Journal of Pharmaceutical Research International

32(25): 112-118, 2020; Article no.JPRI.59764
ISSN: 2456-9119
(Past name: British Journal of Pharmaceutical Research, Past ISSN: 2231-2919, NLM ID: 101631759)

Cytotoxicity of Iron Nanoparticles Synthesized Using Dried Ginger

Akifa Begum[1], M. Jeevitha[2*], S. Preetha[3] and S. Rajeshkumar[4]

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

Authors' contributions

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

Article Information

DOI: 10.9734/JPRI/2020/v32i2530829
Editor(s):
(1) Dr. Pone Kamdem Boniface, University of Sao Paulo, Brazil.
(2) Dr. Giuseppe Murdaca, University of Genoa, Italy.
Reviewers:
(1) Maria Paula Jacobucci Botelho, State University of Londrina, Brazil.
(2) Ahmed Awad Haroun, National Research Centre, Egypt.
(3) Sohier Mohammed Fathey Syame, National Research Centre, Egypt.
Complete Peer review History: http://www.sdiarticle4.com/review-history/59764

Original Research Article

Received 20 June 2020
Accepted 24 August 2020
Published 02 November 2020

ABSTRACT

Zingiber officinale (also called ginger) is commonly used for traditional treatment of various diseases and for culinary purposes. This plant species is a herbaceous and develops yearly pseudostems around one meter tall bearing limited leaf cutting edges. The synthesis of metal nanoparticles and nanocomposites is an emerging area of research and exploration in the field of material science for their unique size and shape and have reliant features that are different from the regular bulk structure. The aim of the present study was to synthesize iron nanoparticles using dried ginger and evaluate their cytotoxic effects against brine shrimp. The nanoparticles were

**Corresponding author: E-mail: jeevitham.sdc@saveetha.com;*

synthesized using dried ginger and characterized by UV-vis spectroscopy. The cytotoxicity assessment was carried out using brine shrimp lethality assay. The iron nanoparticles did not show any cytotoxicity to the brine shrimp. This eco-friendly synthesis of iron nanoparticles from dried ginger has proved to be convenient, inexpensive and can be safely used in wide range of medicine and dental fields.

Keywords: Cytotoxicity; dried ginger; iron; nanoparticles.

1. INTRODUCTION

Ginger (*Zingiber officinale*) is widely utilized for traditional treatment of various diseases [1]. Ginger belongs to the family Zingiberaceae, which also incorporates turmeric, cardamom and galangal. The related dicots in the class Asarum are regularly called wild ginger in light of their comparable taste. Ginger is used in traditional medicine for fever, cold, sore throat and applied as paste for headaches [2].

Nanotechnology is the subdivision of technology that deals with proportions of particles less than 100 nm. The synthesis of metal nanoparticles and nanocomposites is an emerging area of research and exploration in the field of material science for their unique size and shape and have reliant features that are different from the regular bulk structure [3].

Metal nanoparticles are extensively used in a wide range of applications including chemical and biological sensing, catalysis, energy, drug and gene delivery and electronics [4-10]. Nanoparticles have been intensively studied over the last decade due to their characteristics such as the physical, chemical, electronic and electrical properties [11].

Iron nanoparticles are highly reactive materials and are extensively used in magnetic recording media such as magnetic tapes. The nanoparticle-based catalyst showed six times better catalytic activity compared to conventional material. The biomedical applications include MRI (Magnetic Resonance Imaging) contrast enhancement and hyperthermia treatment [12,13].

With reference to our previous studies [14-22] and other available literature, no report has yet highlighted the synthesis of iron nanoparticles using dried ginger. Studies on cytotoxicity of plant mediated iron nanoparticles are less reported [23-25]. Brine shrimp lethality assay utilizing *Artemia salina* larvae is a more comprehensive and effective test more commonly employed to evaluate cytotoxicity of bioactive compounds [26,27]. The present study aimed to biosynthesize iron nanoparticles from dried ginger and to analyse its cytotoxic effect.

2. MATERIALS AND METHODS

First, 100 mL of distilled water was taken in a measuring cylinder and 1 g of dried ginger extract was added into it. In 50 mL of distilled water, 0.5 g of dried ginger extract was added. The prepared extract was measured using a weighing machine. The solution was mixed well and the color of the solution was observed and noted. Secondly, the extract was boiled in the heating mantle for about 5-8 minutes. In each of the steps, the change in the color of the solution was noted and observed. After the extract preparation, iron chloride anhydrous was added (molecular weight-162.2 g). Thirdly, in 60 mL of distilled water, 0.324 g of iron chloride powder was added along with 40 mL of dried ginger extract. The prepared solution was kept in the magnetic stirrer. A magnet was placed inside the solution. The iron nanoparticles thus obtained was purified by repeated centrifugation at 7000 rpm for 10 minutes. The pellet was collected in a cuvette and peak value was measured. After 1 hour, the solution was taken in a cuvette and the peak value was measured in a spectrometer and the color change of the solution was observed periodically.

2.1 Characterization of the Iron Nanoparticles

The synthesized iron nanoparticles were optically characterized using UV-vis absorption spectroscopy. The reduction process to form iron nanoparticles is evident by identifying the characteristic wavelength of the color of the iron nanoparticles as the atoms and molecules undergo transition from ground state to the excited state and exhibit surface plasmon resonance peak positioned at a certain wavelength.

2.2 Cytotoxic Effect of Iron Nanoparticles

Cytotoxicity effect determines whether the bioactive compound is toxic to cells [28]. Brine shrimp lethality assay using the crustacean, *A. salina* is a reliable and convenient method to evaluate the cytotoxic effect of bioactive chemicals. Brine shrimp eggs were procured from Aquatic Remedies, Chennai. Artificial sea water was prepared in a hatching chamber by dissolving 36 g of iodine free salt into 1000 mL of distilled water. The hatching chamber was divided into dark area where shrimp eggs were added and light area with the lamp above. The brine shrimp hatch in two days to mature as larva. The hatched nauplii were used to evaluate the cytotoxic effect of dried ginger mediated iron nanoparticles. 10-12 mL of saline was added in a 6 well ELISA (Enzyme Linked Immunosorbent Assay) plate. Different concentrations of dried ginger mediated iron nanoparticles (5 µl, 10 µl, 15 µl, 20 µl, 25 µl) were added to each well. The artificial sea water upto 10 µl was taken in a well as control. 10 nauplii were added at each well and the number of live nauplii observed after 24 h incubation (Fig. 1).

3. RESULTS AND DISCUSSION

3.1 Visual Observation

In the visual identification, there was color change at various intervals of the incubation time. The first color change was observed when the iron chloride is reduced to iron nanoparticles giving a light yellow color. After 2 hours of the incubation period there is change in the color from light yellow to reddish brown. After 24 hours the color was changed to brown. At the end of 36 hours the color of the solution became dark brown indicating the complete synthesis of the iron nanoparticles (Fig. 2).

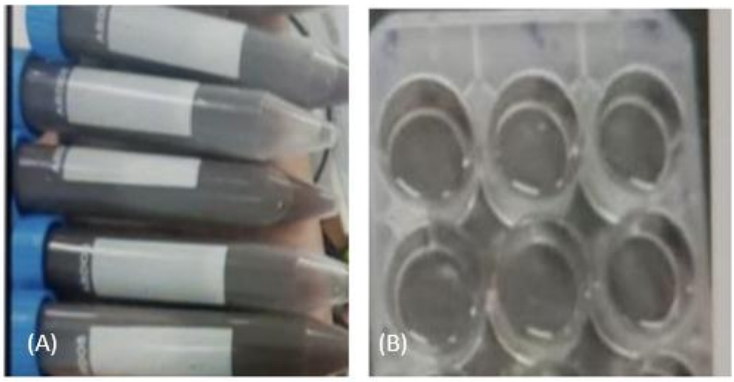

Fig. 1. Cytotoxic effect observation. (A) Different concentrations of iron nanoparticles synthesized from dried ginger. (B) ELISA plate wells with different concentrations of dried ginger mediated iron nanoparticles observed for presence or absence of live nauplii after 24 h incubation

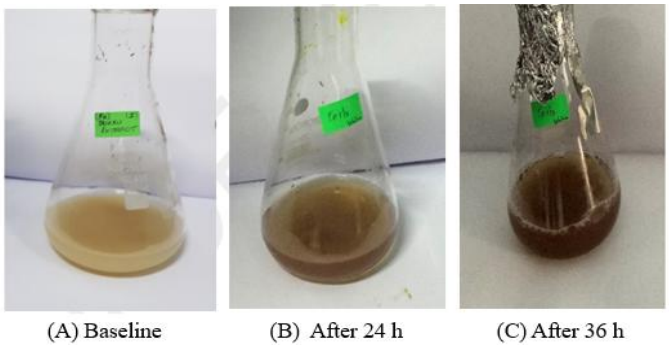

Fig. 2. Visual observation of color change in the synthesis process at various periods of incubation time. (A)- Baseline; (B)- After 24 h of incubation time; (C)- After 36 h of incubation time

3.2 UV– vis Spectrophotometer Analysis

The UV- spectroscopy analysis depends on the arising color of the reaction mixture due to transition of ions from ground state to excited state. The reduction process of the solution was optically measured at different wavelength regions from 250 nm - 650 nm and was recorded at various time periods. In the present study, the UV– vis spectroscopy showed the surface plasmon resonance peak positioned at a wavelength of 450 nm (Fig. 3). This finding is inconsistent to a previously reported study [29] on the synthesis of iron nanoparticles from *Mentha spicata* leaf extract with absorption peak ranging from 360-430 nm.

3.3 Cytotoxic Effect of Iron Nanoparticles

The fatality of the nauplii was observed and the number of live nauplii after 24 h incubation was tabulated based on the concentration of dried ginger mediated iron nanoparticles added to each of the wells in the micro plates (Table 1). In the present study, the cytotoxicity of iron nanoparticles has been shown to be increasing at higher concentrations (Fig. 4). It was noted that the % cytotoxicity against *A. salina* was lowest at 5 µl and 10 µl concentrations (0% and 10%) respectively and moderate at 15 µl (30%) and 20 µl (20%) concentrations. The % cytotoxicity was highest (33%) at 25 µl concentration.

Iron nanoparticles can be synthesized by green approach [30-32]. Iron nanoparticles synthesized from various plant- based materials by reliable and simple methods are available in the literature. These nanoparticles can be synthesized via controlled bio-precipitation using extracts of different plant parts such as leaf extracts of garlic vine and oolong tea extract [30, 32]. The present study indicated that the biosynthesis of iron nanoparticles can be made possible from dried ginger and possess less cytotoxic effects. Kumar et al has studied the mortality rate of *A. salina* to detect the toxicity level of zero-valent iron nanoparticles and found 100% mortality at 100 µl concentration [25] suggesting increase in toxicity with increase in concentration which is in accordance with the present study. The iron oxide nanoparticles synthesized from *Juglans regia* have shown to be non-toxic on normal and cancerous cervical cell lines [23]. Iron nanoparticles synthesized from *Punica granatum* fruit peel extract showed potent anticancer activities against nasopharyngeal carcinoma and not toxic to normal cell lines [24]. Various biological activities like anti-inflammatory and anti-oxidant activities can be evaluated in future studies which would extend its inevitable role as therapeutic agent providing effective and valuable biomedical applications that is safe and economical.

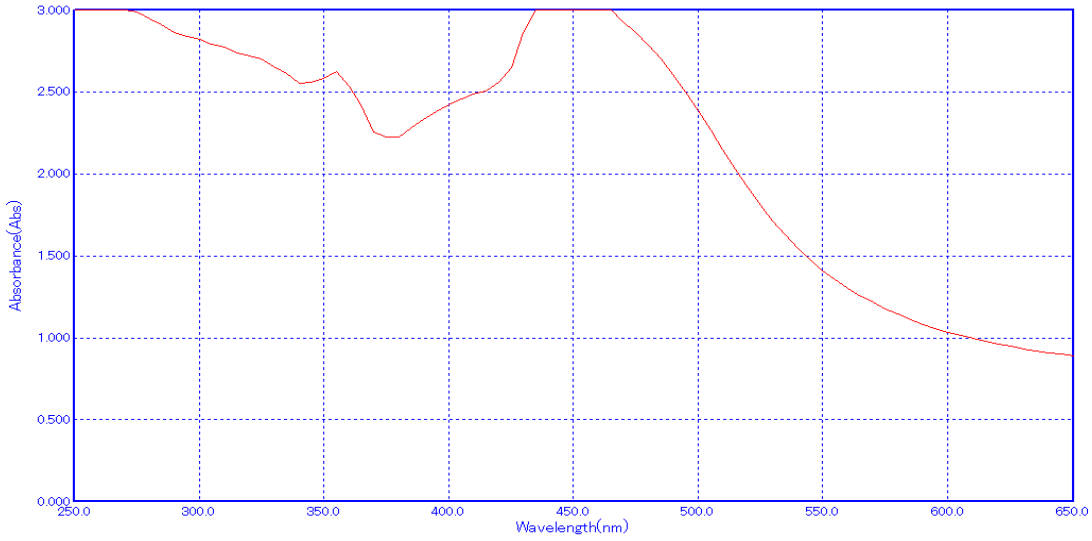

Fig. 3. UV vis-absorption spectra analyses of iron nanoparticles synthesized using dried ginger recorded as function of time

Table 1. Brine shrimp lethality observed for different concentrations of iron nanoparticles

	Concentration	Day 1	Day 2
Test	5 µl	10	10
	10 µl	10	9
	15 µl	10	7
	20 µl	10	8
	25 µl	10	6
Control		10	10

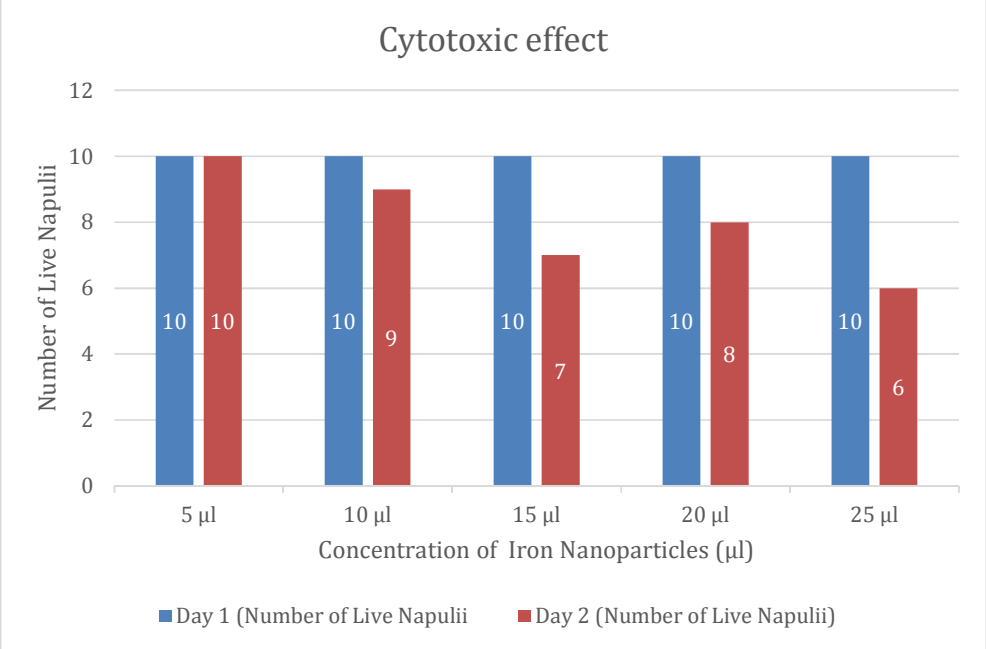

Fig. 4. Cytotoxic effect of dried ginger mediated Iron nanoparticles

4. CONCLUSION

Iron nanoparticles were successfully synthesized using green approach from dried ginger in the present study. The cytotoxic effects of the iron nanoparticles showed less cytotoxicity when used in lower concentrations. Hence these iron nanoparticles prepared from dried ginger are effective and safe when used at optimal concentrations in nanoformulations applied in the medical and dental fields. In the present study, the morphology of the synthesized nanoparticles and other biological activities were not reported. The future scope of the study would focus upon determining the various applications of the iron nanoparticles synthesized from dried ginger that can be utilized in dentistry and medical fields.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Asad SS. Cytotoxic effect of iron nanoparticles *in vitro* on some cell lines. Iraqi Journal of Cancer and Medical Genetics. 2018;10(1):71-7.
2. Ying E, Hwang HM. In vitro evaluation of the cytotoxicity of iron oxide nanoparticles with different coatings and different sizes in A3 human T lymphocytes. Sci Total Environ. 2010;408(20):4475-81.
3. Namvar F, Rahman HS, Mohamad R, Baharara J, Mahdavi M, Amini E,

Chartrand MS, Yeap SK. Cytotoxic effect of magnetic iron oxide nanoparticles synthesized via seaweed aqueous extract. Int J Nanomedicine. 2014;9:2479-88.

4. Agarwal H, Kumar SV, Rajeshkumar S. A review on green synthesis of zinc oxide nanoparticles: An eco-friendly approach. Resour Effic Technol. 2017;3(4):406–13.
5. Abd-Elhalim BT, RF G, Kh A AT, AA H. Biosynthesis of copper nanoparticles using bacterial supernatant optimized with certain agro-industrial byproducts. Novel Research in Microbiology Journal. 2019; 3(6):558-78.
6. El-Nahrawy AM, Abou Hammad AB, Khattab TA, Haroun A, Kamel S. Development of electrically conductive nanocomposites from cellulose nanowhiskers, polypyrrole and silver nanoparticles assisted with Nickel (III) oxide nanoparticles. React Funct Polym. 2020;149:104533.
7. Kamel S, Haroun AA, El-Nahrawy AM, Diab MA. Electroconductive composites containing nanocellulose, nanopolypyrrole, and silver nano particles. J Renew Mater. 2019;7(2):193-203.
8. Mody VV, Siwale R, Singh A, Mody HR. Introduction to metallic nanoparticles. J Pharm Bioallied Sci. 2010;2(4):282-89.
9. Rizk MZ, Abo-El-matty DM, Aly HF, Abd-Alla HI, Saleh SM, Younis EA, Elnahrawy AM, Haroun AA. Therapeutic activity of sour orange albedo extract and abundant flavanones loaded silica nanoparticles against acrylamide-induced hepatotoxicity. Toxicol. Rep. 2018;5:929-42.
10. Wang EC, Wang AZ. Nanoparticles and their applications in cell and molecular biology. Integr Biol. 2014;6(1):9-26.
11. Mamidi N, Leija HM, Diabb JM, Lopez Romo I, Hernandez D, Castrejon JV, Martinez Romero O, Barrera EV, Elias Zuniga A. Cytotoxicity evaluation of unfunctionalized multiwall carbon nanotubes-ultrahigh molecular weight polyethylene nanocomposites. J. Biomed. Mater. Res. Part A. 2017;105(11):3042-9.
12. Huber DL. Synthesis, properties, and applications of iron nanoparticles. Small. 2005;1(5):482-501.
13. Borysiuk J, Grabias A, Szczytko J, Bystrzejewski M, Twardowski A, Lange H. Structure and magnetic properties of carbon encapsulated Fe nanoparticles obtained by arc plasma and combustion synthesis. Carbon. 2008;46(13):1693-701.
14. Jeevitha M, Rajeshkumar S. Antimicrobial activity of silver nanoparticles synthesized using marine brown seaweed spatoglossum asperum against oral pathogens. Indian J Public Health Res Dev. 2019;10(11):3568-73.
15. Rajeshkumar S, Tharani M, Jeevitha M, Santhoshkumar J. Anticariogenic activity of fresh aloe vera gel mediated copper oxide nanoparticles. Indian J Public Health Res Dev. 2019;10(11):3664-7.
16. Menon S, KS SD, Santhiya R, Rajeshkumar S, Kumar V. Selenium nanoparticles: A potent chemotherapeutic agent and an elucidation of its mechanism. Colloid Surface B. 2018;170:280-92.
17. Agarwal H, Menon S, Kumar SV, Rajeshkumar S. Mechanistic study on antibacterial action of zinc oxide nanoparticles synthesized using green route. Chem. Biol. Interact. 2018;286:60-70.
18. Rajeshkumar S, Naik P. Synthesis and biomedical applications of cerium oxide nanoparticles–a review. Biotechnol. Rep. 2018;17:1-5.
19. Menon S, Rajeshkumar S, Kumar V. A review on biogenic synthesis of gold nanoparticles, characterization, and its applications. Resource-Efficient Technologies. 2017;3(4):516-27.
20. Santhoshkumar J, Rajeshkumar S, Kumar SV. Phyto-assisted synthesis, characterization and applications of gold nanoparticles: A review. Biochem Biophys Rep. 2017;11:46–57.
21. Rajeshkumar S, Bharath LV. Mechanism of plant-mediated synthesis of silver nanoparticles–a review on biomolecules involved, characterisation and antibacterial activity. Chem. Biol. Interact. 2017;273: 219-27.
22. Rajeshkumar S. Green synthesis of different sized antimicrobial silver nanoparticles using different parts of plants-A Review. Int. J. Chem Tech Res. 2016;9(4):197–208.
23. Izadiyan Z, Shameli K, Miyake M, Hara H, Mohamad SE, Kalantari K, Taib SH, Rasouli E. Cytotoxicity assay of plant-mediated synthesized iron oxide nanoparticles using Juglans regia green husk extract. Arab. J. Chem. 2020;13(1): 2011-23.
24. Yusefi M, Shameli K, Ali RR, Pang SW, Teow SY. Evaluating anticancer activity of

plant-mediated synthesized iron oxide nanoparticles using *Punica granatum* fruit peel extract. J Mol Struct. 2020;1204: 127539.
25. Kumar D, Roy R, Parashar A, Raichur AM, Chandrasekaran N, Mukherjee A, Mukherjee A. Toxicity assessment of zero valent iron nanoparticles on *Artemia salina*. Environ. Toxicol. 2017;32(5):1617-27.
26. Meyer BN, Ferrigni NR, Putnam JE, Jacobsen LB, Nichols DJ, McLaughlin JL. Brine shrimp: A convenient general bioassay for active plant constituents. Planta medica. 1982;45(05):31-4.
27. Sarah QS, Anny FC, Mir M. Brine shrimp lethality assay. Bangladesh J. Pharmacol. 2017;12(2):186-9.
28. Abitha ST, Rajeshkumar S, Lakshmi T, Roy A. Cytotoxic effects of silver nanoparticles synthesized using amla fruit seed. Drug Invent. Today. 2019;11(9): 2283-2286.
29. Prasad KS, Gandhi P, Selvaraj K. Synthesis of green nano iron particles (GnIP) and their application in adsorptive removal of As (III) and As (V) from aqueous solution. Appl Surf Sci. 2014;317: 1052-9.
30. Prasad AS. Iron oxide nanoparticles synthesized by controlled bio-precipitation using leaf extract of Garlic Vine (*Mansoa alliacea*). Mat Sci in Semicon Proc. 2016; 53:79-83.
31. Kumar KM, Mandal BK, Kumar KS, Reddy PS, Sreedhar B. Biobased green method to synthesise palladium and iron nanoparticles using *Terminalia chebula* aqueous extract. Spectrochim Acta A Mol Biomol Spectrosc. 2013;102:128-33.
32. Huang L, Weng X, Chen Z, Megharaj M, Naidu R. Synthesis of iron-based nanoparticles using oolong tea extract for the degradation of malachite green. Spectrochim Acta A Mol Biomol Spectrosc. 2014;117:801-4.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/59764