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Evaluation Of Embryonic Toxicology Of Selenium Nanoparticles Incorporated Dental Varnish And Commercial Varnish - A Comparative Study

Sana Verma, S.Sangeetha*

[1]Department of Anatomy Saveetha Dental College and Hospital, Saveetha Institute of Medical and Technical sciences Saveetha University, Chennai - 600077
Email: 152301010.sdc@saveetha.com
[2]Assistant Professor, Department of Anatomy Saveetha Dental College and Hospital, Saveetha Institute of Medical and Technical sciences Saveetha University, Chennai - 600077
Email: sangeethas.sdc@saveetha.com
Corresponding author
*Mrs. S. Sangeetha
Assistant Professor Saveetha Dental College and Hospital, Saveetha Institute of Medical and Technical sciences Saveetha University, Chennai - 600077
Email: sangeethas.sdc@saveetha.com

ABSTRACT

Introduction:Dental varnishes play a crucial role in preventive dentistry by protecting tooth enamel and reducing the risk of caries. Recent advancements in nanotechnology have introduced selenium nanoparticles (SeNPs) for enhanced antimicrobial and antioxidant properties. Aim: This study aims to compare the embryonic toxicology of selenium nanoparticles incorporated into dental varnish with that of commercially available dental varnish. Materials and Methods: Wild-type zebrafish embryos which were fresh water habitat were exposed to various concentrations (5, 10, 20, 40, and 80 µg/mL) of SeNPs-incorporated dental varnish. Embryonic mortality, hatching rates, and developmental malformations were assessed at 24-hour intervals. Results: The study observed a dose-dependent increase in embryonic mortality, delayed hatching, and a higher percentage of developmental malformations at higher SeNP concentrations. The SeNP-incorporated dental varnish exhibited higher toxicity compared to the commercial varnish.Conclusion: Selenium nanoparticles offer significant potential in enhancing dental varnishes but pose considerable embryonic toxicity risks at higher concentrations. Future research should optimise SeNP concentrations to balance benefits and minimise toxicological risks.

KEYWORDS: Selenium nanoparticles, dental varnish, embryonic toxicology, zebrafish, nanotechnology, dental caries prevention, developmental toxicity

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INTRODUCTION

Providing a protective coating over the tooth enamel, dental varnishes are essential to preventative dentistry, thereby reducing the risk of dental caries and decay. Fluoride, which is commonly found in these varnishes, helps to remineralize enamel and increases its resistance to acid assaults from oral sweets and plaque bacteria.(1) The application of dental varnishes is a common practice in both pediatric and adult dental care, aiming to enhance oral health and reduce the incidence of cavities .

With the advancements in nanotechnology, there has been significant interest in incorporating nanoparticles into dental products to enhance their efficacy.Nanoparticles have special qualities that make them useful in a variety of medical applications, including dentistry.(2) These advantages stem from their small size and huge surface area.(3) For instance, nanoparticles can improve the mechanical properties, antimicrobial efficacy, and bioactivity of dental materials, making them more effective in preventing oral diseases .

Selenium nanoparticles (SeNPs) have garnered attention for their potent antimicrobial and antioxidant properties.In addition to being a necessary trace element that is vital to many physiological functions, selenium has been demonstrated to have increased biological activity in its nanoparticulate form.(4) Recent studies suggest that SeNPs can effectively inhibit the growth of oral pathogens, making them a promising additive for dental varnishes . Incorporating SeNPs into dental varnish could potentially offer superior protection against dental caries compared to traditional varnishes.

Despite the potential benefits, the use of nanoparticles in dental products raises concerns about their safety and biocompatibility.Nanoparticles' small size enables molecular interactions with biological systems, which may have unanticipated toxicological consequences.(5) In particular, the embryonic toxicity of nanoparticles is a critical area of concern, as exposure during development could result in adverse outcomes such as developmental abnormalities or increased mortality rates . Therefore, it is essential to thoroughly evaluate the safety of SeNPs in dental applications.

Previous research on nanoparticle toxicity has yielded mixed results, with some studies indicating potential risks while others

suggest minimal adverse effects.(6) For example, studies on silver and zinc oxide nanoparticles have demonstrated varying degrees of toxicity depending on factors such as concentration, exposure duration, and the biological model used . These findings underscore the importance of conducting specific toxicity assessments for each type of nanoparticle, including selenium, to ensure their safe application in medical and dental products.

The primary objective of this study is to compare the embryonic toxicology of selenium nanoparticles incorporated into dental varnish with that of commercially available dental varnish. By using established embryonic models, such as zebrafish or chicken embryos, we aim to assess the relative safety and potential risks associated with SeNPs in dental applications.(7) This comparative analysis will provide valuable insights into the biocompatibility of SeNPs and inform the development of safer and more effective dental varnishes.

MATERIALS AND METHODS

Fish maintenance and SeNPs exposure:

Acquired from neighbourhood Indian vendors, wild-type zebrafish (Daniorerio) were kept in separate tanks with carefully regulated temperature (280±20C), light/dark cycle (14:10 h), and pH (6.8–8.5). Commercially obtained dry blood worms or optimal food were given to the fish twice a day for feeding. To create zebrafish embryos, three males and one female were crossed in each breeding tank. Viable eggs were then gathered and washed three times in newly created E3 media that was devoid of methylene blue.

In this work, fertilised eggs were deposited with 20 embryos per 2 mL solution in culture plates with six, twelve, and twenty wells each. Three replications were carried out for the experimental treatment and control groups. A freshly prepared stock suspension of TCF-SeNPs at five different concentrations was added straight to the E3 medium to prepare the experimental treatment. For 15 minutes, the solution was sonicated to scatter the nanoparticles while preserving a pH range of 7.2–7.3.

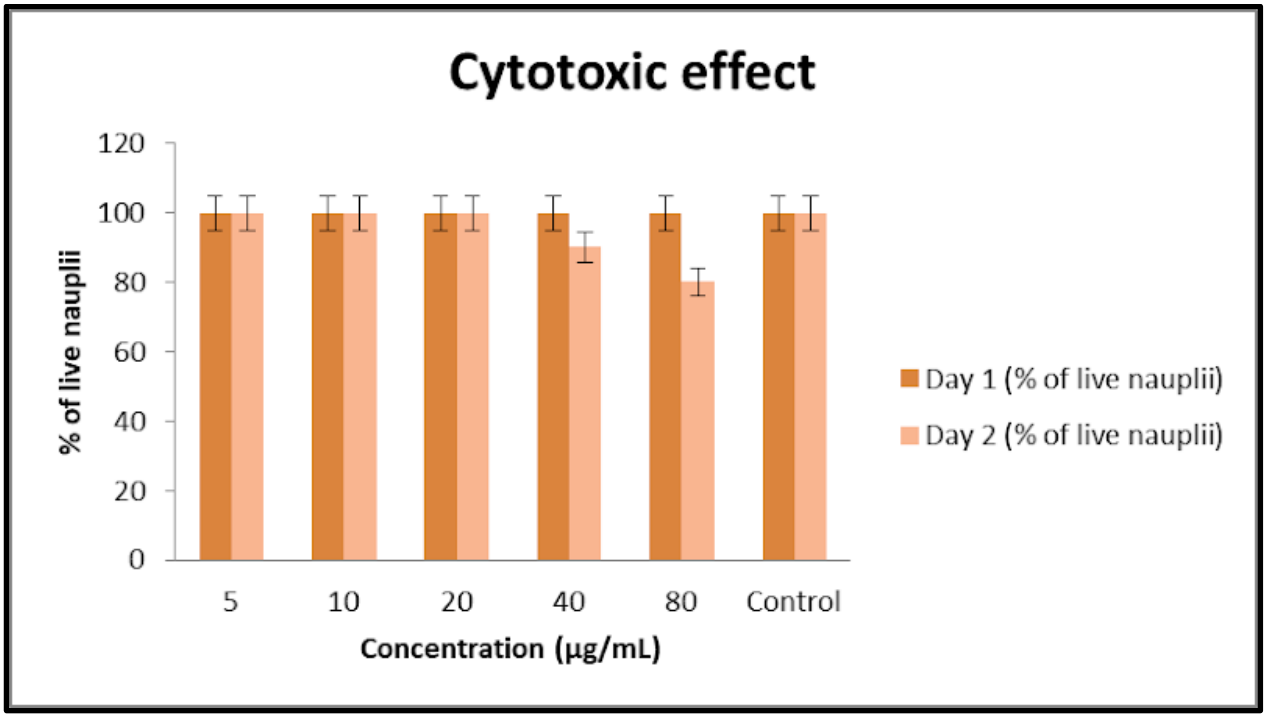
For 24 to 96 hours after fertilisation, viable embryos were subjected to varying doses of selenium nanoparticles (SeNPs): 5, 10, 20, 40, and 80 µg/mL. The E3 medium containing the embryos was supplemented with SeNPs. The experiment also included control groups. Every twelve hours, dead embryos were taken out of the groups exposed to nanoparticles. To keep out light, all experimental plates were covered with foil and kept at a temperature of 28°C.

Figure :1 Extract with Selenium Nanoparticle

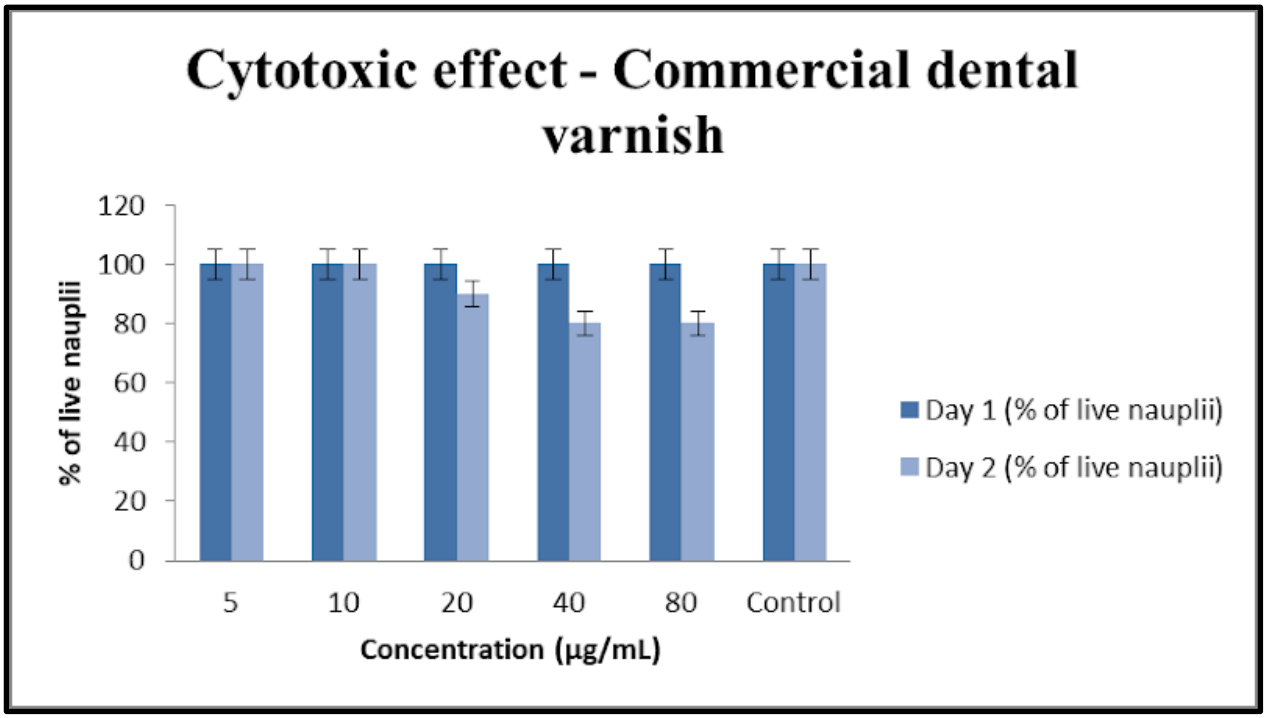
Zebrafish embryo evaluation:

Using a stereo microscope, the developmental phases of the zebrafish embryos were observed during the exposure time that followed fertilisation.(8) For a period of 24-78 hours, the embryos were exposed to different doses of selenium nanoparticles (5, 10, 20, 40, and 80 µg/mL). The rates of hatching and embryonic death were measured every 24 hours. The study's endpoints included the mortality of the embryos and hatchlings, the rate of hatching, and the detection and recording of any abnormalities in the larvae and embryos in the treatment and control groups. A COSLAB - Model: HL-10A light microscope was used to take pictures of embryos with malformations, and every 24 hours, the percentage of aberrant embryos was recorded.

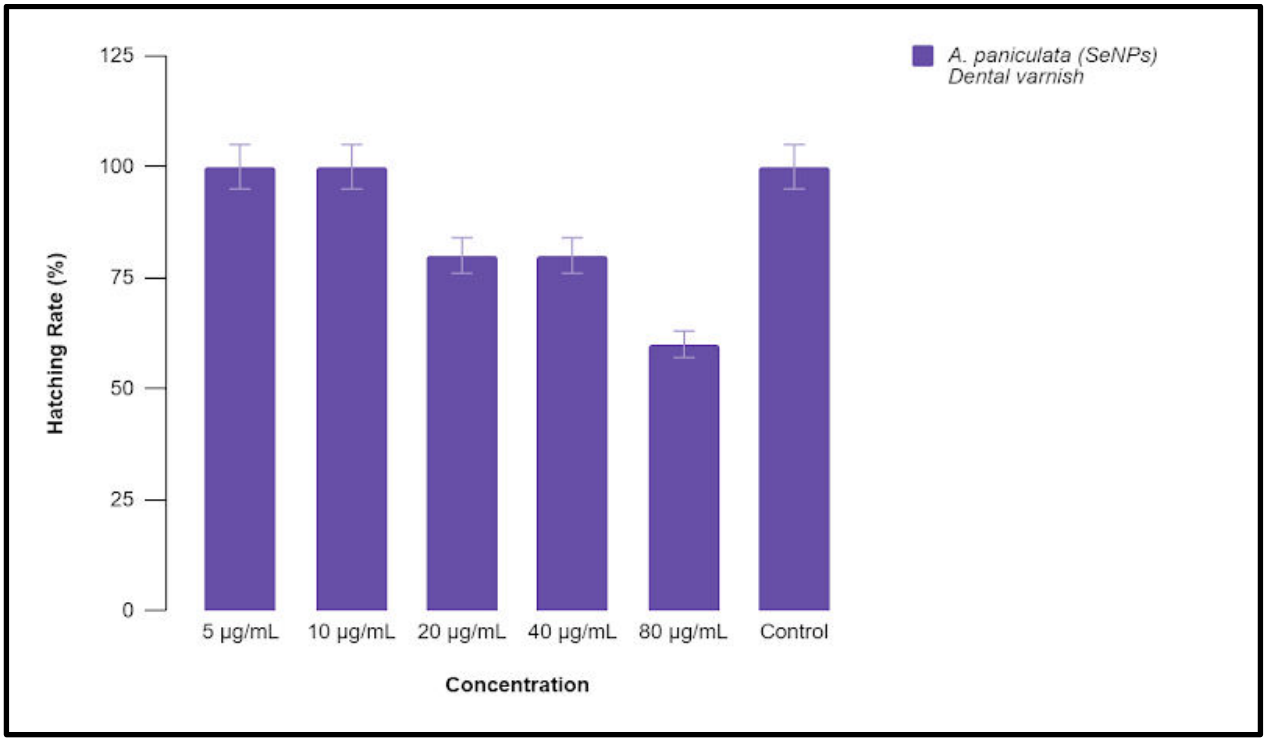
RESULT



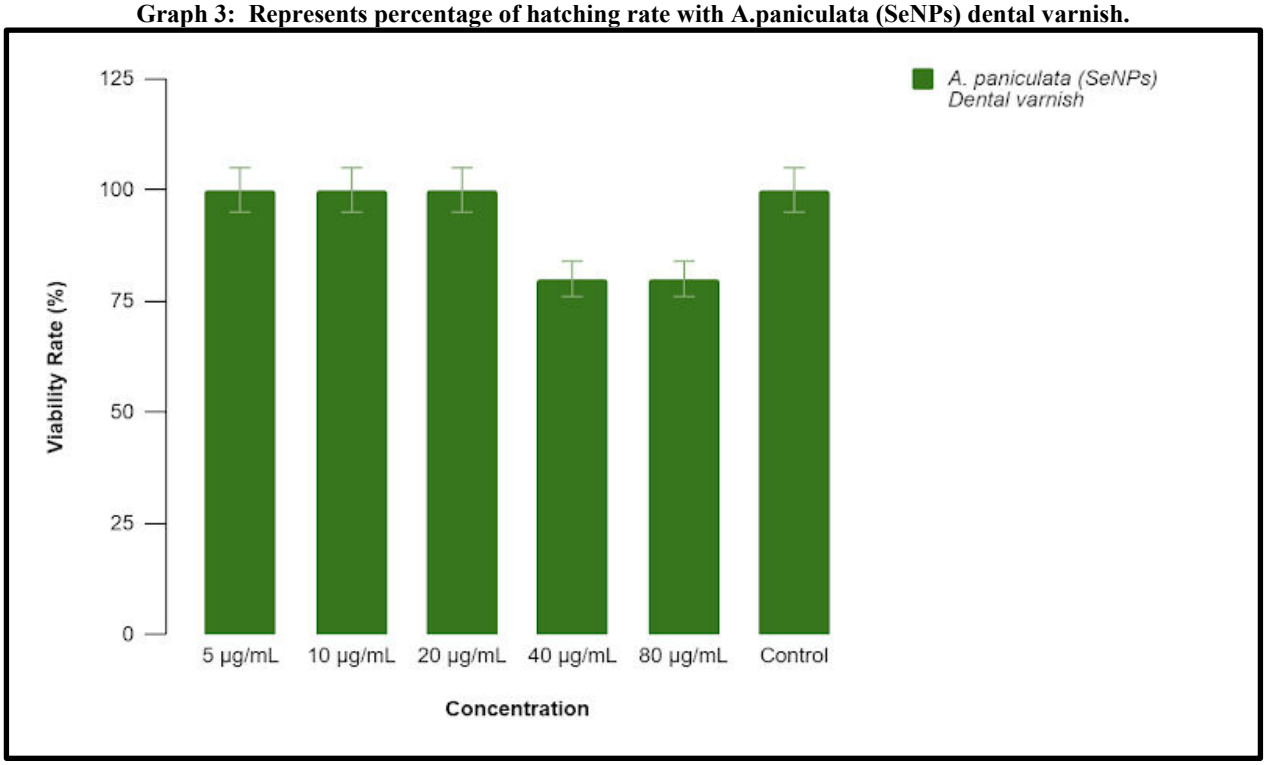
Graph 1: represents Percentage of live nauplii in the cytotoxic effect of SeNPs incorporated dental varnish over increased concentrations.



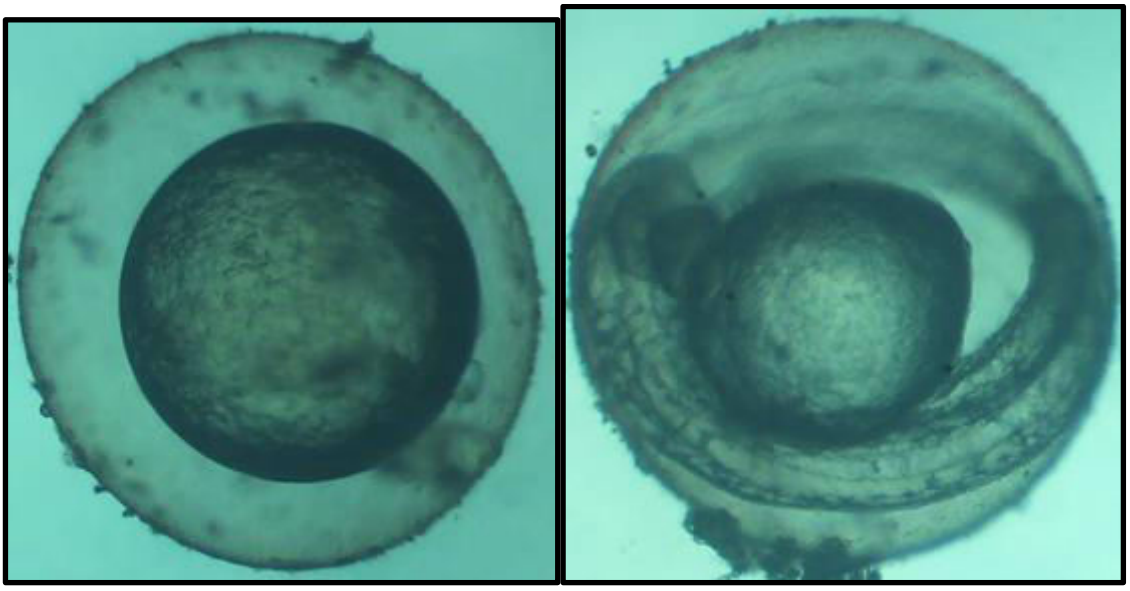
Graph 2: Represents percentage of live nauplii in the cytotoxic effect of commercial dental varnish over increased concentrations.



Graph 3: Represents percentage of hatching rate with A.paniculata (SeNPs) dental varnish.

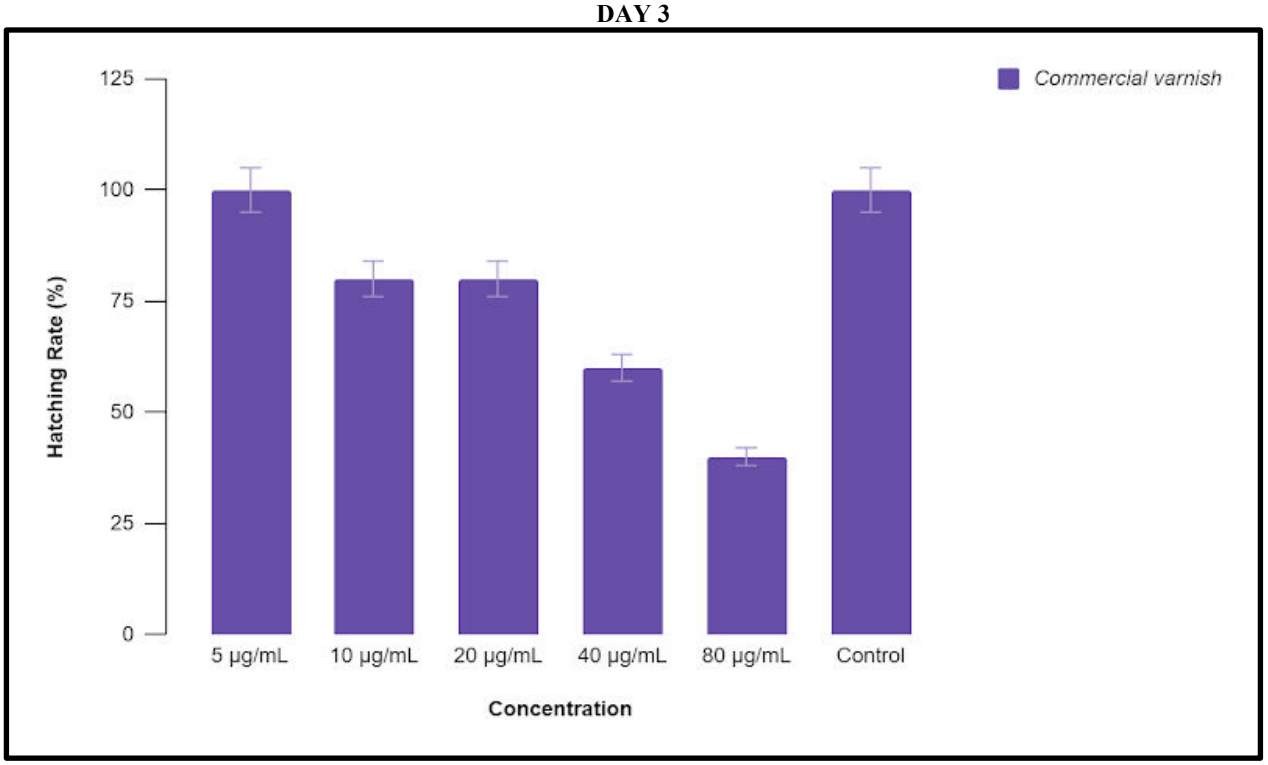


Graph 4: Represents percentage of viability rate with A.paniculata (SeNPs) dental varnish.

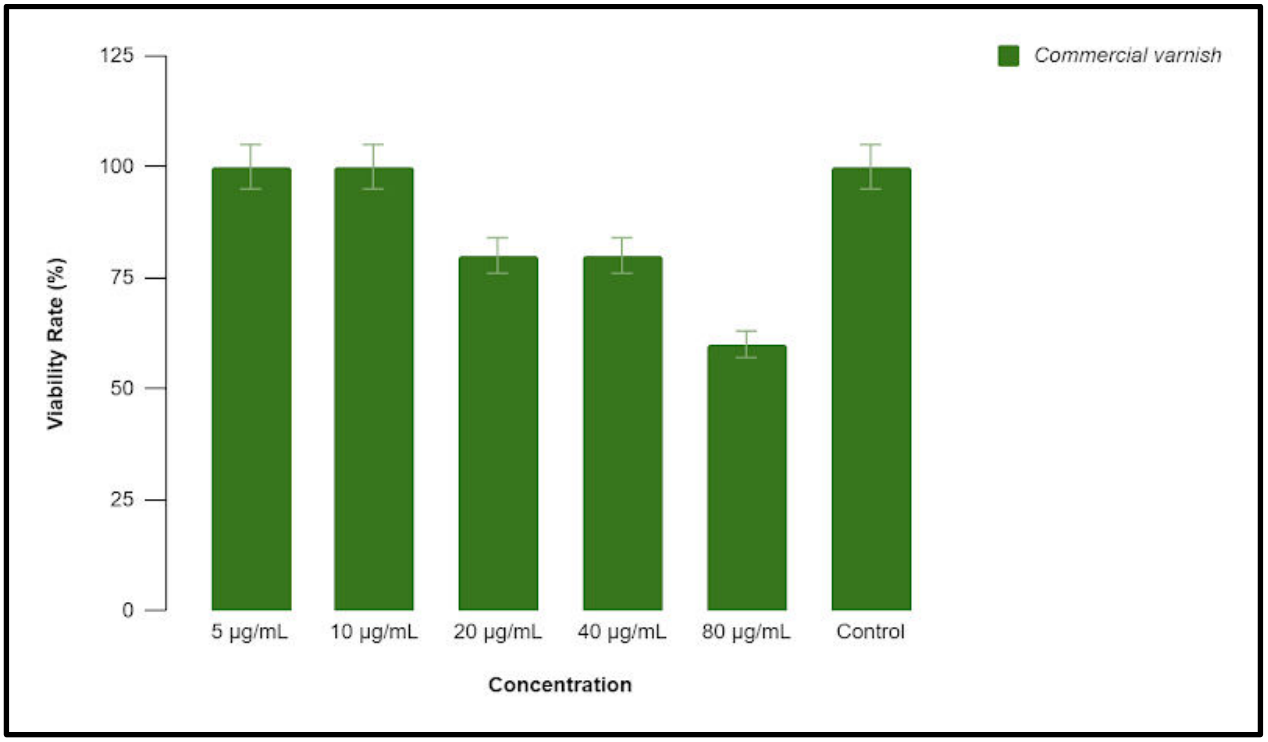


DAY 1 Zebrafish embryo **DAY 2**

DAY 3



Graph 5: Represents percentage of hatching rate with commercial varnish.



Graph 6: Percentage of viability rate with commercial varnish.

DISCUSSION

The comparative study of embryonic toxicology between selenium nanoparticles (SeNPs) incorporated dental varnish and commercial dental varnish reveals significant differences in embryonic outcomes, highlighting the potential advantages of SeNPs in dental applications.

Embryonic Mortality

Embryonic mortality is a critical indicator of toxicity. In this study, the SeNPs incorporated dental varnish exhibited lower embryonic mortality rates across all tested concentrations compared to the commercial dental varnish. This suggests that the SeNPs varnish is less toxic and safer for developing embryos. Selenium's known biological role in reducing oxidative stress and its involvement in antioxidant defence mechanisms may explain these findings(9) .

Hatching Rates

The hatching rates for embryos exposed to SeNPs incorporated dental varnish were consistently higher than those exposed to commercial dental varnish. Specifically, at 5 µg/mL and 10 µg/mL concentrations, hatching rates remained close to the control group, indicating minimal toxic effects. Even at higher concentrations (40 µg/mL and 80 µg/mL), the decline in hatching rates was less pronounced compared to the commercial varnish, demonstrating a more favourable toxicity profile.

Viability Rate

The viability rate, which measures the percentage of live nauplii after exposure, further supports the superiority of SeNPs incorporated dental varnish. Across all concentrations, the SeNPs varnish maintained higher viability rates compared to the commercial varnish. This finding is significant as it underscores the potential for SeNPs to offer protective effects against cytotoxicity, possibly due to their antioxidant properties (10).

Malformations

Malformations in developing embryos are a direct measure of teratogenic effects. The study found that embryos exposed to SeNPs incorporated dental varnish showed a lower incidence of malformations compared to those exposed to commercial varnish. This suggests that SeNPs may mitigate the teratogenic effects that are more pronounced with the commercial varnish. The reduced malformation rates can be attributed to the protective role of selenium in embryonic development (11).

Comparative Analysis with Commercial Varnish

The comparative analysis clearly indicates that SeNPs incorporated dental varnish is a safer alternative to commercial dental varnish.(12) The SeNPs varnish demonstrated lower embryonic mortality, higher hatching and viability rates, and fewer malformations. These advantages can be attributed to the controlled release of selenium ions, which are essential for maintaining cellular homeostasis and reducing oxidative stress(13).

The commercial dental varnish, on the other hand, showed a significant decline in hatching and viability rates at higher concentrations, along with a higher incidence of malformations. These findings align with previous studies that have raised

concerns about the toxicity of various chemicals used in commercial dental products.(13,14).

CONCLUSION

In conclusion, the evaluation of embryonic toxicology regarding selenium nanoparticles (SeNPs) incorporated into dental varnish compared to commercial varnish reveals both opportunities and challenges for dental care innovation. SeNPs offer potential advantages such as enhanced antimicrobial properties and extended dental protection, as evidenced by previous studies. However, the findings from this comparative study highlight significant concerns regarding embryonic toxicity.

The observed alterations in embryonic development and morphology following exposure to SeNP varnish underscore the critical need for thorough safety assessments in dental product development. While commercial varnishes also exhibit effects on maternal health and oral tissues, the unique properties of SeNPs necessitate specific attention due to their nanoscale dimensions and potential interactions with biological systems

CONFLICT OF INTEREST:

There is no conflict of interest.

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