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GREEN-SYNTHESIZED SELENIUM NANOPARTICLES AS POTENTIAL ANTICANCER AGENTS: MOLECULAR SIGNALLING AND CELLULAR RESPONSES

Harini R[1], Sindhu R[2*], M.S. Philomin Elgiva[3], Rajmohan M[4], Dinesh Dhamodhar[5], Lubna Fathima[6], Prabu D[7]

[1]Undergraduate (Bachelor of Dental Surgery), SRM Dental college, Ramapuram, Bharathi Salai, Chennai, TN, India
[2,6] Master of Dental Surgery, Senior lecturer, Department of Public Health Dentistry, SRM Dental college, Ramapuram, Bharathi Salai, Chennai, TN, India
[3]Postgraduate, Department of Public Health Dentistry, SRM Dental college, Ramapuram, Bharathi Salai, Chennai, TN, India
[4,5]Master of Dental Surgery, Reader, Department of Public Health Dentistry, SRM Dental college, Ramapuram, Bharathi Salai, Chennai, TN, India
[7]MDS, PhD, Professor and head, Department of Public Health Dentistry, SRM Dental college, Ramapuram, Bharathi Salai, Chennai, TN, India
***Corresponding Author**: Sindhu R, Email: researchphdsrm@gmail.com

ABSTRACT:
Background: Selenium nano particles synthesised in a bio friendly manner are emerging as a strong alternative to conventional chemotherapy because of their enhanced biological activity and selective cytotoxicity. The anti-cancer effect of green synthesised SeNPs was mainly by induction of apoptosis, DNA fragmentation and cellular damage. Green synthesis is preferred because its more biocompatible, cost effective and additional benefits like antimicrobial, antiviral, anti-inflammatory from the plant extract coated on SeNPs. **Aim:** To evaluate the anti-cancer effect of green synthesized selenium nanoparticles based on their cytotoxic activity, target specificity, MOA and effect against various cancer cell lines. **Method:** Many relevant In vitro and In vivo studies were conducted against various types of cell lines using SeNPs coated with various plant extracts. **Result:** Green synthesized SeNPs showed enhanced anticancer activity against various cancers like breast, prostate, cervical, colon, etc., and plant extracts used to synthesise them made the nanoparticles more biocompatible and gave additional benefits like antimicrobial, antiviral and anti-inflammatory effects. Compared to conventional therapy, treatment using SeNPs showed better target specificity towards tumour cells. **Conclusion:** Thus, there is no doubt that SeNPs showed better results. However more standardized in vivo experiments should be conducted to ensure more safe and secure application.
Key Words: Green synthesised, selenium nano particles, anti-cancer activity, target specificity, minimal adverse effects, apoptosis

INTRODUCTION

As we all know cancer is one of the major challenges in the present world because of its complex behavior, ability to metastasize, resistance to conventional therapy. Chemotherapy is an important management technique but has its own limitation like nonspecific drug distribution, toxicity to normal tissues, adverse effects, short half-life etc. Thus, to overcome these limitations, therapy against cancer was developed using nanotechnology to increase the efficiency and to decrease the damage of normal cells using nano-technology. The SeNPs have attracted interest as nano-therapeutic agents as it is bio compatible and possess anticancer properties.[1]

Selenium is an essential trace element which is used in several biological processes which is converted into selenoproteins which in turn participate in cellular protection and redox regulation. Its biological potential is regulated by its chemical form and concentration. Selenium nano-particles have low toxicity compare to conventional agents. The new approach is made possible while combining the biological properties of selenium with physicochemical characteristics of nano particles which are preferred for targeted therapy and drug delivery. [2]

Selenium has the ability to reduce the number of tumour cells. At minimal concentrations SeNPs can participate in biological processes whereas at higher concentrations it produces as pro-oxidant environment which is capable of inhibiting growth of cancer cells and induces cell death. Several experiments have been conducted against serval cancer types like mammary glands prostate lung colon etc., the activity of selenium is not always uniform as it depends on factors like redox potential, concentration, form etc. [3]

The response of selenium in mammary and prostate cancer was associated with suppression of tumour growth, increase in apoptosis and inhibition of proliferation. The use of selenium as a treatment option showed reduce cycline D1 express increased P27Kip1 levels and activation of JNK signaling.[4] Deficiency of selenium increases the risk of disease as selenium exhibits a complex, dose depended relationship with biological effects. SeNPs exhibits apoptosis, promote oxidative Stress and depresses growth stress and depresses growth of cancer cells and reactive oxygen species (ROS) and this disturbance may result in tumour cell injury through both antioxidant and pro-oxidant mechanisms.[5]

An important aspect of SeNPs is its influence on early barriers to tumorigenesis. The compounds of selenium activate cellular responses associated with DNA damage and cellular senescence. The metabolites produced by selenium are capable of generating oxidative stress which in turn produces DNA modification damage to cancer cells.[6]The development of SeNPs has provided an additional avenue for improving the usage of selenium in biomedical usage. Synthesis of these particles in a biological manner is much better as the conventional way may involve harsh conditions, higher costs and toxic by- products, synthesis by using plants help in utilizing Natural metabolite while

the micro-organism can contribute enzymes and bio-molecule which helps in stabilization of the nano particles for example usage of Portulaca oleracea which contributes to the capping and stabilization of SeNPs [7]

Fabrication of SeNPs using Carica papaya extract showed antioxidant, anti-microbial, anti-mycotoxin and anti-cancer activity. These nanoparticles reduced the growth of a variety of cancer cell lines includes RAW 264.7, CACO-2 MCF-7, and IMR-32 while preserving normal cells. [8] Berberine which is a naturally occurring biologically active compound when combined with SeNPs showed strong cytotoxic activity against HepG2 cells and produces apoptosis associated changes like increased p53, Bax, cytochrome C and reduces Bcl-2 expression. Berberine along with SeNPs showed higher anticancer activities than unprocessed berberine.[9]

Microbial synthesis of SeNPs produces an alternative approach where micro-organism reduces the selenium compound and elemental selenium nano particles are produced for example Paenidacillus motobuensis LY5201 is a selenium resistant micro-organism which produces extra cellular SeNPs. These SeNPs showed antiinvasive activity. Green synthesis is preferred as it is cost effective and environment friendly. [10] The recent research in nano technology as a therapeutic agent has a large number of advantages like early diagnosis, multifunctional therapy and drug delivery system. Doxorubicin is a common anticancer drug which is not so ideal as it has poor solubility lacks specific targeting, serious side effect and drug accumulation. Therefore, it is important to improve their efficacy by incorporating it with SeNPs. [11]The idea of loading therapeutic drugs on to nanoparticles improves drug accumulation at targeted sites while reducing exposure to normal cells. Experiments have been conducted with galactose- modified SeNPs loaded with Doxorubicin to act against hepatocellular carcinoma. Here galactose improve tumour targeting while SeNPs served a carrier for Doxorubicin. Using these SeNPs decreases the damage to major organs and have greater anti tumour efficacy.[12]

Selenite is selectively toxic to tumour cells at appropriate concentration. The main aspect of selenium is that the therapeutic window in-vitro and in-vivo resided at subtoxic dose that is clinically achievable. The content of thiol present both intracellular and extracellular are elevated in many tumour types and this is the reason for resistance against serval therapeutic agents via their conjugation and detoxification. Efflux of thiols to extra cellular environment enhances the uptake of selenide and potentiate its toxicity.[13]

Fungal mediated synthesis of SeNPs helps in utilizing metabolites. Penicillium

Crustasum Ep-1 was used in the production of spherical SeNPs and their anticancer activity was tested against liver cancer cells. Light irradiation increased the anticancer activity compared to dark condition.[14] Synthesis with the help of plants provides a simple bio friendly approach in which Phyto-chemical act as reducing and stabilizing agents. Green synthesized SeNPs using Ceropegia bulbosa showed cytotoxic activity against MDA-ME-231 breast cancer cell with an IC50 of 35mlg alter 48hrs of treatment.[15]

The anticancer activity of selenium involves multiple pathways rather than a single one. Selenium containing compound and selenium supplementation has been investigated in relation to various cancer cell lines.[16] Algae mediated synthesis is also an emerging branch as its capable of stabilizing nanoparticles. These SeNPs demonstrated anticancer effect against HCT-116 colon cancer cells and Ehrlich ascites carcinoma. These nano particles when combined with laser-based therapy showed effect on tumour volume and tumour cell morphology.[17]Green synthesized selenium nanoparticles using Schinus molle extract showed antimicrobial activity against methicillin resistant Staphylococcus aureus and anticancer properties.[18]

All selenium containing compound can be divided into 3 group majorly inorganic organic and nanoparticles. The cytotoxic effect of SeNPs were studied on glioblastoma, colorectal adenocarcinoma, prostate carcinoma and breast adenocarcinoma. Series of experiments were also conducted to study the mRNA expression patterns.[19] Polycladia crinita is a natural brown sea weed which has shown anti-inflammatory and anticancer activity. When this was incorporated into SeNPs and was used against Hep G2 carcinoma cells it halted proliferation of human cells and defeating breast cancer progression in Ehrlich carcinoma includes in mice either alone or with radiation.[20] Estrogen was also found to be a causative reason of breast cancer.[42]

Nano particles, especially semiconductor nano particles are preferred as an anti-cancer Therapeutic Agent because of their unique thermal, optical, electrical and physical properties. Deficiency of selenium is a major concern as it may lead to a lot of diseases like cancer, cardiovascular disorders and inflammatory conditions. However, excessive intake of selenium is also toxic to the body. Various plant extracts like sugars, amino acids, enzymes, tannins, etc., when combined with selenium nano particles, act as an excellent therapeutic agent against cancer.[21]

Nano technology is not only used for anti-cancer therapy, but also can be used for a lot of purposes like nano agriculture, fuel production, food, industries, environmental protection and production of anti-microbial agents. An experiment was conducted in synthesis of selenium, which is an essential micro nutrient in a bio compatible manner along with groundnut. The usage of this green synthesized selenium against Bj1 cell line and Rep1 cell line was very effective.[22]

Ascites caused by malignant tumour is known as malignant ascites. Ovarian malignancy is the most common cause for malignant ascites thus leading to death. Prevention of malignant ascites includes apoptosis rather than proptosis. This is achieved by incorporating Lentinan which is a special type of beta -glucan into selenium nano particles. The results show that lentinan functionalized selenium nano particles, were effective against malignant ascites.[23]

Cervical cancer, which is more frequently seen in females are usually caused by HPV infection. Even though HPV vaccines are available an effective anticancer therapy is required. Therefore, synthesis of gallic acid coated selenium, Nano particles were used against HeLa cell lines which caused mitochondrial dysfunction, increased ROS production, high PARP levels, and low expression levels of pro-caspase-3.[24] A study was done to examine the cytotoxic effect of

selenium nano particles using Cordia myxa extract on Huh-7 cells. Selenium, Nanu particles, showed apoptotic and antioxidant properties.[25]
Various parts of the plant like extracts from flower, leaves, fruits, seed and stem have been used for green synthesis of selenium nano particles. This has many advantages when compared to chemical synthesis of nano particles. [26]This nano technology approach is also being used against most prevalent histological form of lung cancer which is the adenocarcinoma subtype of non-small-cell lung cancer. Here, bacterial polysaccharide is used for coating on the surface of selenium nano particles. [27] Both in-vivo and in-vitro studies have been experimented. [28] Research is also being done to see if nano-Se and radiotherapy can be used in combination to treat lung cancer. [29]
Studies were conducted to synthesize SeNPs using cell suspension and TCP of Acinetobacter sp. SW30 and to see its effect on breast cancer cells. [30] Alginate and chitosan-coated ferulic acid-loaded selenium nanoparticles were also used. [31]Selenium nanoparticles have gained attention when compared to other nanoparticles due to its stability at different environmental conditions and synthesis at low temperatures. [32] Selenium nanoparticles due to the physical and chemical properties, they are widely used photoelectric applications and as semiconductors as well.[33] Various methods like laser ablations, gamma-irradiation, lithography, pyrolysis, etc., are being used in synthesis of SeNPs. [34]
There is a new booming growth in the branch of nanotechnology due to the side effects caused by chemotherapeutic agents like gastrointestinal disorders, Thrombocytopenia and bone marrow depression. [35] SeNPs are excellent drug delivery agents because they are highly absorbed by various types of human cells. [36] ATP conjugated biogenic SeNPs are also used against human colon cancer cells. These SeNPs target the purinoreceptor. [37] These human colon cancer cells underwent apoptosis when treated with rhein-selenium nanoparticles. [38] Colorectal cancer is a concern due to its high prevalence and mortality rates. [39] Thus to conclude, SeNPs have cytotoxic, apoptotic effect against various cancer cells. [40]

MATERIALS AND METHODS

This review used standard rules to carry out both systematic reviews and meta-analyses.

Information Sources

The following electronic databases were searched from the time of their conception until 2026, in compliance with PRISMA guidelines: Scopus, PubMed, Google med, and embase.

Search Strategy

Researcher searched key databases like PubMed, Embase, and google med to find studies linking green synthesized selenium nanoparticles and their anticancer activity. Their search plan used various terms to look at “Selenium nanoparticles”, "green synthesis", “anticancer activity”, and particular cancers such as "colorectal cancer", "gastric cancer", “breast cancer”, “lung cancer”.

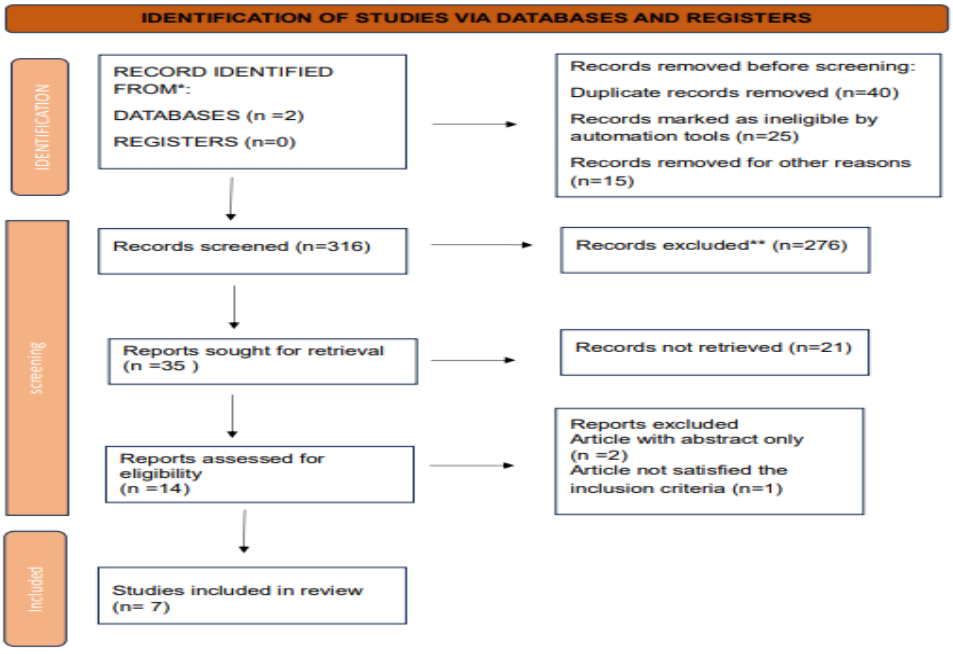
Inclusion Criteria

Research was included when it met specific criteria. These included being in-vitro and in-vivo studies, meta-analyses, or comparative studies. It also needed to be published in peer reviewed journals.

Exclusion Criteria

Studies were excluded if they were not in English or without enough data to analyse.
Studies were excluded if other metals were combined and used along with selenium nanoparticles.

Figure:1 PRISMA Flowchart



RESULT:
The included studies comprise of mainly In vitro studies evaluating and assessing the various outcomes of anticancer activities by green synthesized selenium nano particles.
Studies were conducted against various cell lines like MCF-7, Caco-2, HepG2 etc.

Table 1: Characteristics and the intervention included from the In Vitro studies

S.NO	Author	Year	Study Design	Intervention
1.	Shehata NS et al [27]	2023	In Vitro experimental study	Biologically synthesized SeNPs coated with bacterial exopolysaccharide derived from Lactiplantibacillus plantarum
2.	Sweety A Wadhwani et al [30]	2017	In Vitro experimental study	SeNPs synthesized using Acinetobacter sp SW30 vs chemically synthesized SeNPs.
3.	Duygu Petunya Cetin et al [31]	2025	In Vitro experimental study	Alginate – coated and chitosan – coated ferulic acid – loaded SeNPs were used for the treatment.
4.	Georgia Benitha J et al [35]	2023	In Vitro experimental study	Green synthesized SeNPs using Garcinia mangostana extract
5.	Othman et al [36]	2023	In Vitro experimental study	SeNPs synthesized using Carvacrol
6.	Kandasamy Saravanakumar et al [37]	2022	In Vitro experimental study	ATP conjugated biogenic SeNPs synthesized using Trichoderma harzianum extract
7.	Abd El-Halim MD et al [38]	2026	In Vitro experimental study	Green synthesized Rhein – SeNPs derived from Cassia italica

SeNPs; selenium nanoparticles
Table 1 summarizes the author's name, year of study, type of study and intervention of green synthesized SeNPs. The intervention enumerates the extracts used for the synthesis of selenium nanoparticles.

Table 2: Key Findings from the In Vitro Studies

A549; alveolar, MCF-7; Michigan cancer foundation, HEK293; Human embryonic kidney 293NIH; National institute of health, Caco-2; Carcinoma coli

Table 2 outlines the samples used to test the effect of SeNPs; coatings of various plant and bacterial extracts used during the synthesis of selenium nanoparticles and key findings where the effect of SeNPs against various cancer cell lines.

S.NO	Author	Year	Sample	Coatings on SeNPs	Key Findings
1.	Shehata NS et al[27]	2023	Tested against pathogens and A549 lung cancer cell lines	Coated with bacterial exopolysaccharide	EPS – SeNPs showed strong anticancer activity against A549 lung cancer cells
2.	Sweety A Wadhwani et al[30]	2017	Breast cancer lines (4T1, MCF7) normal cell lines NIH / 3T3 , HEK29	Coated with Acinetobacter sp SW30	Chemically produced SeNPs shows increased cytotoxicity but affects normal cells more than biologically derived SeNPs.
3.	Duygu Petunya Cetin et al [31]	2025	MDA – MB – 231 Triple negative breast cancer cell line	Alginate coated and Chitosan coated and Ferulic acid loaded particles	Alginate coated SeNPs showed higher cytotoxicity than Chitosan coated SeNPs.
4.	Georgia Benitha J et al [35]	2023	MCF – 7 human breast cancer cell lines	Coated with aqueous extract of Garcinia mangostana	SeNPs showed significant anticancer activity
5.	Othman et al[36]	2023	Human breast cell line MCF – 7 and normal vero cells	Coated with Carvacrol	SeNPs – CV showed high anticancer activity compared to SeNPs alone or Carvacrol alone
6.	Kandasamy Saravanakumar et al [37]	2022	Human colon cancer cell line Caco – 2 and HEK293 cell lines	Coated with Trichoderma harzianum extract	ATP conjugated SeNPs showed higher cytotoxicity compared to SeNPs alone
7.	Abd El-Halim MD et al [38]	2026	Colon cancer cell lines (DLD-1, SW620)	Coated with Rhein	Rh – Se-NPs showed better anticancer activity against colon cancer cell lines compared to free Rhein.

Figure 3: Quality Assessment of all the included studies

The risk of bias was assessed across the included studies using study selection, outcome measurement and reporting bias. Only some of the studies showed lower risks in selected domains. The presence of concerns and risks of bias needs more properly reported studies for future research.

Study	Selection Bias	Performance Bias	Detection Bias	Reporting Bias	Other Bias	Overall Risk of Bias
Shehata NS et al. [27], 2023	Unclear	Unclear	Unclear	Unclear	Unclear	**Some concerns**
Sweety A. Wadhwani et al. [30], 2017	Low	Low	Unclear	Unclear	Low	**Some concerns**
Duygu Petunya Cetin et al. [31], 2025	Unclear	Unclear	Unclear	Unclear	Unclear	**Some concerns**
Georgia Benitha J et al. [35], 2023	Unclear	Unclear	Unclear	Unclear	Unclear	**Some concerns**
Othman et al. [36], 2023	Low	Low	Unclear	Unclear	Low	**Some concerns**
Kandasamy Saravanakumar et al. [37], 2022	Low	Low	Unclear	Unclear	Low	**Some concerns**
Abd El-Halim MD et al. [38], 2026	Unclear	Unclear	Unclear	Unclear	Unclear	**Some concerns**

DISCUSSION

Maged Sayed Ahmed et al stated that this study successfully demonstrated the biosynthesis of selenium nanorods by using Streptomyces bikiniensis strain Ess_amA-1. Later their anticancer activity was evaluated against two cell lines Hep-G2 and MCF-7 cancer cell lines. Biosynthesis of SeNPs are preferred because they are eco-friendly and cost effective unlike conventional methods. In this study the selenium nanorods produced were naturally stabilized and capped by the biological macromolecules produced by the microorganism. Formation of selenium nanorods was confirmed by characterization techniques with an average diameter of 17nm. The green synthesized selenium nanorods showed dose-depended cytotoxicity on both cancer cell lines. The particles had a strong inhibitory effect on MCF-7 breast cancer cells than Hep-G2 liver cancer cells. The reported LD50 values were 61.86 micro units/milliliter for MCF-7 cells and 75.96 micro units/milliliter for Hep-G2 cells. The anticancer activity of selenium is because of its generation of reactive oxygen species and creation of oxidative stress inside the cancer. Thus, the finding of this study suggests positive anticancer activity of selenium nanorods but further in vivo studies should be conducted to confirm their safety, efficacy and clinical application.

Katerina Spyridopoulou et al stated that this study demonstrated promising anticancer activity against colorectal cancer with the help of biogenic selenium nanoparticles synthesized using probiotic Lactobacillus casei ATCC 393. Through the studies we infer that the selenium nanoparticles have significant anti proliferative and pro-apoptotic effects on colon cancer cell lines such as CT26 and HT29 while showing lesser toxicity towards normal healthy cells. The anticancer effect was due to various mechanisms like induction of apoptosis, elevation of reactive oxygen species, modulation of apoptosis – related proteins, inhibition of proliferation of tumor cells. The synergistic effect of probiotic and SeNPs have more therapeutic potential than used alone. Another important point to be noted is that biogenic selenium nanoparticles possess lesser toxicity compared to conventional selenium compounds. Biogenic selenium nanoparticles show enhanced tolerability in both in vitro and in vivo studies. The in vivo studies done in animals reveal significant reduction of tumor volume without major toxic effects on liver, spleen and body weight. Synthesis of selenium nanoparticles in a eco-friendly way adds stability and biocompatibility. However certain limitations still remain as most of the studies available are preclinical and involve cell culture or animal models, with limited clinical evidence in humans. Variability in size of nanoparticles, methods of synthesis, dosage also makes comparison between studies quite difficult. Therefore, large scale clinical trials and standard methodologies are necessary for safety, optimal dosage and therapeutic efficiency in treating colorectal cancer.

Karthik Rajkumar et al stated that this study suggest that biologically synthesized SeNPs exhibit significant anticancer potential against cervical cancer cells through mechanisms like inhibition of proliferation of cells, suppression of angiogenesis and metastasis. Green synthesized SeNPs showed better biocompatibility and lower toxicity when compared to chemically synthesized nanoparticles. The SeNPs synthesized using Pseudomonas stutzeri showed marked cytotoxicity against HeLa cells at even low concentration with minimal hemolytic activity toward normal RBCs. The nanoparticles used are uniform in size and have better stability which are important for biomedical application. The use of ecofriendly biological sources such as bacterial strains, plant derived extracts not only produce stability and bioactivity but also cost effective. Several studies show that SeNPs could inhibit cancer cells migration,

clonogenic survival, neovascularization thus showing their anti-angiogenic and anti-metastatic effects. These effects occur due to suppression of signaling pathway involved in progression of tumors, ROS – mediated apoptosis and regulation of extracellular matrix interactions. Even though there are many advantages certain limitations were also seen. Most investigations were done only in vitro models which limited in vivo clinical evidence thus making it unsafe to use in humans. Thus future research should concentrate more on animal and clinical trials and standardized synthesis methods and detailed studies.

Basanth A. Ali et al stated this study demonstrated the synthesis of selenium nanoparticles from marine yeast Candida pseudojiufengensis which possessed anticancer activity against breast cancer cells. The optimal conditions required for the synthesis includes incubation with 0.8 mM SeO2 at 40 degrees Celsius and pH 7.0 for 48 hours, which resulted in stable and uniform nanoparticles with an average size of 12 to 14 nanometer and zeta potential of + 34 mV which indicates good colloidal stability. In addition to the advantages provided via biological synthesis the addition of agro-industrial substrates such as sugarcane molasses enhances the production of nanoparticles due to the presence of natural reducing and stabilizing biomolecules. On analysis of cytotoxicity effect against breast cancer the SeNPs showed higher inhibitory effect against MCF – 7 breast cancer cells with an IC 50 value of 19.59 microgram/milliliter, while showing minimal toxicity towards normal HSF cells. This clearly represents safer therapeutic usage of biologically synthesized SeNPs than conventional ones. Flow cytometry studies demonstrated that the selenium nanoparticles induced significant G2/M phase arrest and increased pre G1 cells population, indicating inhibition of proliferation of cells thus leading cell death. However, Annexin V/PI staining confirm that major mechanism of cell death was apoptosis with the presence of increased early and late apoptosis of cells present after treatment. Another observation to be noted was the role of oxidative stress in mediating anticancer effects of SeNPs. Therapeutic usage of SeNPs showed increased lipid peroxidation and 8 – OhdG levels while reducing the antioxidant enzymes such as SOD and CAT in MCF – 7 cells. Thus the imbalance between ROS generation and antioxidant defense contributes to the DNA damage, apoptosis, and cell cycle arrest. However further in vivo studies and clinical investigations are required for more safety, efficacy and applicability of SeNPs in cancer therapy.

Leili Hosseinpour et al stated this study demonstrated synthesis of selenium nanoparticles using Cordia myxa extract which possess anticancer potential against Huh – 7 liver cancer cells while exhibiting lower toxicity against normal L929 cells. The green synthesis of SeNPs produced stable, spherical and predominantly amorphous SeNPs with an average size of approximately 11.9 nanometer which was confirmed through various analysis like TEM, FESEM, XRD, DLS and FTIR. Through the FTIR we came to know that the phytochemicals present in C. myxa particularly polyphenols and flavonoids played role in stabilization of the nanoparticles. These observations supports previous studies in pronouncing green synthesis enhances therapeutic efficacy through natural capping agent and antioxidant compounds. The cytotoxicity assays reveal that SeNPs inhibits proliferation of Huh – 7 cells in a concentration and time dependent manner with lower IC 50 values observed at prolonged exposure. In contrast to that normal L929 cells exhibited low toxicity and high nanoparticle concentration thus supporting selective action of SeNPs against malignancies. Flow cytometry and ROS analysis demonstrated a marked increase in reactive oxygen species suggesting that oxidative stress is the major underlying mechanism for cancer cell death. In addition to that DAPI staining and Annexin V/PI assays confirm apoptotic morphological changes especially at higher nanoparticle concentrations. Gene expression analysis further supported these findings by demonstrating upregulation of key pro-apoptotic genes such as Bax, p53, caspase-3 and caspase-9 in treated Huh – 7 cells. The major critical mechanism causing cell death is activation of p53 mediated mitochondrial apoptotic pathway. Cytochrome c release and activation of caspase cascades is due to increased Bax expression. Thus, this study highlights C.myxa mediated SeNPs is a potential, ecofriendly, biocompatible nanotherapeutic strategy for treating liver cancer. However further in vivo and clinical investigations are required to validate their safety and applicability for human use.

Alotaibi BS et al stated the findings of the study demonstrates that green synthesized nanoparticles from Polycladia crinita possess anticancer potential against breast cancer cells both in vivo and in vitro. The PCSeNPs exhibits greater cytotoxicity against MDA-MB-231 breast cancer cells compared to the free algal extract, with a markedly lower IC50 value. The flow cytometry analysis reveal G2/M phase arresting cells, indicating inhibition of cellular proliferation and induction of apoptosis. The attributing factors for enhanced effects of SeNPs are nano sized particles, bioavailability and the synergistic interaction between selenium and the phytochemicals present in Polycladia crinita along with fatty acids, oleic acid and fucosterol. The in vivo findings done using solid Ehrlich carcinoma model further supports antitumor activity of PCSeNPs. Treatment with higher doses of PCSeNPs reduce the tumor volume and weight while improving the survival rate. The nano formulation effectively down regulated important oncogenic and inflammatory such as VEGF, NF-kB, notch – 1, cycline D1, IL-6 and Bcl2 while simultaneously upregulating apoptotic markers including caspase-3, caspase-9, Bax and p53. This is due to suppression of angiogenesis, inhibition of inflammatory signaling pathways, induction of cell cycle arrest and apoptosis activation. Thus this study promises the therapeutic potential of green synthesis SeNPs using Polycladia crinita against cancer. However further studies including toxicity evaluation, pharmacokinetic profiling and investigations are required before using it in humans.

Yu Xia et al stated that this study demonstrates that galactose – modified selenium nanoparticles serve as an effective therapeutic, targeted drug delivering system against hepatocellular carcinoma cells. Addition of galactose to selenium nanoparticles enhance the targeting of tumour cells through the interaction with the asialoglycoprotein receptor expressed on HepG2 cells. Galactose modified selenium nanoparticles showed greater cellular uptake in comparison to free doxorubicin and passive Se@DOX formulations mainly through clathrin – mediated endocytosis. Moreover

the nanoparticle action was faster in acidic tumor microenvironment, thereby improving selective delivery of doxorubicin to cancer cells thus minimizing the exposure to normal cells. The in-vitro experiments confirm that GA-Se@DOX inhibited proliferation of cells and induced apoptosis of HepG2 cells more effectively than free doxorubicin. The observation seen through flow cytometry and western blot analysis was activation of the apoptotic pathways by the increased expression of cleaved caspase-3, caspase-8 and caspase-9 along with modulation of Bcl-2 family proteins such as Bax and Bad.

P Priyadarshini et al stated addition of bio-compatible products makes it even more effective. Thus, the anticancer effect produced was due to both caspase-dependent and mitochondrial apoptotic pathways. In support to the therapeutic potential of GA modified SeNPs@DOX was demonstrated through in vivo xenograft model where the mice treated showed tumor growth suppression with minimal systemic toxicity. There was no significant damage to major organs like liver, kidney, heart, spleen and lungs when examined histopathologically. Immunohistochemical studies reveled decreased Ki67 expression and increased TUNEL and caspase-3 positivity which shows enhanced apoptosis and poor proliferation of tumor cells. Thus, the biologically derived GA SeNPs act as a promising nanocarrier for targeted chemotherapy in hepatocellular carcinoma with reduced adverse effects in comparison to conventional chemotherapy.

CONCLUSION

The studies which have been included in this review and the observation of these studies clearly prove that selenium nano particles exhibit anti-cancerous activity against various cell lines especially when it is coated with plant extracts or when biologically synthesized. The main advantages being target specificity and decreased destruction of the non-cancerous cells.

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