Evaluation of Antioxidant and Cytotoxic Effect of Selenium Nanoparticles Synthesised Using Capparis decidua

P. S. Thana Lakshme¹, Preetha S²*, M. Jeevitha³ and S. Rajeshkumar⁴

¹Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, India.
²Department of Physiology, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, India.
³Department of Periodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, India.
⁴Department of Pharmacology, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, India.

Authors’ contributions

This work was carried out in collaboration among all authors. Author PS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors PSTL and MJ managed the analyses of the study. Author SR managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Background: Among the nanoparticles, selenium nanoparticles (SeNP) are one of the most extensively studied as Selenium has zero oxidation state, non toxic and biologically inert material. This is the reason why Selenium is considered as a major nanoparticulate. In this study SeNPs were extracted from the fruit of Capparis decidua which is a xerophytic small herb.

Aim: The aim of the present study is to evaluate the cytotoxic effect and antioxidant capacity of selenium nanoparticles.

Materials and Methods: In this study SeNPs were extracted from the fruit of Capparis decidua which is a xerophytic small herb. The cytotoxic effect of SeNPs was evaluated using Brine Shrimp

*Corresponding author: E-mail: preethas.sdc@saveetha.com;
Selenium (Se) plays a vital role in the antioxidant defense mechanism of the liver and thus protecting against oxidative stress [1]. Also Selenium prevents the accumulation of free radical species, and reduces the cellular damage which makes the researchers choose Selenium for study [2–4]. As it is familiar that Selenium is one of the essential trace elements with zero oxidation state which enhances bioavailability compared to other forms of Selenium [5,6]. But there also exists a limitation of dose which could be toxic when exceeded [7]. Yet another limitation would be that Selenium is a thermostable and biologically inert element and thus it is restricted to be food intake [8,9]. Selenium was designed as a nano-vehicle using polysaccharides, proteins, etc., as stabilisers [10,11]. Cytotoxic refers to a substance or process that results in cell damage or cell death. Even our own immune systems have cells that are considered to be cytotoxic, such as T cells which kill bacteria, viruses, and also cancer cells [12]. These cytotoxic drugs work by interrupting the cells in their growth cycle [13]. The term antioxidant itself infers that it inhibits oxidation. Oxidation being chain reactions, can produce free radicals that may damage the cells of organisms. Certain vitamins like beta carotene, Vitamin A and Vitamin E being a dietary supplement for antioxidant activities has no positive effect on mortality rate [14]. In case of Selenium, it is considered as a better antioxidant supplement though not a dietary intake but it was limited that selenium had no positive impact on cardiovascular disease [15]. The most interesting factor is that antioxidants being reducing agents, can act as pro oxidants but the relative importance of pro oxidants is still a matter of discussion [16]. Capparis decidua, commonly known as Karira which is used as folk medicine and herbalism grown in drought resistant areas [17]. From the prior studies, it was evident that Capparis decidua possesses sterols, fatty acids, flavones and alkaloids [18–20]. Thus the plant Capparis decidua was chosen to enable better results.

In previous studies, involving the antioxidant capacity of SeNPs it establishes low cytotoxicity and enhanced antioxidant capacity. This study by Chitosan also speaks on the ability of considered nanoparticles to penetrate cells or tissue effectively [21]. The present study is the extension of prior studies undertaken with Capparis decidua as it had been acknowledged that this plant is a potent source of various bio chemicals and therapeutics. Similarly, with consideration of selenium it possesses a better antioxidant activity. Thus determining the antioxidant and cytotoxic effect of Selenium nanoparticles with the extract of Capparis decidua would enhance the pharmacological development of drugs in future. The study on the combination of both antioxidant and cytotoxic effects of Selenium nanoparticles as a subject is the uniqueness of our study. Our recent research portfolio slides numerous articles in reputed journals [22–30]. Based on this experience we planned to pursue the cytotoxicity and antioxidant property of Selenium nanoparticles. Thus the aim of the study is to evaluate antioxidant and cytotoxic effects of selenium nanoparticles using Capparis decidua.

1. INTRODUCTION

Selenium (Se) plays a vital role in the antioxidant defense mechanism of the liver and thus protecting against oxidative stress [1]. Also Selenium prevents the accumulation of free radical species, and reduces the cellular damage which makes the researchers choose Selenium for study [2–4]. As it is familiar that Selenium is one of the essential trace elements with zero oxidation state which enhances bioavailability compared to other forms of Selenium [5,6]. But there also exists a limitation of dose which could be toxic when exceeded [7]. Yet another limitation would be that Selenium is a thermostable and biologically inert element and thus it is restricted to be food intake [8,9]. Selenium was designed as a nano-vehicle using polysaccharides, proteins, etc., as stabilisers [10,11]. Cytotoxic refers to a substance or process that results in cell damage or cell death. Even our own immune systems have cells that are considered to be cytotoxic, such as T cells which kill bacteria, viruses, and also cancer cells [12]. These cytotoxic drugs work by interrupting the cells in their growth cycle [13]. The term antioxidant itself infers that it inhibits oxidation. Oxidation being chain reactions, can produce free radicals that may damage the cells of organisms. Certain vitamins like beta carotene, Vitamin A and Vitamin E being a dietary supplement for antioxidant activities has no positive effect on mortality rate [14]. In case of Selenium, it is considered as a better antioxidant supplement though not a dietary intake but it was limited that selenium had no positive impact on cardiovascular disease [15]. The most interesting factor is that antioxidants being reducing agents, can act as pro oxidants but the relative importance of pro oxidants is still a matter of discussion [16]. Capparis decidua, commonly known as Karira which is used as folk medicine and herbalism grown in drought resistant areas [17]. From the prior studies, it was evident that Capparis decidua possesses sterols, fatty acids, flavones and alkaloids [18–20]. Thus the plant Capparis decidua was chosen to enable better results.

2. MATERIALS AND METHODS

The current study has been approved by the Scientific review board, Saveetha Dental College, Chennai.
2.1 Preparation of Plant Extract

The well dried Capparis decidua fruits were collected and made into a powder using mortar and pestle. 1 grams of C. decidua powder was dissolved in distilled water and boiled for 10 mins at a controlled temperature of 60 degree in a hot mantle. The solution was filtered.

2.2 Preparation of Nanoparticle Solution

0.01 milligram of Sodium selenite was dissolved in 8 ml of distilled water. 40 ml of plant extract was added with 60 ml of prepared metal solution and were made into 100 ml solution. This solution was kept in a shaker and readings were taken. These selenium nanoparticles can also be synthesized from an isolated bacterial colony \[31\]. Selenium dioxide nanoparticles were successfully prepared from Equisetum arvense obtained from the north-east of Iran \[32\].

2.3 UV Characterization

Synthesised nanoparticle solution is characterised using UV spectroscopy in the range of 250-650 nm. These results were recorded for graphical analysis.

2.4 Preparation of Nanoparticle Powder

Selenium nanoparticle solution was centrifuged using refrigerated centrifuge at 8000 rpm for 3 minutes and pellet was collected and washed with distilled water twice. The purified pellet was collected and dried for 2-3 days in a hot air oven. Finally, the nanoparticle powder was collected and stored in an airtight Eppendorf tube.

2.5 Determination of Cytotoxic Effect

The cytotoxic effect was determined by carrying out brine shrimp assay method. Distilled water was taken in different concentrations such as 10 microliter, 20 microliter and till 50 microliter. The shrimps were introduced into each well in the count of exactly 10 involving the control. Then the extract was added according to the concentration of distilled water in each well excluding the control. This setup was undisturbed and then observed after 24 hours. Now the alive shrimps were counted.
2.6 Determination of Antioxidant Activity

Antioxidant activity of Se nanoparticle was determined on the basis of radical scavenging mechanism in DPPH assay (2, 2-diphenyl-1-picryl-hydrazyl-hydrate) which is a free radical method based on electron transfer. The value of RSC% (Radical Scavenging Capacity) was calculated using the following formula:

\[ \text{Radical scavenging activity, RSC\% = } \frac{A_0 - A_1}{A_0} \times 100 \]

where \( A_0 \) is the absorbance of the control and \( A_1 \) is the absorbance of the mixed solution of the antioxidant and free radical agent. This assay was carried out based on the work of Xu B J et. al., 2007 [33]. 0.2 mL of nanoparticle powder was mixed vigorously with 3.8 mL of DPPH radical ethanol solution with DPPH concentration as 0.1mmol/L, and then maintained at room temperature in the dark for 30 minutes. The absorbance was measured at 517 nm with a UV spectrophotometer.

This can be concluded that with increase in concentration, the percentage inhibition of Selenium nanoparticles is increased but it remains less than the percentage inhibition of standard ascorbic acid. Hence Selenium nanoparticles possess better antioxidant capacity but it is less effective when compared to the antioxidant property of the standard used.

The synonymous study carried by R. S. Das et.al., performed the similar DPPH assay on SeNPs with ascorbic acid as standard and established the same result which adds evidence to our study and exists as a supporting study [34]. Another supporting study by Mughal Quayam et.al., also performed DPPH assay for antioxidant determination also total phenolic content was estimated ensuring the significant antioxidant capacity in C. decidua and thus adds an evidence to our present study [35]. Yet another similar study by Tapiero H et.al., establishes that selenium compounds like selenite induce cytotoxicity causing apoptosis but Selenium has no cytotoxic effect which is synonymous with our study and thus adds evidence to the present study [1]. The study by Mojdeh Safari et.al., involving SeNPs, cytotoxicity was determined by MTT assay which showed low toxicity toward investigated cell lines for 24 hrs which contradicts our findings and thus remains as an opposite finding to our study [36].

Thus it is evident that there is no significant cytotoxicity in Selenium nanoparticles. For the evaluation of antioxidant capacity, the percentage inhibition of 10 µl was 15.4±0.1, 20 µl was 38.36±0.15, 30 µl was 45.3±0.1, 40 µl was 59.6±0.15 and 50 µl was 65.6± 0.1 which were presented in the form of a graph in comparison with the percentage inhibition of the standard (Ascorbic acid) used.

Table 1. Represents the percentage inhibition of selenium nanoparticles and the standard ascorbic acid for corresponding concentration in DPPH assay

| Concentration (µl) | % inhibition of DPPH (Selenium nanoparticle) | % inhibition of DPPH (Std) |
|-------------------|---------------------------------------------|---------------------------|
| 10 µl             | 15.4 ± 0.1                                  | 24.69 ± 0.59              |
| 20 µl             | 38.36 ± 0.15                                | 51.34 ± 1.46              |
| 30 µl             | 45.3 ± 0.1                                 | 65.54 ± 1.05              |
| 40 µl             | 59.6 ± 0.15                                | 78.42 ± 0.73              |
| 50 µl             | 65.6 ± 0.1                                 | 91.53 ± 1.51              |
Fig. 4. Shows the count of alive shrimps after 24 hours in Brine shrimp assay

Fig. 5. Shows the percentage inhibition of selenium nanoparticles and the standard used with respect to concentration. This graph represents that with increase in concentration, the percentage inhibition of Selenium nanoparticles is increased but it remains less than the percentage inhibition of standard ascorbic acid.

4. CONCLUSION

From the above study it is evident that SeNPs biosynthesised from *Capparis decidua* is a potent source of antioxidant activity with nil cytotoxic effects which can emerge as a better treatment for various diseases.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.
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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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