VOLUME 9 (SPECIAL ISSUE 1) 2023

ISSN 2454 – 3055

Guest Editor: Dr. S. Mohanasundaram
Assistant Guest Editor: Dr. S.S.Syed Abuthahir

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 9 (Special Issue 1), 50-59 (2023)

International Journal of Zoological Investigations

Contents available at Journals Home Page: www.ijzi.net

Editor-in-Chief: Prof. Ajai Kumar Srivastav

Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Green Synthesis of Silver Nanoparticles Using *Terminalia bellirica* (Gaertn.) Roxb Extract and its Anti Cancer Activity Against Pancreatic Cancer Cell Line

Bharathi V. and Anuradha R.*

PG and Research Department of Biochemistry, Sengamala Thayaar Educational Trust Women's College Autonomous) (Affiliated to Bharathidasan University), Sundarakkottai, Mannargudi 614 016, Thiruvarur (Dt.), Tamil Nadu, India

**Corresponding Author*

Received: 20th December, 2022; **Accepted:** 25th January, 2023; **Published online:** 5th February, 2023

https://doi.org/10.33745/ijzi.2023.v09ispl1.008

Abstract: The possible actions of metal nanoparticles have prompted substantial research in this field in recent years. The most common species of *Terminalia* in India, *Terminalia bellirica* (Gaertn.) Roxb**,** is the subject of this study due to its anticancer efficacy and its potential for application in the synthesis of silver nanoparticles (AgNPs). The UV-visible spectra, Fourier Transforms Infrared Spectroscopy (FT-IR), and Scanning Electron Microscopy (SEM) were all used to analyse the produced AgNPs. The data demonstrated that AgNPs had a spherical, cuboid, cylindric form. MTT test analysis of *Terminalia bellirica* at 15.77g against the pancreatic cancer cell line AsPC-1 revealed preferential cytotoxicity against AsPC-1. Therefore, our findings indicated that silver nanoparticles biosynthesized from *Terminalia bellirica* may be useful in the treatment of cancer.

Keywords: Silver nanoparticles, MTT assay, *Terminalia bellirica*, Pancreatic cancer

Citation: Bharathi V. and Anuradha R.: Green Synthesis of silver nanoparticles using *Terminalia bellirica* (Gaertn.) Roxb extract and its anti cancer activity against pancreatic cancer cell line. Intern. J. Zool. Invest. 9(Special Issue 1): 50-59, 2023.

https://doi.org/10.33745/ijzi.2023.v09ispl1.008

Introduction

Nanotechnology is becoming a multidisciplinary field of study. Researchers and scientists are paying increasing attention to the numerous uses of nanoparticles (NPs) in a variety of sectors, including chemistry, biology, physics, pharmaceuticals, and medicine. According to their bulk substance, NPs are particles with diameters ranging from 1 to 100 nm (Auffan *et al.,* 2009). NPs may be divided into many categories according to their characteristics, shapes, and sizes. These include lipid-based NPs, metal NPs, ceramic NPs, semiconductor NPs, polymeric NPs, and carbon-based NPs (Khan *et al.,* 2017). Due to their potential and numerous scientific uses, metal nanoparticles including copper, silver, and gold have drawn researchers' attention for more

than a century. In biomedical applications including antibacterial, antiviral, anticancer, antifungal, and anti-inflammatory activities, AgNPs are preferred over other metallic nanoparticles because of their distinctive physiochemical features and the comparatively inexpensive cost of manufacture (Zhang *et al*., 2016; Beyene *et al.*, 2017). Metal nanoparticles are often synthesized using one of two methods: approaches that are bottom-up and top-down (Ana-Alexandra *et al.,* 2016). The bottom-up strategy is based on the self-assembly of atoms to new nuclei that develop into a nanoscale particle, whereas the top-down approach is described as the breakdown of appropriate bulk material into its components through size reduction (Iqbal *et al.,* 2012). Nanoparticles may be created using a variety of traditional and unconventional techniques. Solvothermal synthesis, ion sputtering, reduction, and sol-gel processes are a few examples of conventional approaches (Ramya and Subapriya, 2012). Conventional methods have several drawbacks, including a high energy need, the use of potentially dangerous chemicals, inefficient purifications, and poor compound conversions. The non-traditional green synthesis of nanoparticles utilizing plants and microbes, in contrast, provides several benefits over traditional synthesis. It is environmentally benign, cost-effective, and does not involve the use of hazardous chemical agents, high temperatures, pressures, or energies (Ana-Alexandra *et al.,* 2016). Natural substances found in plants and microorganisms serve as reducing or capping agents during the creation of nanoparticles. For instance, during the creation of silver NPs, such natural chemicals might diminish the silver metal (Ebrahiminezhad *et al.,* 2017). Therefore, it should be highlighted that the employment of plants rather than microbes, which is more biohazardous, is favored for the synthesis of NPs (Ana-Alexandra *et al.,* 2016).

Fruits can help with hepatitis, bronchitis, asthma, dyspepsia, piles, diarrhea, coughs, hoarseness of voice, eye illnesses, and scorpion stings. They are also laxatives, astringents, anthelmintics, and antipyretics. They are also used as a hair tonic. The green fruit's decoction is used to treat coughs. Leprosy, dropsy, piles, and dysenteric diarrhea can all be treated with fruit pulp. Half-ripe fruit is used as a purgative. The fruit's kernel contains a narcotic. In Khagrachari, fruits are used to treat menstruation irregularities. Rheumatism is treated with seed oil. The bark's demulcent and purgative gum is used. The triterpenoid found in fruits has strong antibacterial properties (Jony Mallik *et al.,* 2012). The primary aim of this work was to create a novel technique for creating silver nanoparticles from plant extracts of *Terminalia bellerica* and to assess the anticancer properties of these nanoparticles.

Materials and Methods

Collection, Identification and authentication of plant materials:

The *Terminalia bellerica* plant, a species of plant, was discovered in and around Mannargudi, Thiruvarur District, Tamil Nadu, India. The Flora of Presidency of Madras was used to identify the plant, and Dr. S. John Britto, of the RAPINAT Herbarium and Center for Molecular Systematics at St. Joseph's College in Tiruchirappalli, validated the identification (Voucher number of the specimen, DS 008).

Plant extract preparation:

The blended and sieved dry fruits were prepared for usage. The coarse-free sample was soaked in ethanol for 72 h. Whatman No. 1 filter paper was used to filter the filtrate. To evaporate ethanol, the extract was maintained in a bath of hot water. The extract without ethanol was utilized for the first analysis.

Green synthesis of silver nanoparticles:

Fruit extract was used to create AgNPs. It was diluted 1:9 in 100 ml of aqueous silver nitrate solutions at 5 and 10 mM. Before adding the silver nitrate solution, the extract's pH was first corrected since the development of a yellowish-dark brown hue in the fluctuation of pH was a

sign that AgNPs were being formed. Five hours were spent on the incubation. The observations were performed every hour to capture the transition from pale green to dark brown. A tiny amount of the reaction mixture was centrifuged at 18,000 rpm for 25 min after each hour, and the supernatant was collected, while the pellet was kept at 40°C (Rodríguez-Luis *et al.,* 2016).

Phytochemical qualitative analysis:

The content of common phytochemicals such as alkaloids, flavonoids, polysaccharides, terpenoids, tannins, and coumarins in the fruit extracts were determined using previously published standard procedures (Edeoga *et al.,* 2005; Khan *et al.,* 2011; Mumtaz e*t al.,* 2014).

Characterization:

A UV-visible spectrophotometer (Spectro UV-2510TS; Labomed, Inc.) was used to record the optical absorbance at the 200-900 nm wavelength range to establish the generation of synthesized NPs. A scanning electron microscope (SEM) was used to study the surface morphology of AgNPs. To identify the potential biomolecules responsible for the reduction, capping, and stability of AgNPs, transform infrared (FTIR) studies were performed. The surface and functional groups, as well as their interaction with the AgNPs, were identified using FTIR spectroscopy. In the transmittance mode, FTIR spectra were scanned between 4000 and 400 cm^{1} at a resolution of 0.07 cm^{1} (Jasco 6300).

Cytotoxicity assays:

Purification of biosynthesized silver nanoparticles:

The silver colloids were centrifuged at 10,000 rpm for 15 min and rinsed three times with millipore water to remove the extra silver ions. For further characterization, a dried powder of silver nanoparticles was produced by freeze-drying in a lyophilizer.

Cell lines:

The National Centre for Cell Sciences (NCCS), Pune, India, provided the pancreatic cancer cell lines (AsPC-1 cell line) that were used in this investigation.

Culture medium:

Pancreatic cell lines from humans in addition to 10% fetal bovine serum, 2 mM glutamine, 100 µl penicillin, 100 µg/mL streptomycin, and 25 µg/mL amphotericin B, AsPC-1 were grown in RPMI 1640 media. The cells were grown in a 37°C incubator with 5% CO2 in a humidified environment.

Cell viability assay:

MTT Assay is a colorimetric assay that quantifies mitochondrial succinate dehydrogenase's reduction of the yellow 3-(4, 5-dimethythiazol-2-yl)-2, 5-diphenyl tetrazolium bromide (MTT). In six-well plates, cancer AsPC-1 cells were planted at well, and the cells received nanoparticle treatment for 24 h. After allowing the cells to adhere for 24 h, the growth medium (MEM) was removed using a micropipette. To remove dead cells and extra FBS, the monolayer of cells was then twice washed with MEM without FBS. Different drug dilutions were dissolved in 1 ml of media (without FBS) and the appropriate wells. 200 µl of MTT (5 mg/ml in PBS) was then added to each well, and the cells were then incubated for an additional 6-7 h in a 5% CO_2 incubator. Each well received 1 ml of DMSO after the medium had been removed. With vehicle-treated cells assumed to be 100% viable, the impact of nanoparticles on cell growth inhibition was measured as a percentage of cell viability. After then, the cells were only exposed to the medium (as positive control). Gemcitabine (10 µg), the standards, and AgNP concentrations ranging from 10 to 100 µg/ml were employed in the investigation. The generated formazan was solubilized by removing the supernatant, adding 50 µl of propanol, and gently shaking the plates. The MTT penetrates the cells and travels to the mitochondria, where it is converted to a formazan product that is insoluble and colored (dark purple).

The solubilized formazan product is then released after the cells have been solubilized using an organic solvent (such as isopropanol). Since only metabolically active cells can reduce MTT, the amount of activity provides a gauge of the viability of the cells. Cell mortality was examined after the cells were treated with the nanoparticles for 24 and 48 h. The absorbance was measured using an enzyme-linked immunosorbent assay (ELISA) reader at 570 nm after the plates were shaken for 15 min. Each experiment was done three times, and the method given below was used to compute the half maximum inhibitory concentration (IC_{50}) of the nanoparticles as the proportion of cells that survived the exposure.

The dose-response method was used to determine the IC_{50} concentration, where

survival rate = [(OD test)/ (OD negative control)] 100

Three times the tests were conducted, and descriptive statistics were used to evaluate the measured optical density.

Results and Discussion

Recently, there has been a lot of interest in studying natural products to find active chemicals and using those molecules to synthesize nanoparticles. In this work, AgNPs were produced using an ethanolic *T. bellerica* extract, and their anticancer efficacy was subsequently examined. In general, a variety of phytochemicals, including alkaloids, flavonoids, terpenoids, tannins, phenol, glycosides and saponins are found in plant extracts (Table 1).

T. bellerica is a perfect plant for the green synthesis of AgNPs since it has a wide range of phytochemicals that may contribute to the reduction and stability of AgNPs (Elizabet, 2005). The *T. bellerica* showed antitumor efficacy against leukemia (HCT-16 and Colo-205), breast (T47D and MCF-7), prostate (PC-3), lung (A549), and colon (HCT-16 and Colo-205) (THP-1, HL-60, and K562) (Diab *et al.,* 2015).

Formation and characterization of AgNPs:

When 3 M NaOH was added to the ethanolic root extracts of *T. bellerica*, the color changed from colorless to light yellow, then dark brown (Fig. 1), indicating the synthesis of AgNPs. The initial sign of the creation of AgNPs, which may be caused by the activation of silver's surface plasmon resonance, is a color shift from yellow to brown.

UV-Visible spectroscopy research proved that silver ions were reduced and stabilized. The *Terminalia bellerica*'s UV-VIS spectrum shows that phytochemicals with the functional groups poly-unsaturated and aromatic compounds, N=O, and aromatic compounds, N=O, and NO_2 are present. This showed the existence of secondary metabolites such as flavone, alkaloids, piperidine, and isoquinoline, which show the transition energy (Fig. 2a). The transfer of the n→π*, σ →π* and σ→ σ *orbitals from the ground state to the excited state is what causes the color to absorb (Table 2).

T. bellerica flower extract was used for the synthesis of AgNP (Edison and Sethuraman, 2012). Several studies showed that *T. bellerica*

Fig. 1: Green synthesis of AgNPs of *Terminalia bellerica.*

Table 1: Preliminary phytochemicals analysis

Name of the compound	Result
Alkaloids	+
Flavonoids	+
Terpenoids	+
Tannins	+
Phenol	+
Glycosides	+
Saponins	+

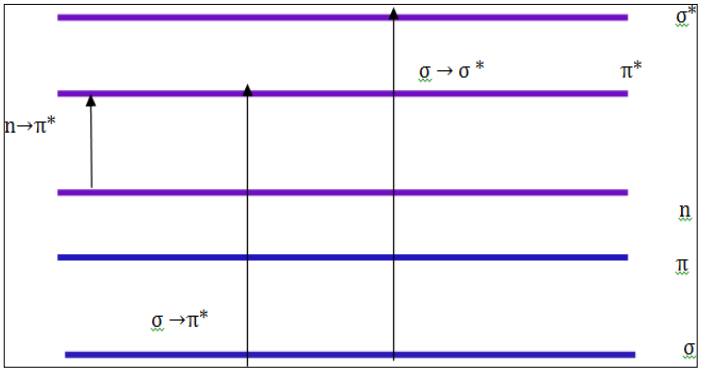


Fig. 2a: Energy changes of electronic transitions.

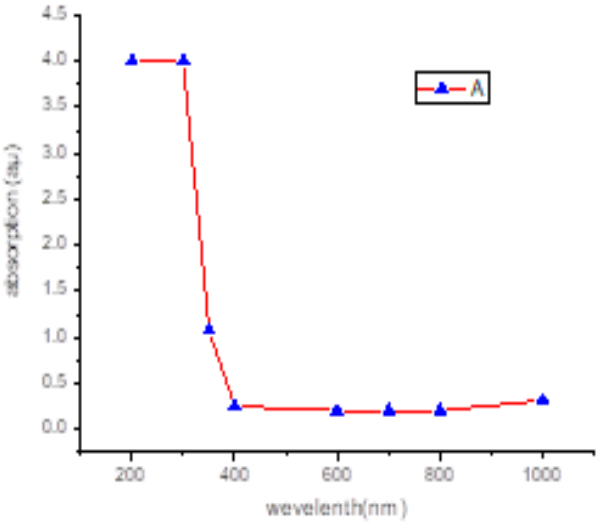


Fig. 2b: UV–visible spectroscopy of silver AgNps.

Table 2: UV-Vis analysis of ethanolic extract of *Terminalia bellerica*

S. No.	Chromophore	Transition	λmax (nm)
1.	Poly-unsaturated and aromatic N=N	n→π*	190-380 nm
2.	N=O	σ →π*	630-700
3.	NO_2	σ → σ *	>1000

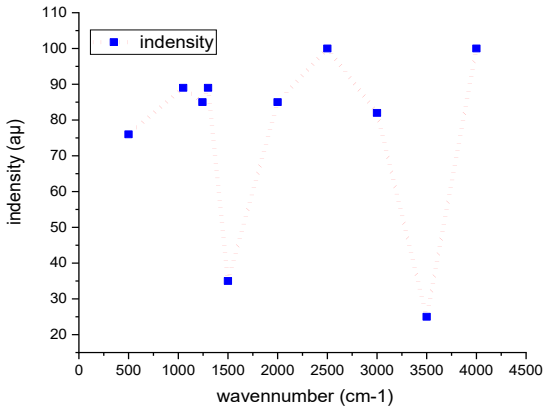
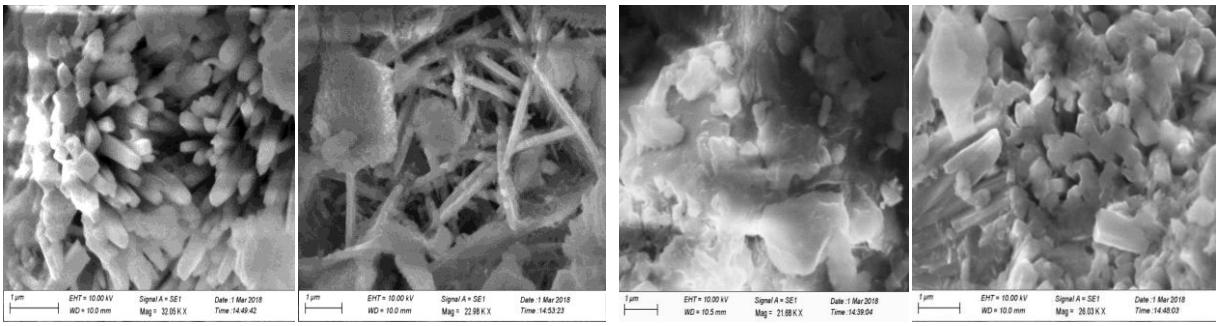


Fig. 3: FT-IR analysis of *Terminalia bellerica.*

Table 3: FT-IR analysis of ethanolic extract of *Terminlia bellerica*

S. No.	Wavelength (nm)	Functional Groups	Compound Identified
1.	3432.74	Amine N-H Stretch	Primary amines produce two N-H stretchabsorptions, secondary amides only one, and tetriary none.
		Amide N-H Stretch	As with amines, an amide produces zeroto two N-H absorptions depending on its type.
2.	2083.21(m or s)	Alkyl C-H Stretch	Alkane C-H bonds are fairly ubiquitous And therefore usually less useful indetermining structure.
3.	1637.72(v)	Alkenyl C-H Stretch Alkenyl C=C Stretch	Absorption peaks above 3000 cm^{-1} are frequently diagnostic of unsaturation
4.	1384.31	symmetric (medium)	**Nitro compounds** (O ,**N+,** O -)
5.	1244.89	(aromatic) **ethers**	Alkoxy C O
6.	1059.06	alkoxy C-O	C-O
7.	668.21	cis disubstituted alkene	R R C CH H

played a role in synthesizing AgNPs (Nandagopal *et al.,* 2014; Ankegowda *et al.,* 2020; Sharma, 2021). AgNPs have distinctive optical characteristics that cause them to interact strongly with particular light wavelengths. The kind, size, and shape of the nanoparticles affect the position and number of peaks (Zhang *et al.*, 2016). Similar to this, AgNPs created from the fruit extract of *Cleome viscosa*, *Azadirachta indica*, and *Ficus benghalensis*, as well as from their bark extracts, showed peaks in surface plasmon resonance absorption between 410 and 450 nm



(a) (b) (c) (d)

Fig. 4 a-d: SEM analysis.

(Fig. 2b) (Nayak *et al.*, 2016; Lakshmanan *et al.*, 2018).

FT-IR studies:

Measurements of the FT-IR spectrum were used to pinpoint the biomolecules that coated the silver nanoparticles. Figure 3 displays the FT-IR spectra of produced AgNPs and dried aqueous extract. The main phytoconstituents in the groups include carbonates, nitrates, O-H, C-H, C=C, C=O, CN, N-H, and C-H (Table 3). The diverse therapeutic effects of *Terminalia bellerica* may be due to the presence of distinctive functional groups such as carboxylic acids, anhydrides, alcohols, phenols, amines, amides, esters, ethers, sulfur compounds, glycosides, nitrates, nitriles, and carbohydrates. The functional group analysis revealed that *Terminalia bellerica* is free of any hazardous substances (Maobe *et al.,* 2013).

SEM studies:

AgNPs of various forms were produced when *Terminalia bellerica* fruit extracts were employed as reducing and capping agents, as evidenced by the surface morphology and topography of AgNPs that were examined by SEM. Fruit extracts from the *Terminalia bellerica* plant produced about spherical and cuboidal cylindrical AgNPs, respectively (Figs. 4 a, b, c, d). This can be because the fruit extracts from *Terminalia bellerica* are available in various quantities and types of capping agents. The changes and differences in peak locations discovered by the FT-IR research also corroborate this. Additionally, because to the various measurement techniques utilized, the observed size in DLS analysis was greater than the outcomes of the SEM picture. The physical size of the particles is measured using SEM. DLS assesses the particle's hydrodynamic size, which takes into account both the physical size of the particle and any associated biomolecules on its surface (Erjaee *et al*., 2017).

Cytotoxic Activities of Terminalia bellerica AgNPs:

Using the MTT assay, the cytotoxic effects of produced *Terminalia bellerica* AgNPs against AsPC-1 cancer cells were evaluated. The AsPC-1 exhibits the highest level of cell viability and no mortality between the intervals of 24 and 48 h, indicating that the metabolically active components in the cell are in charge of the succinate dehydrogenase, a major enzyme in the TCA cycle. When compared to the typical medicine Gemcitabine, which has a cell viability of around 16%, the concentration of 10 g/ml of plant extract exhibits maximum per cent of cell vitality (85%). Our findings supported the 15.77 g IC_{50} value of the AgNP produced from *Terminalia bellerica.*

The produced *Terminalia Bellerica* AgNPs were tested for their cytotoxic and anticancer properties. AgNPs had notable and focused cytotoxic effects on breast cancer cells, one of the most common types of cancer (Eastman and Perez, 2006). The rapid rate of cancer cell growth and aberrant metabolism, which render them

Table 4: *In vitro* MTT assay of ethanolic extract of *Terminalia bellerica*

S. No.	Treatment	Conc (µg/ml)	Absorbance 570nm At 24 s	IC_{50}	% Cell viability
1.	AsPC-1 cells Untreated		0.267		100.0 ± 7.3
2.		10	0.228		85.3 ± 5.2
3.		20	0.169		63.4 ± 5.9
4.	AgNPs treated	40	0.107	15.77	40.1 ± 3.3
5.		80	0.084		31.6 ± 1.9
6.		100	0.055		20.9 ± 1.2
7.	Gemcitabine	10	0.044		16.4 ± 1.1

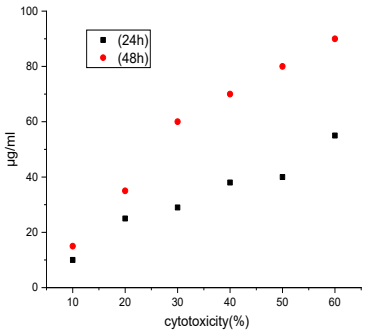


Fig. 5: The AgNPs showed cytotoxicity on the AsPC-1 cell line.

more susceptible and able to absorb AgNPs than normal cells, is believed to be the cause of this selective cytotoxicity (Khorrami *et al.*, 2018; Mousavi *et al.*, 2018). The MTT graph clearly shows (Table 4) that as the concentration of AgNPs increased, the vitality of AsPC-1 cells gradually decreased.

There is a risk that sustainability may deteriorate over time. Time-dependent cytotoxic tests using biologically produced gold and silver nanoparticles against AsPC1 cancer cells indicated a decrease in cell survival after 48 h of NPs treatment compared to 24 h (Nakkala *et al.*, 2014; Suganya *et al.*, 2016). After 24 h, 50% of the AsPC-1 cells in our study were dead, and this dose was designated as the IC_{50} for the AsPC-1 cells (Fig. 5). In a concentration of 100 g/ml, the extract was very effective at killing cells; however, this effect was much attenuated at lower concentrations.

Conclusion

AgNPs were developed using extracts from *Terminalia bellerica* for the first time. This method is efficient, ecologically benign, and risk-free. Plant extracts include a plethora of phytochemicals, some of which have been shown to convert Ag+ into AgNPs. The engineered AgNPs exhibited efficient physical properties and

tailored cytotoxic activities against the pancreatic cancer cell line AsPC-1. Therefore, using *Terminalia bellerica* in the biosynthesis of AgNPs is a promising technique for the discovery of new effective anti-cancer drugs.

References

Ana-Alexandra S, Nuta A, Ion R-M and Bunghez R. (2016) Green synthesis of silver nanoparticles using plant extracts. 4th International Virtual Conference on Advanced Scientific Results, Zilina, Slovakia

Ankegowda VM, Kollur SP, Prasad SK, Pradeep S, Dhramashekara C, Jain AS and Shivamallu C. (2020) Phyto-mediated synthesis of silver nanoparticles using *Terminalia chebula* fruit extract and evaluation of its cytotoxic and antimicrobial potential. Molecules 25(21): 5042.

Auffan M, Rose J, Bottero JY, Lowry GV, Jolivet JP and Wiesner MR. (2009) Towards a definition of inorganic nanoparticles from an environmental, health and safety perspective. Nat Nanotechnol. 4(10): 634-641.

Beyene HD, Werkneh AA, Bezabh HK and Ambaye TG. (2017) Synthesis paradigm and applications of silver nanoparticles (AgNPs), a review. Sustain Mater Technol. 13:18-23.

Diab KA, Guru SK, Bhushan S and Saxena AK. (2015) *In vitro* anticancer activities of *Anogeissus latifolia, Terminalia bellerica, Acacia catechu* and *Moringa oleiferna* Indian plants. Asian Pacific J Cancer Prevent. 16(15): 6423-6428.

Eastman A and Perez RP. (2006) New targets and challenges in the molecular therapeutics of cancer. Br J Clin Pharmacol. 62(1): 5-14.

Ebrahiminezhad A, Taghizadeh S and Ghasemi Y. (2017) Green synthesis of silver nanoparticles using Mediterranean cypress (*Cupressus sempervirens*) leaf extract. Am J Biochem Biotechnol. 13: 1-6.

Edeoga H, Okwu D and Mbaebie B. (2005) Phytochemical constituents of some Nigerian medicinal plants. Afr J Biotechnol. 4(7): 685-688.

Edison TJI and Sethuraman MG. (2012) Instant green synthesis of silver nanoparticles using *Terminalia chebula* fruit extract and evaluation of their catalytic activity on reduction of methylene blue. Process Biochem. 47(9): 1351-1357.

Elizabeth KM. (2005) Antimicrobial activity of *Terminalia bellerica*. Indian J Clin Biochem. 20(2): 150-153.

Erjaee H, Rajaian H and Nazifi S. (2017) Synthesis and characterization of novel silver nanoparticles using *Chamaemelum nobile* extract for antibacterial application. Adv Nat Sci Nanosci Nanotechnol. 8(2): 025004.

Iqbal P, Preece J and Mendes PM. (2012) Nanotechnology: the "top- down" and "bottom-up" approaches. doi.org/10.1002/9780470661345.smc195.

Jony Mallik, Priyanka Das, Bijoy Karon and Sourav D. (2012) A review on phytochemistry and pharmacological activity of *Terminalia belerica*. Int J Drug Formulation Res. 3(6): 1-5.

Khan AM, Qureshi RA, Ullah F, Gilani SA, Nosheen A, Sahreen S, Laghari MK, Laghari MY, Hussain I and Murad W. (2011) Phytochemical analysis of selected medicinal plants of Margalla Hills and surroundings. J Med Plants Res. 5(25): 6055-6060.

Khan I, Saeed K and Khan I. (2017) Nanoparticles: properties, applica tions and toxicities. Arab J Chem. 12(7): 908-931.

Khorrami S, Zarrabi A, Khaleghi M, Danaei M and Mozafari MR. (2018) Selective cytotoxicity of green synthesized silver nanoparticles against the MCF-7 tumor cell line and their enhanced antioxidant and antimicrobial properties. Int J Nanomed. 13: 8013-8024.

Lakshmanan G, Sathiyaseelan A, Kalaichelvan P and Murugesan K. (2018) Plant-mediated synthesis of silver nanoparticles using fruit extract of *Cleome viscosa* L. assessment of their antibacterial and anticancer activity. Karbala Int J Mod Sci. 4(1): 61-68.

Maobe MAG and Nyarango, RM. (2013) Fourier transformer infra-red spectrophotometer analysis of *Warburgia ugandensis* medicinal herb used for the treatment of Diabetes, Malaria and Pneumonia in Kisii Region, Southwest Kenya. Global J Pharmacol. 7(4): 61-68.

Mousavi B, Tafvizi F and Zaker Bostanabad S. (2018) Green synthesis of silver nanoparticles using *Artemisia turcomanica* leaf extract and the study of anti-cancer effect and apoptosis induction on gastric cancer cell line (AGS). Artif Cells Nanomed Biotechnol. 46(sup1): 499-510.

Mumtaz F, Raza S, Ahmad Z, Afitakhar A and Hussain M. (2014) Qualitative phytochemical analysis of some selected medicinal plants occurring in local area of Faisalabad, Pakistan. J Pharm Altern Med. 3(3): 17-21.

Nakkala JR, Mata R, Gupta AK and Sadras SR. (2014) Biological activities of green silver nanoparticles synthesized with *Acorous calamus* rhizome extract. Eur J Med Chem. 85: 784-794.

Nandagopal S, Kumar AG, Dhanalaksmi DP and Prakash P. (2014) Bioprospecting the antibacterial and

anticancer activities of silver nanoparticles synthesized using *Terminalia chebula* seed extract. Int J Pharm Pharm Sci. 6(2): 368-373.

Nayak D, Ashe S, Rauta PR, Kumari M and Nayak B. (2016) Bark extract mediated green synthesis of silver nanoparticles: evaluation of antimicrobial activity and antiproliferative response against osteosarcoma. Mater Sci Eng C. 58: 44-52.

Ramya M and Subapriya MS. (2012) Green synthesis of silver nano-particles. Int J Pharma Med Biol Sci. 1(1): 55-61.

Rodríguez-Luis OE, Hernandez-Delgadillo R, Sánchez-Nájera RI, Martínez-Castañón GA, Niño-Martínez N, Sánchez Navarro MdC, Ruiz F and Cabral-Romero C. (2016) Green synthesis of silver nano- particles and their bactericidal and antimycotic activities against oral microbes. J Nanomater. 2016: 9204573.

Sharma R. (2021) Synthesis of *Terminalia bellirica* fruit extract mediated silver nanoparticles and application in photocatalytic degradation of wastewater from textile industries. Materials Today Proc. 44: 1995-1998.

Suganya KU, Govindaraju K, Kumar VG, Karthick V and Parthasarathy K. (2016) Pectin mediated gold nanoparticles induces apoptosis in mammary adenocarcinoma cell lines. Int J Biol Macromol. 93: 1030-1040.

Zhang XF, Liu ZG and Shen W andGurunathan S. (2016) Silver nano-particles: synthesis, characterization, properties, applications, and therapeutic approaches. Int J Mol Sci. 17(9): 1534.