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RESEARCH ARTICLE

Developing Biodegradable Nanoparticles from Corn for Treating Brain Cancer: Insights from Live Cell Imaging

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ABSTRACT: Nanoparticles (NPs) have emerged as the most suitable means of delivering drugs to target cells. This specific functional property of NPs can extend conventional cancer treatments' current coverage. Corn starch-based nanoparticles are a possibility for cancer treatment. Because of the NPs' biocompatibility, low toxicity, and friendly nature, several drugs based on NPs have been synthesized. The purpose of this research is to determine the ability of corn-derived nanoparticles (cNPs) to treat human brain cancers, including glioblastoma and neuroblastoma. This research mainly concentrates on how these cNPs can exploit the properties of cancer in corn to locate and destroy cancer cells. This study seeks to present a method in cancer therapy that is effective and in line with sustainability and accessibility principles through an extraction process that isolates these nanoparticles and tests them on cancer cell cultures. The findings suggesting a decrease in cancer cell density after exposure to cNP are a step forward in applying plant-derived nanoparticles in medical oncology.

KEYWORDS: Nanoparticles, Corn, Brain Cancer, Cell Viability, Live Cell Imaging.

Introduction

Nanoparticles, or NPs, contain 1 to 100 nm parameters. The size of NPs may affect characteristics such as ductility, rigidity, and melting points that differ from those of their larger-sized counterparts.[1] These NPs can be easily engineered for drug delivery systems and exhibit specific characteristics that render them valuable across numerous domains.[2] Therefore, research on NPs is rapidly increasing in medicine, cosmetics, sports, and aerospace engineering. In particular, they carry chemotherapeutic drugs to cancer cells.

Edible nanoparticles (ENPs) refer to nano-sized vesicles from edible plants containing plant-derived microRNAs, proteins, lipids, and phytochemicals.[3] The enzymic substances are extracted from different plant species like ginger, lemon, tomato, broccoli, orange, kiwi, pear, soybean, grapefruit, and coconut.[4] Lately, it has been observed that nanoscale particles extracted from corn (CNP) grain have demonstrated anti-tumor properties.[5] The anticancer effects of CNPs are attributed to the presence of vitamins, minerals, and xanthophylls found in corn, all of which exhibit potent anticancer properties.[6] The simplicity of corn nanoparticles synthesis, which can be gained from maize plants, a high-productivity harvest that can be raised speedily and in huge volumes, makes them an affordable option for managing carcinomas.[7] The ultimate goal of engineering edible nanoparticles is to develop them as a promising avenue for cancer treatment.

Current therapeutic options for brain cancer are often constrained by their ineffectiveness: the adverse side effects and difficulty in delivering treatments across the blood-brain barrier.[8] Traditional approaches like surgical interventions, radiation therapy, and chemotherapy are still used for brain cancer treatment.[9] Furthermore, the invasive nature of surgeries and the considerable systemic toxicity from chemotherapy are still considered significant side effects of brain cancer treatment.[10]

This study analyzed whether corn nanoparticles have an anticancer effect on treating human brain cancer. The CNPs were isolated and tested to see if they could induce cancer cell death. The two most common types of brain cancer cell lines were used to analyze the effect of cNPs on brain cancer cell death: glioblastoma and neuroblastoma. Then, explore the impact of cNPs that could slow down the growth of brain cancer cells. This new research might give us a better way to use nanoparticles to treat brain cancer, making treatments safer and more effective.

Methods

Isolation of Corn-Derived Nanoparticles:

Figure 1: Workflow for cNP isolation. Corn kernels were homogenized, centrifuged, filtered, and subjected to sucrose gradient ultracentrifugation to extract the corn-derived nanoparticle (cNP) layer. This process yields a reproducible and pure cNP sample suitable for biological testing.

The corn was bought from a market and washed three times with distilled water. 100 g of corn kernels were mixed with 100 mL of distilled water and homogenized for 5 minutes using a food processor. The homogenized corn juice was centrifuged at

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2000 × g for 30 minutes. Then, the samples were centrifuged at 5000 × g for 40 min. Lastly, the samples were centrifuged at 10,000 × g for 1 hour at a temperature of 4˚C. Afterward, the supernatant was filtered using a 0.45 µm-pore size syringe filter made by Millipore. To the filtrate (38 mL), 2 mL of a 60% sucrose solution was added in a 50 mL ultracentrifuge tube. The mixture was then ultra-centrifuged at 100,000 × g for 160 minutes at 4˚C using a Beckman Optima XL-100 K with an SW28 centrifuge rotor made by Beckman Coulter. The top supernatant was removed with a syringe. The yellow-colored cNP layer above the clear 60% sucrose solution was collected carefully with a syringe. The isolated cNPs were stored at -80˚C. The isolated cNPs from 100 g of corn were indicated as 100% concentration (Figure 1).

Cell Culture and Treatment Conditions:

The initial cell number of 0.12 x 106 cells was prepared in a 12-well culture plate for both A172 and SH-SY5Y cells. Then, various concentrations (0, 2.5, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50%) of cNPs were added to each cell culture well. The cell cultures mixed with cNPs were incubated for seven days. Then, the cells were photographed using an EVOS M5000 microscope (Invitrogen). The cells were visualized and photographed using transmitted light and a phase objective with 10X magnification. The selected concentration range of 0–50% cNP was chosen based on preliminary trials and existing literature on plant-derived nanoparticles, allowing the investigation of both low-dose cellular responses and high-dose cytotoxic effects. This range aimed to identify the minimum effective dose capable of inducing morphological changes and cell death in brain cancer cells.

Cell Viability Assay:

To quantify cell viability, LUNA-FL™ dual fluorescence cell counter was used to quantify cell viability. After the cells were stained with acridine orange (AO) and propidium iodide (PI), live and dead cells were analyzed. AO permeates all cells and emits a green fluorescence, marking both live and dead cells, whereas PI penetrates only dead cells, emitting a red fluorescence.

Result and Discussion

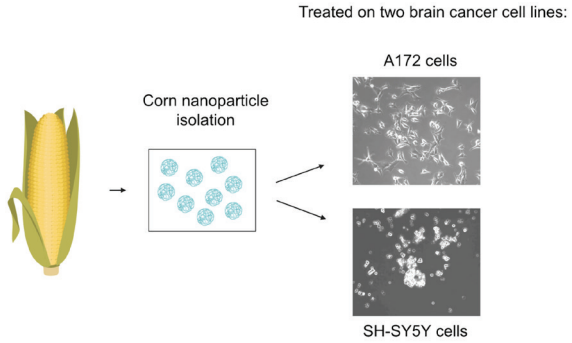

Figure 2: Experimental overview. Schematic illustrating the isolation of cNPs and their application to glioblastoma (A172) and neuroblastoma (SH-SY5Y) cell lines for viability assessment. The workflow enables systematic evaluation of plant-derived nanoparticles as anti-cancer agents in brain cancer models.

We aimed to investigate the effectiveness of corn nanoparticles in treating human brain cancer. Firstly, we isolated nanoparticles from corn (Figure 2). Since brain cancer requires novel and effective therapies, we investigated the two most common human brain cancer types: glioblastoma and neuroblastoma. Therefore, we tested the potential anticancer effects on two cancer cell lines, A172 and SH-SY5Y cells (Figure 2). Also, we aimed to determine the therapeutic potential of corn-derived nanoparticles by testing on the growth and proliferation of brain cancer cells.

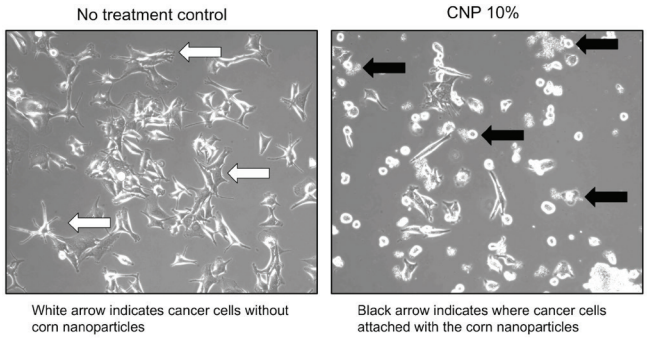

Figure 3: Morphological changes in A172 glioblastoma cells after cNP exposure (10%). Black arrows indicate cells with attached cNPs and rounded morphology; white arrows indicate untreated cells with normal morphology. Exposure to cNPs leads to loss of adhesion and altered morphology in cancer cells, suggesting early signs of cytotoxicity.

Our current research is focused on examining the effects of corn nanoparticles (CNP) on the morphology and behavior of glioblastoma cancer cells. In Figure 3, the visual representations of cancer cell morphology in both the untreated control and CNP10% samples are different. Typically, A172 cancer cells exhibit a distinct glia-like, star-like structure, depicted in the images of the untreated control (Figure 3 left). However, after exposure to CNP10%, the cancer cells underwent a remarkable transformation, adopting a rounded shape. This indicates the loss of their ability to adhere to the surface of the culture plate. Also, the presence of CNPs was visually apparent as they formed sizable and firmly attached complexes on the surface of the cancer cells (Figure 3, right). Even after subjecting the cells to agitation, the corn nanoparticles remained steadfastly bound to the cells. This result indicates that CNP showed a profound and enduring interaction.

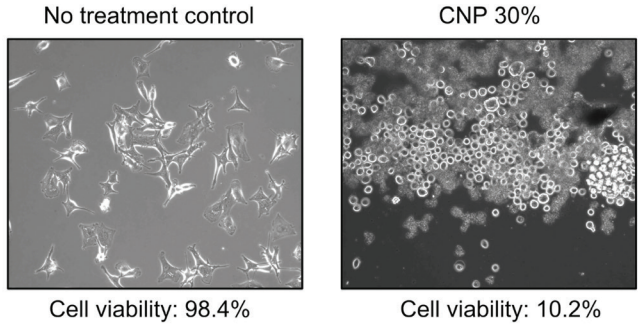

Figure 4: Cell viability of A172 cells after 30% cNP treatment. Significant reduction in viable cell count indicates cytotoxic effects of high-dose cNP exposure. At 30% concentration, cNPs reduce glioblastoma cell survival to 10.2%, demonstrating potent anticancer activity.

Next, we experimented by increasing the CNP concentration to 30% and checking how well the cancer cells survived. Not surprisingly, the control group with no treatment had a cell survival rate of 98.4%. However, when we hit the A172 cells with 30% CNP, their survival rate plummeted to just 10.2% (Figure 4). This tells us that the round shape of the A172 cells we saw in Figure 6 was caused by the CNP treatment-induced cell death. Therefore, this result indicates that CNP treatment showed promising results in treating A172 glioblastoma cancer cells.

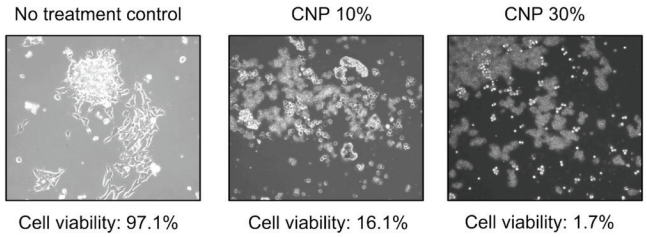

Figure 5: Viability of SH-SY5Y cells under 10% and 30% cNP treatments. Higher cNP concentrations correlate with increased cancer cell death. cNPs induce strong dose-dependent cytotoxicity in neuroblastoma cells, reinforcing their therapeutic potential.

In the next experiment, we used the SH-SY5Y neuroblastoma cancer cell line and tested the effect of CNPs on inducing cancer cell death. We tested three conditions: no treatment, CNP 10%, and CNP 30%. Then, cell viability was analyzed under each condition. Like with the A172 cancer cell line, CNP caused the neuroblastoma cancer cells to induce cell death (Figure 5). Specifically, CNP 10% reduced the cell viability to 16.1%, while CNP 30% lowered it to 1.7%. This indicates that higher concentrations of CNP result in more cancer cell death.

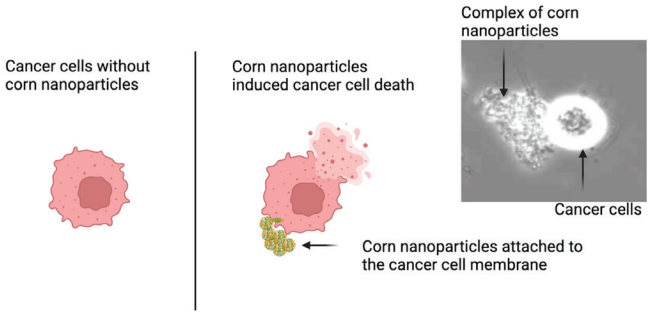

Figure 6: Proposed mechanism of cNP-induced cell death. Illustration summarizing cNP interaction with brain cancer cells, promoting adhesion, morphological changes, and apoptosis. cNPs act through physical binding and membrane disruption to induce cancer cell death, supporting their role as plant-derived nanomedicine agents.

From the current study, we can assertively confirm that CNPs possess potent anticancer properties against glioblastoma and neuroblastoma cell lines. This may offer a new method of more effective and safer treatments for brain cancer. Indeed, CNPs that can directly bind to brain cancer cells and cause cell death may serve as a potential therapeutic approach (Figure 6). This work indicates the possibility of using plant-derived nanoparticles in oncology. This result also shows the need to continue finding environmentally friendly and sustainable sources of agents in the discovery of new cancer therapies.

Nevertheless, several limitations should be noted regarding the outcomes presented in this study. Since all experiments were conducted in vitro, future research should involve in vivo validation using animal models of glioblastoma and neuroblastoma to assess the biodistribution, blood-brain barrier penetration, and systemic toxicity of corn-derived nanoparticles. Additionally, mechanistic studies using molecular assays such as caspase activation, ROS quantification, or gene expression profiling are needed to elucidate the apoptotic or necrotic pathways involved in cNP-induced cancer cell death. Finally, comparing the efficacy of cNPs with existing chemotherapeutics could help position these nanoparticles as potential adjuncts or alternatives in current treatment regimens.

The second drawback is that there is no comparison of cNPs with the existing therapies for brain cancer that would give a better idea of the effectiveness of cNPs. Last but not least, the long-term impacts of cNPs on human health and specifically on the blood-brain barrier (BBB) and healthy brain tissue are yet to be explored. Overcoming these limitations will be important for the further development of cNPs in clinical practice and the optimal use of cNPs in the treatment of brain cancer.

cNPs may exert anticancer effects through several potential molecular mechanisms. First, their phytochemical components—such as polyphenols, flavonoids, and xanthophylls—can induce reactive oxygen species (ROS) generation within cancer cells, leading to oxidative stress and mitochondrial dysfunction. This oxidative damage can activate intrinsic apoptotic pathways, including mitochondrial membrane permeabilization and caspase-3/9 activation, ultimately resulting in programmed cell death. Additionally, cNPs may disrupt cancer cell membrane integrity through direct adhesion and surface interaction, impairing adhesion-dependent signaling and promoting detachment-induced apoptosis (anoikis). Some plant-derived nanoparticles have also been shown to modulate cell cycle regulators, such as downregulating cyclin D1 or upregulating p21, thereby inhibiting proliferation. In brain cancer specifically, the ability of cNPs to cross or interact with the BBB—potentially facilitated by their nano-size and surface bioactivity—makes them promising carriers for both intrinsic cytotoxic effects and targeted drug delivery. Further mechanistic studies are required to validate these pathways and clarify the role of specific bioactive molecules present in corn-derived nanoparticles.

■ Conclusion

This study demonstrates that corn-derived nanoparticles (cNPs) exhibit significant anticancer activity against glioblastoma and neuroblastoma cell lines, causing notable morphological changes and a dose-dependent reduction in cell viability. These findings highlight the potential of plant-based nanomedicine in brain cancer therapy. However, as the experiments were conducted entirely *in vitro*, the results may not fully reflect the complex biological environment of human brain tumors. To advance the clinical relevance of cNPs, future studies should involve in vivo models to assess their biodis-

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tribution, toxicity, and ability to cross the blood-brain barrier. Additionally, mechanistic investigations using molecular assays are needed to clarify the pathways involved in cNP-induced cell death. Comparative studies with existing chemotherapeutic agents would also help contextualize the efficacy of cNPs and support their development as complementary or alternative treatments.

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Donghyeon Oh is a student at Avon Old Farms School. He is interested in biology and plans to continue his studies in this field. He loves researching and is strongly curious about living cells and cell biology.