise in popularity of other Amazonian fruits, not just in Brazil but also in other nations(Prathap & Lakshmanan, 2022). Alpha amylase inhibitor assay was used to measure the anti-diabetic efficacy. Among the many other metallic nanoparticles used or related to in biomedical applications, silver nanoparticles (AgNPs) are one of the most significant and fascinating nanomaterials.(Vikneshan *et al.*, 2020). In particular, AgNPs are essential to nanomedicine and other fields of nanoscience and nanotechnology. (Neelakantan, 2011).AgNPs offer a significant potential for applications in cancer

ISSN 1462 2815

diagnostics and anti-diabetic effects, despite the fact that other noble metals have been used for a variety of purposes. 2021 (Abd-Elsalam)

Recent discoveries have clearly shown that the form, size, and size distribution of silver nanoparticles, which are always changed by modifying the synthesis processes, reducing agents, and stabilisers, greatly characterise their electromagnetic, optical, and catalytic capabilities. (Maaz, 2018)

The nanoparticle needs to be enclosed before being injected into the tissues.(Sathivel *et al.*, 2008) Trisodium citrate and polyvinylpyrrolidone (PVP) are the most often employed capping ligands, although many others are also used under various conditions to manufacture particles with certain sizes, morphologies, and surface qualities. (2010) Welles. The production of silver nanoparticles can be accomplished in a variety of methods, one of which is by the use of monosaccharides. (Preethi and Sekar, 2021)This covers sucrose but not other sugars like glucose, fructose, maltose, and maltodextrin. In other words, because it typically only requires one step or one step, it is also a straightforward approach to convert silver ions back to silver nanoparticles.(Ezhilarasan, 2021)

There have been numerous or numerous ways that have suggested or demonstrated the significance of these reducing sugars in the creation of silver nanoparticles. (Kumar, Kumar and Pathak, 2021).Many studies indicated that this method of green synthesis or biological synthesis, specifically using Cacumen platycladi extract, helped in the reduction of silver. (Azeem and Sureshbabu, 2018). Bacterial and fungal synthesis of nanoparticles is easy and practical because bacteria and fungi are much easy or simpler to handle and can be modified according to the purpose(Krishnan and Lakshmi, 2013) .This provides a way to develop biomolecules that can synthesize or produce AgNPs of varying shapes and sizes in high yield, which is at the front of the current challenges or issues in nanoparticle synthesis(Prathap & Lakshmanan, 2022). Silver nanoparticles can be created using lactic acid-producing bacteria. Lactobacillus species and Lactococcus garvieae are bacteria that may be able to convert silver ions into silver nanoparticles. The interactions or reactions between the silver ions and the cell's organic molecules result in the formation or synthesis of the nanoparticles inside the cell. With an average size of 11.2 nm, it was discovered that the bacterium Lactobacillus fermentum generated or produced the tiniest silver nanoparticles (Thakur and Devaraj, 2020). Additionally, it was discovered that this bacterium created nanoparticles with the narrowest size distribution, which were primarily found on the outside of the cells. Additionally, it was discovered that this bacterium created nanoparticles with the narrowest size distribution, which were primarily found on the outside of the cells. Additionally, it was discovered that a rise in pH caused an increase in both the production rate and quantity of nanoparticles.(Liaqat *et al.*, 2022)(Varshan and Prathap, 2022). Geranium leaves were used to reduce silver ions into silver nanoparticles. It was discovered that adding geranium leaf extract to silver nitrate $AgNO_3$ solutions could fast decrease the silver ions and create stable nanoparticles for other reactions.(Padavala and Sukumaran, 2018)(Shehnaz *et al.*, 2023)

In order to create silver nanoparticles with non-spherical geometries and to functionalize nanoparticles with various substances, such as silica, synthetic methods for their synthesis can be altered. Greater or greater control can be exerted over the size-specific properties of silver nanoparticles by producing them in a variety of forms, sizes, and surface coatings.(Sahu, Sahu and Kukreja, 2014). Ethylene glycol can be used as a reducing agent and PVP as a capping agent in a polyol synthesis procedure to create silver nanocubes. A typical synthesis with these reagents involves with addition of fresh silver nitrate and PVP to a solution of ethylene glycol heated at 140 °C. A typical synthesis using these reagents entails adding fresh silver nitrate and PVP to an ethylene glycol solution that has been heated to 140 °C.(Vishaka, Sridevi and Selvaraj, 2022)

(Bhattacharjee *et al.*, 2022; Remigante *et al.*, 2022; Vijayaraghavan *et al.*, 2022)

MATERIALS AND METHODS

A powdered extract was created from the acai berry fruit. Acai berry fruit weighing 0.875 grammes was combined with 100 cc of purified water. With the use of a cylindrical measuring tube, 100 ml of distilled water are taken. The berry fruit extract-containing solution is now transferred to a conical flask and covered with a sheet of aluminium foil. For the synthesis of silver nanoparticles through reduction of AgNO3, 0.17 gramme of silver nitrate and 0.17 gramme of AgNO3 were taken. In a different conical flask, 0.17 g of AgNO3 was combined with 100 ml of distilled water. 100 ml of AgNO3 solution were combined with 0.12 ml of the extract.The extract solution, which had been stored in a conical flask, was now heated for five minutes at 70 degrees Celsius using a heating mantle. It is thereafter put into a collecting tube. The extract's colour changing from light to dark brown indicates the presence of silver nanoparticles.

A-Amylase Inhibition Assay

A-amylase inhibition was accomplished. In a nutshell, the reaction was started by adding 490, 470, and 450 L buffer to various volumes (10, 30, and 50 ML) of 30 mg/mL of garlic extract, synthesised silver nanoparticles, stored (at room temperature at 37°C and 4°C), and calcined (300, 500, and 700°C) GAgNPs samples, in that order. The final volume of the reaction solution was 500 micro litres. The reaction vessels then received the addition of 500 microliters of a-amylase and 1,000 microliters of starch. The reaction containers were then heated to 100°C in a water bath for 5 minutes. The next stage is the addition of 500 microliters of NaOH.The transition of the hue from yellow to orange revealed the presence of a-amylase inhibition. The a-amylase % inhibition was estimated as

((Ao - Ai)/Ao)× 100, where A, was the absorbance of the standard and A; was the absorbance of the test samples.

Protein Kinase Inhibitor Assay

With a small modification, the streptomyces strain was employed in the protein kinase inhibition experiment. Under sterile circumstances, an entire experiment was conducted.

The kinase assay simply measures the kinase's activity. An enzyme called a kinase helps transport phosphate from ATP to a particular molecule. They control a variety of bodily functions. To determine how possible medications would alter kinase activity, the measurement is used.

Alpha Glucosidase Inhibitor Assay

In comparison to alpha-amylase inhibitors, alpha-glucosidase inhibitors are an effective class or group of antidiabetic medications capable of reducing postprandial

ISSN 1462 2815

hyperglycemia in particular. Postprandial hyperglycemia is a sudden increase in blood glucose levels following a meal or other meals.

α-glucosidase Inhibitory Activity

The extract and fractions were tested for their ability to inhibit -glucosidase using the conventional methodology with a few minor adjustments. A reaction mixture of 50 ml of phosphate buffer (100 mM, pH = 6.8), 10 ml of alpha-glucosidase (1 U/ml), and 20 ml of extract and fractions at various concentrations (0.1, 0.2, 0.3, 0.4, and 0.5 mg/ml) were placed on a 96-well plate and pre-incubated at 37 °C for 15 minutes. The substrate was then added to 20 l of P-NPG (5 mM), and the reaction was continued for 20 more minutes at 37°C. As a control, ignoring the test material was set up in parallel, and each of these trials was carried out three times. Using the formula, the results were expressed in terms of percentage inhibition.

Inhibitory activity (%) = $(1 - As/Ac) \times 100$

Figure 1: *Acai Berry* was taken and made into a Powder Form and 0.875 Gram of *Acai Berry* Fruit Powdered form was taken and Mixed with 100 ml of Distilled Water

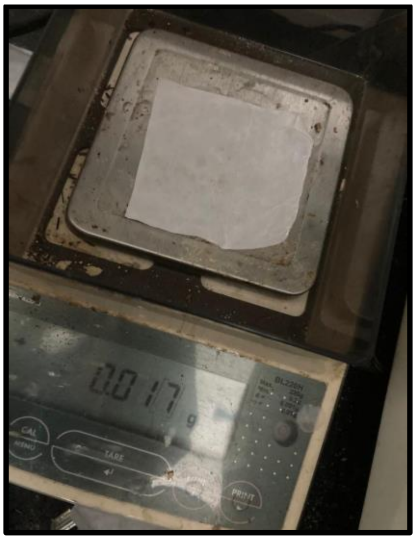


Figure 2: 0.17 Gram of Silver Nitrate was taken, 0.17 Gram of AgNO3 was taken for the Preparation of Silver Nanoparticles through Reduction of AgNO3

ISSN 1462 2815

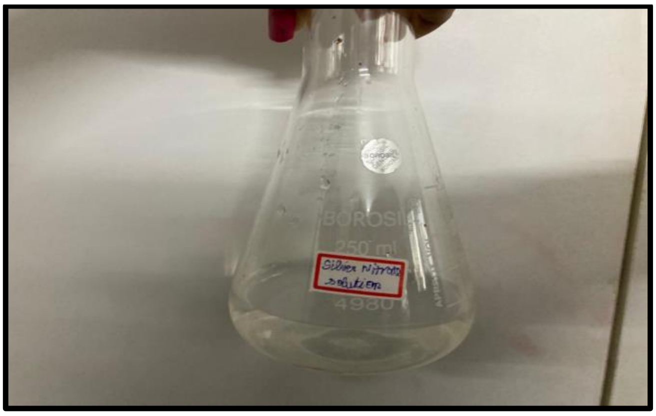


Figure 3: 0.17 g of AgNO3 was Mixed with 100 ml of Distilled Water and taken in a Separate Conical Flask

Figure 4: The Extract Solution which was Kept in a Conical Flask was now Heated with the Help of Heating Mantle for 5 minutes at 70 Degree Celsius

Figure 5: The Presence of Silver Nanoparticles in the Extract can be Confirmed by the Colour Change from Light to Dark Brown

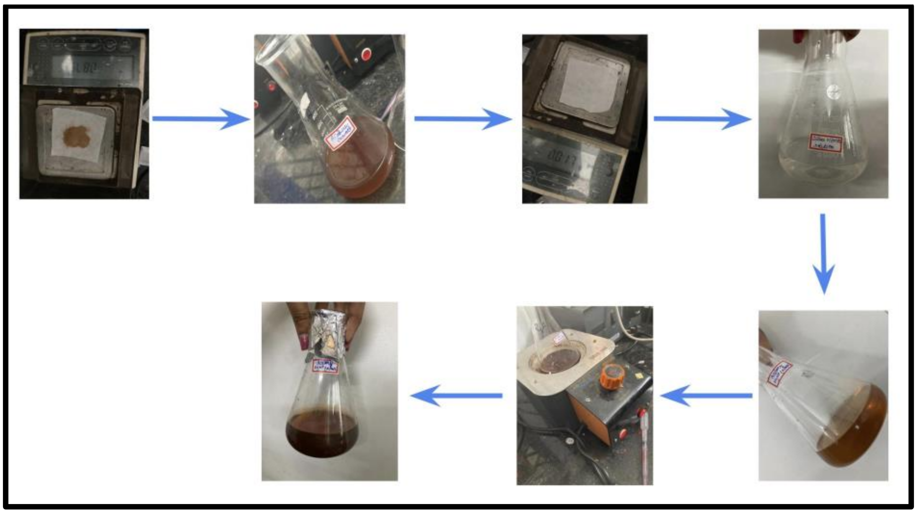
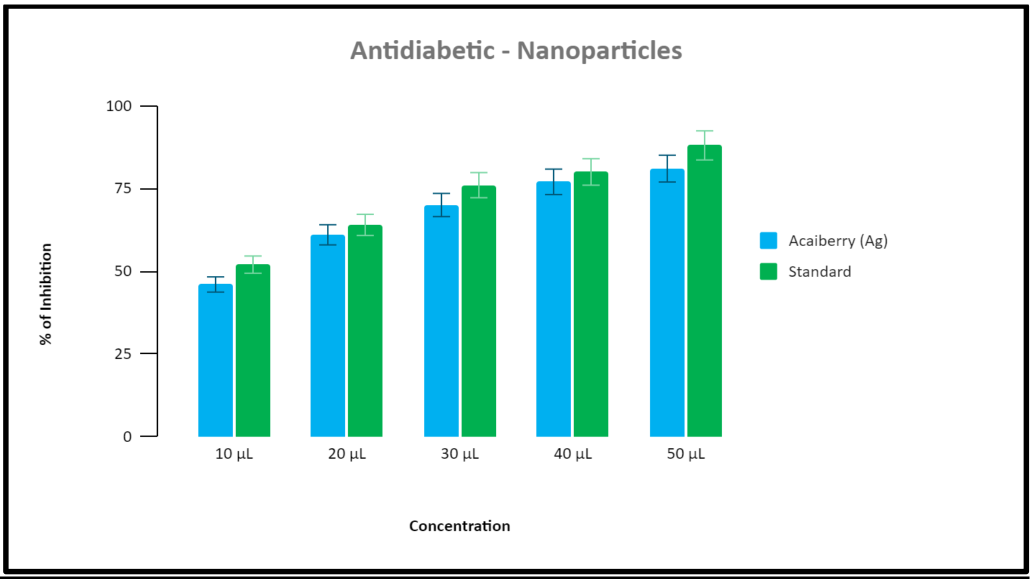


Figure 6: Summary of all methods carried out

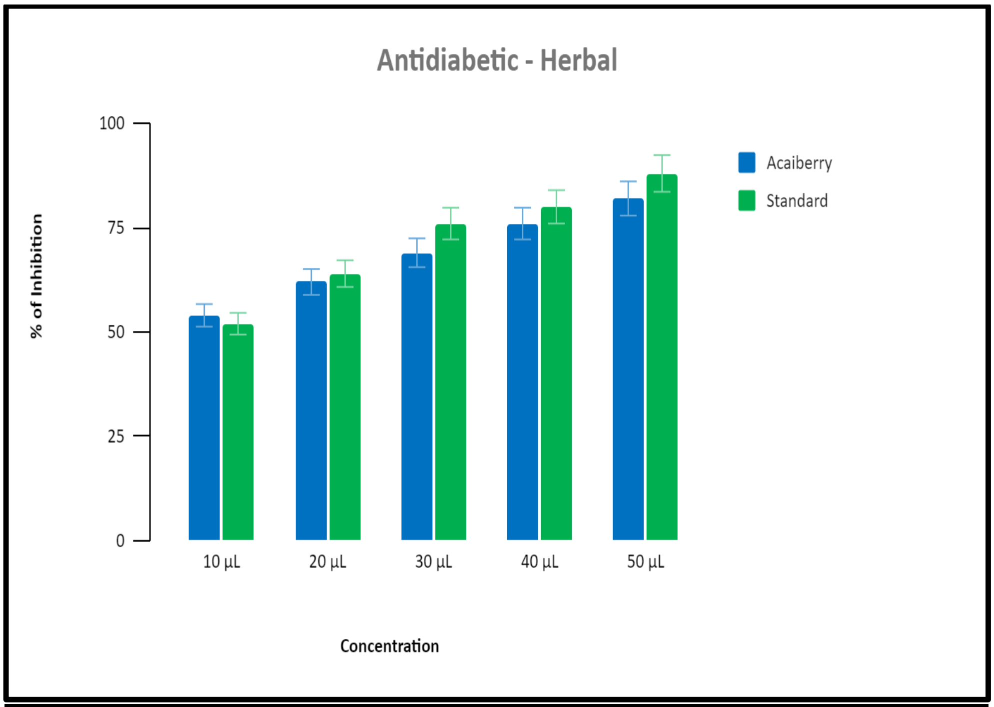
RESULTS



Graph:1

The graph shows the correlation between the concentration of produced extract and the percentage of alpha amylase enzyme inhibition. According to the comparison, our extract demonstrated a comparable proportion of alpha amylase inhibition to that of a common diabetes medication With increasing concentration,the proportion of inhibition grew.

ISSN 1462 2815



Graph:2

The graph shows the correlation between the concentration of produced extract and the percentage of alpha glucosidase enzyme inhibition. According to the comparison, our extract demonstrated a comparable proportion of alpha amylase inhibition to that of a common diabetes medication. With increasing concentration, the proportion of inhibition grew.

DISCUSSIONS

The discussion on the potential of plant-derived inhibitors, particularly those found in acai berry extract, in managing hyperglycemia in diabetes patients is intriguing. Traditional anti-diabetic medications like sulfonylureas, biguanides, and others have been the cornerstone of diabetes management. However, their lack of specificity often leads to gastrointestinal side effects, compromising patient adherence and quality of life. This has prompted a search for alternative treatments, including natural remedies like plant-derived inhibitors.

The inhibition of alpha-amylase and alpha-glucosidase, key enzymes involved in carbohydrate metabolism, offers a promising avenue for controlling blood glucose levels. By slowing down the breakdown of starch and glycogen in the intestine, these inhibitors can delay the absorption of carbohydrates, preventing sudden spikes in blood sugar levels after meals. Acai berry extract, rich in polyphenols like anthocyanins and catechins, has shown potential in inhibiting these enzymes, thus presenting a natural and potentially safer alternative for diabetes management. The specificity of plant-derived inhibitors targeting mammalian alpha-amylases while sparing plant and microbial counterparts underscores their potential as effective and selective anti-diabetic agents. Moreover, the structural flexibility of these inhibitors allows for optimal binding and potentially broad-spectrum target specificity, enhancing their therapeutic potential. Furthermore, the benefits of natural herbal medicines extend beyond their potential efficacy in treating chronic illnesses like diabetes. They often come with fewer

ISSN 1462 2815

side effects, greater affordability, and wider availability compared to synthetic medications. This makes them particularly appealing for long-term management of conditions like diabetes, where adherence to medication regimens is crucial for preventing complications. However, despite their promise, further research is needed to fully understand the efficacy, safety, and optimal dosing of plant-derived inhibitors like those found in acai berry extract. Clinical trials comparing their effectiveness to traditional anti-diabetic medications would be valuable in determining their place in diabetes management protocols. In conclusion, the exploration of plant-derived inhibitors as potential treatments for hyperglycemia in diabetes patients offers a promising avenue for improving outcomes and reducing the burden of side effects associated with traditional medications. Acai berry extract, with its rich polyphenol content and inhibitory effects on key carbohydrate-metabolizing enzymes, represents a particularly intriguing candidate worthy of further investigation.

FUTURE SCOPE OF RESEARCH

For silver nanoparticles to have the best anti-diabetic effect, plant extracts and other reactive product attributes should be optimised and standardised. One of the potential future directions in the development of silver nanoparticles for anti-diabetic action, particularly in class mammalia, should be in vivo investigations

CONCLUSIONS

It was discovered that silver nanoparticles function as antidiabetic drugs because they lower blood sugar levels, raise insulin levels and expression, boost glucokinase activity and expression, and improve IRA and GLUT2 expression levels. It was discovered that silver nanoparticles play a crucial part in healing diabetic wounds to lower the likelihood of limb amputation. The combination of silver nanoparticles and biopolymers shown higher efficacy, which may expedite wound regeneration by repairing damaged areas. The percentage of inhibition of silver nanoparticles synthesised from Acai berry fruit extract is comparable to standard values in all concentrations, suggesting that they may be employed as an antidiabetic drug in the near future

Acknowledgment

We extend our sincere gratitude to Saveetha dental College and hospitals for their constant support and successful completion of this work.

Conflict of Interest

The authors hereby declare that there is no conflict of interest in this study.

References

1) Al-Quisi, A., AL-Obaidi, A. and Hallab, Z.S. (2016) *Effect of Anti Diabetic Drugs on Glucose-6-phosphatase Activity in Pa: Glucose-6-phosphatase Activity in Patients with Type 2 Diabetes Mellitus*.

2) Appleton, J. (2007) *Acai Berry: Fruits of Paradise*. Woodland Pub.

3) Azeem, R.A. and Sureshbabu, N.M. (2018) 'Clinical performance of direct versus indirect composite restorations in posterior teeth: A systematic review', *Journal of conservative dentistry: JCD*, 21(1), pp. 2–9.

4) Bhattacharjee, R. *et al.* (2022) 'The emergence of metal oxide nanoparticles (NPs) as a phytomedicine: A two-facet role in plant growth, nano-toxicity and anti-phyto-microbial activity', *Biomedicine & pharmacotherapy = Biomedecine & pharmacotherapie*, 155, p. 113658.

5) Campbell, D.B. *et al.* (2022) 'Patterns and Patients' Characteristics Associated With Use of Sodium/Glucose Cotransporter 2 Inhibitors Among Adults With Type 2 Diabetes: A Population-based Cohort Study', *Canadian journal of diabetes* [Preprint]. Available at: https://doi.org/10.1016/j.jcjd.2022.08.002.

6) Devi, A., Gnanavel, G. and Antoni gracy, G. (2014) 'MCS-51 microcontroller based industrial automation and control system using CAN protocol', *2014 International Conference on Communication and Signal Processing* [Preprint]. Available at: https://doi.org/10.1109/iccsp.2014.6949799.

7) *Drug Concentration Monitoring Microbial Alpha-Glucosidase Inhibitors Plasminogen Activators* (2012). Springer Science & Business Media.

8) Ezhilarasan, D. (2021) 'Deciphering the toxicological role of Porphyromonas gingivalis derived endotoxins in liver diseases', *Environmental toxicology and pharmacology*, 88, p. 103755.

9) Ezhilarasan, D. (2023) 'Antitubercular drugs induced liver injury: an updated insight into molecular mechanisms', *Drug metabolism reviews*, 55(3), pp. 239–253.

10) Felicita, A.S. (2017) 'Quantification of intrusive/retraction force and moment generated during en-masse retraction of maxillary anterior teeth using mini-implants: A conceptual approach', *Dental press journal of orthodontics*, 22(5), pp. 47–55.

11) Fisher, M. and McKay, G. (2016) *Essentials of SGLT2 Inhibitors in Diabetes*. Springer.

12) Ghani, U. (2019) *Alpha-glucosidase Inhibitors: Clinically Promising Candidates for Anti-diabetic Drug Discovery*. Elsevier.

13) Krishnan, V. and Lakshmi, T. (2013) 'Bioglass: A novel biocompatible innovation', *Journal of Advanced Pharmaceutical Technology & Research*, p. 78. Available at: https://doi.org/10.4103/2231-4040.111523.

14) Kumar, S., Kumar, P. and Pathak, C.S. (2021) *Silver Micro-Nanoparticles: Properties, Synthesis, Characterization, and Applications*. BoD – Books on Demand.

15) Liaqat, N. *et al.* (2022) 'Green synthesized silver nanoparticles: Optimization, characterization, antimicrobial activity, and cytotoxicity study by hemolysis assay', *Frontiers in chemistry*, 10, p. 952006.

16) Maaz, K. (2018) *Silver Nanoparticles: Fabrication, Characterization and Applications*.

17) Malek, M.A.H. (2021) *A Short Profile of Antidiabetic Drugs: Profiles of Antidiabetics*. Eliva Press.

18) Neelakantan, P. (2011) 'Technology supersedes basic science: Are we really in the path of progress?', *Journal of the International Clinical Dental Research Organization*, p. 2. Available at: https://doi.org/10.4103/2231-0754.115760.

19) Neira-Vielma, A.A. *et al.* (2022) 'Green Synthesis of Silver Nanoparticles Using Pecan Nut () Shell Extracts and Evaluation of Their Antimicrobial Activity', *Antibiotics (Basel, Switzerland)*, 11(9). Available at: https://doi.org/10.3390/antibiotics11091150.

20) Padavala, S. and Sukumaran, G. (2018) 'Molar Incisor Hypomineralization and Its Prevalence', *Contemporary clinical dentistry*, 9(Suppl 2), pp. S246–S250.

21) Patturaja, K. and Pradeep, D. (2016) 'Awareness of Basic Dental Procedure among General Population', *Research Journal of Pharmacy and Technology*, p. 1349. Available at: https://doi.org/10.5958/0974-360x.2016.00258.4.

22) Preethi, K.A. and Sekar, D. (2021) 'Dietary microRNAs: Current status and perspective in food science', *Journal of food biochemistry*, 45(7), p. e13827.

23) Remigante, A. *et al.* (2022) 'Açaì () Extract Protects Human Erythrocytes from Age-Related Oxidative Stress', *Cells* , 11(15). Available at: https://doi.org/10.3390/cells11152391.

24) Roy, A. *et al.* (2021) 'Autoinjector - A smart device for emergency cum personal therapy', *Saudi pharmaceutical journal : SPJ : the official publication of the Saudi Pharmaceutical Society*, 29(10), pp. 1205–1215.

25) Sahu, G., Sahu, V. and Kukreja, L.M. (2014) 'Ultraviolet photoluminescence from stressed silicon nanoclusters', *Journal of Applied Physics*, p. 083103. Available at: https://doi.org/10.1063/1.4866361.

26) Sathivel, A. *et al.* (2008) 'Anti-peroxidative and anti-hyperlipidemic nature of Ulva lactuca crude polysaccharide on D-galactosamine induced hepatitis in rats', *Food and chemical toxicology: an international journal published for the British Industrial Biological Research Association*, 46(10), pp. 3262–3267.

27) Sekaran, S., Roy, A. and Thangavelu, L. (2022) 'Re-appraising the role of flavonols, flavones and flavonones on osteoblasts and osteoclasts- A review on its molecular mode of action', *Chemico-biological interactions*, 355, p. 109831.

28) Shehnaz, S.I. *et al.* (2023) 'Modulation of PPAR-γ, SREBP-1c and inflammatory mediators by luteolin ameliorates β-cell dysfunction and renal damage in a rat model of type-2 diabetes mellitus', *Molecular biology reports* [Preprint]. Available at: https://doi.org/10.1007/s11033-023-08804-8.

29) Shree Harini, K. and Ezhilarasan, D. (2023) 'Reply to "Wnt/beta-catenin signaling inhibitors and nonalcoholic fatty liver disease: Potential therapeutic implications"', *Hepatobiliary & pancreatic diseases international: HBPD INT*, pp. 439–440.

30) Sivamurthy, G. and Sundari, S. (2016) 'Stress distribution patterns at mini-implant site during retraction and intrusion--a three-dimensional finite element study', *Progress in orthodontics*, 17, p. 4.

31) Stiefel, D.J. (1971) *The Preparation and Properties of Human Pancreatic Alpha-amylase Including a Comparison with Human Parotid Alpha-amylase*.

32) Thakur, R.S. and Devaraj, E. (2020) '*Lagerstroemia speciosa*(L.) Pers. triggers oxidative stress mediated apoptosis via intrinsic mitochondrial pathway inHepG2cells', *Environmental Toxicology*, pp. 1225–1233. Available at: https://doi.org/10.1002/tox.22987.

33) Thuy Linh, N.T. *et al.* (2022) 'Chemical constituents of and their -glucosidase inhibition activity', *Natural product research*, pp. 1–6.

34) Varshan, I. and Prathap, L. (2022) 'Evaluation of mandibular condylar morphology using orthopantomogram in South Indian population', *Journal of advanced pharmaceutical technology & research*, 13(Suppl 2), pp. S530–S533.

35) Vijayaraghavan, R. *et al.* (2022) 'Safety evaluation of antibacterial and analgesic autoinjector devices for rapid administration during emergency situations: a crossover study in rabbits', *SAGE open medicine*, 10, p. 20503121221108614.

36) Vikneshan, M. *et al.* (2020) 'Algal biomass as a source for novel oral nano-antimicrobial agent', *Saudi journal of biological sciences*, 27(12), pp. 3753–3758.

37) Vishaka, S., Sridevi, G. and Selvaraj, J. (2022) 'An analysis on the antioxidant and anti-diabetic properties of rhizome using different solvent systems', *Journal of advanced pharmaceutical technology & research*, 13(Suppl 2), pp. S505–S509.

38) Wakim, J.M. (1965) *Porcine Pancreatic [alpha] Amylase: Part I, Its Mechanism of Action, and Part II, Its Multiple Forms*.

39) William-Olsson, T. (1985) *Alpha -glucosidase Inhibition in Obesity*.

40) Zhang, X. (2016) *Binding of Substrates and Inhibitors to Human Pancreatic Alpha Amylase*.

41) Kumaresan, A., Suganthirababu, P., Srinivasan, V., Vijay Chandhini, Y., Divyalaxmi, P., Alagesan, J., . . . Prathap, L. (2022). Prevalence of burnout syndrome among Work-From-Home IT professionals during the COVID-19 pandemic. *Work, 71*(2), 379-384.

42) Prathap, L., & Lakshmanan, G. (2022). Evaluation of incidence of various types of coronoid process in South Indian population. *Journal of Pharmaceutical Negative Results*, 1387-1390.