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Anticancer potential of bimetallic nanoparticles synthesized from quercetin and gallic acid

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Background: The synthesis of metal nanoparticles from plant extracts is a single step process used for the reduction of metal salts to nanoparticles. The compounds or chemical entities present in the plants reduce the metal ions to nanoparticles and stabilize them. This method of synthesis is advantageous over existing chemical and physical methods and can be easily scaled up. Metal nanoparticles are emerging nano-products that have gained much attention towards the field of nanomedicine. Biomolecules present in the plants such as proteins/enzymes, polysaccharides, alkaloids, flavonoids, terpenoids, phenolic compounds and vitamins are generally involved in the reduction, formation and stabilization of metal nanoparticles. The aim of the present study was to synthesize metal nanoparticles using bio-active flavonoids, phenolics (quercetin and gallic acid) and find out its cytotoxic effect on the Dalton lymphoma (DL) cells.

Experimental: To synthesize the nanoparticles from a mixture of gallic acid and quercetin, different concentrations of the salts were prepared. The resulting solutions were reacted with a mixture of silver and selenium salt by incubating at 35°C (200 rpm) in dark condition. Various parameters for nanoparticle synthesis (quercetin, gallic acid and metal salt concentration, pH, temperature and reaction time) were optimized to enhance the yield of the nanoparticles. These nanoparticles were characterized using various techniques including UV-Vis spectroscopy, Dynamic light scattering (DLS or Zetasizer), Fourier transform infrared spectroscopy (FTIR), Electron microscopy (TEM and S-TEM), Differential scanning calorimetry (DSC), Elemental analysis (EDS) and Thermo gravimetric analysis (TGA) analysis. Various concentrations of these nanoparticles were evaluated for cytotoxic effect against DL cell lines by MTT assay.

Results and discussion: Silver and selenium bimetallic nanoparticles were synthesized using quercetin and gallic acid as a standard flavonoids and phenolics. Quercetin and gallic acid were added to the aqueous solution of silver nitrate and sodium selenite. The color of the resulting solution was changed from clear to dark brown indicating the formation of bimetallic nanoparticles (Ag-Se NPs). A combination of quercetin and gallic acid resulted bimetallic nanoparticles but neither of the chemical compounds could produce nanoparticles alone. A mixture of silver nitrate (1 mM) and sodium selenite (1 mM) was reacted with gallic acid and quercetin. A mixture of gallic acid and quercetin (each 1000 µl) gave maximum yield of bimetallic nanoparticles. Above or below this concentration of quercetin and gallic acid, the yield of synthesized of nanoparticles decreases sharply. When only quercetin was used it was also able to produce bimetallic nanoparticles but the yield was lower than that of the salt mixture (gallic acid and quercetin). The characterization data of Ag-Se NPs revealed the stable mono-dispersity with controlled shape and size (~35 nm in diameter). These results showed that flavonoids and phenolics act as reductant as well as stabilizer of nanoparticles. The effect of these biogenic nanoparticles on the viability of tumor cells was determined by MTT assay. The Ag-Se NPs reduced the viability of Dalton lymphoma cell lines in a dose dependent manner. Silver nanoparticles at a concentration of 50 µg/ml decreased the viability of DL cell lines to 50% of the initial level and this was chosen as the IC50.

Conclusion: The findings of the present study suggest that the Ag-Se bimetallic nanoparticles are synthesized as well as stabilized by quercetin and gallic acid. These biogenic nanoparticles being highly cytotoxic to the cancer cell lines have great importance as a therapeutic agent in preventing or lowering oxidative stress related to degenerative diseases, such as cancer.

Summary: The synthesis of bimetallic nanoparticles (Ag-Se NPs) was accomplished using quercetin and gallic acid at room temperature. The synthesized Ag-Se nanoparticles were characterized by various analytical techniques and their size was determined to be 30 to 35 nm. Our findings suggest that the flavonoids and phenolics were responsible for both the reduction as well as stabilization of nanoparticles. The present study also shows the efficacy of biologically synthesized Ag-Se nanoparticles as an anticancer agent by destroying Dalton lymphoma (DL) cells in vitro. At 50 µg/ml, Ag-Se nanoparticles decreased the viability of DL cells to 50% of the initial level. Overall, our study was very useful for the biomedical research as it involved the biosynthesis of bimetallic nanoparticles followed by the anti-cancer studies.

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