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Anticancer Potential of Biosynthesized *Faidherbia albida* Nanoparticles against MDA-MB-231 Breast Cancer Cells

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ABSTRACT

Background: Breast cancer is one of the most prevalent malignancies worldwide, necessitating the development of alternative therapeutic approaches. Nanotechnology-based treatments have gained significant attention for enhancing drug bioavailability and minimizing systemic toxicity. This study assesses the anticancer activity of biosynthesized *Faidherbia albida* nanoparticles (NPs) against the triple-negative breast cancer cell line, MDA-MB-231.

Methods: *Faidherbia albida* roots were collected, authenticated and used for extract preparation. Biosynthesized nanoparticles were characterized using dynamic light scattering (DLS), Fourier-transform infrared spectroscopy (FTIR), transmission electron microscopy (TEM) and X-ray diffraction (XRD). MDA-MB-231 cells were treated with varying concentrations of *F. albida* crude extract and its NPs and cell viability was assessed using the MTT assay. Apoptotic markers Bcl-2 and Bax were measured using ELISA and lipid peroxidation levels were determined through the TBARS assay.

Result: The synthesized *F. albida* NPs had an average size of 114.4 nm, as determined by DLS. TEM analysis confirmed a clustered morphology and FTIR and XRD analyses validated the presence of functional groups and crystalline structures. MDA-MB-231 cells exhibited significant morphological alterations upon NP treatment, including cellular shrinkage and increased debris accumulation. The MTT assay revealed a concentration-dependent decrease in the viability of cells, with NP-treated cells exhibiting 14-26% greater cytotoxicity than crude extract-treated cells. ELISA assays demonstrated a significant increase in the regulation of the pro-apoptotic marker Bax and downregulation of the anti-apoptotic marker Bcl-2. Furthermore, NP treatment resulted in a notable reduction in lipid peroxidation levels compared to crude extract treatment.

Key words: Breast cancer, *F. albida*, Gene expression, MDA-MB-231, Nanoparticles.

INTRODUCTION

One of the most common cancers in the world, breast cancer, is becoming more common in both developed and developing countries. The World Health Organization (WHO) estimates that about 25% of all cancer cases in women are breast cancer. It is characterized by the unchecked production of breast cells, which, if untreated, could spread to other body areas. The most aggressive form of breast cancer, triple-negative breast cancer (TNBC), lacks estrogen, progesterone and HER2 receptors, making it particularly challenging to treat (Bianchini *et al*., 2016).

Breast cancer's causes and risk factors include a complex interaction of lifestyle, environmental and hereditary variables. Genetic mutations that significantly raise the chance of developing the disease include those found in the BRCA1 and BRCA2 genes (Narod and Salmena, 2011). Other risk factors include age, hormonal imbalances, obesity, exposure to ionizing radiation and excessive alcohol consumption (Sun *et al*., 2017). The development of breast cancer has also been linked to oxidative stress and chronic inflammation, highlighting the necessity of cancer prevention and treatment techniques that are rich in antioxidants.

Traditional and new approaches for treating breast cancer

Traditional methods of treating breast cancer include hormone therapy, radiation, chemotherapy and surgery (Waks and Winer, 2019). Phytochemicals such as flavonoids, alkaloids and polyphenols have been shown to reduce breast cancer cell proliferation and trigger apoptosis. Numerous studies emphasize the function of nanoparticles derived from plants in improving medication delivery and therapeutic efficacy against resistant cancer cell lines.

Plant-based breast cancer treatment

Recent research has looked at the traditional usage of medicinal plants in an attempt to authenticate their use, their actions and motivate the pharmaceutical sector to provide innovative, safe, and effective alternatives (Al-Thubaiti *et al*., 2025). Medicinal plants have been extensively researched for their anticancer capabilities due

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to their bioactive chemicals, which have antioxidant, anti-inflammatory, and cytotoxic effects on cancer cells (Newman and Cragg, 2020). Phytochemicals like flavonoids, alkaloids, and polyphenols have shown promising results in inhibiting breast cancer cell proliferation and inducing apoptosis (Warra and Prasad, 2020). Many studies highlight the work of plant-derived nanoparticles in enhancing therapeutic efficacy and drug delivery against resistant cancer cell lines.

Nanotechnology in cancer treatment

Nanotechnology has revolutionized cancer treatment by improving drug solubility, stability and targeted delivery (Biswas *et al*., 2014). By enabling the regulated release of medicinal drugs, nanoparticles reduce systemic toxicity and improve therapy effectiveness. Because of their eco-friendliness and biocompatibility, biosynthesized nanoparticles made from plant extracts have garnered a lot of interest (Patra *et al*., 2018).

***Faidherbia albida*: A potential medicinal plant**

Faidherbia albida, commonly known as the Apple-Ring Acacia, is a drought-resistant tree native to Africa and parts of the Middle East. Traditionally, it has been used in folk medicine for treating numerous disorders (Hyeladzira *et al*., 2025). The plant is abundant in bioactive substances with antibacterial and antioxidant qualities, including tannins, flavonoids and saponins (Ohouko *et al*., 2020).

Nanoparticle biosynthesis using *Faidherbia albida* extract

Recent studies have investigated the environmentally friendly synthesis of nanoparticles by employing plant extracts as stabilizing and reducing agents (Hussain *et al*., 2016). *Faidherbia albida* nanoparticle biosynthesis has demonstrated promise in creating stable, bioactive nanomaterials with improved medicinal qualities. These plant-mediated nanoparticles exhibit significant cytotoxicity against cancer cells, making them promising candidates for alternative cancer treatments.

Anticancer activity of biosynthesized *Faidherbia albida* nanoparticles

Previous studies have demonstrated that plant-derived nanoparticles exhibit selective cytotoxicity against cancer cells while sparing normal cells (Rani *et al*., 2022). The cytotoxic effects of biosynthesized nanoparticles depend on their size, shape and surface charge, which influence cellular uptake and interaction with cancer cells. The administration of *Faidherbia albida*-based nanoparticles against aggressive breast cancer cell lines, such as MDA-MB-231, warrants further investigation.

The purpose of this study is to assess the anticancer potential of biosynthesized *Faidherbia albida* NPs against the human breast cancer cell line MDA-MB-231. Specifically, it focuses on synthesizing and characterizing these nanoparticles, assessing their cytotoxic effects and looking into how they contribute to cell cycle arrest and apoptotic induction. Additionally, the study compares their efficacy with conventional chemotherapeutic agents to determine their potential as a safer and more effective alternative for breast cancer treatment.

MATERIALS AND METHODS

Sample collection and extract preparation

The roots of *Faidherbia albida* were collected from Kaboushia town, River Nile State, Sudan. The plant was authenticated at the Herbarium of the Botany and Microbiology Department, King Saud University. The roots were thoroughly washed with running tap water multiple times, followed by rinsing with distilled water to remove surface contaminants. Afterward, the roots were air-dried under shade at room temperature for two weeks to prevent the degradation of bioactive compounds. Once completely dried, they were ground using an electric grinder to obtain a fine powder (El-Amin, 1990).

50 mL of boiling distilled water was mixed with 250 mg of the root powder to prepare the extract. After 30 minutes of constant stirring, the mixture was left to cool at room temperature. The extract was filtered using Whatman No.1 filter paper to remove any particulate matter, yielding a clear extract solution, which was stored at 4°C until further use (Alsulami *et al*., 2023).

Nanoparticle synthesis

The biosynthesis of *F. albida* NPs was performed as described by Shreyash *et al*. (2021) with slight modifications. Briefly, 50 mg of *F. albida* root powder was suspended in 10 mL of absolute ethanol. A 3 mL aliquot of this solution was gradually introduced into boiling distilled water dropwise at a flow rate of 0.2 mL/min for 5 min under ultrasonic conditions. After that, the sonicated solution was constantly stirred for an hour at room temperature. To create a powdered nanoparticle sample, the resulting nanoparticles were collected by centrifugation at 10,000 rpm for 15 minutes, cleaned twice with distilled water and dried in a vacuum oven at 50°C (Hussain *et al*., 2016).

Nanoparticle characterization

A range of analytical methods was used to analyze the produced nanoparticles. The size distribution and zeta potential of the nanoparticles were ascertained by means of dynamic light scattering (DLS) with a ZetaSizer (Malvern Panalytical, UK) (Austin *et al*., 2020). Transmission electron microscopy was performed using a JEOL JEM-2100 high-resolution transmission electron microscope (JEOL Ltd., Tokyo, Japan) at an accelerating voltage of 200 kV to examine the shape and morphology of the nanoparticles (Malatesta, 2021). Fourier-transform infrared spectroscopy (Perkin-Elmer FTIR-spectrum BX, USA) was used to identify functional groups responsible for nanoparticle formation (Baudot *et al*., 2010). X-ray diffraction analysis was conducted using an X-ray diffractometer (Rigaku MiniFlex 600, Japan) to determine the crystalline structure and phase composition of the synthesized nanoparticles (Sharma *et al*., 2012).

Cell culture

The human breast cancer cell line MDA-MB-231 was used as the experimental model. Cells were cultured in T75 flasks containing Dulbecco's Modified Eagle Medium (DMEM) supplemented with 10% fetal bovine serum (FBS) and 100 U/mL penicillin/100 µg/mL streptomycin (Pezzanite *et al*., 2021). The cells were kept in a humidified incubator with 5% CO_2 at 37°C. The cells were subcultured after confluence by being washed with phosphate-buffered saline (PBS), separated using 0.25% trypsin-EDTA (Gibco TrypLE™ Express) and then incubated for 5 min at 37°C. The detached cells were centrifuged, resuspended in fresh medium and seeded into new culture flasks.

MTT assay for cell viability

Viability of the cell was evaluated using the MTT assay as described by Mosmann (1983) with modifications. Cells were seeded in 96-well plates at a density of 1×10^4 cells per well in 200 µL of complete medium and incubated for 24 hours at 37°C. After treatment with different concentrations of *F. albida* extract or biosynthesized nanoparticles for 24 hr, the medium was removed and each well was washed with 100 µL PBS. Next, 100 µL of serum-free medium and 10 µL of MTT solution were added to each well. The plates were incubated at 37°C for 4 hours and absorbance was measured at 570 nm using a microplate reader (Biotek, ELX 800, USA) (Mosmann, 1983).

Cell treatment and protein extraction

Cells were seeded (104 cells/well) into 96-well plates and incubated at 37°C in a 5% CO_2 incubator. After 24 hours, cells in each well reached 80% confluency. The medium was discarded, cells were washed with 200 µL PBS and then the excess solution was removed. Next, 200 µL of serum-free DMEM was added along with different concentrations of *F. albida* extract or its biosynthesized nanoparticles (2, 5, 10, 15, 20, 50, 70 and 100 µg/mL). Cells post-treatment were collected for protein extraction using a cell lysing buffer (Laemmli buffer, Bio-Rad, USA).

Bradford protein assay

Total protein concentration was determined using the Bradford assay. A standard curve was prepared using serial dilutions of bovine serum albumin (BSA) in the range of 0.1 to 0.9 mg/mL. In a 96-well plate, 10 µL of each protein sample or standard was mixed with 200 µL of Bradford reagent. The reaction was incubated at room temperature for 30 minutes and absorbance was measured at 595 nm. The protein concentration was calculated based on the BSA standard curve.

Determination of apoptotic markers

The expression levels of apoptosis-related proteins Bcl-2 and Bax were quantified using enzyme-linked immunosorbent assay (ELISA) kits (Abcam, UK) in accordance with the manufacturer's protocols.

Lipid peroxidation assay (MDA measurement)

The levels of malondialdehyde (MDA), a marker of lipid peroxidation, were determined using the Thio barbituric acid reactive substances (TBARS) assay as described by Ohkawa *et al*. (1979) with modifications.

Statistical analysis

All experiments were performed in triplicate and results were expressed as mean ± standard deviation (SD) using GraphPad Software (2022). Statistical significance was measured using one-way ANOVA followed by Tukey's post hoc test. A p-value <0.05 was considered statistically significant.

RESULTS AND DISCUSSION

Characterization of *Faidherbia albida*-based nanoparticles

The nanoparticles biosynthesis from the plant extraction provides an eco-friendly and possible replacement due to their non-toxic nature (Shreyash *et al*., 2021). To determine the average particle size of *F. albida*-based NPs, dynamic light scattering (DLS) analysis was conducted, revealing an average particle size of 114.4 nm (Fig 1A). TEM images provided further insights into the size and morphology of the synthesized NPs, demonstrating a clustered arrangement with grape-like formations. The particle sizes ranged from 75 to 120 nm, with individual crystalline structures observed within the 20.075 to 23.060 nm range (Fig 1B and 1C).

FTIR analysis confirmed the presence of functional groups in the synthesized NPs (Fig 2A). The O-H stretching vibrations were identified at peaks 3805.55, 3752.44, 3805.24 and 3751.99 cm^{-1}, while NH stretching was observed at 3403.51 and 3411.58 cm^{-1}. Additional peaks at 2928.99-2132.35 cm^{-1} corresponded to CH2 stretching, while the C=O stretching was identified at 1740.90-1742.99 cm^{-1}. The results indicated successful formation of bioactive NPs containing flavonoid-associated C=O bonds between 1630 and 1665 cm^{-1} (Baudot *et al*., 2010).

XRD was used to compare the crystalline structure of crude *F. albida* powder and its NPs. While the crude sample exhibited a highly crystalline structure (Fig 2B), the nanoparticle sample displayed distinct diffraction peaks, indicating a combination of amorphous and crystalline structures (Fig 2C).

Morphological changes in MDA-MB-231 cells

MDA-MB-231 cells, which typically exhibit a spindle-like shape *in vitro*, showed significant morphological changes upon treatment with *F. albida* NPs. After 24 hours of exposure to 5 µg/ml of both crude *F. albida* extract and its NPs, the treated cells appeared thinner and less confluent compared to control cells (Fig 3B and 3C vs. 3A). These changes became more pronounced at 48 hours, with increased cell debris accumulation, especially in NP-treated samples (Fig 3D and 3E).

At 10 µg/ml, a more drastic decrease in cell integrity was observed (Fig 4). The cells exhibited a thin appearance

with increased debris, suggesting significant cytotoxic effects. At 20 µg/ml, the crude extract-treated cells formed empty spaces between cells, while NP-treated cells showed complete loss of cell integrity (Fig 5). Increasing the concentration to 50 µg/ml resulted in a small cell group in crude extract-treated samples, whereas NP-treated cells showed extensive cytotoxicity with no intact cells observed (Fig 6). At 70 µg/ml, destruction of cells was evident, particularly in NP-treated samples, confirming the potent anticancer effects of *F. albida* NPs (Fig 7).

Cytotoxicity assessment using MTT assay

The MTT assay was utilized to quantify the cytotoxicity of *F. albida* crude extract and NPs on MDA-MB-231 cells at different concentrations (5, 10, 20, 50 and 70 µg/ml). A completely randomized design (CRD) with one factor (concentration level) was followed by one-way ANOVA. A significant decrease in the viability of the cell was observed at 50 and 70 µg/ml after 48 hours, with *F. albida* NPs demonstrating greater cytotoxicity than the crude extract ($p<0.05$) (Fig 8). NP-treated cells exhibited 14-26% greater viability reduction compared to crude extract-treated cells, indicating the enhanced efficacy of nanoparticle formulations.

Apoptotic marker analysis

To investigate apoptotic mechanisms, levels of Bcl-2 (anti-apoptotic protein) and Bax (pro-apoptotic protein) were quantified using ELISA. At all tested concentrations, Bcl-2 levels were significantly higher in treated samples compared to controls, with the elevation becoming more pronounced after 48 hours ($p<0.05$) (Fig 9). Similarly, Bax levels increased significantly in both crude and NP-treated groups compared to controls ($p<0.05$), with a more pronounced effect observed in NP-treated samples (Fig 10). The results suggest that *F. albida* NPs induce apoptosis more effectively than the crude extract.

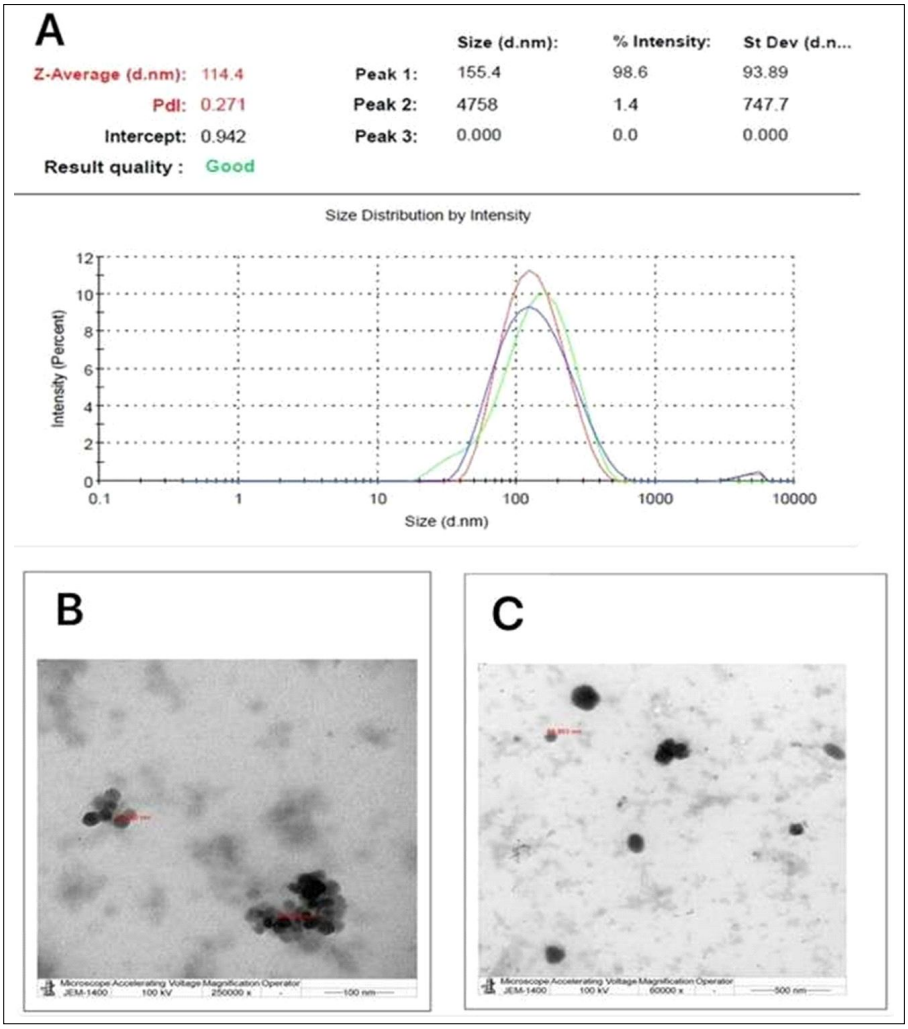
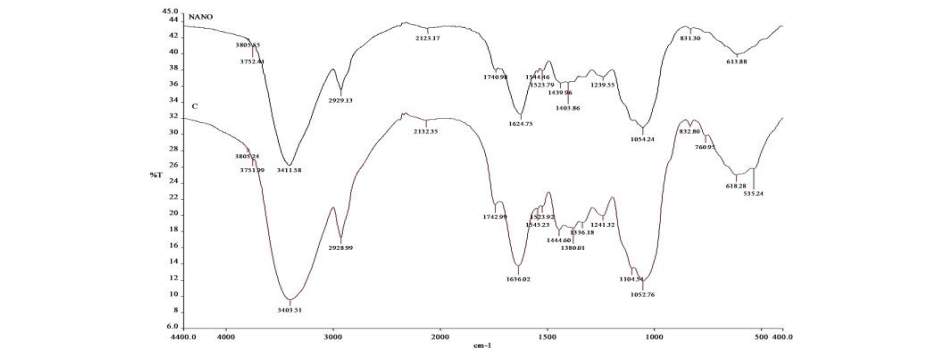


Fig 1: (A) shows the histogram of a ZetaSizer for measuring the average size of natural nanoparticles from *Faidherbia albida*. (B and C) show TEM microscopy of nanoparticles synthesized from *Faidherbia albida* (Scale bar: 100-200 nm).



It is missing information about the meaning of each curve and the presentation of the peaks. While (B and C) are the graphs of XRD analysis of crude and natural nanoparticles synthesized from *F. albida*.

Fig 2: (A) shows the characterization carried out by fourier-transform infrared spectroscopy.

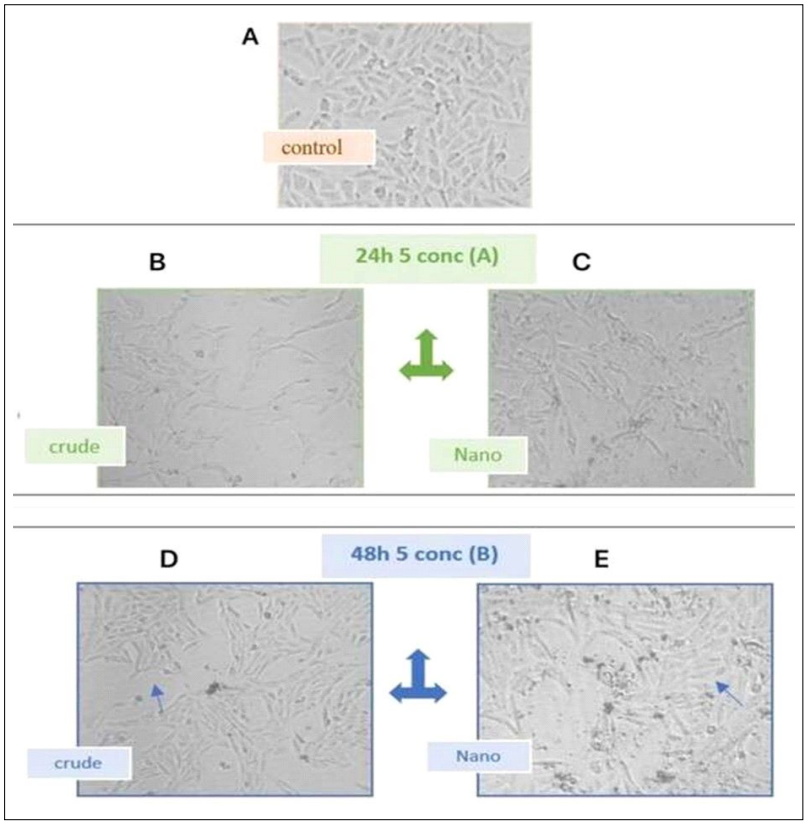


Fig 3: (A) shows healthy cells (control), while (B and C) show the cells' morphology after 24 hours of treatment. (D and E) indicate the morphology of MDA-MB-231 cells after 48 hours of treatment (at 5 µg/ml).

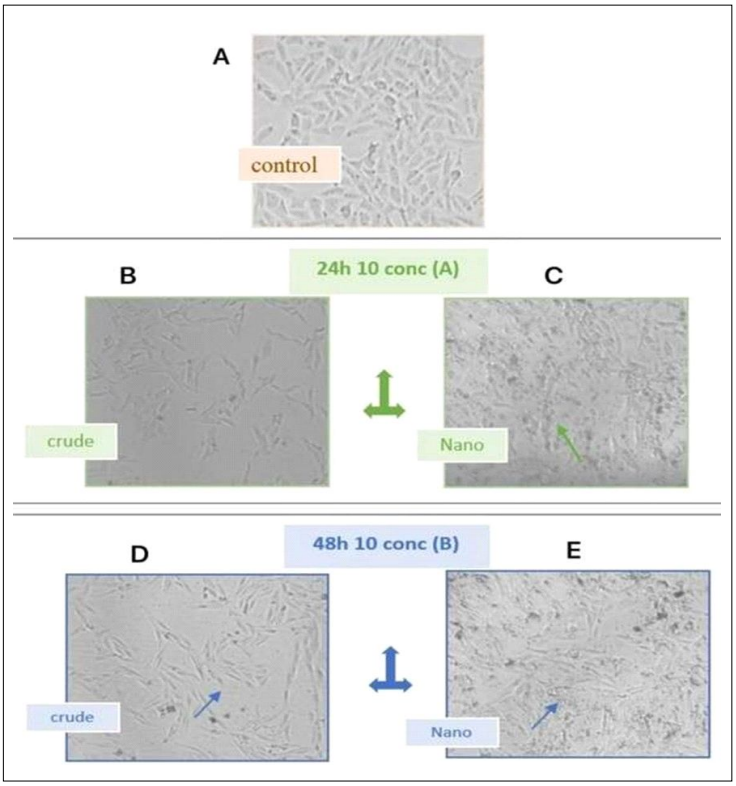


Fig 4: (A) shows healthy cells (control), while (B and C) show the cells' morphology after 24 hours of treatment (at 10 µg/ml). (D and E) indicate the morphology of MDA-MB-231 cells after 28 hours of treatment (at 10 µg/ml).

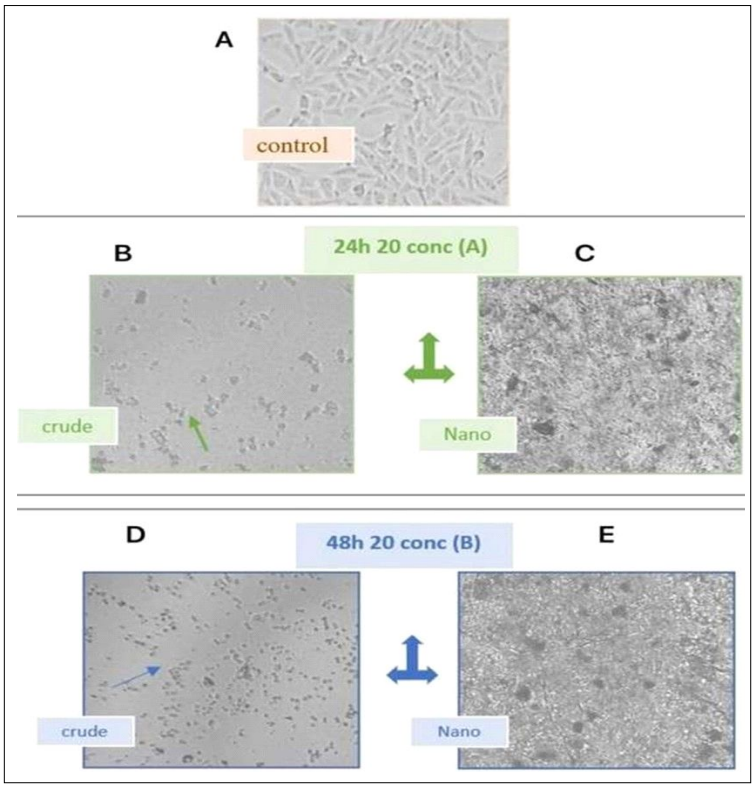


Fig 5: (A) shows healthy cells (control), while (B and C) show the cells' morphology after 24 hours of treatment (at 20 µg/ml). (D and E) indicate the morphology of MDA-MB-231 cells after 28 hours of treatment (at 20 µg/ml).

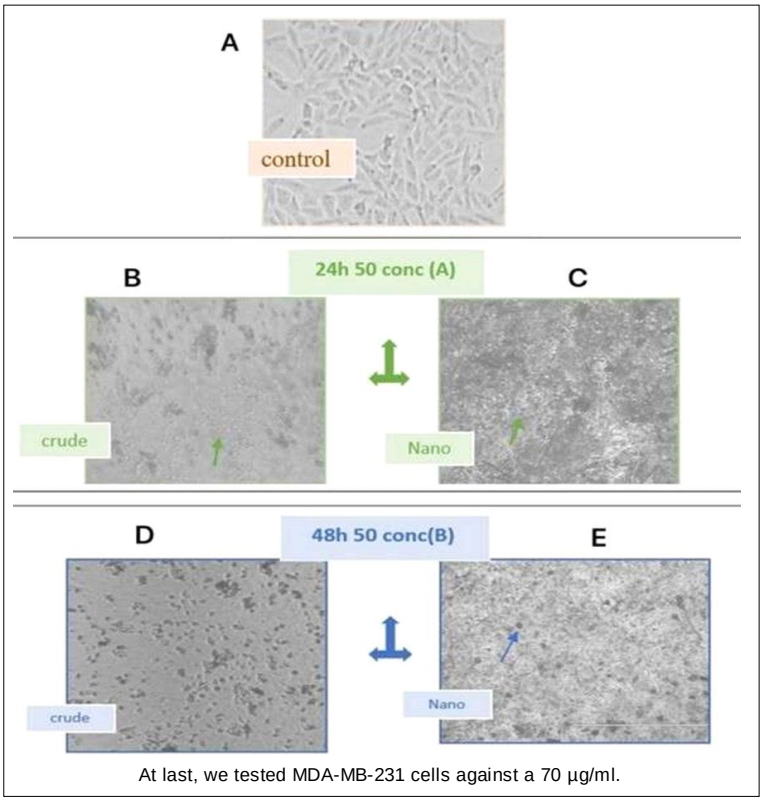


Fig 6: (A) shows healthy cells (control), (B and C) show the cells' morphology after 24 hours of treatment (at 50 µg/ml). (D and E) indicate the morphology of MDA-MB-231 cells after 28 hours of treatment (at 50 µg/ml).

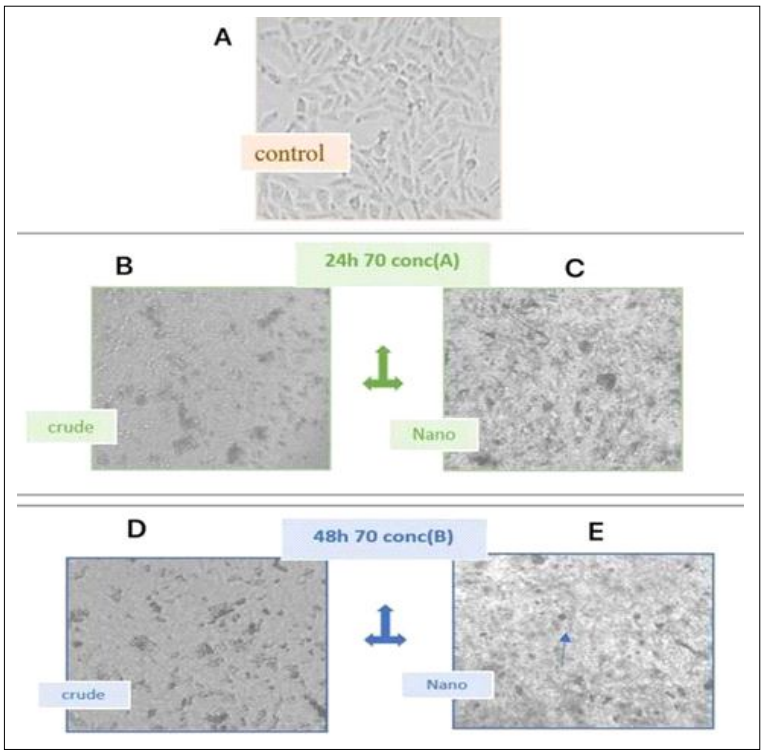
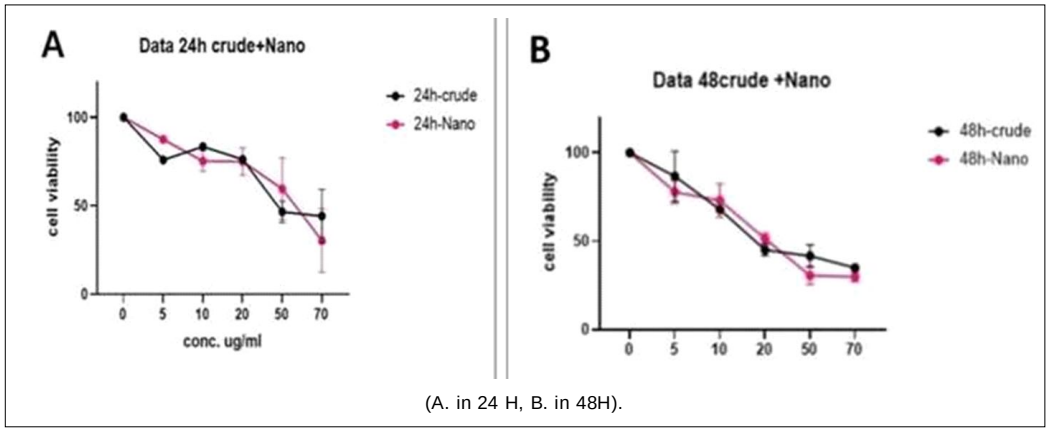


Fig 7: (A) shows healthy cells (control), while (B and C) show the cells' morphology after 24 hours of treatment (at 70 µg/ml). (D and E) indicate the morphology of MDA-MB-231 cells after 28 hours of treatment (at 70 µg/ml).

Lipid peroxidation measurement

Oxidative stress is implicated in cancer development, often causing increased lipid peroxidation (LPO). To evaluate this effect, LPO levels were measured in treated and control cells. A significant reduction in LPO levels was noticed in NP-treated samples compared to crude extract-treated cells at all tested concentrations ($p<0.05$) (Fig 11). These findings align with previous studies indicating that plant-derived nanoparticles reduce oxidative stress in cancer cells (Yadav *et al*., 2015).

Breast cancer is among the most extensive malignancies worldwide and novel therapeutic approaches have focused



(A. in 24 H, B. in 48H).

Fig 8: Shows the gradual decrease in cell viability with different concentrations.

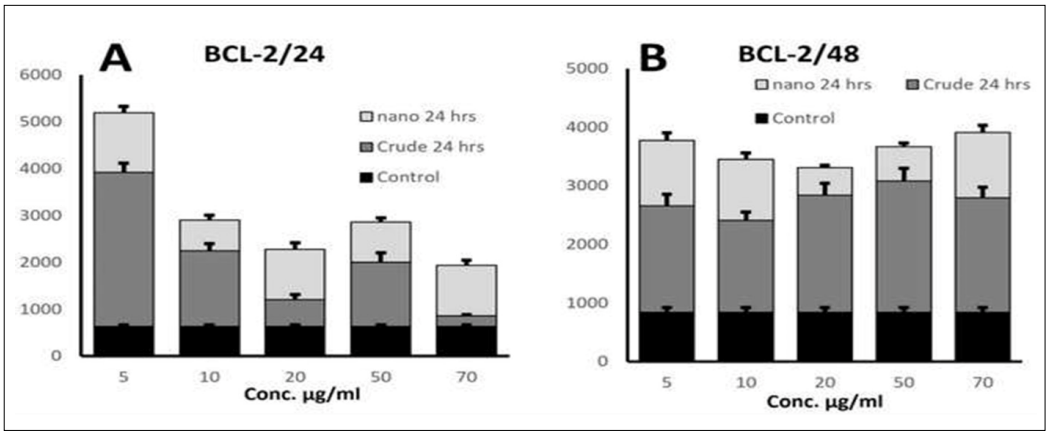


Fig 9: Bcl-2 levels at 5, 10, 20, 50, and 70 µg/ml of crude and nanoparticles samples from *Faidherbia albida* extract after 24 hours (A) and 48 hours (B).

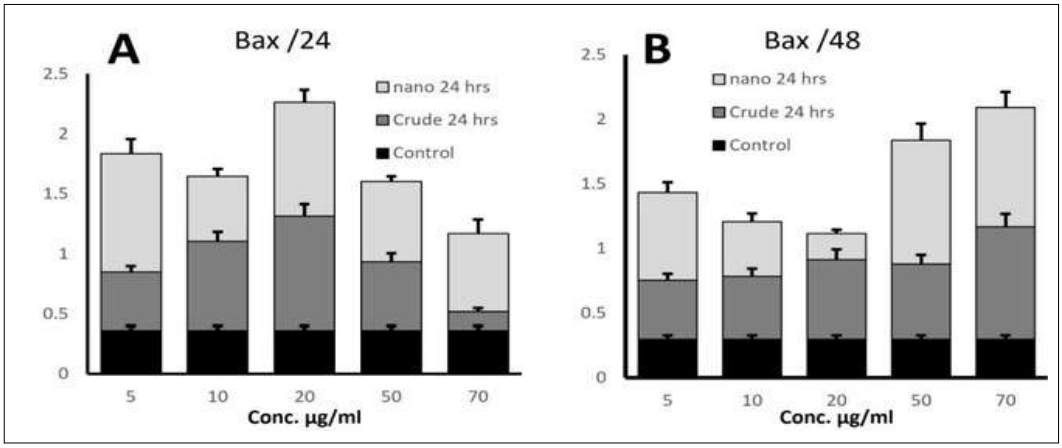


Fig 10: Bax levels at 5, 10, 20, 50, and 70 µg/ml of crude and nanoparticle samples from *Faidherbia albida* extract after 24 hours (A) and 48 hours (B).

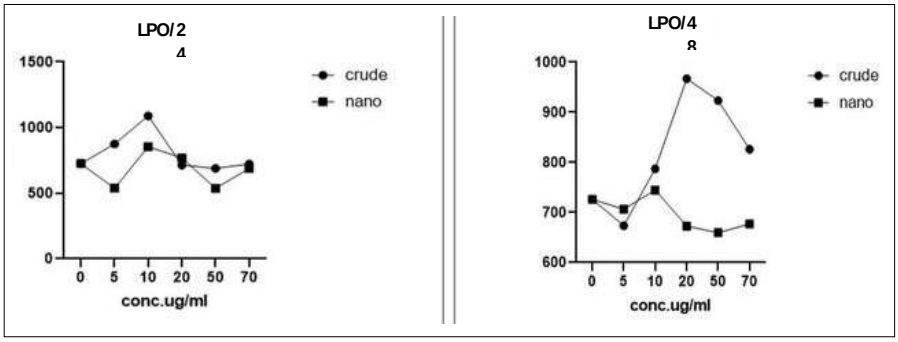


Fig 11: LPO levels at 5, 10, 20, 50, and 70 µg/ml of crude and nanoparticle samples from *Faidherbia albida* extract after 24 hours (A) and 48 hours (B).

on minimizing toxicity while enhancing efficacy (Yadav and Sahu, 2024). Nanoparticles have garnered interest due to their potential to enhance targeted medication delivery and improve bioavailability (Xu *et al*., 2022). In this study, *F. albida*-derived nanoparticles demonstrated superior anticancer properties compared to crude extract, particularly in decreasing cell viability and increasing apoptosis in MDA-MB-231 cells. Phytoconstituents in Acacia species, including flavonoids and phenolics, have been reported to have cytotoxic effects (Alajmi *et al*., 2017). These bioactive substances may be responsible for the reported apoptotic effects of *F. albida* NPs, which could promote cell death brought on by reactive oxygen species (ROS) (Alsulami *et al*., 2023). Furthermore, the increased cytotoxicity of *F. albida* NPs supports earlier findings on plant-based nanoparticles for cancer treatment by indicating that nano formulation enhances the bioactivity of plant extracts (Jeyaraj *et al*., 2013).

CONCLUSION

This study showed that *F. albida* NPs exhibit superior anticancer properties compared to crude extract, significantly reducing MDA-MB-231 cell viability and causing apoptosis. The findings suggest that *F. albida* NPs could serve as a promising alternative for breast cancer therapy by enhancing oxidative stress-induced apoptosis. Further research is warranted to elucidate the molecular mechanisms underlying these effects.

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Conflict of interest

All authors declare that they have no conflicts of interest.

REFERENCES

Ajeel, K.K. and Hasan, A.F. (2024). Nanotechnology, Synthesis and theoretical investigation of antimicrobial and anticancer effects of silver nanoparticles in faster diagnosis and treatment of various cancers: A review. *Agricultural Reviews*. 1-6. doi: 10.18805/ag.RF-397.

Alajmi, M.F., Alam, P., Alqasoumi, S.I., Ali Siddiqui, N., Basudan, O.A., Hussain, A., Mabood Husain, F. and Khan, A.A. (2017). Comparative anticancer and antimicrobial activity of aerial parts of *Acacia salicina*, *Acacia laeta*, *Acacia hamulosa* and *Acacia tortilis* grown in Saudi Arabia. *Saudi Pharmaceutical Journal*. **25(8):** 1248-1252. https://doi.org/https://doi.org/10.1016/j.jsps.2017.09.010.

Alsulami, W.L., Ali, D., Almutairi, B.O., Yaseen, K.N., Alkahtani, S., Almeer, R.A. and Alarifi, S. (2023). Green lead nanoparticles induced apoptosis and cytotoxicity in MDA-MB-231 cells by inducing reactive oxygen species and caspase 3/7 enzymes. *Dose-Response*. **21(4):** 1-8. https://doi.org/10.1177/15593258231214364.

Al-Thubaiti, E.H., Hamza, R.Z., Alaidaroos, B.A., Al-Gheffari, H.K., Albaqami, N.M. and El-Megharbel, S.M. (2025). Chemical characterization of pollen grains ethanolic extract (PGE) with evaluation of its potent antioxidant, antibacterial and anti-cancer activities against hepatocellular carcinoma (HepG2). *Indian Journal of Animal Research*. **59(10):** 1653-1662. doi: 10.18805/IJAR.BF-1953.

Austin, J., Minelli, C., Hamilton, D., Wywijas, M. and Jones, H.J. (2020). Nanoparticle number concentration measurements by multi-angle dynamic light scattering. *Journal of Nanoparticle Research*. **22(5):** 108.

Baudot, C., Tan, C.M. and Kong, J.C. (2010). FTIR spectroscopy as a tool for nano-material characterization. *Infrared Physics and Technology*. **53(6):** 434-438.

Bianchini, G., Balko, J.M., Mayer, I.A., Sanders, M.E. and Gianni, L. (2016). Triple-negative breast cancer: Challenges and opportunities of a heterogeneous disease. *Nature Reviews Clinical Oncology*. **13(11):** 674-690.

Biswas, A.K., Islam, M.R., Choudhury, Z.S., Mostafa, A. and Kadir, M.F. (2014). Nanotechnology based approaches in cancer therapeutics. *Advances in Natural Sciences: Nanoscience and Nanotechnology*. **5(4):** 43001.

El-Amin, H.M. (1990). Trees and Shrubs of the Sudan. Ithaca Press, 484 p.

Hussain, I., Singh, N.B., Singh, A., Singh, H. and Singh, S.C. (2016). Green synthesis of nanoparticles and its potential application. *Biotechnology Letters*. **38(4):** 545-560.

Hyeladzira, Y.B., Muhammad, F., Hussaina, S.I., Samuel, A.E., Gachi, J.A. and Joseph, G. (2025). Phytochemical characteristics, *in vitro* and *in vivo* antioxidant potentials of ethyl acetate fraction from apple-ring acacia [*Faidherbia albida* (Delile) A. Chev.] leaves extract on albino rats. *Journal of Applied Sciences and Environmental Management*. **29(2):** 563-568.

Jeyaraj, M., Sathishkumar, G., Sivanandhan, G., MubarakAli, D., Rajesh, M., Arun, R., Kapildev, G., Manickavasagam, M., Thajuddin, N., Premkumar, K. and Ganapathi, A. (2013). Biogenic silver nanoparticles for cancer treatment: An experimental report. *Colloids and Surfaces B: Biointerfaces*. **106:** 86-92. https://doi.org/10.1016/j.colsurfb.2013.01.027.

Malatesta, M. (2021). Transmission electron microscopy as a powerful tool to investigate the interaction of nanoparticles with subcellular structures. *International Journal of Molecular Sciences*. **22(23):** 12789.

Mosmann, T. (1983). Rapid colorimetric assay for cellular growth and survival: Application to proliferation and cytotoxicity assays. *Journal of Immunological Methods*. **65(1-2):** 55-63.

Narod, S.A. and Salmena, L. (2011). BRCA1 and BRCA2 mutations and breast cancer. *Discovery Medicine*. **12(66):** 445-453.

Newman, D.J. and Cragg, G.M. (2020). Natural products as sources of new drugs over the nearly four decades from 01/ 1981 to 09/2019. *Journal of Natural Products*. **83(3):** 770-803.

Ohouko, O.F.H., Koffi, K., Novidzro, K., Dougnon, V., Agbonon, A., Tozo, K., Dougnon, T. and Messanvi, G. (2020). Phytochemical and toxicological studies of *Acacia nilotica* and *Faidherbia albida* used in West African traditional medicine. *Int. J. Recent Sci. Res*. **3:** 10-18.

Ohkawa, H., Ohishi, N. and Yagi, K. (1979). Assay for lipid peroxides in animal tissues by thiobarbituric acid reaction. *Analytical Biochemistry*. **95(2):** 351-358.

Patra, J.K., Das, G., Fraceto, L.F., Campos, E.V.R., Rodriguez-Torres, M. del P., Acosta-Torres, L.S., Diaz-Torres, L.A., Grillo, R., Swamy, M.K. and Sharma, S. (2018). Nano based drug delivery systems: Recent developments and future prospects. *Journal of Nanobiotechnology*. **16(1):** 71.

Pezzanite, L., Chow, L., Griffenhagen, G., Dow, S. and Goodrich, L. (2021). Impact of three different serum sources on functional properties of equine mesenchymal stromal cells. *Frontiers in Veterinary Science*. **8:** 634064.

Rani, V., Venkatesan, J. and Prabhu, A. (2022). Plant based Polysaccharide Nanoparticles for Anticancer Applications. In: Polysaccharide Nanoparticles. *Elsevier*. pp. 231-246.

Sharma, R., Bisen, D.P., Shukla, U. and Sharma, B.G. (2012). X-ray diffraction: A powerful method of characterizing nanomaterials. *Recent Res. Sci. Technol*. **4(8):** 77-79.

Shreyash, N., Bajpai, S., Khan, M.A., Vijay, Y., Tiwary, S.K. and Sonker, M. (2021). Green synthesis of nanoparticles and their biomedical applications: A review. *ACS Applied Nano Materials*. **4(11):** 11428-11457.

Sun, Y.S., Zhao, Z., Yang, Z.N., Xu, F., Lu, H.J., Zhu, Z.Y., Shi, W., Jiang, J., Yao, P.P. and Zhu, H.P. (2017). Risk factors and preventions of breast cancer. *International Journal of Biological Sciences*. **13(11):** 1387.

Waks, A.G. and Winer, E.P. (2019). Breast cancer treatment: A review. *Jama*. **321(3):** 288-300.

Warra, A.A. and Prasad, M.N.V. (2020). African Perspective of Chemical Usage in Agriculture and Horticulture-their Impact on Human Health and Environment. In: Agrochemicals Detection, Treatment and Remediation. *Elsevier*. pp. 401-436.

Xu, J.J., Zhang, W.C., Guo, Y.W., Chen, X.Y. and Zhang, Y.N. (2022). Metal nanoparticles as a promising technology in targeted cancer treatment. *Drug Delivery*. **29(1):** 664-678.

Yadav, A. and Sahu, D. (2024). Synthesis of silver nanoparticles from plant extracts and their potential applications in cancer treatment: A Comprehensive review. *International Journal of Pharmacognosy and Herbal Drug Technology (IJPHDT)*. **1(1):** 53-76.

Yadav, N.K., Saini, K.S., Hossain, Z., Omer, A., Sharma, C., Gayen, J.R., Singh, P., Arya, K.R. and Singh, R.K. (2015). Saraca indica bark extract shows *in vitro* antioxidant, antibreast cancer activity and does not exhibit toxicological effects. *Oxidative Medicine and Cellular Longevity*. **2015(1):** 205360.