

Green Synthesis of Silver Nanoparticles Using Citrus Orange Peels and Evaluation of Their Anticancer Property

Chhavi Acharya¹, Priyanka Singh^{2*}

¹Phd Scholar, Department of Microbiology, Nims Institute of Allied Medical Science and Technology, Nims University Rajasthan, Jaipur, India, 303121

²Department of Biotechnology, Nims Institute of Allied Medical Science and Technology, Nims University Rajasthan, Jaipur, India, 303121

*Corresponding Author: priyay20@gmail.com

Received: 17th Mar, 2026 | Revised: 29th Mar, 2026 | Accepted: 19th Apr, 2026 | Available Online: 5th May, 2026

ABSTRACT

The present study demonstrates that orange peel extract (*Citrus sinensis*) is an effective, eco-friendly, and cost-efficient resource for the green synthesis of silver nanoparticles (AgNPs). The successful formation of nanoparticles, confirmed through visual observation and characterization techniques, highlights the crucial role of phytochemicals present in the peel extract as both reducing and stabilizing agents. The synthesized AgNPs exhibited desirable physicochemical properties, including small particle size, stability, and uniform morphology, which are essential for biomedical applications. SEM and TEM analysis confirmed the formation of spherical and uniform nanoparticle. The average size of the synthesized nanoparticle was 50-60 nm as measured by DLS technique. FTIR analysis of the green synthesized AgNPs showed the presence of alcohols, phenolics, alkynes, aliphatic primary amines, and amino acid groups. Finally, the evaluation of the cytotoxic effect of the green synthesized AgNPs were done using human colon carcinoma cell line (HCT-116). The results revealed the concentration has a direct correlation with cell viability. Nanoparticles of concentration (8-10 µg/ml) showed significant anticancer activity against HCT-116 cancer cell lines, with a dose-dependent reduction in cell viability. This effect is likely mediated through mechanisms such as oxidative stress induction, apoptosis, and cellular damage. Overall, this study supports the potential of orange peel-mediated silver nanoparticles as promising candidates in cancer therapeutics. Additionally, it emphasizes the value of agricultural waste in developing sustainable nanotechnology. However, further investigations, including *in vivo* studies and clinical evaluations, are necessary to fully establish their safety, efficacy, and practical applicability in medical treatments.

Keywords: Citrus Orange Peel, Silver Nanoparticle, Characterisation, Anticancer Agent

How to cite this article: Acharya C, Singh P., Green Synthesis of Silver Nanoparticles Using Citrus Orange Peels and Evaluation of Their Anticancer Property. *Int J Drug Deliv Technol.* 2026;16(43s): 1418-1426; Doi: 10.25258/Ijddt.16.43s.150

Introduction

Nanoparticles (1 to 100 nm) have significant role in biotechnology sector with commercial, industrial, agricultural and medicinal applications. Silver (Ag) have biocompatibility, bactericidal properties, and therapeutic abilities. Therefore, they are preferred for medical treatment, cosmetic agent and management of various diseases. Silver is routinely used in the form of silver nitrate for antimicrobial activity.

A number of benefits, including ease of use, environmental friendliness, and ease of scaling, have generated considerable interest in green nanotechnology. Many plant extracts have shown anticancer activity against several cancer cells. Silver nanoparticles have shown to be able to

penetrate microbial membranes, and altered cell function, cellular structure and potentially inducing cell death [1]. One study used a nanocrystalline silver structure and examined that it suppressed the expression of tumour necrosis factor alpha and IL-12, both cytokines that promote an immune response once recognized by immune cells [2]. Mukherji and Agnihotri synthesised silver nanoparticles using AgNO₃, as a precursor. It has been reported that ethanol is a good reducing agent for the synthesis of silver nanoparticles having a size range of 5-20 nm. Flavonoid compounds isolated from citrus peel have been identified as agents with utility in the treatment of cancer. This work provides the anticancer potential found within the citrus peel. Historical studies have identified a number of cellular

Green Synthesis Of Silver Nanoparticles Using Citrus Orange Peels And Evaluation Of Their Anticancer Property

processes that can be modulated by citrus peel flavonoids including cell proliferation, cell cycle regulation, apoptosis, metastasis, and angiogenesis. More recently, molecular studies have started to elucidate the underlying cell signalling pathways that are responsible for the flavonoids' mechanism of action. These growing data support further research into the chemo preventative potential of citrus peel extracts, and purified flavonoids in particular [3]

In this study, we aimed to investigate the green synthesis of silver nanoparticles using orange peel extract, and evaluate their cytotoxic effects.

Method and Methodology

2.1. Collection of Citrus orange peels and preparation of extract:

Citrus orange peels were collected and cleaned thoroughly using distilled water to remove the dust particles adhering to the surface of the fruit peel. Ten grams of peels were transferred into 25 mL of boiled distilled water and left to boil for 10 min. The extract obtained was filtered through filter paper, and then, it was stored at 4 °C for further use.

2.2. Green synthesis of AgNPs using Citrus orange peel extract:

Green synthesis of AgNPs involved the addition of 0.008 g (1 mM) silver nitrate (AgNO₃) to 50 mL of distilled water, and then, the solution was stirred with magnetic stirrer for 15 min at 45 C at 1100 rpm. Citrus orange peels extract (5ml) was further added to above solution.

2.3. Characterization of silver nanoparticles

2.3.1. Visible observation:

Colour change of the mixture to brown colour had confirmed the formation of AgNPs.

2.3.2. UV-Visible spectrophotometry:

Green synthesized AgNPs were analysed with the help of UV-Visible spectrophotometer with typical optical spectrum for AgNPs is in the range 350–550 nm [4]

2.3.3. Dynamic light scattering evaluation:

For the size evaluation, 3ml AgNPs from orange peel extract were filtered through 0.20 mm pore sized syringe, and then, the solution was analysed.

2.3.4. Transmission electron microscopy (TEM):

The morphology of the green synthesized AgNPs was examined using TEM. A drop of AgNPs solution was loaded on carbon-coated copper grid and the solvent was allowed to evaporate. The TEM micrograph images were captured using JEM-1400(Jeol Ltd, Japan) with an accelerating voltage of 100 kV.

2.3.5. Energy dispersive x-ray equipped with TEM:

A drop of the sample was loaded on the carbon-copper coated grid and left to dry. The elemental composition of the synthesized AgNPs was evaluated using the energy dispersive x-ray analyser (JEM-2100F 200 kV, Joel Ltd, Japan).

2.3.6. Fourier-transform infrared spectroscopy:

FTIR analysis was conducted using Thermo 6700 (Thermo Fisher Scientific, USA) to determine the functional groups found in the LPE that led to the formation of AgNPs. The absorption bands were observed in the regions of 500–4000 cm⁻¹.

2.3.8. Analysis of cytotoxic effect of the AgNPs:

HepG2 cell lines were treated with optimum concentration of crude extract of orange and its silver nanoparticle. The dilutions were prepared in DMSO. After treatment the cells were incubated for 24 hours in CO₂ incubator. After 24 hours, 20 µl of MTT reagent was added and incubated for 4 hours at 37°C. After incubation, the formazan produced was solubilized by the addition of 100 µl of DMSO and the absorbance was recorded at 570 nm by ELISA reader. Cells without treatment were used as a positive control. Effective dose is required for inhibiting cell growth by 50 % (IC₅₀ micrograms per mil-litre) was determined.

Cell viability was calculated as follows:

$$\frac{[\text{Mean OD (Treated sample)} - \text{Blank OD}]}{[\text{Mean OD (Control)} - \text{Blank OD}]} \times 100$$

The cytotoxicity test was conducted according to the method described by [5].

2.4. Statistical analysis

The standard deviation of the mean was calculated according to [6]

3. Results:

The aqueous extract of *Citrus sinensis* (orange) peels was successfully used as a reducing and stabilizing agent for the synthesis of silver nanoparticles. Upon addition of silver nitrate (AgNO₃) solution to the peel extract, a visible color change from pale yellow to dark brown was observed, indicating the formation of AgNPs. This color change is attributed to **surface plasmon resonance (SPR)**, a characteristic property of metallic nanoparticles. The formation of AgNPs was confirmed by UV-Vis spectroscopy. A strong absorption peak was observed around 350–550nm, which is typical for silver nanoparticles as shown in Fig. 1. The sharpness of the peak suggested that the nanoparticles were relatively uniform in size and well-dispersed.

Green Synthesis Of Silver Nanoparticles Using Citrus Orange Peels And Evaluation Of Their Anticancer Property

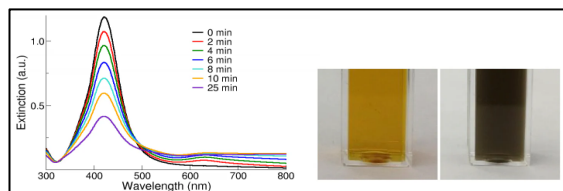


Fig. 1. UV-Visible spectra and colour change during silver nanoparticle formation

The topography and morphology of nanoparticles can be observed by SEM, which is also used to calculate the size of various nanoparticles at the micro- (10^{-6}) and nano (10^{-9}) scales [7,8]. A high-energy electron beam, produced by SEM, is directed at the surface of the sample nanoparticles. and the backscattered electrons produced give the characteristic features of the sample [9]. Electron microscopy analysis is used to examine the changes in the morphology of the cell before and after nanoparticle treatment (Fig2, Fig3). Several studies have reported that the visible modifications in cell shape and perforations of nanoparticles in the cell wall have been used as indicators of the antimicrobial action of nanoparticles [10,11]. Using SEM control bacterial cells exhibited smooth and undamaged structures, while cells treated with silver nanoparticles for 60 min were significantly damaged, with clear morphological changes to the cell membrane leading to loss of membrane integrity [12]. The average size of AgNPs synthesized was found to be 59.74 nm as measured by Dynamic Light Scattering (DLS) technique (Fig4).

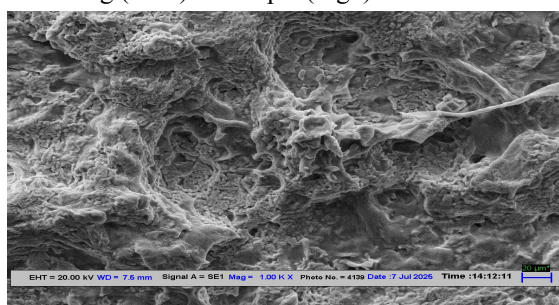


Fig2. Morphological analysis of orange peel extract by SEM Microscopy

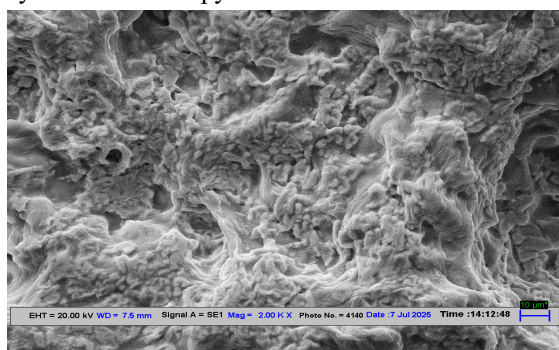


Fig3. Morphological analysis of green synthesized silver nanoparticle by SEM Microscopy

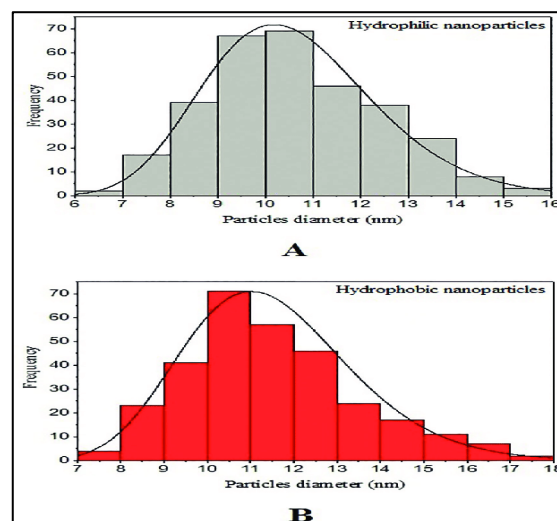


Fig.4. Particle size analysis of nanoparticle by DLS Technique

TEM images for orange peel extract (Fig5) and their synthesized silver nanoparticles (Fig6) confirmed the spherical shape of synthesized AgNPs with size ranges 50-60nm. Smaller particle size contributes to higher surface area, which enhances biological activity.

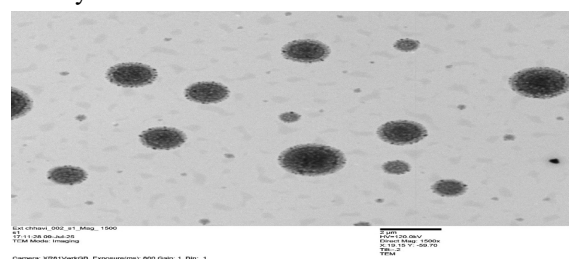


Fig. 5 Surface Morphology of nanoparticle of orange peel extract by TEM Microscopy

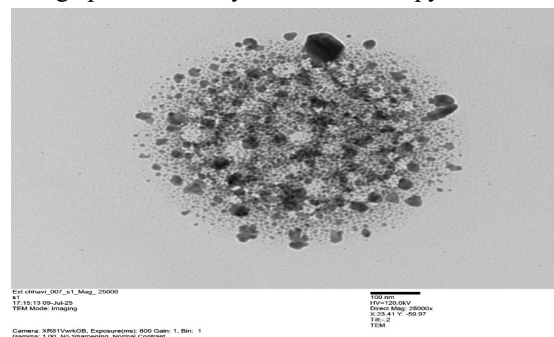


Fig.6 Surface Morphology of nanoparticle of orange peel extract by TEM Microscopy

3.5. Fourier-transform infrared spectroscopy results:

FTIR analysis revealed the presence of functional groups such as $-OH$, $-COOH$, and $-C=O$, which are derived from phytochemicals (like flavonoids,

Green Synthesis Of Silver Nanoparticles Using Citrus Orange Peels And Evaluation Of Their Anticancer Property

phenolics, and terpenoids) in orange peel extract. These biomolecules play a dual role in reducing Ag^+ ions to Ag^0 and stabilizing the formed nanoparticles. The crude extract showed absorption peaks at 3303.05, 2198.40, and 1987.95 cm^{-1} (Fig.7). The green synthesized AgNPs showed absorption peaks at 3273.24, 2223.71, 1972.46, and 2047.29 cm^{-1} (Fig. 8).

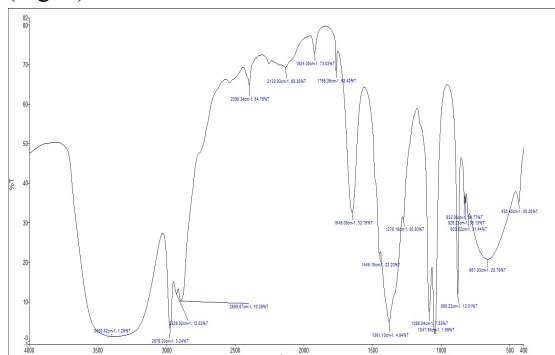


Fig.7 FTIR Peaks for green synthesized silver nanoparticles for orange peel extract

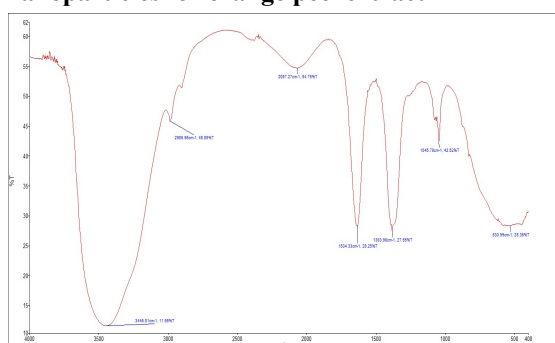


Fig.8 FTIR Peaks for orange peel extract

The evaluation of the cytotoxic effect of the green synthesized AgNPs were done using two types of cell lines, human breast cancer cell line (MCF-7) and human colon carcinoma cell line (HCT116). The results revealed the concentration has a direct correlation with cell viability as shown in Fig. 9 and Fig 10. The inhibitory concentration (IC_{50}) with 50% of HCT-116 cell line was observed with concentration of silver nanoparticle of 8-10 $\mu g/ml$ (Fig11).

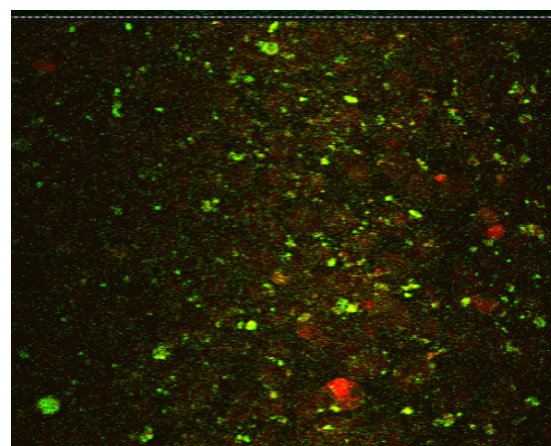


Fig.9: Images of cancer cell line Hep-G2 growth with crude orange extract

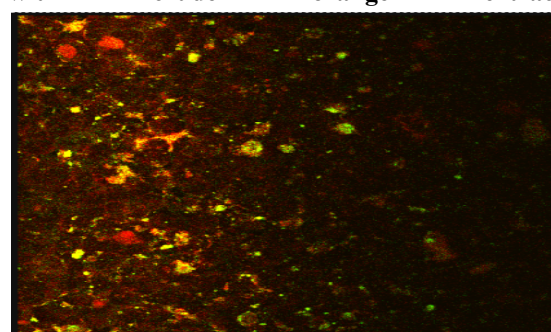


Fig.10: Images of cancer cell line of Hep-G2 with silver nanoparticle

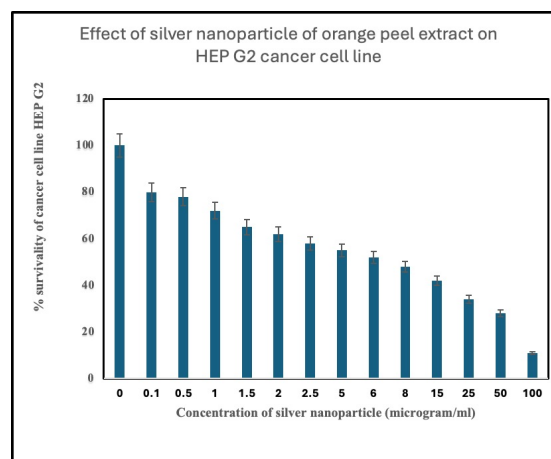


Fig.11. *In Vitro* study of silver nanoparticle of orange extract against the growth of HEP-G2 cancer cell lines

4. Discussion:

The present study demonstrated the green biosynthesis of AgNPs using extract of Citrus limon peels, that were treated with 1 mM $AgNO_3$. The colourless $AgNO_3$ solution started turning brown after 15 min; this change could possibly be due to the reduction of Ag ions to silver nanoparticles [13]. For characterization, UV-visible spectrophotometry revealed the maximum peak of the AgNPs at 437

Green Synthesis Of Silver Nanoparticles Using Citrus Orange Peels And Evaluation Of Their Anticancer Property

nm; the peak was due to the excitation of the surface plasmon resonance. During the DLS evaluation, the semi-broad peak of the green synthesized AgNPs from LPE (59.74 r. nm) indicated variation in size or an aggregated structure of metal nanoparticles. The Pdi of 0.463 indicated mono-dispersed nanoparticles [14] TEM images confirmed the existing of spherical and rod-like shaped nanoparticles. The results also showed an aggregated structure of the silver nanoparticles; the aggregation could be due to the layer (capping agents) covering the NPs, which causes the NPs to be attached to each other resulting in decreased space between the NPs. These results corroborated with those obtained from UV-visible spectrophotometry and DLS analysis. From the EDX analysis, the absorption peak was observed at 3 KeV indicating the presence of a silver element [15]. The presence of copper and carbon could be due to the grid's composition. Other signals were also observed indicating the presence of oxygen in the range of 0.0 – 1.5 KeV, chlorine was observed near 3 KeV, and chromium was seen in the range of 0.0 – 6.0 KeV; thus, these could also be components of the peel extract. In FTIR, LPE revealed several peaks at 3303.05, 2198.40, and 1987.95 cm⁻¹. Peak 3303.05 cm⁻¹ may correspond to alcohols, phenolics, mono-substituted alkynes, aliphatic primary amines, sodium salt, amino acid, or SiOH alcohol. Peak 2198.40 cm⁻¹ may correspond to NH₃ or alkynes. Peak 1987.95 cm⁻¹ may correspond to cumulated alkenes, indicating a typical aromatic benzenoid compound. The green synthesized AgNPs showed absorption peaks at 3273.24, 2223.71, 1972.46, and 2047.29 cm⁻¹. The peak 3273.24 cm⁻¹ may represent alcohols, phenolics, monosubstituted alkynes, aliphatic primary amines, sodium salt, amino acid, or SiOH alcohol. The peak 2223.71 cm⁻¹ could correspond to alkynes or ammonium. Peak 1972.46 cm⁻¹ may correspond to cumulated alkenes, indicating a typical aromatic benzenoid compound. Peak 2047.29 cm⁻¹ could correspond to NH₃ [16]. From the comparison between the spectra of the LPE and the green synthesized AgNPs, the shifts in the positions of the peaks indicated the presence of the functional groups that reduced the silver ions to silver nanoparticles. Regarding the antimicrobial activity of the prepared AgNPs, the results showed varying degrees of antibacterial activity against human pathogenic bacteria. It is elucidated that these nanoparticles have significant antimicrobial behaviour against the tested Gram-negative (*E. coli*, *Salmonella typhimurium* and *P. aeruginosa*) and

Gram-positive (*S. aureus*) bacteria. Based on the inhibitory and bactericidal behaviour of the nanoparticles, it was revealed that these nanoparticles are able to inhibit the growth of microbial strains when used in very low concentrations. The antibacterial effect for these particles might be due to the ability of the AgNPs to enhance the permeability of the cell membrane, formation of free radicals, and interaction with thiol groups, prevent DNA replication, affect cellular signalling, and prevent biofilm formation [17]. Four types of mechanisms have been proposed to interpreting the mechanism of antimicrobial activity of AgNPs, these were; (1) Interaction of AgNPs with cell membranes, alterations in the membrane permeability, and perturbation of respiratory chain enzymes; (2) Gradual diffusion of nanoparticles into the cells, which could both adversely affect the activity of cellular enzymes and restrict the transcription process by conjugation of silver particles to DNA; (3) Leakage of subcellular components as a result of nanoparticles interaction with the plasma membrane leading to cell death and (4) Generation of free radicals when the cell membrane is affected by silver ions [18,19]. For the cytotoxicity evaluation, different concentrations of the AgNPs were used. By increasing the concentration of the AgNPs, the cell viability decreased, resulting in IC₅₀ of 23.5 ± 0.97 mL/100 mL for MCF-7 and IC₅₀ of 37.48 ± 5.93 mL/100 mL for HCT-116. The possible cytotoxic effect might be attributed to the ability of AgNPs to stimulate reactive oxygen species generation in the cellular components, resulting in cell death [20]. It has been postulated that AgNPs interact with mitochondria and disrupt the cellular electron transfer chain function leading to an increase in the ROS level [21, 22]. Consequently, the oxidative stress generated by ROS could be considered as a main toxicity mechanism of AgNPs against cells. The elevated anticancer activity of the AgNPs could be attributed to a synergy between AgNPs and the covering polyphenols. It is proposed that the superior cytotoxicity of AgNPs against cancerous cells occurs owing to the highest uptake of nanoparticles by these cells rather than healthy cells, given that cancerous cells have an abnormal metabolism and high proliferation rate, which in turn makes them more vulnerable [23]. The simultaneous effect of AgNPs and polyphenols not only increases the ROS generation but also inhibits the transcription process. It is noteworthy that antioxidants such as

Green Synthesis Of Silver Nanoparticles Using Citrus Orange Peels And Evaluation Of Their Anticancer Property

polyphenols show cytotoxicity only against nonhealthy cells [24]. This report is in good agreement with the data in the literature, which report the concentration-dependent toxicity of nanoparticles, particularly at lower levels [25, 26 27]. It seems that the prominent cell death mechanism is conjugation of nanoparticles with cells and change in the permeability of plasma membrane, which leads to free-radical and ROS generation. This assumption is further augmented by the emergence of pigments (such as beta carotene) in the tested bacteria as a defence mechanism against the oxidative stress.

Silver nanoparticles (AgNPs) are of great interest due to their unique and controllable characteristics. A significant improvement in the cytotoxicity characteristics of the green synthesized Ag nanoparticles against a cancerous cell line. These findings imply that the synthesized nanoparticles using green nanotechnology could be an ideal strategy to combat cancer and infectious diseases. The synthesized AgNPs proved to possess improved anticancer, antimicrobial activity in comparison with the extract. The method of AgNPs synthesis introduced in this study, therefore, holds great potential as a simple, low-cost, and environmentally-friendly approach for producing value-added products from waste material. The synthesized AgNPs exhibited selective cytotoxicity toward the cancerous cell line when compared to their effect on the normal cell line tested. These findings are very promising in utilizing the biological effects of the AgNPs synthesized using walnut green husk extract.

The cytotoxic and oxidative effects of silver nanoparticles synthesised from orange peel extracts were examined in human cancer cell lines. The study demonstrated that the nano-formulation had anticancer activity [28]. Khateef and associates investigated the cytotoxicity of different concentrations of silver nanoparticles. It was observed that as the nanoparticle concentration increased, the inhibition of cell growth increased as well. To corroborate our findings and elucidate the molecular mechanism of action, more studies in vivo lung cancer models should be conducted. Normal Human Epidermal Keratinocytes (NHEK) produced somewhat more IL-12 when exposed to silver nanoparticles at concentrations of 2.5 and 0.25 ppm with an average size of 10 ± 5 nm. MCF-7 breast cancer cell lines were suppressed in a dose-dependent manner by silver nanoparticles encased in

chitosan nano formulations [29]. The viability, migration, and phosphorylation of A549, MCF-7, and HepG2 cell lines were all decreased by silver nanoparticles made from Panax ginseng Meyer and Origanum vulgare. NPs from Cleome viscosa fruit extract caused dose-dependent cytotoxicity in lung A549 and PA1 ovarian cancer cell lines [30]. embedded silver nanoparticles in a particular polysaccharide.

The distinct and controllable properties of silver nanoparticles (AgNPs) make them very interesting. The green produced Ag nanoparticles' cytotoxicity properties against a malignant cell line significantly improved. These results suggest that employing green nanotechnology to create nanoparticles could be a perfect way to fight infectious diseases and cancer. When compared to the extract, the produced AgNPs shown enhanced antibacterial and anticancer activities. Therefore, the AgNPs synthesis process shown in this study has a lot of promise as an easy, affordable, and eco-friendly way to turn waste materials into value-added goods.

When compared to their impact on the tested normal cell line, the produced AgNPs showed preferential cytotoxicity toward the malignant cell line. These results show great promise for harnessing the biological effects of AgNPs made from walnut green husk extract. In the human lung epithelial cell line, the impact of silver nanoparticles on gene expression was examined. According to the study, exposure to silver nanoparticles affected the cell cycle and caused a G2/M phase arrest [31]. According to a recent investigation, silver nanoparticles activated the Ptdins3K signaling pathway in cancer cells, causing autophagy. Additionally, green synthesized silver nanoparticles had a dose-dependent response based on the human lung cancer study [33], and wortmannin, an autophagy inhibitor, greatly increased the antitumor effect of silver nanoparticles in a melanoma cell model [32]. Notably, it is preferable to activate apoptotic pathways without causing inflammation when treating cancer. These findings, in our opinion, will open the door for the application of AgNO₃ in in vitro investigations of various cancer kinds.

Conclusion:

The green synthesis approach using orange peel extract is eco-friendly, cost-effective, and avoids toxic chemicals. The presence of bioactive compounds in the peel extract not only facilitates nanoparticle synthesis but also enhances their biological activity. Compared to chemically synthesized nanoparticles, green-

Green Synthesis Of Silver Nanoparticles Using Citrus Orange Peels And Evaluation Of Their Anticancer Property

synthesized AgNPs show better biocompatibility, enhanced stability, and improved therapeutic potential. The observed anticancer activity suggests that these nanoparticles could be promising candidates for nanomedicine and targeted cancer therapy. However, further studies such as in vivo experiments, toxicity profiling, and clinical trials are necessary before practical applications.

Ethical Approval and Consent to participate:

- **Human Ethics:** we have not performed any In Vivo study using animal model. This is reviewing article, therefore, ethical approval is not applicable.

- **Consent for publication:** The review article is original and we both authors are mutually agree to submit this review article in this journal

- **Availability of supporting data:** The article includes the data collected from referred journal and authenticate site

-- **Funding:** The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

- **Authors' contributions:** All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Ms. Chhavi Acharya (Research Scholar). Dr. Priyanka Singh (as supervisor) has guided her for designing of experiment, compilation of data and drafting of manuscripts. All authors have read and approved the final manuscript.

- **Acknowledgements:** Authors are thankful to Nims University Rajasthan for providing lab facility for completion of this research work. We are also thankful for CRF Institute of IIT Delhi and AIRF centre of JNU for giving facility for SEM, TEM analysis and FTIR characterization

- **Declaration statement:** The authors have no relevant financial or non-financial interests to disclose. We agree that all data, materials as well as software application has supported their published claims and complied with field standards.

Reference

1. Lara H.H., Garza-Treviño E.N., Itxtepan-Turren L., Singh D.K. Silver nanoparticles are broad-spectrum bactericidal and virucidal compounds. *J. Nanobiotechnol.* 2011; 9:30. doi: 10.1186/1477-3155-9-30. [DOI] [PMC free article] [PubMed] [Google Scholar]

2. Sharma V., Kaushik S., Pandit P., Dhull D., Yadav J.P. Green synthesis of silver nanoparticles from medicinal plants and evaluation of their antiviral potential against chikungunya virus. *Appl. Microbiol. Biotechnol.* 2019;103:881–891. doi: 10.1007/s00253-018-9488-1. [DOI] [PubMed] [Google Scholar]
3. Koolaji, N., Shammugasamy, B., Schindeler, A., Dong, Q., Dehghani, F., Valtchev, P., 2020. Citrus peel flavonoids as potential cancer prevention agents. *Current Developments. Nutrition.* 4. <https://doi.org/10.1093/cdn/nzaa025>.
4. Singh, P.S., Vidyasagar, G.M., 2014. Biosynthesis, characterization, and antidermatophytic activity of silver nanoparticles using Raamphal Plant (*Annona reticulata*) aqueous leaves extract. *Indian Journal of Materials Science.* <https://doi.org/10.1155/2014/412452>.
5. Mosmann, T., 1983. Rapid colorimetric assay for cellular growth and survival: application to proliferation and cytotoxicity assays. *Journal of Immunological Methods.* 65 (1–2), 55–63.
6. Lee, D.K., In, J., Lee, S., 2015. Standard deviation and standard error of the mean. *Korean Journal of Anesthesiol.* 68 (3), 220–223.
7. Noruzi M, Zare D, Khoshnevisan K, Davoodi D. synthesis of gold nanoparticles using Rosa hy extract at room temperature. *Spectrochim Acta Spectrosc.* 2011;79(5):1461-5. doi: 10.1016/j.saa.2011.05.001.
8. Sundrarajan M. Gowri S. Green synthesis of tita nanoparticles by nyctanthes arbor tristis leaves Chalcogenide Lett. 2011;8:447-51. doi: 10.1016/7645(14)60171-1.
9. Hudlikar M, Joglekar S, Dhaygude M, Kodam K. synthesis of TiO2 nanoparticles by using aqueo Jatropha curcas L. latex. *Mater Lett.* 2012;75:19 doi: 10.1016/j.matlet.2012.02.018.
10. Rahimi-Nasrabadi M, Pourmortazavi SM, Shandiz SAS, Ahmadi F. Batooli H. Green synthesis of silver nanoparticles using Eucalyptus leucoxydon leaves extract and evaluating the antioxidant activities of

Green Synthesis Of Silver Nanoparticles Using Citrus Orange Peels And Evaluation Of Their Anticancer Property

- extract. *Nat Prod Res.* 1969,28(22):1964-9. doi: 10.1080/14786419.2014.918124.
11. Zhang M, Zhang K, Gussem BD, Verstraete W, Field R. The antibacterial and anti-biofouling performance of biogenic silver nanoparticles by *Lactobacillus fermentum*. *Biofouling*. 2014;30(3):347-57. doi: 10.1080/08927014.2013.873419.
 12. Roy A, Bulut O, Some S, Kumar Mandal A, Deniz Yilmaz M. Green synthesis of silver nanoparticles
 13. Ahmad, A., Mukherjee, P., Senapati, S., Mandal, D., Khan, M.I., Kumar, R., Sastry, M., 2003. Extracellular biosynthesis of silver nanoparticles using the fungus *Fusarium oxysporum*. *Colloids and surfaces B: Biointerfaces*. 28 (4), 313–318.
 14. Stetefeld, J., McKenna, S.A., Patel, T.R., 2012. Dynamic light scattering: a practical guide and applications in biomedical sciences. *Biophysical Reviews*. 8 (4), 409–427.
 15. Velmurugan, P., Lee, S.M., Iydroose, M., Lee, K.J., Oh, B.T., 2013. Pine cone-mediated green synthesis of silver nanoparticles and their antimicrobial activity against agricultural pathogens. *Applied Microbiology and Biotechnology*. 97 (1), 361–368.
 16. Silverstein, R., Webster, F., Kiemle, D., 2005. *Spectrometric identification of organic compounds*. John Wiley & Sons Inc, New York, pp. 71–143.
 17. Rai, M.K., Deshmukh, S.D., Ingle, A.P., Gade, A.K., 2012. Silver nanoparticles: the powerful nanoweapon against multidrug-resistant bacteria. *Journal of Applied Microbiology*. 112, 841–852.
 18. Prabhu, S., Poulouse, E.K., 2012. Silver nanoparticles: mechanism of antimicrobial action, synthesis, medical applications, and toxicity effects. *Int Nano Lett*. 2 (1), 32–41.
 19. Rizzello, L., Pompa, P.P., 2014. Nanosilver-based antibacterial drugs and devices: mechanisms, methodological drawbacks, and guidelines. *Chem Soc Rev*. 43 (5), 1501–1518.
 20. Venugopal, K., Ahmad, H., Manikandan, E., Thanigai Arul, K., Kavitha, K., Moodley, M., Rajagopal, K., Balabhaskar, R., Bhaskar, M., 2017. The impact of anticancer activity upon *Beta vulgaris* extract mediated biosynthesized silver nanoparticles (ag-NPs) against human breast (MCF-7), lung (A549) and pharynx (Hep-2) cancer cell lines. *Journal of Photochemistry and Photobiology B: Biology*. 173, 99–107.
 21. Park, E.J., Yi, J., Kim, Y., Choi, K., Park, K., 2010. Silver nanoparticles induce cytotoxicity by a Trojan-horse type mechanism. *Toxicol In Vitro*. 24 (3), 872–878.
 22. Singh, R.P., Ramarao, P., 2012. Cellular uptake, intracellular trafficking and cytotoxicity of silver nanoparticles. *Toxicol Lett*. 213 (2), 249–259.
 23. Cairns, R.A., Harris, I.S., Mak, T.W., 2011. Regulation of cancer cell metabolism. *Nat Rev Cancer*. 11 (2), 85–95.
 24. Li, L., Tsao, R., Yang, R., Liu, C., Zhu, H., Young, J.C., 2006. Polyphenolic profiles and antioxidant activities of heartnut (*Juglans ailanthifolia* Varcordiformis) and Persian walnut (*Juglans regia* L.). *J Agric Food Chem*. 54 (21), 8033–8040.
 25. Park, E.J., Yi, J., Kim, Y., Choi, K., Park, K., 2010. Silver nanoparticles induce cytotoxicity by a Trojan-horse type mechanism. *Toxicol In Vitro*. 24 (3), 872–878.
 26. Palaniappan, P., Sathishkumar, G., Sankar, R., 2015. Fabrication of nano-silver particles using *Cymodocea serrulata* and its cytotoxicity effect against human lung cancer A549 cells line. *Spectrochim Acta A Mol Biomol Spectrosc*. 138, 885–890.
 27. Dhand, V., Soumya, L., Bharadwaj, S., Chakra, S., Bhatt, D., Sreedhar, B., 2016. Green synthesis of silver nanoparticles using *Coffea arabica* seed extract and its antibacterial activity. *Mater Sci Eng C Mater Biol Appl*. 58, 36–43.
 28. Nayak, Minz, et al., 2016
 29. Lakshmanan, Sathiyaseelan, et al., 2018
 30. Tomlinson E. Theory and practice of site-specific drug delivery. *Adv Drug Delivery Rev*. 1987;1(2):87-198. doi: 10.1016/0169-409X(87)90001-9
 31. Foldbjerg R, Irving ES, Hayashi Y, Sutherland DS, Thorsen K, Autrup H, et al. Global gene expression profiling of human lung epithelial cells after exposure to

Green Synthesis Of Silver Nanoparticles Using Citrus Orange Peels And Evaluation Of Their Anticancer Property

- nanosilver. *Toxicol Sci.* 2012;130(1):145-57. doi: 10.1093/toxsci/kfs225.
32. Lin J, Huang Z, Wu H, Zhou W, Jin P, Wei P, et al. Inhibition of autophagy enhances the anticancer activity of silver nanoparticles. *Autophagy.* 2014;10(11):2006-20. doi: 10.4161/auto.36293.
33. Sankar R, Karthik A, Prabu A, Karthik S, Shivashangari KS, Ravikumar V. *Origanum vulgare* mediated biosynthesis of silver nanoparticles for its antibacterial and anticancer activity. *Colloids Surf B Biointerfaces.* 2013; 108:80-4. doi: 10.1016/j.colsurfb.2013.02.033.