Boerhavia diffusa Mediated Selenium Nanoparticles and their Antioxidant and Anti-Inflammatory Activity

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Authors’ contributions

This work was carried out in collaboration among all authors. Author RVG designed the study and draft of the manuscript. Author SRK performed the guidance for research, data verification of the study. Author BS managed the literature search, analysis, manuscript writing. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: Boerhavia diffusa belongs to species of flowering plant which is commonly called as "punarnava". Its leaves are used as green leafy vegetables, with its high anti-inflammatory and expectorant properties selenium particles are synthesised. Selenium particles are used as nutritional supplements and an anti-microbial coating. Selenium (Se) was found to have anti-inflammatory properties, but its bioavailability and toxicity are limiting factors considerably.

Aim: To find the antioxidant and anti-inflammatory activities of Boerhavia diffusa mediated selenium nanoparticles

Materials and Methods: 1 gm of Boerhavia diffusawas added to 100 ml of distilled water and allowed to boil for 10-15 minutes at 70 degree celsius and filtered. 60 ml of 20 milli molar sodium selenite is prepared in 250 ml of conical flask, 40 ml of filtered plant extract was mixed to it. The synthesized nanoparticle was preliminarily analysed using UV visible spectroscopy. Prior to the final step the nanoparticle solution was centrifuged at 8000 rpm to prepare nanoparticle pellet powder, it was dried in a hot air oven at 80 degree celsius. The dried powder was sent for

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characterisation. The leftover nanoparticle solution extract was sent to evaluate antioxidant activity through DPPH assay and anti-inflammatory activity through albumin denaturation assay.

Results: Selenium nanoparticles were achieved from boerhavia diffusa plant extract, which was evident with its significant colour change in the cultivation medium. The final centrifuge was found to have potent antioxidant and anti-inflammatory activities.

Conclusion: The selenium nanoparticles synthesized from leaf extract of Boerhaavia diffusa were evaluated for antioxidant and anti-inflammatory activities. This study concludes that extract bound selenium nanoparticles had potent antioxidant and anti-inflammatory activities. Therefore selenium nanoparticles may provide a great implication in the later studies for its potential activity.

Keywords: Boerhavia diffusa; selenium nanoparticles; characterization; antioxidant activity; anti-inflammatory activity; innovative technology.

1. INTRODUCTION

Boerhavia diffusa belongs to species of flowering plant which is called as "punarnava". Its leaves are used as green leafy vegetables. With its high anti-inflammatory and expectorant properties selenium particles are synthesized. Rural areas of many developing countries had a great awareness on usage of medicinal plants. Boerhavia diffusa is classified under the family Nyctaginaceae. It is a hairless, semi-prostrate, perennial herb of 60cm high with a thick, fleshy rootstock that reproduces from seeds. The stem is slender, jointed, more or less fleshy and woody below. It is green or purple, low branching, glabrous and not sticky from root hairs. The leaves are opposite, little fleshy, ovate shaped, 2.5-4 cm long and 2-4 cm wide, with petioles 1-3 cm long, blunt-tipped and smooth [1]. Boerhavia diffusa is grouped under the rasayana category according to ayurvedic claims. It is found to have anti-aging properties, disease prevention, and life strengthening activities which had much influence on disease burden and availability of healthcare in the world. Chemical analysis of B. diffusa provided a wide variety of chemical constituents, namely - rotenoids, flavonoids, purine nucleoside, steroids, etc... Various ethnopharmacological reports emphasize its role in disorders of reproductive system, gastrointestinal system, respiratory system, urinary system, hepatic system/ jaundice, cardiovascular system, and cancer [2,3].

Selenium particles are used as nutritional supplements and an anti-microbial coating. Selenium (Se) was found to have anti-inflammatory properties, but its bioavailability and toxicity are limiting factors considerably. Nanoparticles of Se were administered orally with a dosage of 2.55 mg/kg once before carrageenan administration in the first model and two times in the second model [4,5]. The antioxidant activity of selenium nanoparticles was determined by production of reactive oxygen species using man’s umbilical vein endothelial cells. Electron microscopic pictures show intracellular and extracellular deposits of selenium particles. These particles which are of <100 nm are used as preservatives due to antioxidant properties that are relevant to human health [6,7]. Selenium nanoparticles are related to health care and other concerned issues. Pectin, well known food grade polysaccharide is used as stabilizer to form better dispensed and stable SeNPs under a simple redox reaction, and also Se / PEC ratio affects the colour of suspension for easy identification [8,9]. Cytotoxic effect of the SeNPs and selenium dioxide (SeO2) on MCF-7 cell line was assessed by MTT assay. Transmission electron micrograph (TEM) of the purified Se NPs showed individual and spherical nanostructures in a range of about 80–220 nm [10]. In the previous studies, the biosynthesis of SeNPs that employ microorganisms, especially probiotics, had given great attention and are considered a green process because of several advantages adding on safety, cost effectiveness, and an eco-friendly approach and is currently trending as an alternative to conventional methods which include, physical and chemical synthesis methods of SeNPs [11,12].

The present study focussed on antioxidant and anti-inflammatory activity of boerhavia diffusa mediated selenium nanoparticles. Previous studies on various activities of selenium nanoparticles like antifungal, antimicrobial and cytotoxic activities and based on various sources of plants other than boerhavia diffusa had given a detailed explanation of all the activities. Our team has extensive knowledge and research experience translated into high quality publications [13–24].
2. MATERIALS AND METHODS

In the present study, 1gm of boerhaavia diffusa was added in 100 ml of distilled water and boiled for 10-15 minutes at 70 degrees celsius. After boiling, the plant extract was filtered by Whatman No 1 filter paper. 60 ml of 20 milli molar sodium selenite is prepared in 250 ml of conical flask, 40 ml of filtered plant extract was mixed to it and kept in a magnetic stirrer for nanoparticle synthesis. The synthesized nanoparticle was preliminarily analysed using UV visible spectroscopy. Prior to the final step the nanoparticle solution was centrifuged at 8000 rpm to prepare nanoparticle pellet powder, it was dried in a hot air oven at 80 degree celsius. The dried powder was sent for characterisation. Finally, the left over solution was taken to calculate antioxidant and anti-inflammatory activity. All the results were taken photographs and recorded in the excel sheets.

2.1 Antioxidant Activity - DPPH Method

DPPH assay was used to test the antioxidant activity of biogenic synthesized selenium nanoparticles. Diverse concentrations (2-10 μg/ml) of boerhaavia diffusa leaf extract interceded selenium nanoparticle was mixed with 1 ml of 0.1 mM DPPH in methanol and 450 μl of 50 mM Tris HCl buffer (pH 7.4) and incubated for 30 minutes. Later, the reduction in the quantity of DPPH free radicals was assessed dependent on the absorbance at 517 nm. BHT was employed as control. The percentage of inhibition was determined from the following equation,

\[
\% \text{ inhibition} = \frac{\text{Absorbance of control} - \text{Absorbance of test sample} \times 100}{\text{Absorbance of control}}
\]

2.2 Anti-Inflammatory Activity - Albumin Denaturation Assay

The anti-inflammatory activity for selenium nanoparticles was tested by the following convention proposed by Muzushima and Kabayashi with specific alterations (Pratik Das et al.,2019). 0.05 mL of Solanum torvum gel of various fixation (10 µL, 20 µL, 30 µL, 40 µL, 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 the following equation,

\[
\% \text{ inhibition} = \frac{\text{Absorbance of control} - \text{Absorbance of sample} \times 100}{\text{Absorbance of control}}
\]
3. RESULTS

Selenium nanoparticles were achieved from Boerhavia diffusa plant extract which was evident with its significant colour change in the cultivation medium. The final centrifuge was found to have potent antioxidant and anti-inflammatory activities. All the parameters were recorded and represented. Fig. 2 shows the UV light spectroscopy of selenium nanoparticles which showed decreased absorbance when compared with the serial wavelengths, electron microscopy picture showed that the nanoparticles are spherical and square and many undefined shapes are there may be the binding of plant extract with nanoparticles (Fig. 3) later the antioxidant and anti-inflammatory bar graphs of selenium nanoparticles compared with standards showed a potent activity (Figs. 4 and 5).

The Fig. 2. shows the UV light spectroscopy of selenium nanoparticles which showed decreased absorbance compared with the serial wavelengths.

Fig. 3 clearly shows that the nanoparticles are spherical and square and with many undefined shapes, there may be the binding of plant extract with nanoparticles.

Fig. 4. the bar graph denotes the antioxidant activity of selenium nanoparticles derived from the plant extract of boerhaavia diffusa. X-axis denotes the concentration of plant extract with selenium nanoparticles and Y-axis denotes the percentage of inhibition towards the oxidant activity. It shows the increase in percentage of inhibition with increase in concentrations but decreased activity when compared with the standard.
Fig. 4. Bar graph showing antioxidant activity of SeNps

Fig. 5. Bar graph showing anti-inflammatory activity of SeNps

Fig. 5 the bar chart shows the anti-inflammatory activity of selenium nanoparticles derived from the boerhavia diffusa plant extract. X-axis denotes the percentage of inhibition and Y-axis denotes the concentration of plant extract containing selenium nanoparticles. It shows the increase in percentage of inhibition for inflammatory activity with an increase in concentrations. At 50 μl concentration, the selenium nanoparticles' activity is more than the standard, whereas the activity is less than standard activity at the rest of the concentrations.

4. DISCUSSION

Green tea extract was used as the Na2SeO3-reducing agent at room temperature and the LBP acted as the coating agent to prevent SeNPs agglomeration in dispersion, finally enhancing the stability and biological activity under physiological conditions. Results have shown that SeNPs have ability to utilize as food materials in green synthesis of selenium nanoparticles and also in applications in biomedical, cosmetic and pharmaceutical products, as main antioxidant supplement and neuroprotective agents [25-27]. FTIR results show that SeNPs were combined to the hydroxyl groups of GA, The hydroxyl radical scavenging ability and DPPH scavenging ability of GA-SeNPs were higher than those of AGHA-SeNPs and could reach 85.3 ± 2.6%, 85.3 ± 1.9% at a concentration of 4 mg/ml, respectively [28].
SeNPs show an excellent antioxidant performance by the 2,2′-azino-bis (3-ethylbenzothiazoline -6-sulphonic acid) (ABTS) and ferric reducing antioxidant power (FRAP) methods [29]. The biogenic biomolecules capped-SeNPs possess low cytotoxicity, and significant antioxidant and anticancer activities. The current study suggests that probiotics could provide a better alternative to synthesize biogenic SeNPs with potential applications as anticancer and antioxidant agents [30,31].

SeNP at a concentration of 250 µg/kg b.w. acted as potent anti-inflammatory agent and significantly reduced (p < 0.05) arthritis induced parameters. The enzymatic antioxidant levels in liver, kidney, and spleen were regained significantly (p < 0.05) at 100 µg/kg b.w. while CRP was regained to normal at concentration of 100 µg/kg b.w. determining SeNP at 500 µg/kg b.w. can be a potential antiarthritic drug supplement [32]. The synthesized nanoparticles were assessed for the anti-inflammatory and antioxidant properties by albumin denaturation assay and α, α-diphenyl-β-picryl hydrazyl free radical scavenging assay. From the synthesized selenium nanoparticles, both the anti-inflammatory and antioxidant activities showed a good percentage of inhibition [32-35].

5. CONCLUSION

The selenium nanoparticles synthesized from leaf extract of Boerhavia diffusa were evaluated for antioxidant and anti-inflammatory activities. This study concludes that selenium nanoparticles had potent antioxidant and anti-inflammatory activities. With these properties, it can be used in healthcare centers and camps. Therefore selenium nanoparticles may provide a great impact in later studies for the potential activity.

6. LIMITATIONS

Only antioxidant and anti-inflammatory activities are evaluated.

FUTURE SCOPE

We expect further studies on characterisation of selenium nanoparticles and other activities derived from different studies.

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.

REFERENCES

1. Akinnibosun FI, Akinnibosun HA, Ogedegbe D. Investigation on the antibacterial activity of the aqueous and ethanolic extracts of the leaves of Boerhavia diffusa L [Internet]. Science World Journal. 2010;4. Available: http://dx.doi.org/10.4314/swj.v4i2.51839
2. Mishra S, Aeri V, Gaur PK, Jachak SM. Phytochemical, therapeutic, and ethnopharmacological overview for a traditionally important herb: Boerhavia diffusa Linn. Biomed Res Int. 2014 May 14;2014:808302.
3. Satheesh MA, Pari L. Antioxidant effect of Boerhavia diffusa L. in tissues of alloxan induced diabetic rats. Indian J Exp Biol. 2004 Oct;42(10):989–92.
4. El-Ghazaly MA, Fadel N, Rashed E, El-Batal A, Kenawy SA. Anti-inflammatory effect of selenium nanoparticles on the inflammation induced in irradiated rats. Can J Physiol Pharmacol. 2017 Feb;95(2):101–10.
5. Menon S, Ks SD, Santhiya R, Rajeshkumar S, S VK. Selenium nanoparticles: A potent chemotherapeutic agent and an elucidation of its mechanism [Internet]. Colloids and Surfaces B: Biointerfaces. 2018;170:280–92. Available: http://dx.doi.org/10.1016/j.colsurfb.2018.06.006
6. Torres SK, Campos VL, León CG, Rodríguez-Llamazares SM, Rojas SM, González M, et al. Biosynthesis of selenium nanoparticles by Pantoea agglomerans and their antioxidant activity. J Nanopart Res [Internet]. 2012 Nov;14(11). Available: http://dx.doi.org/10.1007/s11051-012-1236-3
7. Menon S, Agarwal H, Rajeshkumar S, Jacqueline Rosy P, Shanmugam VK. Investigating the Antimicrobial Activities of the Biosynthesized Selenium Nanoparticles and Its Statistical Analysis [Internet]. BioNanoScience. 2020;10:122–35. Available:http://dx.doi.org/10.1007/s12668-019-00710-3
8. Qiu W-Y, Wang Y-Y, Wang M, Yan J-K. Construction, stability, and enhanced antioxidant activity of pectin-decorated selenium nanoparticles. Colloids Surf B Biointerfaces. 2018 Oct;170:692–700.
9. S B, Balamithra S, Rajeshkumar S, Roy A, Lakshmi T. Antibacterial activity of selenium nanoparticles synthesized using Maranta arundinacea root extract [Internet]. International Journal of Research in Pharmaceutical Sciences. 2020;11:2695–700. Available:http://dx.doi.org/10.26452/ijrps.v1i2.2289
10. Forootanfar H, Adeli-Sardou M, Nikkhoo M, Mehrabani M, Amir-Heidari B, Shahverdi AR, et al. Antioxidant and cytotoxic effect of biologically synthesized selenium nanoparticles in comparison to selenium dioxide. J Trace Elem Med Biol. 2014 Jan;28(1):75–9.
11. Xu C, Qiao L, Ma L, Yan S, Guo Y, Dou X, et al. Biosynthesis of Polysaccharides-Capped Selenium Nanoparticles Using NZ9000 and Their Antioxidant and Anti-inflammatory Activities. Front Microbiol. 2019 Jul 26;10:1632.
12. Chellappa LR, Shanmugam R, Indiran MA, Samuel SR. Biogenic nanoselenium synthesis, its antimicrobial, antioxidant activity and toxicity [Internet]. Bioinspired, Biomimetic and Nanobiomaterials. 2020;9:184–9. Available:http://dx.doi.org/10.1680/jbibn.19.00054
13. Priyadharsini JV, Vijayashree Priyadharsini J, Smiline Girija AS, Paramasivam A. In silico analysis of virulence genes in an emerging dental pathogen A. baumannii and related species [Internet]. Archives of Oral Biology. 2018;94:93–8. Available:http://dx.doi.org/10.1016/j.archoralbio.2018.07.001
14. Vijayashree Priyadharsini J. In silico validation of the non-antibiotic drugs acetaminophen and ibuprofen as antibacterial agents against red complex pathogens. J Periodontol. 2019 Dec;90(12):1441–8.
15. Paramasivam A, Vijayashree Priyadharsini J, Raghunandhakumar S. N6-adenosine methylation (m6A): A promising new molecular target in hypertension and cardiovascular diseases. Hypertens Res. 2020 Feb;43(2):153–4.
16. Vijayashree Priyadharsini J, Smiline Girija AS, Paramasivam A. An insight into the emergence of Acinetobacter baumannii as an oro-dental pathogen and its drug resistance gene profile - An in silico approach. Heliyon. 2018 Dec;4(12):e01051.
17. Paramasivam A, Vijayashree Priyadharsini J. Novel insights into m6A modification in circular RNA and implications for immunity. Cell Mol Immunol. 2020 Jun;17(6):688–9.
18. Paramasivam A, Priyadharsini JV, Raghunandhakumar S. Implications of m6A modification in autoimmune disorders. Cell Mol Immunol. 2020 May;17(5):550–1.
19. Girija ASS, Shankar EM, Larsson M. Could SARS-CoV-2-Induced Hyperinflammation Magnify the Severity of Coronavirus Disease (CoVID-19) Leading to Acute Respiratory Distress Syndrome? Front Immunol. 2020 May 27;11:1206.
20. Jayaseelan VP, Arumugam P. Exosomal microRNAs as a promising theragnostic tool for essential hypertension. Hypertens Res. 2020 Jan;43(1):74–5.
21. Ushanthika T, Smiline Girija AS, Paramasivam A, Priyadharsini JV. An in silico approach towards identification of virulence factors in red complex pathogens targeted by reserpine. Nat Prod Res. 2021 Jun;35(11):1893–8.
22. Ramalingam AK, Selvi SGA, Jayaseelan VP. Targeting prolyl tripeptidyl peptidase from Porphyromonas gingivalis with the bioactive compounds from Rosmarinus officinalis. Asian Biomed. 2019 Oct 1;13(5):197–203.
23. Kumar SP, Girija ASS, Priyadharsini JV. Targeting NM23-H1-mediated inhibition of tumour metastasis in viral hepatitis with bioactive compounds from Ganoderma lucidum: A computational study. Pharmaceutical-Sciences [Internet]. 2020;82(2).
Available:https://www.ijpsonline.com/articles/targeting-nm23h1-mediated-inhibition-of-tumour-metastasis-in-viral-hepatitis-with-bioactive-compounds-from-ganoderma-lucidum-a-comp-3883.html

24. Mathivadani V, Smiline AS, Priyadharsini JV. Targeting Epstein-Barr virus nuclear antigen 1 (EBNA-1) with Murraya koengii bio-compounds: An in-silico approach. Acta Virol. 2020;64(1):93–9.

25. Zhang W, Zhang J, Ding D, Zhang L, Muehlimann LA, Deng S-E, et al. Synthesis and antioxidant properties of Lycium barbarum polysaccharides capped selenium nanoparticles using tea extract. Artif Cells Nanomed Biotechnol. 2018 Nov;46(7):1463–70.

26. Lakshme PST, Thana Lakshme PS, Preetha S, Jeevitha M, Rajeshkumar S. Evaluation of Antioxidant and Cytotoxic Effect of Selenium Nanoparticles Synthesised Using Capparis decidua [Internet]. Journal of Pharmaceutical Research International. 2020;60–6. Available:http://dx.doi.org/10.9734/jpri/2020/v32i1930709

27. A MTAK, Mohamed Thamemul Ansari K, Roy A, Rajeshkumar S. Anti-inflammatory activity of cinnamon oil mediated silver nanoparticles -An in vitro study [Internet]. International Journal of Research in Pharmaceutical Sciences. 2019;10:2970–2. Available:http://dx.doi.org/10.26452/ijrps.v1i4.1579

28. Kong H, Yang J, Zhang Y, Fang Y, Nishinari K, Phillips GO. Synthesis and antioxidant properties of gum arabic-stabilized selenium nanoparticles. Int J Biol Macromol. 2014 Apr;65:155–62.

29. Mellinas C, Jiménez A, Garrigos MDC. Microwave-Assisted Green Synthesis and Antioxidant Activity of Selenium Nanoparticles Using Bean Shell Extract. Molecules [Internet]. 2019 Nov 8;24(22). Available:http://dx.doi.org/10.3390/molecules24224048

30. Xu C, Qiao L, Guo Y, Ma L, Cheng Y. Preparation, characteristics and antioxidant activity of polysaccharides and proteins-capped selenium nanoparticles synthesized by Lactobacillus casei ATCC 393. Carbohydr Polym. 2018 Sep 1;195:576–85.

31. Mohapatra S, Leelavathi L, Rajeshkumar S, D. SS, P. J. Assessment of Cytotoxicity, Anti-Inflammatory and Antioxidant Activity of Zinc Oxide Nanoparticles Synthesized Using Clove and Cinnamon Formulation - An in-vitro Study [Internet]. Journal of Evolution of Medical and Dental Sciences. 2020;9:1859–64. Available:http://dx.doi.org/10.14260/jemds/2020/405

32. Malhotra S, Welling MN, Mantri SB, Desai K. In vitro and in vivo antioxidant, cytotoxic, and anti-chronic inflammatory arthritic effect of selenium nanoparticles. J Biomed Mater Res B Appl Biomater. 2016 Jul;10(5):993–1003.

33. Choudhary A, Rajeshkumar S, Roy A, Lakshmi T. Free radical scavenging activity of Maranta arundinacea assisted selenium nanoparticles [Internet]. International Journal of Research in Pharmaceutical Sciences. 2020;11:4214–7. Available:http://dx.doi.org/10.26452/ijrps.v1i3.2630

34. Francis T, Rajeshkumar S, Roy A, Lakshmi T. Anti-inflammatory and Cytotoxic Effect of Arrow Root Mediated Selenium Nanoparticles [Internet]. Pharmacognosy Journal. 2020;12:1363–7. Available:http://dx.doi.org/10.5530/pj.2020.12.188

35. Ali SJ, Preetha S, Jeevitha M, Prathap L, S. R. Antifungal activity of selenium nanoparticles extracted from capparis decidua fruit against Candida albicans [Internet]. Journal of Evolution of Medical and Dental Sciences. 2020;9:2452–5. Available:http://dx.doi.org/10.14260/jemds/2020/533

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