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Cytotoxicity screening of selected antimalarial botanicals in Ekiti State, Nigeria

Olamilekan Ogunsakin,¹ Ayoola Oluwajobi,² James Agbolade,² Philip Olakunle,³ Oluremi Odedeji,⁴ Tijani Adelani,⁵ Benedicta Adewoyin,⁶ Omosalewa Adewoyin,⁷ Dorcas Owolabi³

¹Department of Biotechnology, Federal University of Technology and Environmental Sciences, Iyin Ekiti, ²Department of Plant Science and Biotechnology, Federal University, Oye Ekiti, Ekiti State; ³Department of Biological Sciences, University of Ilesa, Osun State; ⁴Department of Food Science and Technology, University of Medical Sciences Ondo, Ondo City; ⁵Department of Nursing Science, Federal University Oye-Ekiti, Ekiti State; ⁶Department of Crop Science, Federal University Oye-Ekiti Ekiti State; ⁷Department of Environmental Health Science, University of Medical Sciences Ondo, Ondo City, Nigeria

Correspondence: Olamilekan Daniel Ogunsakin, Department of Biotechnology, Federal University of Technology and Environmental Sciences, Iyin Ekiti, Nigeria.

Tel.: +234 816-292-0548

E-mail: danielolamilekan604@gmail.com ; olamilekan.ogunsakin@futes.edu.ng

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Abstract

Malaria remains a major public health challenge in Ekiti State, Nigeria, contributing significantly to morbidity and mortality, especially among vulnerable populations. In response to persistent malaria transmission, increasing drug resistance, and limited access to healthcare, the use of antimalarial botanicals has risen due to their affordability and cultural acceptance. This growing reliance on herbal remedies necessitates scientific evaluation of their potential cytotoxic effects to ensure safety and efficacy in malaria treatment. This study investigates the cytotoxic and genotoxic effects of selected

antimalaria botanicals, namely, *Mangifera indica* and *Blighia sapida* leaf extracts on *Allium cepa* roots, focusing on root length, root number, mitotic index, and phase index. A concentration-dependent decrease in root length and number was observed, indicating significant growth inhibition and cytotoxicity at higher extract concentrations. The mitotic index and phase index also decreased with increasing concentrations of the extracts (72%-19% *Mangifera indica*, 72%-20% *Blighia sapida*), suggesting that the extracts hinder cell division by interfering with the mitotic spindle and causing cell cycle arrest. Chromosomal aberrations, including anaphase bridges and sticky chromosomes, were noted, reflecting the genotoxic potential of the phytochemicals present in the extracts. The study identified key bioactive compounds such as quercetin, mangiferin, and scopoletin, which are known to disrupt microtubule dynamics, inhibit cell proliferation, and induce apoptosis. These findings underscore the importance of comprehensive toxicity testing in evaluating the safety and efficacy of plant extracts for medicinal or agricultural applications. The significant cytotoxic and genotoxic effects observed in this study highlight the potential risks associated with the use of *Mangifera indica* and *Blighia sapida* extracts, emphasizing the need for careful consideration in their application.

Introduction

The widespread use of botanical remedies for treating diseases, particularly in traditional medicine, has drawn significant scientific attention due to their potential therapeutic benefits.¹ Among these, antimalarial botanicals have garnered interest as alternatives to synthetic drugs, which often come with significant side effects and the risk of resistance development by malaria parasites.² However, while the efficacy of these plants is often highlighted, their cytotoxic effects remain a critical concern, necessitating thorough investigation. This study focuses on evaluating the cytotoxicity and cytological impacts of two widely used antimalarial botanicals: Mango (*Mangifera indica*) and Ackee Apple (*Blighia sapida*), using the *Allium cepa* bioassay. *Mangifera indica* (Mango), a plant native to South Asia but widely cultivated in tropical and subtropical regions, has been traditionally used not only for its nutritional value but also for its medicinal properties. The leaves, bark, and seeds of Mango are reported to possess antimalarial, anti-inflammatory, and antimicrobial properties, making it a popular

choice in traditional medicine.³ Similarly, *Blighia sapida* (Ackee Apple), primarily found in West Africa and the Caribbean, is known for its use in various folk remedies.⁴ The seeds and arils of Ackee Apple have been utilized for their purported antimalarial, analgesic, and anti-inflammatory effects.⁴ Despite their widespread use, there is limited scientific data on the cytotoxicity and cytological effects of these plants, which raises concerns about their safety as therapeutic agents.

The *Allium cepa* (onion) bioassay is a widely recognized method for assessing cytotoxicity and genotoxicity in plants.^{3,4} This assay is particularly valuable for its simplicity, cost-effectiveness, and ability to provide insights into cellular mechanisms such as mitosis, chromosomal aberrations, and root growth inhibition.⁵ By employing the *Allium cepa* bioassay, this study aims to assess the cytotoxic effects of Mango and Ackee Apple on root growth, mitotic index, chromosomal aberrations, and phase indices. These parameters are critical indicators of the plants' potential to cause cellular damage, which could have implications for their safety as antimalarial agents. The cytotoxicity of plant extracts is closely linked to their chemical constituents, which can interact with cellular components to induce toxicity or therapeutic effects. In the context of malaria treatment, cytotoxicity can be a double-edged sword.⁶ On one hand, cytotoxic compounds might target the malaria parasite effectively; on the other hand, they might also pose risks to the host's cells.⁷ This study investigates the cytotoxic and genotoxic effects of selected antimalaria botanicals, namely, *Mangifera indica* and *Blighia sapida* leaf extracts using *Allium cepa* bioassay.

Materials and Methods

Study area and duration

This study was conducted between November 2023 and March 2024 in Oye-Ekiti, Ekiti State, Nigeria. Oye-Ekiti, situated at latitude 7.79°N and longitude 5.33°E, has an approximate population density of 206,300 and is predominantly inhabited by the Yoruba ethnic group. The economy of the region is primarily based on agriculture.

Selection of plant material

Two medicinal plants traditionally used in the management of malaria were selected for this study: *Blighia sapida* (K.D. Koenig) and *Mangifera indica* L.

Phytochemical analysis

Phytochemical screening was done as described by Sil et al.⁸ The phytochemical analysis was performed using Reverse-Phase High-Performance Liquid Chromatography (RP-HPLC) (comprising a Shimadzu LC-20AT solvent delivery system, SIL-20A autosampler, and DGU-20A5 degasser, Shimadzu Corporation, Kyoto, Japan). The analysis was carried out using an Agilent ZORBAX Eclipse Plus C18 reverse-phase column (4.6 × 250 mm, 5 µm; Agilent Technologies, Santa Clara, California, USA) under standard chromatographic conditions. The mobile phase consisted of a gradient system of water (acidified with 0.1% formic acid) and acetonitrile, with a flow rate of 1.0 mL/min. Detection was performed using an SPD-20A Ultraviolet-Visible detector (Shimadzu Corporation, Kyoto, Japan) at appropriate wavelengths for phenolic compounds (typically 254–280 nm). The injection volume was 20 µL, and the column temperature was maintained at 30°C. The results are presented in Table 1 and 2 below.

Cytotoxicity testing

The cytotoxicity and morphotoxicity evaluation were carried out according to Celik and Aslantruk and Leme and Marin-Morales,^{9,10} with little adjustments to align to the research aim. The cytotoxicity testing of the selected botanicals was conducted using the *Allium cepa* bioassay, a widely accepted method for assessing the potential toxic effects of substances.⁹ The bioassay involved growing onion (*Allium cepa*) bulbs in disposable cups with water before transferring them into varying concentrations of the extracts to evaluate their impact on root growth. The leaf extracts of Ackee Apple (*Blighia sapida*) and Mango (*Mangifera indica*) were powdered using SC-1589 Multifunctional Blender (5000W, Zhongshan Fabulous Electrical Appliance Co., Ltd, Guangdong, China), and used for the test. Each extract was dissolved in water to prepare solutions at concentrations of 5%, 10%, 15%, 25%, 50%, 75%, and 100%. A control group was maintained with tap water. Onion bulbs were placed in 100 mL plastic cups filled with the prepared extract solutions. The bases of the bulbs were immersed in the solutions, while the bulbs were placed in the dark to avoid photosynthesis, which could influence root

growth. Each concentration was tested in triplicate to ensure reliable results. The bulbs were exposed to the test solutions for 96 hours. During this period, the solutions were replaced with fresh ones every 24 hours to maintain the effectiveness of the treatment. At the end of the exposure period, three bulbs exhibiting the best root growth from each concentration were selected for further analysis. The macroscopic evaluation focused on key parameters: root length and root number. Measurements of root length were taken with a meter rule, while the number of roots per bulb was counted. The percentage of root growth inhibition was calculated to quantify the toxic effect of the extracts. The formula used for this calculation was:

$$\frac{(\text{Mean root length of control} - \text{Mean root length of treated})}{\text{Mean root length of control}} \times 100$$

For a detailed understanding of the cytotoxic effects, microscopic evaluation was performed to assess chromosomal integrity and mitotic activity. This involved examining the root tips of the onions under a light microscope (Olympus Biological Binocular Microscope Cx23, Tokyo, Japan). After the macroscopic evaluation, root tips from the bulbs exposed to different concentrations of extracts and the control were fixed in Carnoy's solution (3:1 ethanol and glacial acetic acid). This fixative preserves the cellular structure by rapidly killing the cells and denaturing proteins, which helps in maintaining chromosomal integrity. The fixed root tips were stored at 4°C for 24 hours before processing. The root tips were treated with 1N hydrochloric acid and heated for 5 minutes to soften the tissue, according to Okaiyeto and Oguntibeju¹¹ and Pathiratne *et al.*¹² They were then rinsed with distilled water, placed on microscopic slides, and stained with 2% acetocarmine. This stain helps visualize the chromosomes under the microscope. Cover slips were carefully placed over the stained samples, and excess stain was blotted out to minimize artifacts. The prepared slides were examined using a light microscope (Olympus Biological Binocular Microscope Cx23, Tokyo, Japan) at 40× magnification. A total of 500 cells from three scorable slides per sample were observed for various mitotic stages and chromosomal abnormalities. Key metrics included the mitotic index, which measures the proportion of cells undergoing mitosis, and the number of chromosomal aberrations.

Data analysis and calculated parameters

Data analysis was conducted using R Studio to interpret the results from both macroscopic and microscopic evaluations. One-Way Analysis of Variance (ANOVA) followed by Tukey's Honestly Significant Difference (HSD) test was employed to compare the effects of different extract concentrations and the control group. This analysis assessed whether differences in root growth, mitotic index, and chromosomal abnormalities were statistically significant at p values less than 0.05.

Root growth inhibition

The mean root length was compared between treated and control groups to calculate the percentage of root growth inhibition.

Mitotic index

The proportion of dividing cells was calculated using the formula: Mitotic index = (Number of Dividing Cells / Total Number of Cells) $\times$ 100

Chromosomal aberrations

The percentage of aberrant cells (%AB) was determined with: Percentage Aberrant Cells (%AB) = (Number of Aberrant Cells / Total Number of Cells) $\times$ 100. In cytogenetic and mitotic studies, %AB quantifies the proportion of cells showing chromosomal abnormalities or aberrations.

Results

The results are summarized in tables and charts to provide a clear visual representation of the effects of each extract concentration. The phytochemical screening shows the bioactive compounds present in the leaves of *Mangifera indica* (Table 1) and *Blighia sapida* (Table 2). The macroscopic results highlighted the degree of root growth inhibition, while the microscopic analysis provided insights into the cellular and chromosomal impacts of the extracts.

Phytochemical analysis results

Table 1 shows the RP-HPLC data for *Mangifera indica* leaves; quercetin is the dominant phytochemical, with the highest concentration of 0.394 µg/mL (peak area: 9393.69 mAU·s), contributing 39.36% of the total identified compounds. Mangiferin (0.158 µg/mL; 15.79%) and luteolin (0.144 µg/mL; 14.42%) are also major constituents. Gallic acid represents 11.94% (0.119 µg/mL), while other phenolics like chlorogenic acid (0.052 µg/mL; 5.16%) and catechin (0.040 µg/mL; 3.89%) are present at lower levels. Minor compounds (such as, ferulic acid, friedelin, shikimic acid) each constitute $\leq 0.56\%$, with concentrations as low as 0.004 µg/mL. Table 2 shows the RP-HPLC data for *Blighia sapida* leaves; quercetin is the predominant compound, with the highest concentration of 0.531 µg/mL (peak area: 7123.14 mAU·s), contributing 53.08% of the total identified phytochemicals. Persin follows at 0.150 µg/mL (14.98%), while zeaxanthine (0.094 µg/mL; 9.37%) and persenone A (0.049 µg/mL; 4.93%) are also notable. Minor constituents include beta-cryptoxanthine (0.037 µg/mL; 3.72%), persenone B (0.034 µg/mL; 3.42%), and scopoletin (0.021 µg/mL; 2.10%). Low-level compounds like catechin, epicatechin, afzelin, each represent $\leq 1.16\%$, with concentrations as low as 0.009 µg/mL.

Macroscopic analysis results

Table 3 (A) shows the effect of different concentrations of *Mangifera indica* on root inhibition of *A. cepa*. As presented in the table, the root length and the root number decreased as the concentration increased. As observed in the table, 5%, 10% and 15% are not significantly different for the root length (3.67 ± 0.08 , 3.70 ± 0.05 , and 3.53 ± 0.09) but 15% is significantly different for the root number (27.67 ± 1.20). The concentrations 25% and 50% are significantly different for root length (2.90 ± 0.06 and 1.63 ± 0.09) while 75% and 100% are not significantly different (0.73 ± 0.09 and 0.60 ± 0.06) for root length but significantly different for root number (15.00 ± 0.58 and 8.00 ± 0.88). It was also observed from the percent root growth that all the concentrations are significantly different. The root length decreased from the control from 4.1 cm to 0.6 cm, number of roots 56.67 to 8.0, and root growth inhibition from 100% to 4.17%. Table 3 (B) shows the effect of different concentrations of *Blighia sapida* on the root inhibition of *A. cepa* root. According to the results, 10%, 15% and 25%

concentration are not significantly different (3.17 ± 0.33 , 3.07 ± 0.22 , and 2.83 ± 0.21) in the root length, but significantly different for the number of roots. For the percent root growth inhibition, only 25% and 50% are not significantly different (16.67 ± 0.41 and 11.42 ± 0.37) from each other. The root length was observed to decrease from 4.33 cm for control to 0.53 cm for 100%, while the number of roots decreased from 55.00 ± 0.00 to 6.33 ± 0.00 (control to 100%). The percent root growth inhibition significantly decreased from 100% for control to 5.17 ± 0.32 at 100% concentration.

Mitotic Index Results

Table 4 (A) presents the effect of crude leave extract of *Mangifera indica* on the mitotic index and the percent chromosomal aberration of *A. cepa* root. As presented in the table, the mitotic index decreased as the concentration increased. The result of the mitotic index is significantly different for all concentrations. The same was observed for the percent mitotic inhibition for all the concentrations (27.23%-72.00%). Significant decrease of the mitotic index of the concentrations 5%-100% was observed (from 0.51 ± 0.00 at 5% to 0.19 ± 0.00 at 100%). Table 4 (B) presents the effect of crude leave extract of *Blighia sapida* on the mitotic index and the percentage chromosomal aberration of *A. cepa* root. As shown in the table, the mitotic index decreased as the concentration increased. The result of the mitotic index for all the concentrations is significantly different from each other from 5%-100% (0.54 ± 0.00 , 0.48 ± 0.01 , 0.44 ± 0.00 , 0.38 ± 0.00 , 0.33 ± 0.00 , 0.26 ± 0.00 and 0.20 ± 0.00 respectively). The same was observed for the percent mitotic inhibition for all the concentrations. Significant decrease was also noticed for the mitotic inhibition of all the concentration (27.30 ± 1.02 to 73.00 ± 0.46).

Chromosomal aberration results

Table 5 (A) shows the effect of *Mangifera indica* crude leaf extract on the percentage chromosomal aberration of *A. cepa* root. According to the table below, eight different aberrations were observed in the *A. cepa* root tip across the different concentrations. With 5%, 10%, and 15% concentration, no chromosomal aberration was observed. At 25%, nuclear lesion (8.00 ± 0.55) and vagrant chromosome (8.00 ± 0.55) was observed. For the 50% concentration, the observed chromosomal aberrations included micronuclei (5.00 ± 0.00), stickiness (4.00 ± 0.24), nuclear lesion (13.12 ± 0.00), intertwined chromosome (8.01 ± 0.20) and vagrant chromosome (30.13 ± 0.56). For the 75% concentration, only micronuclei were

not observed among the eight aberrations, while only intertwined chromosome was not observed in the 100% concentration of the *A. cepa* root. Table 5 (B) shows the effect of crude leaf extract of *Blighia sapida* on the percentage chromosomal aberration of *A. cepa* root. According to the table below, nine different aberrations were observed in the *A. cepa* root tip across the different concentrations. At 5% and 10%, concentration, no chromosomal aberration was observed. At 15%, giant chromosome (4.03 ± 0.20), nuclear lesion (3.00 ± 0.00) and vagrant chromosome (7.03 ± 0.00) were observed. For the 25% concentration, the observed chromosomal aberrations included micronuclei (3.10 ± 0.00), giant chromosome (3.20 ± 0.40), stickiness (3.00 ± 0.00), nuclear lesion (5.00 ± 0.55), and vagrant chromosome (14.00 ± 0.55). For the 50% concentration, only vagrant chromosome, blebbed chromosome and multinucleated cells were not observed among the eight aberrations. For the 75%, only vagrant chromatid was not observed, while every of the nine aberrations were observed in the 100% concentration of the *A. cepa* root. Figure 1 shows the compared effect of the leaf extract of *Mangifera indica* and *Blighia sapida* on the number of aberrant cells of *A. cepa* root. From the figure, *Blighia sapida* has more severe effect compared to *Mangifera indica*. The effect became visible from 15% to 100%, and a similar effect was noticed at 50% and 75%. Figure 2 photomicrographs show the appearance of the observed chromosomal aberrations.

Discussion

The *Allium cepa* assay is a validated and widely accepted preliminary screening model for assessing the cytotoxicity and the genotoxicity of plant extracts. It is recognized by international organizations such as the World Health Organization (WHO) and the United Nations Environment Programme (UNEP) as a reliable bioassay due to its sensitivity, genetic similarity to higher eukaryotes, and correlation with mammalian test systems. It is a relevant and valid, predictive and ethical alternative to initial animal testing, proving its role in identifying potential risks prior to advanced *in vivo* studies. The root length and number are essential indicators of the health and viability of *Allium cepa* roots exposed to plant extracts.¹⁰ Changes in these parameters can reflect the cytotoxic, genotoxic, and growth-regulating effects of the phytochemicals present in the extracts. The root length and number are sensitive indicators of growth inhibition and overall root health. A decrease in root length and number indicates growth inhibition, while an increase may suggest root proliferation or abnormal growth patterns. Adekola *et al.* observed a concentration-dependent decrease in root length and number in

Allium cepa roots treated with ethanol and ethyl acetate extracts of *Blighia sapida*, indicating growth inhibition due to the cytotoxic effects of the extracts.¹³ Changes in root morphology, such as inhibition of growth, swelling, necrosis, lesions, curling, and tumor formation, reflect the complex interactions between the plant compounds and cellular processes in the root meristem.^{14,15} Understanding these effects is crucial for evaluating the safety and efficacy of plant extracts for medicinal or agricultural purposes and underscores the importance of comprehensive toxicity testing in plant-based research.

The mitotic index is a measure of the number of cells undergoing mitosis in a given cell population, reflecting the overall proliferation rate¹⁵. The mitotic index, on the other hand, refers to the proportion of cells in specific phases of mitosis (prophase, metaphase, anaphase, and telophase).¹² A concentration-dependent decrease in both the mitotic index and phase index in *Allium cepa* roots indicates that the plant extracts inhibit cell division, with greater concentrations leading to more pronounced effects.¹² Compounds in the plant extracts can induce cytotoxic and genotoxic effects, causing cell cycle arrest or cell death. This reduces the number of cells entering and progressing through mitosis.¹⁵ The leaf extract concentrations of *Blighia sapida* are significantly different from each other in the mitotic index and mitotic inhibition, and decreased as the concentration increased.¹⁰ Many bioactive compounds disrupt microtubule dynamics, leading to faulty spindle formation, which hinders proper chromosome alignment and segregation. High concentrations of these compounds can trigger programmed cell death, further reducing the population of dividing cells. The phytochemicals identified in the extracts of *Mangifera indica* and *Blighia sapida*, include quercetin, luteolin, kaempferol, mangiferin, scopoletin, and others. These compounds are known for their bioactivity, which includes potential antiproliferative effects.¹²

Studies have shown that quercetin can inhibit cell proliferation by causing cell cycle arrest at various checkpoints. In *Allium cepa*, quercetin's ability to induce DNA damage and spindle apparatus disruption likely leads to a concentration-dependent decrease in mitotic index and phase index.¹⁶⁻¹⁸ Rutin can interfere with microtubule assembly, causing a reduction in the number of cells progressing through mitosis.^{19,20} Mangiferin, known for its antimitotic properties, can cause cell cycle arrest by interfering with DNA replication and mitotic spindle formation. This leads to a significant decrease in the mitotic index and phase index as observed in *Allium cepa* roots.⁷ This compound has been shown to cause G2/M phase arrest, which prevents cells from entering mitosis and reduces the overall mitotic index.¹⁶ Scopoletin induces cytotoxicity and genotoxicity, which can cause cell cycle arrest and apoptosis, reducing the mitotic index and phase index in a concentration-dependent manner.¹⁷ Persin,

also known for its antiproliferative effects, can also lead to reduced mitotic activity by causing cell cycle arrest and apoptosis.²¹ It has been reported that Kaempferol induce mitotic arrest and apoptosis by disrupting microtubule dynamics, thereby lowering the mitotic index and phase index in *Allium cepa* roots.¹⁸

Many studies have documented similar effects of plant extracts on the mitotic index and phase index. Akinboro and Bakare reported that aqueous extracts of five medicinal plants caused a significant concentration-dependent decrease in the mitotic index of *Allium cepa* roots, attributing this to the genotoxic and cytotoxic properties of the extracts.¹⁹ Celik and Aslantruk found that *Inula viscosa* leaf extracts led to a marked decrease in the mitotic index and phase index, correlating with the presence of bioactive compounds that interfere with mitosis.⁹ Khakdan and Piri observed that the aqueous root extract of *Arctium lappa* caused a concentration-dependent decrease in the mitotic index of *Allium cepa*, suggesting that the extract's compounds induced cell cycle arrest and apoptosis.¹⁵ The concentration-dependent decrease in the mitotic index and phase index in *Allium cepa* roots exposed to extracts of *Mangifera indica* and *Blighia sapida* highlights the significant antiproliferative effects of these plant compounds. The observed effects are primarily due to the genotoxic and cytotoxic properties of phytochemicals such as quercetin, mangiferin, kaempferol, and scopoletin, which interfere with cell cycle progression, spindle formation, and induce apoptosis. These findings are consistent with existing literature that documents similar inhibitory effects of plant extracts on cell division, underscoring the importance of evaluating the potential genotoxicity of these botanicals, particularly in their use as therapeutic agents. Okaiyeto and Oguntibeju discussed the adverse effects and cytotoxic potentials of African herbal medicines, emphasizing the need for careful evaluation of these plant-based remedies before therapeutic use.¹¹ Pathiratne *et al.* demonstrated the efficacy of the *Allium cepa* test system for detecting cytotoxicity and genotoxicity in industrial effluents, reinforcing the model's value in environmental monitoring.¹² Therefore, understanding the cytotoxic profile of antimalarial botanicals is crucial for their safe use and development into therapeutic agents. This study is particularly significant given the global burden of malaria and the ongoing search for effective, affordable, and safe treatments. As resistance to conventional antimalarial drugs continues to rise, the exploration of plant-based alternatives becomes increasingly important. However, for these alternatives to be viable, they must not only be effective but also safe. The extract concentrations used (25–100%) were selected to represent a broad biological range, from sub-therapeutic to potentially cytotoxic levels, to observe concentration-dependent effects. While these doses may exceed typical medicinal exposure,

they are appropriate for *in vitro* preliminary toxicity screening aimed at identifying safe thresholds. The concentrations serve as experimental models rather than direct equivalents of human therapeutic doses, and further *in vivo* and clinical evaluations are required to establish safe pharmacological ranges. The findings of this research contribute to the growing body of knowledge on the cytotoxic effects of medicinal plants, specifically focusing on Mango and Ackee Apple, and provide insights into their potential risks and benefits as antimalarial agents.

Conclusions

This study evaluated the cytotoxic and genotoxic effects of *Mangifera indica* and *Blighia sapida* leaf extracts on *Allium cepa* root growth and mitotic activity. The results revealed a concentration-dependent inhibition of root length and number, with significant reductions observed at high extract concentrations. *Mangifera indica* caused reduction of root length from 4.2 cm (control) to 0.6 cm at 100%, while *Blighia sapida* decreased it from 4.33 cm to 0.53 cm. Similarly, the number of roots declined markedly with increasing extract concentrations. Mitotic index analysis showed a progressive decrease, with values ranging from 72% to 19% for *Mangifera indica* and 72% to 20% for *Blighia sapida*. Chromosomal aberrations, including anaphase bridges and sticky chromosomes, were more pronounced in *Blighia sapida*, indicating stronger genotoxic effects. Phytochemical analysis identified bioactive compounds such as quercetin and mangiferin, which may disrupt cell division. Statistical analysis confirmed significant differences at $p < 0.05$.

The findings highlight the potent cytotoxic and genotoxic effects of *Mangifera indica* and *Blighia sapida* leaf extracts, with *Blighia sapida* exhibiting a more severe impact. The concentration-dependent inhibition of root growth, mitotic activity suppression, and chromosomal aberrations suggest that these plant extracts interfere with normal cell cycle processes, likely due to their bioactive phytochemicals. The presence of quercetin and mangiferin as reported by existing literature underscores their potential to disrupt microtubule dynamics, induce apoptosis, and inhibit cell proliferation. Given these effects, caution is necessary when considering these plants for medicinal or agricultural applications. Further studies on their toxicity mechanisms and potential therapeutic thresholds are essential to ensure safe usage.

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Table 1: Phytochemical composition of *Mangifera indica* leaves.

Phytochemicals	Area (mAU·s)	Concentration (µg/mL)	Percentage (%) composition
Chlorogenic Acid	1232.01	0.052	5.16
Gallic acid	2849.33	0.119	11.94
Catechin	929.51	0.040	3.89
Protocatechin	452.71	0.019	1.89
Aromandrene	329.80	0.014	1.38
Beta-elemene	120.41	0.005	0.5
Kinic-acid	150.57	0.006	0.63
Mangostin	127.78	0.005	0.53
Quercetin	9393.69	0.394	39.36
Mangiferin	3770.23	0.158	15.79
Luteolin	3440.92	0.144	14.42
Isomagniferin	133.91	0.006	0.56
Apiginin	648.01	0.027	2.72
Ferulic acid	92.79	0.004	0.39
Friedelin	96.50	0.004	0.4
Shikimic acid	95.52	0.004	0.4
Total	23863.69	1	100

mAU·s (milli-Absorbance Units × seconds); µg/mL (micrograms per millilitre)

Table 2: Phytochemical composition of *Blighia sapida* leaves.

Pytochemicals	Area (mAU·s)	Concentration (µg/mL)	Percentage Composition (%)
Beta-Cryptoxanthine	499.38	0.037	3.72
Zeaxanthine	1257.74	0.094	9.37
Scopoletin	282.91	0.021	2.10
Catechin	110.06	0.008	0.82
Epicatechin	110.13	0.008	0.82
Coumarine	136.71	0.010	1.01
Obovaten	156.22	0.012	1.16
Obovatinal	142.09	0.011	1.05
Quercetin	7123.14	0.531	53.08
Persin	2010.85	0.150	14.98
Persenone A	661.80	0.049	4.93
Persenone B	460.17	0.034	3.42
Lutein	217.30	0.016	1.61
Lingueresitol	130.88	0.010	0.97
Afzelin	117.81	0.009	0.87

mAUs (milli-Absorbance Units × seconds); µg/mL (micrograms per millilitre)

Table 3. Effects of different concentrations on *A. cepa* root inhibition.

<i>A. Mangifera indica</i>			
Concentration (%)	Root length (cm)	Number of roots	% Root Growth
0	4.10±0.05 ^a	56.67±1.45 ^a	100±0.00 ^a
5	3.67±0.08 ^b	38.00±1.52 ^b	64.00±0.44 ^b
10	3.70±0.05 ^b	35.33±0.33 ^b	43.05±0.43 ^c
15	3.53±0.09 ^b	27.67±1.20 ^c	29.86±0.43 ^d
25	2.90±0.06 ^c	21.67±0.88 ^d	16.67±0.41 ^e
50	1.63±0.09 ^d	18.33±0.58 ^{de}	10.42±0.37 ^e
75	0.73±0.09 ^e	15.00±0.58 ^e	7.63±0.34 ^{ef}
100	0.60±0.06 ^e	8.00±0.88 ^f	4.17±0.32 ^f
<i>B. Blighia sapida</i>			
Concentration (%)	Root length (cm)	Number of roots	%Root Growth
0	4.33 ±0.24 ^a	55.00 ±0.00 ^a	100±0.00 ^a

5	3.63 ±0.21 ^b	37.00 ±0.21 ^b	64.00±0.44 ^b
10	3.17 ±0.33 ^c	35.33 ±0.01 ^b	43.05±0.43 ^c
15	3.07 ±0.22 ^c	26.00 ±0.01 ^c	30.86±0.43 ^d
25	2.83 ±0.21 ^c	23.33 ±0.21 ^{cd}	16.67±0.41 ^e
50	1.50 ±0.21 ^d	17.33 ±0.21 ^{de}	11.42±0.37 ^e
75	0.93 ±0.25 ^e	12.33 ±0.01 ^{ef}	7.63±0.34 ^{ef}
100	0.53 ±0.24 ^e	6.33 ±0.00 ^f	5.17±0.32 ^f

Each value represents Mean ± Standard Error (SE), n=3 readings. Mean± SE with different superscript across the column are considered statistically significant at p< 0.05 Tukey's Honestly Significant Difference (HSD) when compared to the control (0%).

Table 4. Effects of crude leaf extracts of *Mangifera indica* (A) and *Blighia sapida* (B) on the mitotic index and the percent chromosomal aberrations in *A. cepa* root.

A. Mangifera indica

Conc. (%)	TCC	Prophase	Metaphase	Anaphase	Telophase	TD	Mitotic Index	MH (%)
0	500±0.00 ^a	69.33±0.21 ^{ab}	72.33±0.04 ^a	55.33±0.22 ^a	64.67±0.14 ^a	263.00±0.33 ^a	0.72±0.01 ^a	0.00±0.00 ^h
5	500±0.00 ^a	70.33±0.24 ^a	65.00±0.02 ^b	55.00±0.36 ^a	64.33±0.24 ^a	254.00±1.25 ^b	0.51±0.00 ^b	27.23±1.02
10	500±0.00 ^a	67.00±0.36 ^b	54.67±0.02 ^c	51.33±0.01 ^b	60.33±0.11 ^b	233.67±5.36 ^c	0.47±0.01 ^c	32.33±0.55

15	500±0.00 ^a	49.33±0.22 ^c	57.00±0.33 ^c	51.00±0.08 ^b	60.33±0.24 ^b	220.00±4.58 ^d	0.43±0.00 ^d	40.33±1.44
25	500±0.00 ^a	51.00±0.24 ^c	54.67±0.47 ^c	44.00±0.17 ^c	51.00±0.00 ^c	191.67±3.69 ^e	0.36±0.00 ^e	48.33±1.23
50	500±0.00 ^a	41.00±0.33 ^d	37.00±0.15 ^d	43.67±0.14 ^c	46.67±0.24 ^d	171.00±1.24 ^f	0.33±0.00 ^f	54.33±0.25
75	500±0.00 ^a	41.00±0.22 ^d	22.67±0.24 ^e	41.67±0.24 ^c	34.67±0.01 ^e	141.00±1.98 ^g	0.26±0.00 ^g	62.67±0.78
100	500±0.00 ^a	27.33±0.01 ^e	20.67±0.14 ^e	26.67±3.01 ^d	24.67±0.01 ^f	101.67±1.77 ^h	0.19±0.00 ^h	72.00±0.46

B. Blighia sapida

Conc. (%)	TCC	Prophase	Metaphase	Anaphase	Telophase	TD	Mitotic Index	MH (%)
0	500±0.00 ^a	71.33±0.21 ^a	68.33±0.04 ^a	76.33±0.22 ^a	56.67±0.14 ^a	359.00±0.33 ^a	0.72±0.01 ^a	0.00±0.00 ^h
5	500±0.00 ^a	71.33±0.24 ^a	66.00±0.02 ^b	70.00±0.36 ^{ab}	55.33±0.24 ^a	261.00±1.25 ^b	0.54±0.00 ^b	27.30±1.02
10	500±0.00 ^a	67.00±0.36 ^b	63.67±0.02 ^c	52.33±0.01 ^b	52.33±0.11 ^b	234.67±5.36 ^c	0.48±0.01 ^c	34.82±0.55
15	500±0.00 ^a	59.33±0.22 ^c	57.00±0.33 ^d	52.00±0.08 ^b	44.33±0.24 ^{bc}	212.00±4.58 ^d	0.44±0.00 ^d	40.96±1.44
25	500±0.00 ^a	55.00±0.24 ^{cd}	43.67±0.47 ^e	50.00±0.17 ^c	38.00±0.00 ^c	186.67±3.69 ^e	0.38±0.00 ^e	48.19±1.23
50	500±0.00 ^a	50.00±0.33 ^d	32.00±0.15 ^f	43.67±0.14 ^{cd}	38.67±0.24 ^c	163.00±1.24 ^f	0.33±0.00 ^f	54.87±0.25
75	500±0.00 ^a	42.00±0.22 ^{ef}	26.67±0.24 ^g	30.67±0.24 ^d	32.67±0.01 ^d	130.00±1.98 ^g	0.26±0.00 ^g	63.78±0.78
100	500±0.00 ^a	31.33±0.01 ^f	18.67±0.14 ^h	23.67±3.01 ^e	26.67±0.01 ^e	98.67±1.77 ^h	0.20±0.00 ^h	73.00±0.46

Total cells counted (TCC), Total Dividing cells (TD); Mitotic Inhibition (MH). Each value represents Mean ± Standard Error (SE), n=3 readings. Mean ± SE with different superscript across the column are considered statistically significant at p< 0.05 Tukey's Honestly Significant Difference (HSD) when compared to the control (0%).

Table 5. Effects of leaf extract of *Mangifera indica* (A) and *Blighia sapida* (B) on the percent chromosomal aberrations in *A. cepa* root.

<i>A. Mangifera indica</i>									
Conc (%)	MIC	GC	SC	BBC	NL	IC	MN	VA	% AB
0	0.00±0.00 ^d	0.00±0.00 ^b	0.00±0.00 ^d	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^b	0.00±0.00 ^d	0.00
5	0.00±0.00 ^d	0.00±0.00 ^b	0.00±0.00 ^d	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^b	0.00±0.00 ^d	0.00
10	0.00±0.00 ^d	0.00±0.00 ^b	0.00±0.00 ^d	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^b	0.00±0.00 ^d	0.00
15	0.00±0.00 ^d	0.00±0.00 ^b	0.00±0.00 ^d	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^b	0.00±0.00 ^d	0.00
25	0.00±0.00 ^d	0.00±0.00 ^b	0.00±0.00 ^d	0.00±0.00 ^c	8.00±0.55^d	0.00±0.00 ^c	0.00±0.00 ^b	8.00±0.55^c	4.20
50	5.00±0.00^c	0.00±0.00 ^b	4.00±0.24^c	0.00±0.00 ^c	13.12±0.00^c	8.01±0.20^b	0.00±0.00 ^b	30.13±0.56^c	17.54
75	9.07±0.06^b	10.71±0.24^a	6.02±0.01^b	6.00±0.01^b	17.00±0.00^b	11.26±0.00^a	0.00±0.00 ^b	60.06±0.32^b	41.55

100	10.00±	11.01±	13.21	7.01±0	20.00±	0.00±	10.00±	71.63±		
	0.34^a	0.10^a	±0.31	.01^a	0.00^a	0.00 ^c	0.46^a	1.22^a	68.	
			a							93

B. Blighia sapida

C	MIC	VG	GC	SC	BBC	NL	IC	MN	VA	%A
on										B
c										
(										
%										
)										
0	0.00±	0.00±	0.00±	0.00±	0.00±	0.00±	0.00±	0.00±	0.00±	0.9
	0.00 ^e	0.00 ^b	0.00 ^f	0.00 ^e	0.00 ^c	0.00 ^f	0.00 ^d	0.00 ^c	0.00 ^f	9
5	0.00±	0.00±	0.00±	0.00±	0.00±	0.00±	0.00±	0.00±	0.00±	0.0
	0.00 ^c	0.00 ^b	0.00 ^f	0.00 ^e	0.00 ^c	0.00 ^f	0.00 ^d	0.00 ^c	0.00 ^f	0
10	0.00±	0.00±	0.00±	0.00±	0.00±	0.00±	0.00±	0.00±	0.00±	0.0
	0.00 ^c	0.00 ^b	0.00 ^f	0.00 ^e	0.00 ^c	0.00 ^f	0.00 ^d	0.00 ^c	0.00 ^f	0
15	0.00±	0.00±	4.03±	0.00±	0.00±	3.00±	0.00±	0.00±	7.03±	3.3
	0.00 ^c	0.00 ^b	0.20^d	0.00 ^e	0.00 ^c	0.00^e	0.00 ^d	0.00 ^c	0.00^e	0
25	3.10±	0.00±	3.20±	3.00±	0.00±	5.00±	0.00±	0.00±	14.00	7.5
	0.00^d	0.00 ^b	0.40^e	0.00^d	0.00 ^c	0.55^d	0.00 ^d	0.00 ^c	±0.55	3
									d	
50	5.00±	0.00±	8.00±	6.00±	0.00±	8.12±	4.00±	0.00±	31.12	19.
	0.00^c	0.00 ^b	0.00^c	0.24^c	0.00 ^c	0.00^c	0.20^c	0.00 ^c	±0.56	01
									c	
75	8.06±	0.00±	11.00	9.00±	7.00±	12.00	9.06±	7.00±	63.12	48.
	0.06^b	0.00 ^b	±0.00	0.01^b	0.01^b	±0.00	0.00^b	0.00^b	±0.32	46
			b			b			b	

10	12.00	5.02±	13.00	12.00	9.00±	15.00	12.00	9.00±	87.02	88.
0	±0.34	0.10 ^a	±0.10	±0.31	0.01 ^a	±0.00	±0.00	0.46 ^a	±1.22	77
	a		a	a		a	a		a	

Each value represents Mean ± Standard Error (SE), n=3 readings. Mean± SE with different superscript across the column are considered statistically significant at $p < 0.05$ Tukey's Honestly Significant Difference (HSD) when compared to the control (0%). Micronuclei (MIC), Vagrant Chromosome (VA), Giant Chromosome (GC), Stickiness (SC), Vagrant Chromatid (VG); Bleb Chromosome (BBC), Nuclei Lesion (NL), Intertwined Chromosome (IC), Multiuclei (MN). %AB quantifies the proportion of cells showing chromosomal abnormalities or aberrations, and is determined by Percentage Aberrant Cells (%AB)= (Number of Aberrant Cells / Total Number of Cells) × 100

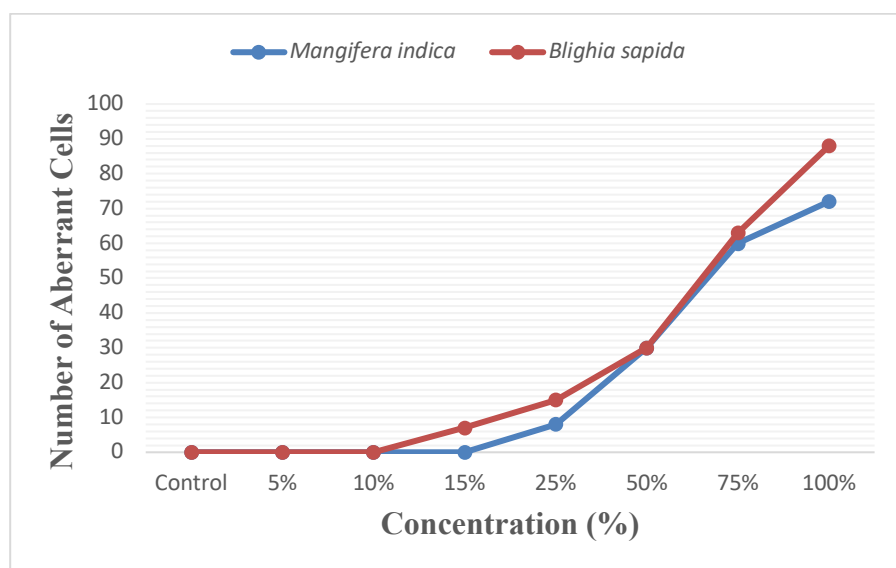


Figure 1. Compared effect of leaf extract of *Mangifera indica* and *Blighia sapida* on total aberrant cells.

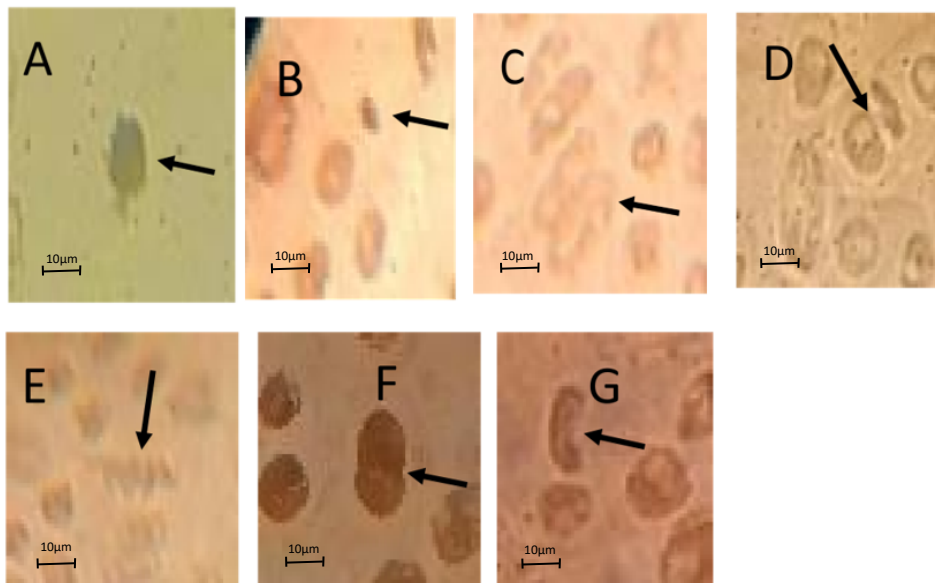


Figure 2: Photomicrograph showing the appearance of chromosomal aberrations [A] Chromosome stickiness [B] Micronuclei [C] Giant Chromosome [D] Blebbed Chromosome [E] Vagrant Chromosome [F] Intertwined Chromosome [G] C-Mitosis

Contributions: Olamilekan Ogunsakin, James Agbolade, conceptualization; Philip Olakunle, Dorcas Owolabi, data curation; Olamilekan Ogunsakin, Tijani Adelani, formal analysis; Olamilekan Ogunsakin, Ayoola Oluwajobi, Benedicta Adewoyin, investigation; Olamilekan Ogunsakin, Dorcas Owolabi, Oluremi Odedeji, methodology; Olamilekan Ogunsakin, software; James Agbolade, Dorcas Owolabi, supervision; Oluremi Odedeji, James Agbolade, Omosalewa Adewoyin, visualization; Olamilekan Ogunsakin, Oluremi Odedeji, James Agbolade, writing – original draft; Olamilekan Ogunsakin, James Agbolade, writing – review & editing.

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