

Eco-friendly formulated zinc oxide nanoparticles: induction of cell cycle arrest and apoptosis in the MCF-7 cancer cell line

ABSTRACT

Green products have strong potential in the discovery and development of unique drugs. Zinc oxide nanoparticles (ZnO NPs) have been observed to have powerful cytotoxicity against cells that cause breast cancer. The present study aims to examine the cell cycle profile, status of cell death, and pathways of apoptosis in breast cancer cells (MCF-7) treated with biosynthesized ZnO NPs. The anti-proliferative activity of ZnO NPs was determined using MTT assay. Cell cycle analysis and the mode of cell death were evaluated using a flow cytometry instrument. Quantitative real-time-PCR (qRT-PCR) was employed to investigate the expression of apoptosis in MCF-7 cells. ZnO NPs were cytotoxic to the MCF-7 cells in a dose-dependent manner. The 50% growth inhibition concentration (IC₅₀) of ZnO NPs at 24 h was 121 µg/mL. Cell cycle analysis revealed that ZnO NPs induced sub-G₁ phase (apoptosis), with values of 1.87% at 0 µg/mL (control), 71.49% at IC₂₅, 98.91% at IC₅₀, and 99.44% at IC₇₅. Annexin V/propidium iodide (PI) flow cytometry analysis confirmed that ZnO NPs induce apoptosis in MCF-7 cells. The pro-apoptotic genes *p53*, *p21*, *Bax*, and *JNK* were upregulated, whereas anti-apoptotic genes *Bcl-2*, *AKT1*, and *ERK1/2* were downregulated in a dose-dependent manner. The arrest and apoptosis of MCF-7 cells were induced by ZnO NPs through several signalling pathways.

Keyword: ZnO NPs; Annexin V; Cell cycle; Apoptosis; *Pichia kudriavzevii*; Green method