The Effect of Nano Selenium Prepared by Plasma Jet Method on Liver and Kidney Functions

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Abstract: Selenium is an essential trace element that plays a crucial role in antioxidant activity, immune regulation, and metabolic processes in living organisms. In this study, selenium nanoparticles (Se NPs) were successfully synthesized using a plasma jet technique as a simple, environmentally friendly, and cost-effective preparation method. The structural and optical properties of the prepared nanoparticles were investigated using UV–Visible spectroscopy and X-ray diffraction (XRD) analysis. The UV–Visible spectra confirmed the formation of Se NPs with characteristic absorption peaks in the range of 280–320 nm. XRD results revealed that the crystallinity of the nanoparticles improved with increasing plasma exposure time, while the sample prepared at 12 min exhibited the highest crystalline quality with diffraction peaks located at 28.1°, 30°, 42°, 44°, and 56°, corresponding to the standard selenium phase. The biological impact of the synthesized Se NPs was evaluated through in vivo experiments on rats to investigate their effects on liver and kidney functions. Biochemical analyses demonstrated that the administered doses of selenium nanoparticles did not produce significant adverse effects on liver enzymes or kidney function indicators compared with the control group. These findings indicate that plasma jet synthesized Se NPs possess good biocompatibility and may be considered promising candidates for future biomedical and therapeutic applications.

1 INTRODUCTION

One modern scientific field that has a big impact on many aspects of daily life is nanotechnology. The production, modification, and use of materials at the nanoscale is referred to as nanotechnology. Copper, zinc, titanium, magnesium, gold, alginate, and silver are currently used to create a variety of metallic nanostructures [1]. Nanoparticles are used by many industries for a range of applications, including medicinal applications, energy storage in solar and oxide fuel batteries, and extensive integration into commonplace products like clothing and cosmetics [2]. Nanoparticles can be produced by biological or chemical means [3], [4].

Selenium is a dietary micronutrient that is vital for healthy metabolism and physiology in both humans and animals. The biological properties of selenium nanoparticles are influenced by their size and structure. Even more attention is drawn to selenium nanoparticles (SeNPs) because of their great bioavailability and significantly lower toxicity compared to organic and inorganic firms. This research paper summarizes the information and methods for producing selenium nanoparticles. SeNPs have been created in a variety of ways, including chemical, physical, and biological. In the production of selenium nanoparticles, biological methods have become increasingly significant in recent years [5].

For the immune system, productivity, reproductive efficiency, and general health of farm animals, selenium is an essential trace element. The novel characteristics of selenium nano-elements, such as their large specific surface area, high surface activity, high bioavailability, and comparatively low toxicity, have drawn a lot of attention [6]. This component is mostly associated with proteins in biological systems. Adverse clinical illnesses are caused by a lack of these compounds, but they can be avoided or treated with the right replacement. Low selenium levels increase the risk of death, reduce the effectiveness of the immune system, and impair cognitive function. Selenium insufficiency is linked to thyroid enlargement, thyroid malignancy, Hashimoto's disease, Graves' disease, hypothyroidism, and subclinical hypothyroidism. On the other hand, increased selenium levels or selenium supplements have antiviral effects, affect the reproductive health of both men and women, and reduce the prevalence of autoimmune thyroid disease. The endocrine gland known as the thyroid produces and secretes the metabolic hormones thyroxine (T4) and triiodothyronine (T3). utilizing its follicular cells. Hormones are necessary to keep the body in a state of equilibrium. They promote metabolic responses to variations in caloric intake, regulate glucose and lipid metabolism, and govern oxidative metabolism, thermogenesis, and basal metabolism. The thyroid gland's main hormone, T4, makes up about 93% of its entire hormonal production. However, T3 has a 10-15 times greater affinity for thyroid hormone receptors than T4, making it the most metabolically active hormone. For thyroid hormones to be functional, deiodinase enzymes must convert T4 to T3 intracellularly [7], [8].

Nano selenium can be prepared using a variety of techniques, including laser ablation [9], chemical synthesis [10], and the green approach [11]. In this study, selenium nanoparticles were prepared in a green and environmentally friendly way and their effect on the functions of liver and kidney function in vivo.

2 MATERIAL AND METHOD

2.1 Synthesis of Se NPs

Preparation of the solution. Nano-selenium can be prepared from selenium nitrate at a concentration of 0.5 mM using (1) [12], [13].

$$Concentration(mM) = (mass)/molecular\ weight*volume. \quad (1)$$

Preparation of nanoparticles. To prepare Se NPs, we followed the following steps:

The completed form will be put on a holder inside the metal tube as instructed once the solution of Se salts with the necessary sizes and concentrations has been created. The catcher holds the metal tube vertically in place. The metal tube of the beaker was also rounded, leaving 1 cm between the nozzle of the tube and the liquid's surface. Additionally, the argon gas delivered through metal tubes was controlled by the flow of Sanpur gas. Figure 1 shows how the value that corresponded to the voltage supplied by the system progressively grew until plasms developed between the tube and the liquid's surface [14].

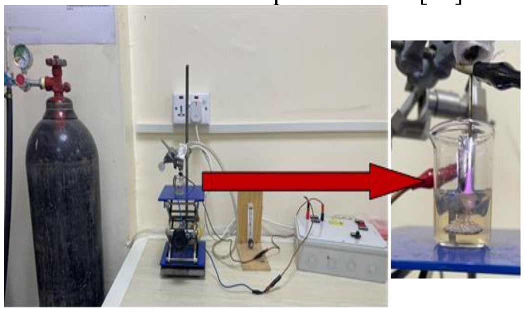

Figure 1: Plasma jet scheme to prepare Se nanoparticles.

2.2 In Vivo Study

We had fifteen adult female rats that weighed between 150 and 200 grams. The rats were kept at room temperature (25°C) and exposed to dim light and darkness for 12 hours each. The rats were kept in clear plastic cages covered with stainless steel wire, and sawdust was used as bedding. They received water, food, andThe rats were subsequently split up into three groups, each with five rats, and given different doses of SeNPs (0.5,1) mL. The control group was not given any dose. The oral exposure method, depicted in Figure 2, was used to repeat the dosage three times each week.

Each animal's relative weight was determined by using (2) and tracking the animal's weight on a weekly basis [15].

$$WR = W(di)/W(d0). \quad (2)$$

Where *WR* is relative weight, *W(di)* is weight of rats during the study period, *W(d0)* weigh rats before exposure.

Figure 2: The Method of dosing rats by Se NPs.

3 RESULT AND DISCUSSION

3.1 UV-Visible Absorption Spectra of Se NPs

In this study, nanoparticles (SeNPs) with varying exposure times (8, 10, and 12 minutes) were produced using Ar gas and a plasma jet. Utilized (Fig. 3). The formation of nanoparticles is shown by a shift in the color of the solution from yellow to orange (Fig. 1). The hue of (SeNPs) NP molecules. Thus, the composition of the nanoparticles was demonstrated using visible wavelength spectroscopy. The produced nanoparticle solutions' optical properties were investigated. Each line in the image shows one aberration, which is very noticeable at 3 nm, and the absorption edge is skewed in wavelength from 280 to 320 nm.

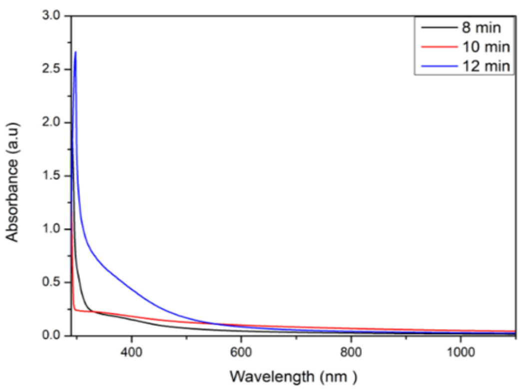

Figure 3: UV-Visible absorption spectra of Se NPs as different exposure time.

3.2 The Results of X-Ray Diffraction Patterns of Selenium Nanoparticles Prepared

The crystallinity of selenium nanoparticles prepared by cold plasma was studied at different exposure times using X-ray diffraction (XRD) (8, 10, 12) min. Figure 4 shows the results the change in the behavior of selenium nanoparticles with exposure time; the optimal result was obtained at 12 min, with three peaks at 2θ=28.1°, 30°, 42°, 44°, and 56° according to the JCPDS standard card (No. 06–0362) for Se NPs. It helped in obtaining particles with better crystal structure and higher purity, while reducing impurities [11], [12].

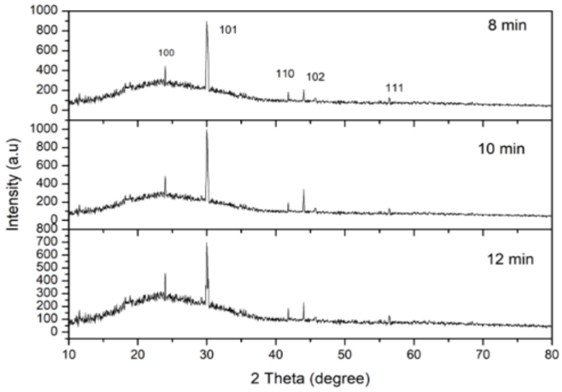

Figure 4: X-ray patterns of Se NPs as a function of exposure time.

3.3 In Vivo Study to Observing the Effect of Selenium Nanoparticles on the Liver and Kidney Function

It was also studied whether Se NPs had effects on liver and kidney functions for the doses used We showing from Figures 5, 6 and 7 that there is no negative effect on liver function, and no negative effect on kidney function showing Figures 8, 9 and 10.

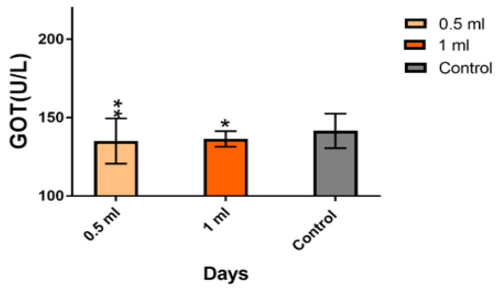

Figure 5: The level of liver function (GOT) of rat's blood.

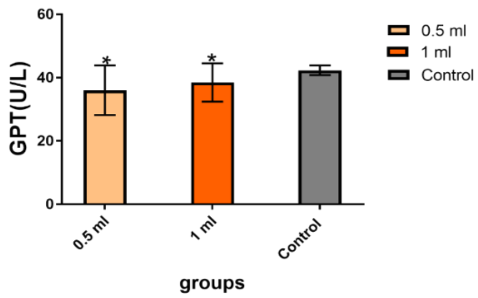

Figure 6: The level of liver function (GPT) of rat's blood.

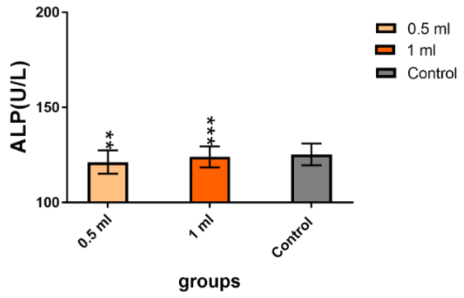

Figure 7: The level of liver function (ALP) of rat's blood.

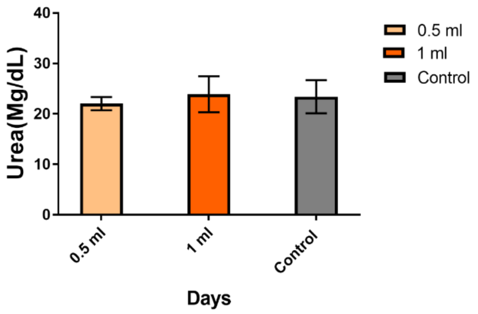

Figure 8: The level of kidney function (Urea) of rat's blood.

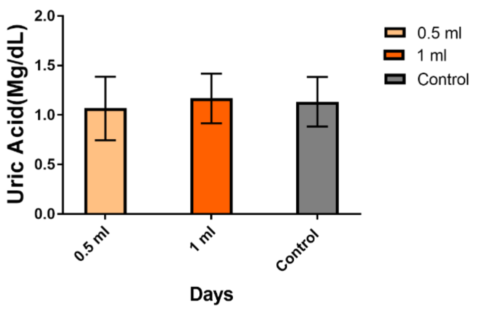

Figure 9: The level of kidney function (Uric acid) of rat's blood.

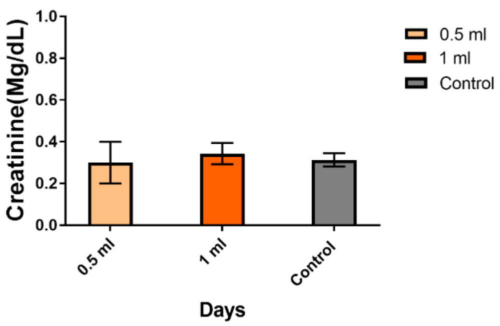

Figure 10: The level of kidney function (creatin) of rat's blood.

4 CONCLUSIONS

The study successfully prepared selenium nanoparticles using plasma jett. The results showed that the optimal exposure time of 12 minutes achieved the best absorbance by UV-vis analysis and the highest degree of crystallinity according to X-ray diffraction analysis. The study also confirmed the biosafety of these particles, as no toxic effects were recorded on liver and kidney functions in mouse models, opening up promising prospects for their safe biomedical applications as antimicrobials or biosensors. Because of the enhanced bioactivity, decreased toxicity, precise targeting, and controlled release of nanoparticles, nanotechnology holds great promise for a wide range of biological applications. This comprehensive review outlines the diverse biological activities of selenium nanoparticles (SeNPs) and their most recent developments, emphasizing their revolutionary potential in biomedical research and applications.

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