

Gongcheng Kexue Xueba

ISSN 2095-9389

Volume 11 || Issue 5 || 2026

Impact Factor: 6.7

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Plant-mediated Synthesis and Characterization of Silver Nanoparticles from Broccoli Stem (*Brassica oleracea* var. *italica*) - Antimicrobial Performance

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ABSTRACT

The development of eco-friendly methods for nanoparticle synthesis has gained significant attention due to increasing environmental and health concerns associated with chemical synthesis. In this present study, silver nanoparticles (AgNPs) were synthesized using aqueous extract of *Brassica oleracea* (broccoli) stem, an agricultural waste material, as a reducing and stabilizing agent. The formation of AgNPs was initially confirmed by a visible color change from pale yellow to dark brown and further characterized using UV-visible spectroscopy, Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), and energy dispersive X-ray spectroscopy (EDX). The UV-visible spectrum showed a characteristic surface plasmon resonance peak around 460 nm, indicating successful nanoparticle synthesis. The SEM images show the synthesized silver nanoparticles are predominantly spherical in shape with aggregates. The biosynthesized AgNPs exhibited significant antibacterial activity against both Gram-positive and Gram-negative bacterial strains as demonstrated by agar well diffusion assay. The study highlights the potential of broccoli stem as a cost-effective, sustainable, and green resource for synthesis of biologically active silver nanoparticles with promising antimicrobial applications.

Keywords: Silver Nanoparticles, Green synthesis, Broccoli stems, Antimicrobial activity, SEM.

1. INTRODUCTION

Nanotechnology has emerged as a rapidly advancing field with wide applications in medicine ,agriculture , environmental science[1][2] .Among various nanomaterials ,silver nanoparticles have attracted considerable attention due to their unique physiochemical properties and strong antimicrobial activity [3] .Their small size and large surface area enable enhanced interaction with microbial cells, making them effective against a broad range of pathogenic microorganisms .[4][5]. Green synthesis using plant extracts has been recognized as an efficient and eco-friendly strategy for the preparation of metal nanoparticles[6][7]. Plant-derived biomolecules such as phenolics ,flavonoids, proteins and organic acids can act simultaneously as reducing ,capping, and stabilizing agents, eliminating the need for additional chemical reagents. This approach is not only safer but also cost- effective and suitable for large- scale production.[8][9][10]. Brassica oleracea (broccoli) is widely cultivated and consumed[11] .However significant portion of the plant ,particularly the stem are known to contain various phytochemicals ,including antioxidants and bioactive compounds , which can potentially facilitate the reduction of metal ions and stabilize the synthesized nanoparticles[12][13] .using such plant waste for nanoparticle synthesis provides a value-added approach to waste management while promoting sustainable technology[14]. In recent years , several plant species have been explored for the biosynthesis of silver nanoparticles[15] ; however ,studies focusing on the use of broccoli stem extract remain limited[16]. Investigating the underutilized plant material for nanoparticle production may contribute to both environmental sustainability and the development of novel antimicrobial agents[17]. Therefore ,the present study aims to synthesize silver nanoparticles using aqueous extract of broccoli stem through a green synthesis approach that tend to characterize the synthesized nanoparticles using spectroscopic and microscopic techniques[18][19] .In addition , the antimicrobial potential of the biosynthesized nanoparticles was evaluated against selected bacterial strains to assess their possible biomedical applications[20].

2. MATERIALS AND METHODS

2.1 Materials

Fresh broccoli (*Brassica oleracea*) stems were collected from a local vegetable market. Silver nitrate (AgNO_3) of analytical grade was used as the precursor for nanoparticle synthesis. All glassware was thoroughly cleaned and rinsed with distilled water prior to use to avoid contamination.

2.2 Preparation of Broccoli Stem Extract

The collected broccoli stems were washed several times with tap water followed by distilled water to remove dust and surface impurities. The cleaned stems were cut into small pieces and air-dried. A known quantity of the chopped plant material was boiled in distilled water for a specific period to obtain the aqueous extract. The extract was cooled to room temperature and filtered using Whatman No. 1 filter paper to remove solid residues. The filtrate was stored at 4 °C and used for nanoparticle synthesis.

2.3 Green Synthesis of Silver Nanoparticles:

For the biosynthesis of silver nanoparticles, the prepared broccoli stem extract was mixed with an aqueous solution of silver nitrate. The reaction mixture was incubated at room

temperature under continuous stirring. The formation of silver nanoparticles was initially indicated by a gradual colour change of the solution from pale yellow to dark brown, suggesting the reduction of silver ions and formation of nanoparticles from Fig.1.

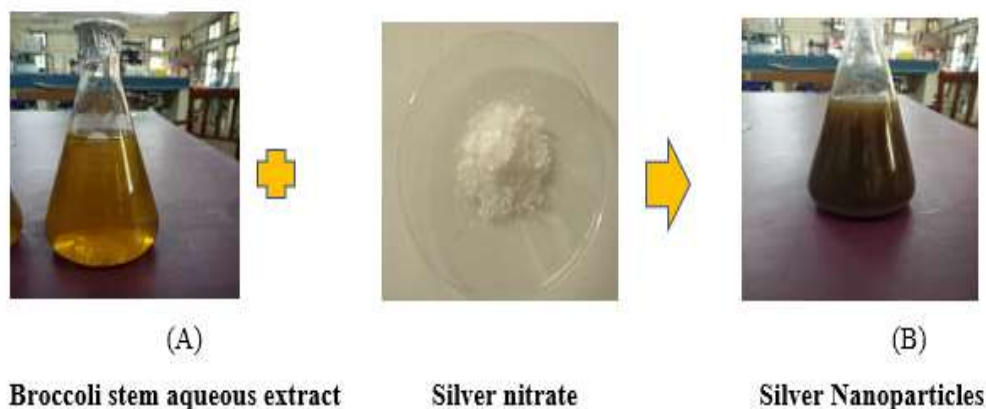


Fig:1: Confirmation of Silver Nanoparticles by Colour change from light brown(A) to dark brown(B)

2.4 Antibacterial Activity Assay:

The antimicrobial activity of the synthesized silver nanoparticles was evaluated using the agar well diffusion method against selected Gram-positive and Gram-negative bacterial strains. Sterile nutrient agar plates were inoculated with bacterial cultures, and wells were created using a sterile cork borer. Different concentrations of nanoparticle suspension were added to the wells and the plates were incubated at 37 °C for 24 hours. The antibacterial activity was assessed by measuring the diameter of the zone of inhibition around each well.

2.5 CHARACTERIZATION STUDIES

2.5.1 Scanning Electron Microscope (SEM)

Scanning Electron Microscope analysis was used to know the shape of silver nanoparticles. SEM images of silver nanoparticles viewed at different of *Brassica oleracea* var. *Italica* (Broccoli). The images confirmed the formation of few nanoparticles capped with the biomolecules present in the biomass supernatant. The SEM images show the synthesized silver nanoparticles are predominantly spherical in shape with aggregates (Fig.2). The protein molecules perform as a surface coating molecule which keep away from the internal agglomeration of the particle and indicating stabilization of nanoparticles. The energy dispersive X-ray analysis (EDX) reveals the strong signal in the silver nanoparticle by acting the flower Extract of Broccoli. The synthesized silver Nanoparticle was stable in solution more than the period of two months at room temperature

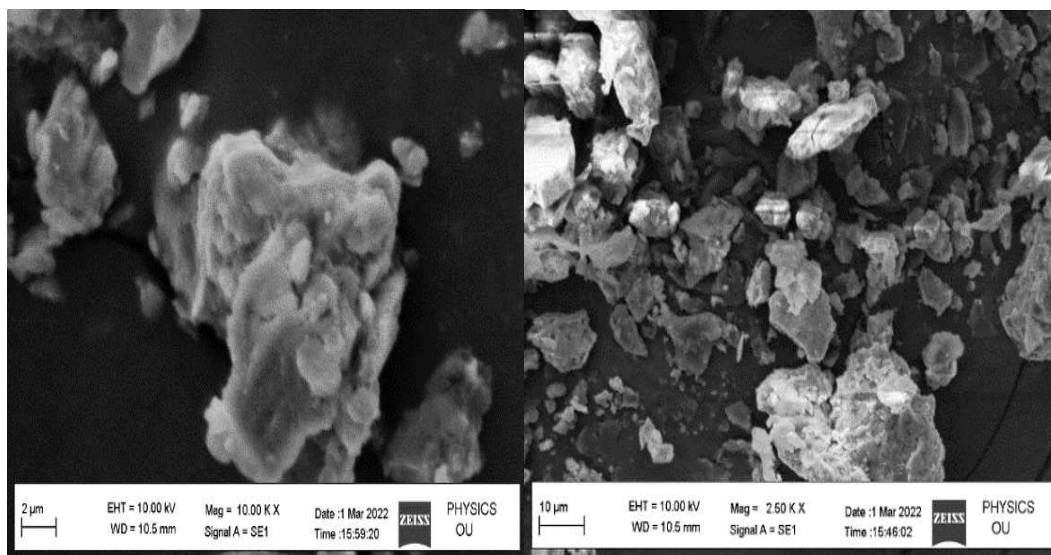
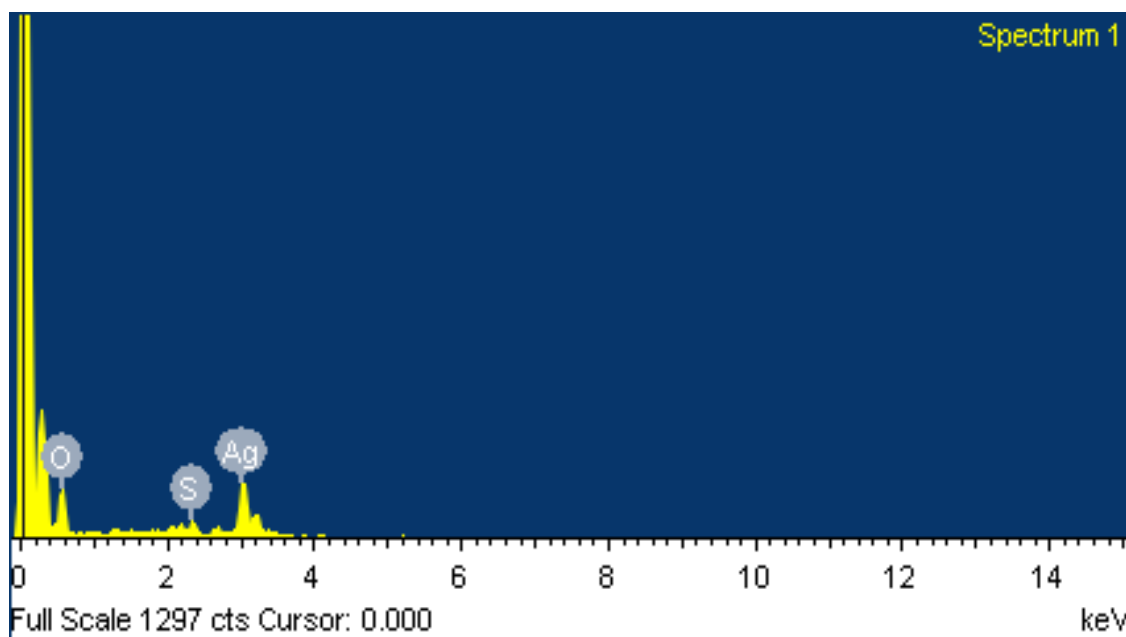


Fig.2 : SEM image of the Broccoli silver nanoparticles 2 μ m,10 μ m.

2.5.2 . Energy dispersive X-ray spectroscopy (EDX):

Energy dispersive X-ray spectrometers take advantage of the photon nature of light. In the X-ray range the energy of a single photon is just sufficient to produce a measurable voltage pulse X-ray, the output of an ultra-low noise preamplifier connected to the low noise are a statistical measure of the corresponding quantum energy. The EDAX pattern clearly shows that silver nanoparticles formed by the reduction of silver ions using fresh Broccoli extract are crystalline in nature. The EDS spectrum was recorded in the spot- profile mode. The optical absorption peak is observed at 3KeV, which is typical for the absorption of metallic AgNPs. Strong signals from the Ag atoms are observed, while weaker signals from C, Cu and Si atoms were also recorded. From the EDS signals, AgNPs reduced by Broccoli extract have the weight percentage of elemental Ag as 73.76%.



Element	Weight (%)	Atomic (%)
O k	35.61	76.88
S K	3.31	3.57
Ag L	61.08	19.56
Total	100.00	

Fig.3 : SEM- Energy Dispersive X- spectroscopy (EDX) analysis of BAgNPs.

3. RESULTS & DISCUSSIONS

3.1 Optimization of physicochemical parameters :(for the batch extraction process)

3.1.1. Effect of Different solvents on extraction of Rutin ,Caffeic acid from Broccoli (brassica oleracea var.italica) powder:

Table 1: Concentrations of Rutin and Caffeic acid at different type of solvent.

Solvent type	Concentration (µg/ml)of Rutin	Concentration(µg/ml)of caffeic acid
Methanol	69.5	2.21
Ethanol	64.2	2.18
Ethyl acetate	61.7	2.07
Water	55.2	1.87

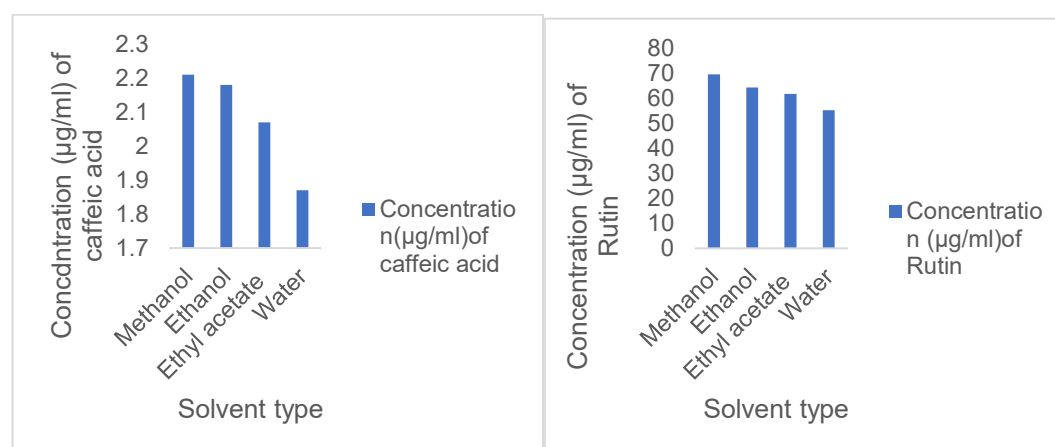


Fig.4: Caffeic acid vs Solvent type

Fig. 5: Rutin vs Solvent type

3.1.2. Effect of Different Solvent Percentage on Extraction of Rutin and Caffeic acid

Table 2: Concentrations of Rutin , Caffeic acid at different Solvent concentrations

Solvent concentration (%)	Concentration($\mu\text{g/ml}$)of Rutin	Concentration ($\mu\text{g/ml}$)of Caffeic acid
20	53.74	2.29
40	57.29	2.314
60	59.91	2.422
80	44.29	2.357
100	20.12	2.003

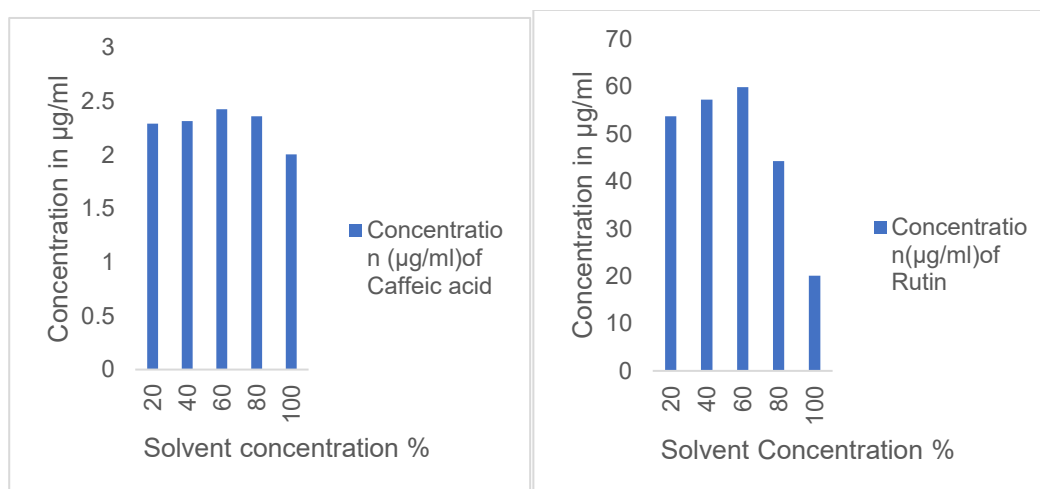


Fig 6: Caffeic acid vs Solvent concentration % **Fig. 7:** Rutin vs Solvent concentration %

3.1.3. Effect of soaking time on Rutin and Caffeic acid at different soaking times:

Table 3: Concentrations of Rutin and Caffeic acid at different soaking times

Soaking time (Mins)	Concentration ($\mu\text{g/ml}$)of Rutin	Concentration ($\mu\text{g/ml}$ of Caffeic acid
30	51.71	2.268
60	55.28	2.29
90	57.64	2.415
120	46.14	2.34
150	19	2.148

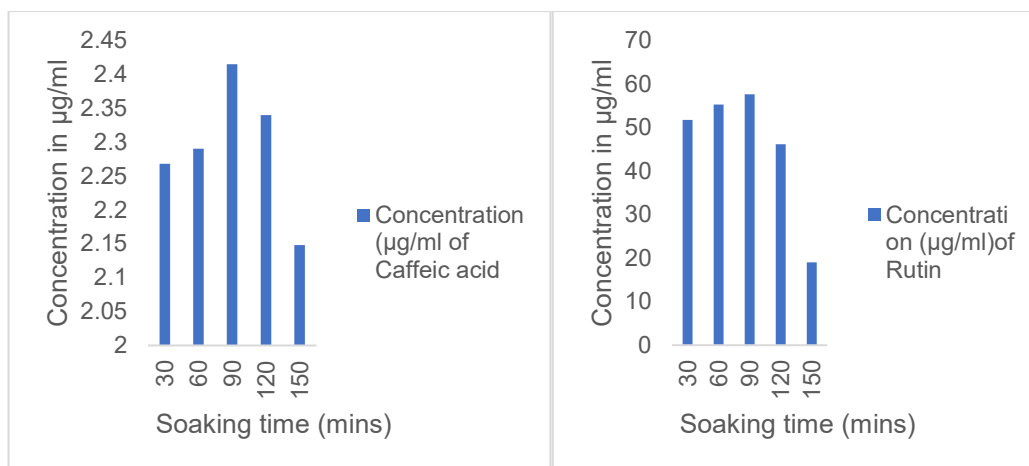


Fig. 8: Caffeic acid vs Soaking time (mins) **Fig. 9:** Rutin vs Soaking time (mins)

3.1.4. Effect of extraction temperature of rutin and caffeic acid at different Extraction temperature

Table 4: Concentration of Rutin and Caffeic acid at different extraction temperatures (°C)

Extraction Temperature (°C)	Concentration (µg/ml) of Rutin	Concentration (µg/ml) of Caffeic acid
32	60.42	2.439
34	62.21	2.512
36	63.42	2.553
38	63.78	2.535

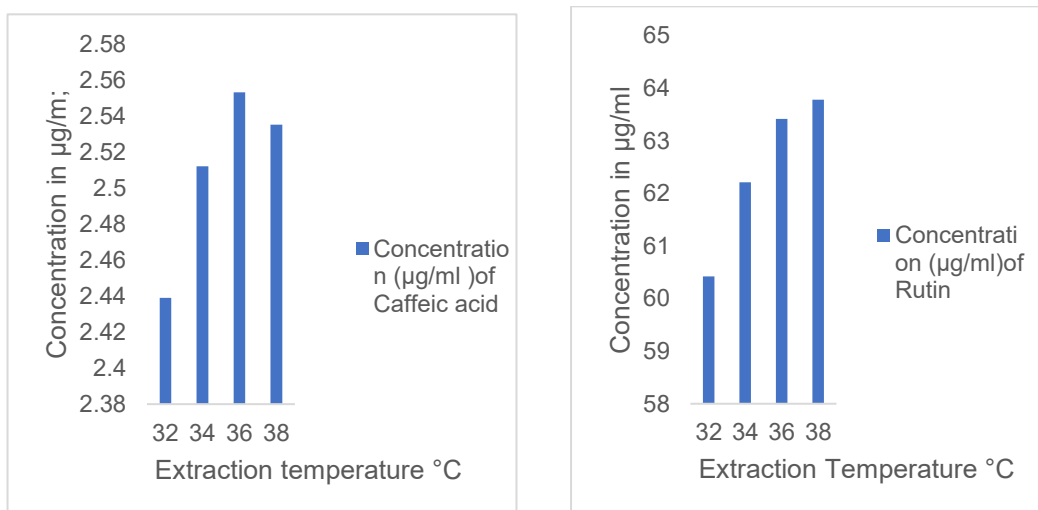


Fig. 10: Caffeic acid vs Extraction temperature **Fig. 11:** Rutin vs Extraction temperature

3.1.5. Effect of pH on Extraction of Rutin and Caffeic acid

Table 5: Concentrations of Rutin and Caffeic acid at different extraction pH

Extraction pH	concentration ($\mu\text{g/ml}$) of Rutin	Concentration in ($\mu\text{g/ml}$) of Caffeic acid
6	50.28	2.288
7	60.42	2.439
8	54.85	2.333
9	44.85	2.203
10	19.64	1.983

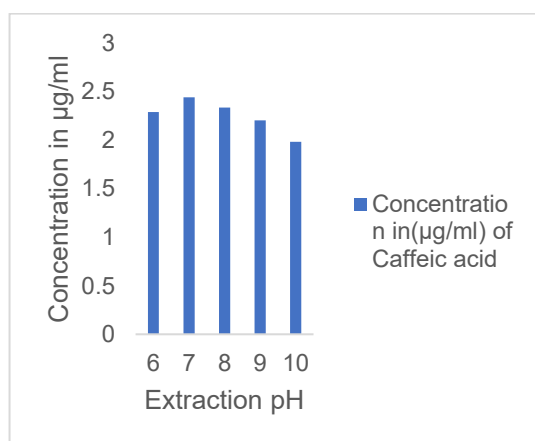


Fig.12: Caffeic acid vs Extraction pH

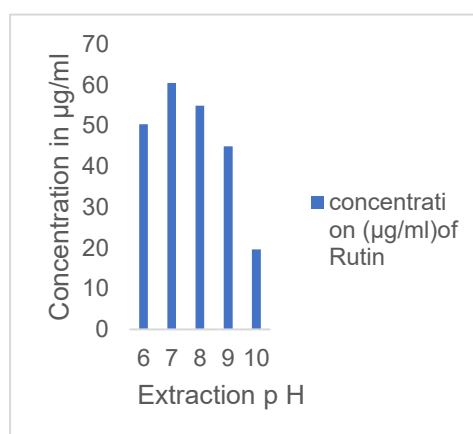


Fig. 13: Rutin vs Extraction pH

3.1.6. Effect of Rutin and Caffeic acid at different material ratio

Table 6: Concentrations of Rutin and Caffeic acid at different material ratio

Material Ratio	Concentration ($\mu\text{g/ml}$) of Rutin	Concentration ($\mu\text{g/ml}$) of Caffeic acid
01:10	51.4	2.163
01:20	60.71	2.598
01:30	59.81	2.379
01:40	47.17	2.189
01:50	23.21	1.832

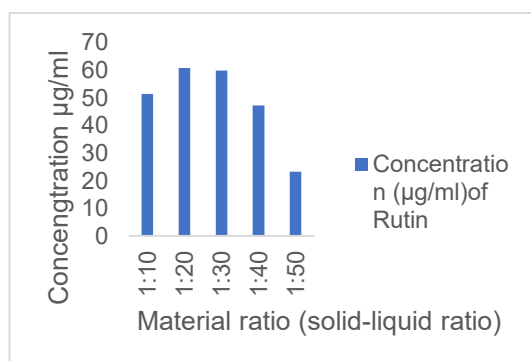


Fig.14: Rutin VS Material ratio

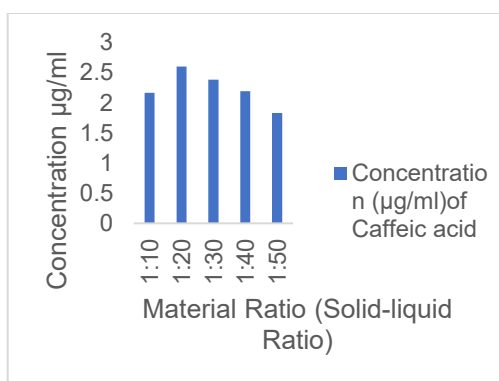
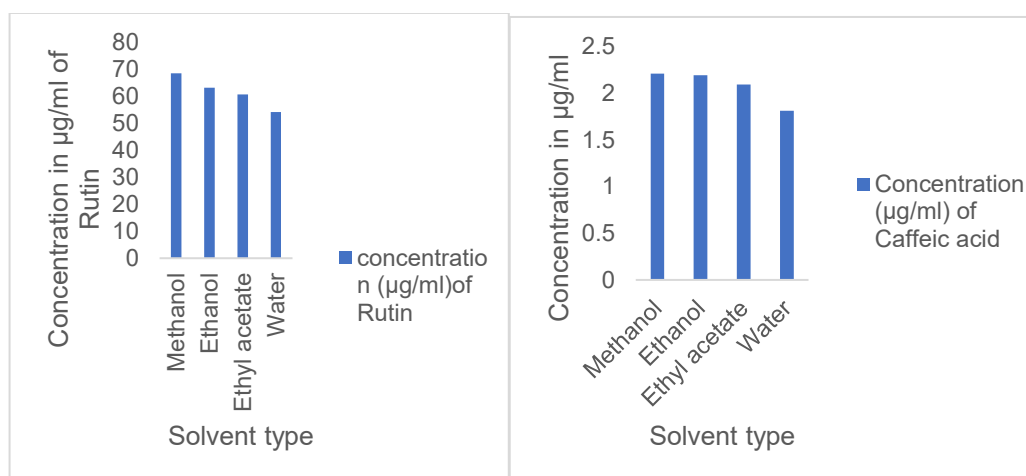


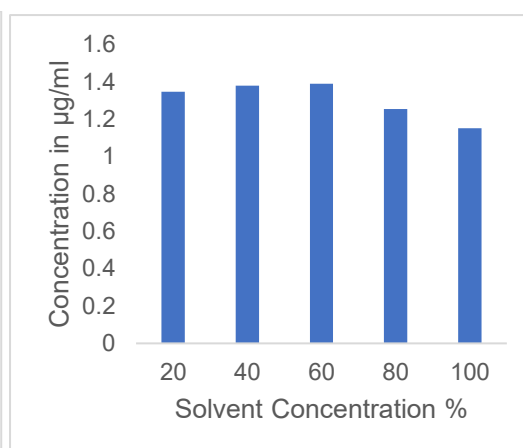
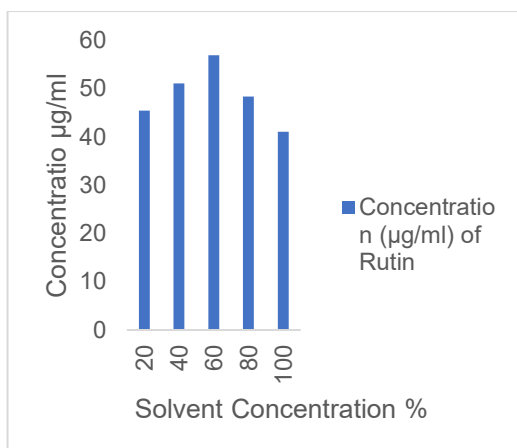
Fig.15: Caffeic acid Vs material ratio

BROCCOLI SILVER NANOPARTICLES:**3.2 Optimization results of extraction processes physio-chemical parameters for batch extraction processes (AgNPs)****3.2.1.Effect of Different solvents on extraction of Rutin, Caffeic acid from Broccoli(*brassica oleracea* var. *italica*) assisted silver nanoparticles powder.****Table 7:** Concentration of Rutin and Caffeic acid at different type of solvents

Solvent type	concentration ($\mu\text{g/ml}$)of Rutin	Concentration ($\mu\text{g/ml}$) of Caffeic acid
Methanol	68.5	2.208
Ethanol	63.2	2.191
Ethyl acetate	60.7	2.09
Water	54.2	1.81

**Fig.16:** Rutin Vs Solvent type**Fig.17:** Caffeic acid Vs Solvent type**3.2.2 Effect of different solvent percentage on extraction of Rutin and Caffeic acid****Table 8:** Concentrations of Rutin and Caffeic acid at different solvent concentrations

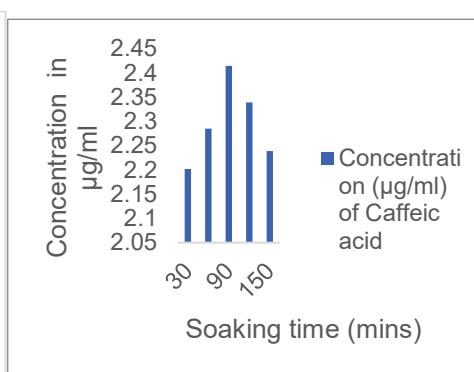
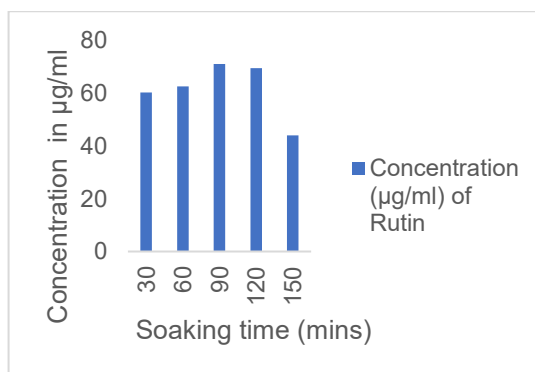
Solvent concentration	Concentration ($\mu\text{g/ml}$) of Rutin	Concentration ($\mu\text{g/ml}$) of Caffeic acid
20	45.42	1.346
40	51.07	1.379
60	56.92	1.389
80	48.35	1.255
100	41.07	1.151

**Fig.18:** Rutin vs Solvent extraction %**Fig.19:** Caffeic acid vs Solvent extraction %

3.2.3. Effect of soaking time of Rutin and Caffeic acid at different soaking time

Table 9: Concentration of Rutin and Caffeic acid at different soaking times

Soaking time (mins)	Concentration (µg/ml) of Rutin	Concentration (µg/ml) of Caffeic acid
60	62.642	2.285
90	71.071	2.414
120	69.5	2.339
150	44.071	2.239

**Fig.20:** Rutin vs Soaking time (mins)**Fig.21:** Caffeic acid vs Soaking time (mins)

3.2.4. Effect of extraction temperature on Rutin and Caffeic acid

Table 10: Concentration of Rutin and Caffeic acid at different extraction temperature

Extraction Temperature (°C)	Concentration (µg/ml) of Rutin	Concentration (µg/ml) of Caffeic acid
32	62.5	2.57
34	64.42	2.59
36	67.92	2.6
38	68.28	2.61

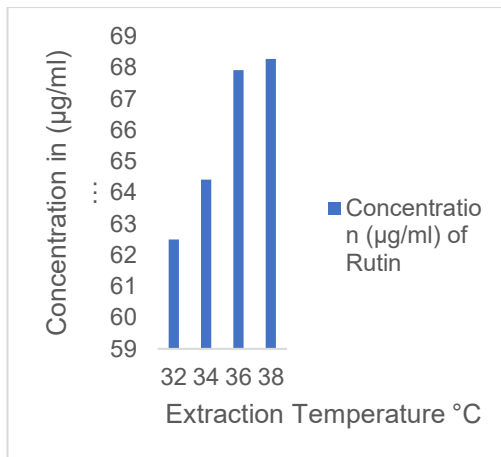


Fig.22: Rutin vs Extraction temperature °C

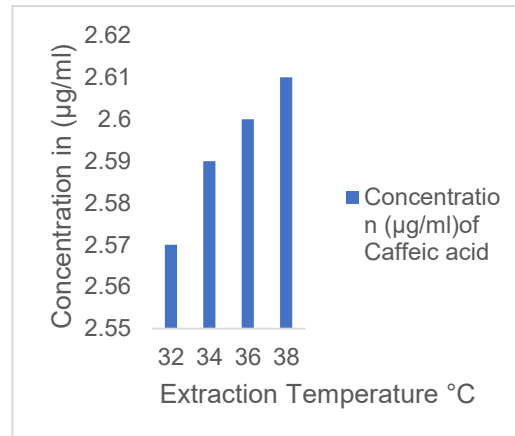


Fig.23: Caffeic acid vs Extraction Temperature °C

3.2.5. Effect of pH on extraction of Rutin and Caffeic acid

Table 11: Concentration of Rutin and Caffeic acid at different extraction pH

Extraction p H	Concentration (µg/ml) of Rutin	Concentration (µg/ml) of Caffeic acid
6	50.92	2.299
7	60.85	2.303
8	62.71	2.33
9	49	2.316
10	44.64	2.077

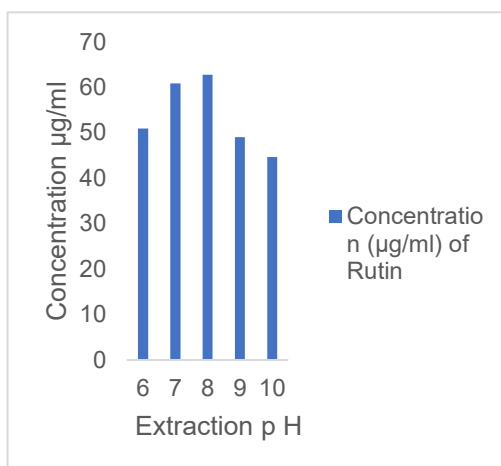


Fig. 24: Rutin vs Extraction pH

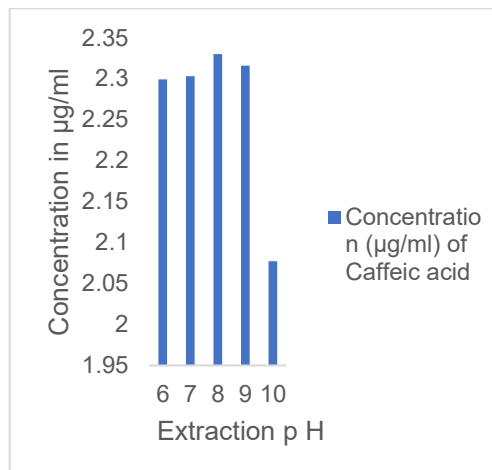


Fig. 25: Caffeic acid vs Extraction pH

3.2.6. Effect of Material ratio on extraction of Rutin and Caffeic acid at different material ratio:

Material ratio (Solid-liquid ratio)	Concentration (µg/ml) of Rutin	Concentration (µg/ml) of Caffeic acid
01:10	46.31	1.568
01:20	49.28	1.663
01:30	58.31	1.982
01:40	52.12	1.531
01:50	40.72	1.258

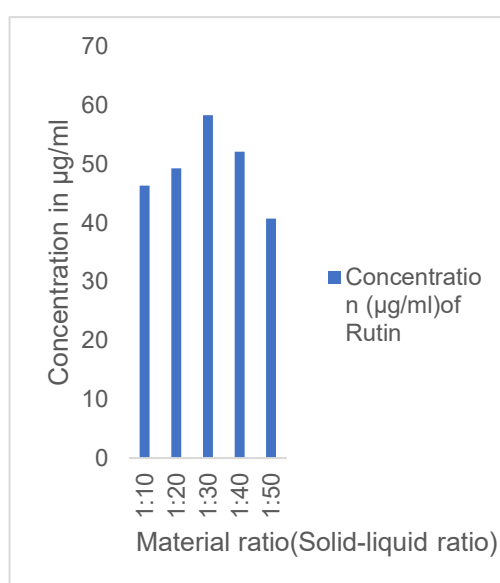


Fig. 26: Rutin vs Material ratio

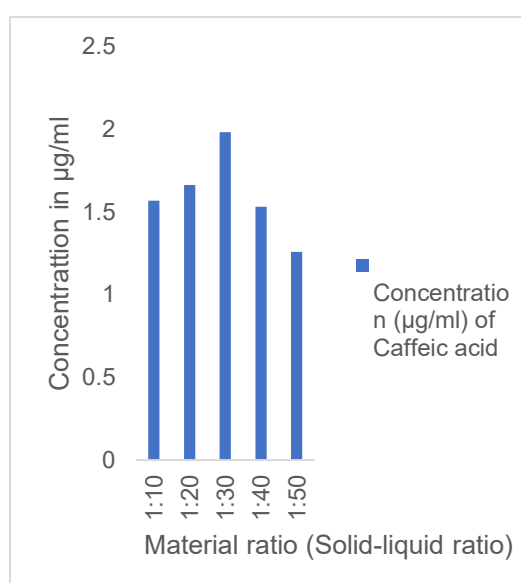


Fig.27: Caffeic acid vs Material ratio

3.3 Antimicrobial activity testing

Using a well-diffusion process, we determined the antibacterial properties of synthesised silver nanoparticles against *E. coli* Fig.28 and *B. subtilis* Fig.29. AgNP's synthesised with *Brassica oleracea* var. *Italica* (Broccoli) had ZOI's of 1.08 ± 0.073 cm and 1.23 ± 0.039 cm against *E. coli* and *Bacillus subtilis*, respectively, at concentrations of 10 g/mL. One of the positive controls for the experiment was Gentamicin, A ZOI of 2.12 ± 0.047 cm was found. According to these findings, the Broccoli extract used in the biosynthesis of the AgNPs was more effective at inhibiting bacteria than the extract alone.



Fig.28 : Zone Inhibition of Broccoli AgNPs by gram-negative bacteria *Escherichia coli*



Fig.29 : Zone Inhibition of Broccoli AgNPs by gram-positive bacteria *Bacillus subtilis*.

3.4 Antifungal activity testing

Generally speaking, silver nanoparticles are efficient against a variety of diseases. Utilizing fungus strains like candida albicans, the disc diffusion method was used to test the antifungal activity. The zone of inhibition was recorded, and fluconazole was maintained as the standard. According to the process, a series of dilutions for the manufactured silver nanoparticles were performed, and it was discovered that the least inhibitory concentration of silver nanoparticles is 100g ml. Fig. 30 displays the zone of inhibition for silver nanoparticles. The silver nanoparticles that have been produced have superior antifungal activity. silver nanoparticles size and concentration are crucial for displaying antibacterial activity.

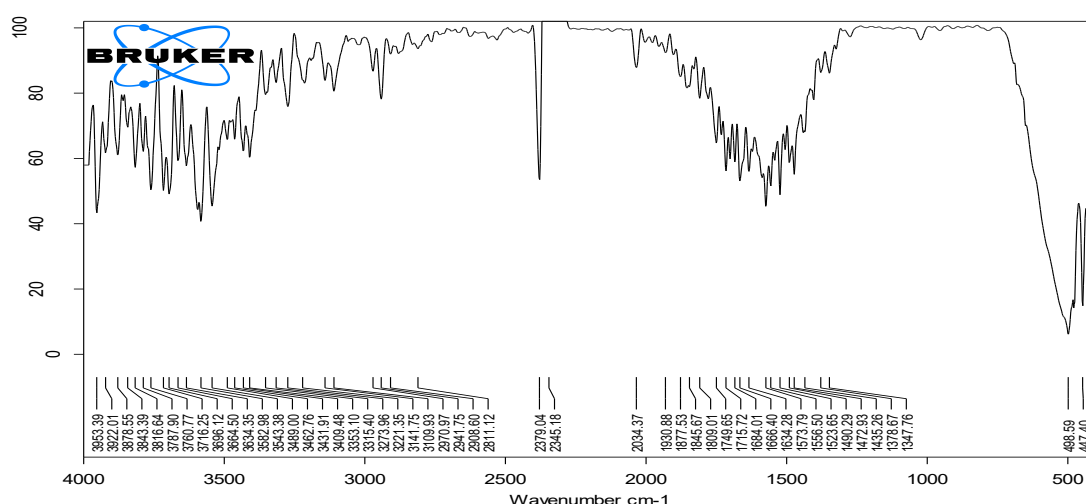


Fig. 32 FTIR spectra of green produced Broccoli AgNPs after extraction.

4. CONCLUSION

Development of new synthetic protocols for nanomaterials more than a range of composition, sizes and shapes constitutes a steadily evolving branch of nanotechnology. Chemical methodologies for the synthesis of nanoparticles are most popular and extensively practiced. However, use of chemicals and ecologically hazardous non-polar organic solvents may cause environmental damage due to their excessive use. Therefore, it has become necessary to devise alternate, environmentally friendly, “green chemistry” based methods for the synthesis of nanoparticles. In the present study an attempt has been made up design biological methods for the synthesis of semiconductor and metal nanoparticles using microorganism. Naturally going on biomineralization of interesting inorganic structures by living organism has led the foundation of our study where we have used microbes for premeditated synthesis of nanoparticles. The present study deals about the synthesis of silver nanoparticles using Extract of *Brassica oleracea* var. *Italica* (Broccoli). The synthesized nanoparticles are characterized by UV-vis spectroscopy, SEM, EDAX, and FTIR analysis. Further, the plant synthesized silver nanoparticles are used for antifungal and antibacterial activity applications.

The Extract of *Brassica oleracea* var. *Italica* (Broccoli), used for synthesis of silver nanoparticles. The formation of brown in the reaction mixture could confirm the formation of silver nanoparticles. The UV-vis spectrum of Broccoli extract of *Brassica oleracea* var. *Italica* synthesized silver nanoparticles exhibited a strong absorption band at 220 nm, due to the vibration of electron on the surface of the nanoparticles. The size of the silver nanoparticles synthesized by seed extract of *Brassica oleracea* var. *Italica* 1-200 nm. The overall findings show the seed mediated synthesis is the rapid process for production of silver nanoparticles. A comparative study is carried out between the silver synthesis process. In addition, the size tuned synthesis of silver nanoparticles is also an advantageous process of plants. Based on the results, the synthesized silver nanoparticles are further used clinical and antibacterial activity applications. This thesis focuses on the formation of biocompatible silver nanoparticles by *Brassica oleracea* var. *Italica* and synthesis of silver nanoparticles shows more compatible and eco-friendlier, low cost and less time consume process. Here in, the silver nanoparticles were synthesized by using Extract of *Brassica oleracea* var. *Italica* within 24 h and the size of the silver nanoparticles ranges from 1-200

and 1-220 nm, respectively. Elemental analysis of nanoparticles was characterized by EDX, Functional groups of plant extracts involved in the bio-reduction process of silver ions were characterized by FT-IR.

The silver nanoparticles synthesized by using Extract of *Brassica oleracea* var. *Italica* were tested for antibacterial activity against *Bacillus subtilis*, *Escherichia coli* and antifungal activity against *Candida albicans*. Among Extract of *Brassica oleracea* var. *Italica*, mediated synthesized silver nanoparticles shows the higher antibacterial and antifungal activity. Moreover, synthesized silver nanoparticles show more zone of inhibition. Synthesized silver nanoparticles show more inhibition activity against bacteria this may be due to the presence of small sized silver nanoparticles. In this study, while increasing the concentration of silver nanoparticles the antibacterial and antifungal activity was also increased. The plant mediated synthesis was finalized as best method for synthesis of silver nanoparticles due to its simple, less time consumption and environmentally benign method.

The silver nanoparticles from the seed extracts of *Brassica oleracea* var. *Italica*, compared shows better zone of inhibition when compared to the control. The results of green approached silver nanoparticles may lead to remarkable promising antibacterial agents obtain from natural and traditional source material as an alternative to substitute the existing antibiotics.

5. REFERENCES

1. Ramya Golli, Chandana Thummaneni, Meena Vangalapati, Green synthesis and characterization for the extraction of kaempferol from *Brassica oleracea* var. *italica* Antibacterial activity, Materials Today: Proceedings, Volume 62, Part 6, 2022, Pages 34573461, ISSN 22147853.
<https://doi.org/10.1016/j.matpr.2022.04.280>
2. Wali, S., et al. "Brassica oleracea L. (Acephala Group) based zinc oxide nanoparticles and their efficacy as antibacterial agent." *Brazilian Journal of Biology* 84 (2022).
3. Sana Awan, Kiran Shahzadi, Sumera Javad, Amina Tariq, Asma Ahmad, Saiqa Ilyas, A preliminary study of influence of zinc oxide nanoparticles on growth parameters of *Brassica oleracea* var. *italica*, Journal of the Saudi Society of Agricultural Sciences, Volume 20, Issue 1, 2021, Pages 18-24, ISSN 1658-077X.
<https://doi.org/10.1016/j.jssas.2020.10.003>.
4. González-Ballesteros, N., Vidal-González, J. & Rodríguez-Argüelles, M.C. Wealth from by-products: an attempt to synthesize valuable gold nanoparticles from *Brassica oleracea* var. *acephala* cv. Galega stems. *J Nanostruct Chem* 11, 635–644 (2021).
<https://doi.org/10.1007/s40097-021-00389-7>
5. Dhanraj, Ganapathy, and Shanmugam Rajeshkumar. "Anticariogenic effect of selenium nanoparticles synthesized using brassica oleracea." *Journal of Nanomaterials* 2021 (2021).
6. Shanmuga Sundaram, C., et al. "Antibacterial and anticancer potential of *Brassica oleracea* var. *acephala* using biosynthesized copper nanoparticles." *Med J Malaysia* 75.6 (2020): 615.
7. D Renuga¹, J Jeyasundari², A S Shakthi Athithan² and Y Brightson Arul Jacob³ Synthesis and characterization of copper oxide nanoparticles using *Brassica oleracea* var. *italica* extract for its antifungal application, Published by IOP Publishing Ltd, Materials Research Express, Volume 7, Number 4 Citation D Renuga et al 2020 Mater. Res. Express 7 045007
8. Poveda, J., Zabalgoitia, I., Soengas, P. et al. *Brassica oleracea* var. *acephala* (kale) improvement by biological activity of root endophytic fungi. *Sci Rep* 10, 20224 (2020).
<https://doi.org/10.1038/s41598-020-77215-7>
9. Jejenija Osuntokun, Damian C. Onwudiwe & Eno E. Ebenso (2019) Green synthesis of ZnO nanoparticles using aqueous *Brassica oleracea* L. var. *italica* and the photocatalytic activity, Green Chemistry Letters and Reviews, 12:4, 444-457.
DOI: [10.1080/17518253.2019.1687761](https://doi.org/10.1080/17518253.2019.1687761)

10. Vicas, Simona Ioana; Cavalu, Simona; Laslo, Vasile; Tocai, Mariana; Costea, Traian O; et al. Growth, Photosynthetic Pigments, Phenolic, Glucosinolates Content and Antioxidant Capacity of Broccoli Sprouts in Response to Nano selenium Particles Supply Notulae Botanicae Horti Agrobotanici Cluj-Napoca; Cluj-Napoca Vol. 47, Iss. 3, (2019): 821-828. DOI:[10.15835/nbha47311490](https://doi.org/10.15835/nbha47311490)
11. Das, Subhankar, Mohan Chandra Kalita, and Susmita Shukla. "Rapid biosynthesis of silver nanoparticles using leaf extract of Brassica oleracea Var. Gongylodes and their antimicrobial activity against bacteria." *World Journal of Pharmacy and Pharmaceutical sciences* 7.8 (2018): 1135-1145.
12. Osuntokun J, Onwudiwe DC, Ebenso EE. Aqueous extract of Broccoli mediated synthesis of CaO nanoparticles and its application in the photocatalytic degradation of bromocresol green. *IET Nanobiotechnol.* 2018 Oct;12(7):888-894. doi: [10.1049/iet-nbt.2017.0277](https://doi.org/10.1049/iet-nbt.2017.0277)
13. Shahi, D., Bhattarai, E., Poudel, M., Pradhan, P., Pradhananga, R. R., & Awal, S. C. (2018). Green Synthesis of Silver Nanoparticles Using Different Plant Materials and Their Antibacterial Activity. *International Journal of Applied Sciences and Biotechnology*, 6(4), 294–301. <https://doi.org/10.3126/ijasbt.v6i4.22112>
14. Singh, Amarjeet, Bhavana Sharma, and Renu Deswal. "Green silver nanoparticles from novel Brassicaceae cultivars with enhanced antimicrobial potential than earlier reported Brassicaceae members." *Journal of Trace Elements in Medicine and Biology* 47 (2018): 1-11.
15. Kapur M, Soni K, Kohli K (2017) Green Synthesis of Selenium Nanoparticles from Broccoli, Characterization, Application and Toxicity. *Adv Tech Biol Med* 5:198.
16. Ndayazi, Désiré, et al. "Phytochemical screening and antibacterial properties of hydroalcoholic and ethanolic extracts from Brassica oleracea L." *IOSR J Pharm* 7 (2017): 38-43.
17. Prasad, P. Reddy, S. Kanchi, and E. B. Naidoo. "In-vitro evaluation of copper nanoparticles cytotoxicity on prostate cancer cell lines and their antioxidant, sensing and catalytic activity: One-pot green approach." *Journal of Photochemistry and Photobiology B: Biology* 161 (2016): 375-382.
18. Piruthiviraj, Prakash, Anita Margret, and Poornima Priyadharsani Krishnamurthy. "Gold nanoparticles synthesized by Brassica oleracea (Broccoli) acting as antimicrobial agents against human pathogenic bacteria and fungi." *Applied Nanoscience* 6.4 (2016): 467-473.
19. Palak, Soni K., A. Thakur, and K. Kohli. "Broccoli: An insight into formulation and patentability aspects." *Drug Des* 5.139 (2016): 2169-0138.
20. R. Tamileswari, M. Haniff Nisha1, Sr. S. Jesurani Green Synthesis of Silver Nanoparticles using Brassica Oleracea (Cauliflower) and Brassica Oleracea Capitata (Cabbage) and the Analysis of Antimicrobial Activity *International Journal of Engineering Research & Technology (IJERT)* ISSN: 2278-0181 IJERTV4IS041196 www.ijert.org (This work is licensed under a Creative Commons Attribution 4.0 International License.) Vol. 4 Issue 04, April-2015.