Phytochemical Constituents of Aqueous Leaf Extract of *Morinda Lucida* and Their Potential Antimalarial Relevance

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ABSTRACT

Morinda lucida Benth. is widely used in African traditional medicine for the treatment of malaria and other febrile illnesses. Scientific characterization of its phytochemical constituents is essential to validate its ethnomedicinal use and identify bioactive compounds with potential antimalarial activity. This study qualitatively and quantitatively characterized the phytochemical constituents of the aqueous leaf extract of *M. lucida* and evaluated their relevance to its reported antimalarial properties. Fresh leaves were collected, authenticated, air-dried, pulverized, and extracted by cold maceration using distilled water. Qualitative and quantitative phytochemical analyses were conducted using standard analytical procedures to determine the presence and concentrations of major secondary metabolites. Qualitative screening revealed the presence of alkaloids, flavonoids, phenolics, tannins, saponins, and glycosides, whereas terpenoids, steroids, and anthraquinones were not detected. Quantitative analysis showed that phenolics (21.2 ± 1.1 mg/g dry extract) and flavonoids (18.1 ± 1.2 mg/g dry extract) were the most abundant phytochemical constituents, followed by glycosides (13.5 ± 0.6 mg/g), alkaloids (12.3 ± 0.6 mg/g), saponins (9.3 ± 0.6 mg/g), and tannins (7.2 ± 0.5 mg/g). The high levels of phenolic and flavonoid compounds, together with the presence of other pharmacologically important secondary metabolites, may contribute to the plant's reported antiplasmodial and antioxidant activities. These findings provide scientific evidence supporting the traditional use of *M. lucida* in malaria management and establish the aqueous leaf extract as a promising source of bioactive compounds for further pharmacological evaluation and natural product-based antimalarial drug development. Further studies involving compound isolation, mechanistic investigations, and toxicity assessment are recommended to validate its therapeutic potential.

Keywords: *Morinda lucida*, Phytochemical constituents, Aqueous leaf extract, Antimalarial activity, Medicinal plants.

INTRODUCTION

Malaria remains one of the most significant vector-borne infectious diseases worldwide and continues to constitute a major public health concern despite sustained global control and elimination efforts. According to the World Health Organization (WHO), an estimated 282 million malaria cases and 610,000 malaria-related deaths occurred globally in 2024, representing an increase of approximately 9 million cases compared with 2023. The WHO African Region remains disproportionately affected, accounting for approximately 94% of global malaria cases and 95% of malaria-related deaths, with children under five years of age and pregnant women experiencing the highest risk because of their relatively low immunity and increased susceptibility to severe infection (World Health Organization [WHO], 2025). Beyond its direct health consequences, malaria imposes substantial socioeconomic burdens through increased healthcare costs, reduced labour productivity, school absenteeism, and impaired economic development in endemic countries, particularly across sub-Saharan Africa (Oladipo et al., 2022).

Malaria is caused by protozoan parasites of the genus *Plasmodium*, which are transmitted to humans through the bites of infected female *Anopheles* mosquitoes. Among the five *Plasmodium* species known to infect

humans, *Plasmodium falciparum* is the most virulent and is responsible for the majority of severe malaria cases and malaria-related deaths. Its pathogenicity is associated with complications including severe anaemia, cerebral malaria, metabolic acidosis, acute kidney injury, and multi-organ dysfunction, particularly among vulnerable populations (Tseha, 2021). Although remarkable progress has been achieved through integrated malaria control interventions, including insecticide-treated nets, indoor residual spraying, rapid diagnostic testing, seasonal malaria chemoprevention, and the widespread use of artemisinin-based combination therapies (ACTs), the emergence and spread of resistance to both antimalarial drugs and insecticides continue to undermine these achievements (Belete, 2020; Mlugu, 2023). Reports of delayed parasite clearance associated with partial artemisinin resistance and declining susceptibility to ACT partner drugs have heightened concerns regarding the long-term effectiveness of existing therapies. Consequently, the identification of novel, safe, affordable, and effective antimalarial agents with alternative mechanisms of action remains a global research priority.

Natural products have historically served as invaluable sources of therapeutic agents, particularly in the development of antimalarial drugs. Landmark discoveries such as quinine from *Cinchona* species and artemisinin from *Artemisia annua* demonstrate the immense contribution of medicinal plants to modern malaria chemotherapy (Chaachouay & Zidane, 2024). The World Health Organization estimates that a substantial proportion of the population in developing countries relies on traditional herbal medicine for primary healthcare because of its accessibility, affordability, and cultural acceptance. Consequently, ethnopharmacological knowledge continues to provide an important framework for identifying medicinal plants with promising antiplasmodial properties and potential for drug discovery.

Among the medicinal plants extensively employed in African traditional medicine is *Morinda lucida* Benth. (Rubiaceae), commonly known as the Brimstone tree. The species is widely distributed across tropical West Africa, including Nigeria, Ghana, Benin, Côte d'Ivoire, and Cameroon, where it has long been used in the management of malaria, fever, diabetes mellitus, gastrointestinal disorders, hypertension, microbial infections, and inflammatory diseases (Adewole et al., 2021). In many malaria-endemic rural communities, aqueous leaf decoctions and infusions of *M. lucida* remain among the most frequently prescribed herbal remedies for uncomplicated malaria because of their perceived therapeutic effectiveness, affordability, and widespread availability.

The therapeutic potential of *M. lucida* has been largely attributed to its diverse array of secondary metabolites. Previous phytochemical investigations have identified numerous bioactive constituents, including alkaloids, flavonoids, phenolic compounds, tannins, saponins, glycosides, anthraquinones, and terpenoids (Oladeji et al., 2022). These phytochemicals exhibit a broad spectrum of biological activities, including antioxidant, anti-inflammatory, antimicrobial, immunomodulatory, antipyretic, and antiplasmodial effects. Phenolic compounds and flavonoids possess potent antioxidant properties capable of scavenging reactive oxygen species generated during malaria infection, thereby reducing oxidative stress and tissue damage. Alkaloids have been reported to interfere with parasite metabolism, nucleic acid synthesis, and haem detoxification pathways, whereas terpenoids may inhibit parasite development through disruption of essential biochemical processes. Collectively, these phytochemicals may exert complementary or synergistic effects that contribute to the antimalarial activity of the plant. Therefore, comprehensive qualitative and quantitative phytochemical characterization is essential for understanding the pharmacological basis of the therapeutic efficacy of *M. lucida* and other medicinal plants.

Despite increasing evidence supporting the medicinal value of *M. lucida*, considerable variability in its phytochemical composition has been reported across different studies (Babangida et al., 2021; Gboeloh et al., 2021). Such inconsistencies may arise from variations in geographical origin, climatic conditions, soil composition, seasonal changes, plant maturity, harvesting period, post-harvest processing, extraction solvent, and analytical methodologies. Since the pharmacological activity of medicinal plants depends largely on the nature and concentration of their bioactive constituents, these variations may significantly influence biological activity, therapeutic efficacy, and reproducibility of experimental findings. Consequently, location-specific phytochemical profiling is essential for the standardization, quality assurance, and rational therapeutic application of herbal medicines.

Furthermore, aqueous extraction warrants particular scientific attention because it closely replicates the traditional methods of preparation commonly practiced in malaria-endemic communities. Unlike organic solvent extraction, aqueous extraction reflects the form in which *M. lucida* is most frequently consumed by local populations, thereby enhancing the translational relevance of phytochemical findings to ethnomedicinal practice. Characterizing the phytochemical constituents of aqueous extracts may also facilitate the identification of bioactive compounds suitable for isolation, pharmacological evaluation, quality control, and the development of standardized phytomedicines.

Therefore, this study aimed to qualitatively and quantitatively characterize the phytochemical constituents of the aqueous leaf extract of *Morinda lucida* Benth. The findings are expected to establish a comprehensive phytochemical profile of the plant, provide scientific evidence supporting its traditional use in malaria management, identify bioactive compounds that may contribute to its reported antimalarial activity, and provide a foundation for subsequent pharmacological investigations and the development of novel plant-derived antimalarial therapeutics.

METHODOLOGY

This laboratory-based experimental study was conducted to qualitatively and quantitatively characterize the phytochemical constituents of the aqueous leaf extract of *Morinda lucida* Benth. All laboratory procedures, including aqueous extraction and qualitative and quantitative phytochemical analyses, were carried out in the Biology Laboratory, Department of Biology, School of Biological Sciences, Federal University of Technology, Owerri, Imo State, Nigeria.

Fresh leaves of *Morinda lucida* Benth. were collected from mature, healthy plants within the premises of the Federal University of Technology, Owerri (FUTO), Imo State, southeastern Nigeria, in December 2025. Diseased, insect-infested, and mechanically damaged leaves were excluded to ensure the quality and integrity of the plant material. The plant was identified and authenticated by Prof. C. M. Duru, Plant Taxonomist, Department of Biology, School of Biological Sciences, Federal University of Technology, Owerri, Imo State, Nigeria. A voucher specimen (No. FUTO-B-4736) was prepared and deposited in the departmental herbarium for future reference.

The collected leaves were thoroughly washed under running tap water and rinsed with distilled water to remove adhering dust and debris. The leaves were shade-dried under ambient laboratory conditions (25–28 °C) for 10–14 days until a constant weight was attained to preserve thermolabile phytochemicals. The dried leaves were pulverized into a fine powder using an electric laboratory grinder and stored in airtight containers at room temperature until extraction.

The aqueous leaf extract was prepared by cold maceration. A total of 500 g of the powdered leaf material was macerated in 2.5 L of distilled water (1:5, w/v) for 72 h at room temperature with intermittent agitation to facilitate the extraction of water-soluble phytochemicals. The resulting mixture was filtered sequentially through sterile muslin cloth and Whatman No. 1 filter paper to remove particulate matter. The filtrate was concentrated under reduced pressure using a rotary evaporator maintained at a temperature not exceeding 40 °C to minimize thermal degradation of heat-sensitive constituents. The concentrated extract was further dried to obtain a semi-solid crude extract, transferred into sterile amber-coloured bottles, and stored at 4 °C until phytochemical analysis.

The percentage extraction yield was calculated using the equation:

$$\text{Extraction Yield (\%)} = \frac{\text{Weight of dried extract}}{\text{Weight of powdered plant material}} \times 100$$

The aqueous extraction yielded 10.0% (w/w) of crude extract.

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Qualitative phytochemical screening of the aqueous leaf extract of *M. lucida* was carried out using standard procedures described by Harborne (1998), Trease and Evans (2009), and Oladeji et al. (2022). The extract was screened for the presence or absence of major classes of secondary metabolites, including alkaloids, flavonoids, phenolic compounds, tannins, saponins, glycosides, terpenoids, steroids, and anthraquinones.

Alkaloids were detected using Dragendorff's and Mayer's reagents, flavonoids by the alkaline reagent and lead acetate tests, phenolic compounds and tannins using ferric chloride reagent, saponins by the frothing test, glycosides by Keller–Killiani's test, terpenoids by Salkowski's test, steroids by the Liebermann–Burchard reaction, and anthraquinones by Bornträger's test. The presence or absence of each phytochemical constituent was recorded based on the characteristic colour changes or precipitate formation described in the referenced methods.

Quantitative estimation of the detected phytochemical constituents was carried out according to the methods described by Harborne (1998), Trease and Evans (2009), and Oladeji et al. (2022). The concentrations of alkaloids, flavonoids, total phenolic compounds, tannins, and saponins were determined using standard analytical procedures, while the concentrations of individual phytochemicals were expressed as milligrams per gram (mg/g) of dry extract.

All qualitative and quantitative phytochemical analyses were performed in triplicate using standardized protocols adapted from previously validated methods. Laboratory instruments were calibrated according to the manufacturers' specifications before each analytical procedure, and analytical-grade reagents were used throughout the study to ensure analytical accuracy and reliability. Quantitative phytochemical data were expressed as mean ± standard deviation (SD). Statistical analyses were conducted using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). As the study was designed for descriptive phytochemical characterization rather than inferential hypothesis testing, the results were summarized using descriptive statistics only.

RESULT

Table 1. Qualitative phytochemical constituents of the aqueous leaf extract of *Morinda lucida* Benth

Phytochemical constituent	Result
Alkaloids	++
Flavonoids	+++
Saponins	+
Tannins	+
Phenolics	+++
Glycosides	++
Terpenoids	−
Steroids	−
Anthraquinones	−

Key: +++ = strongly present; ++ = moderately present; + = slightly present; − = not detected.

Table 1 shows the qualitative phytochemical constituents of the aqueous leaf extract of *Morinda lucida* Benth. The extract contained alkaloids, flavonoids, saponins, tannins, phenolic compounds, and glycosides, whereas

terpenoids, steroids, and anthraquinones were not detected. Flavonoids and phenolic compounds exhibited strong presence (+++), while alkaloids and glycosides were moderately present (++). Saponins and tannins were detected in low amounts (+).

Figure 1. **Quantitative phytochemical constituents of the aqueous leaf extract of *Morinda lucida* Benth. Values are expressed as** mean ± SD (n = 3)**.**

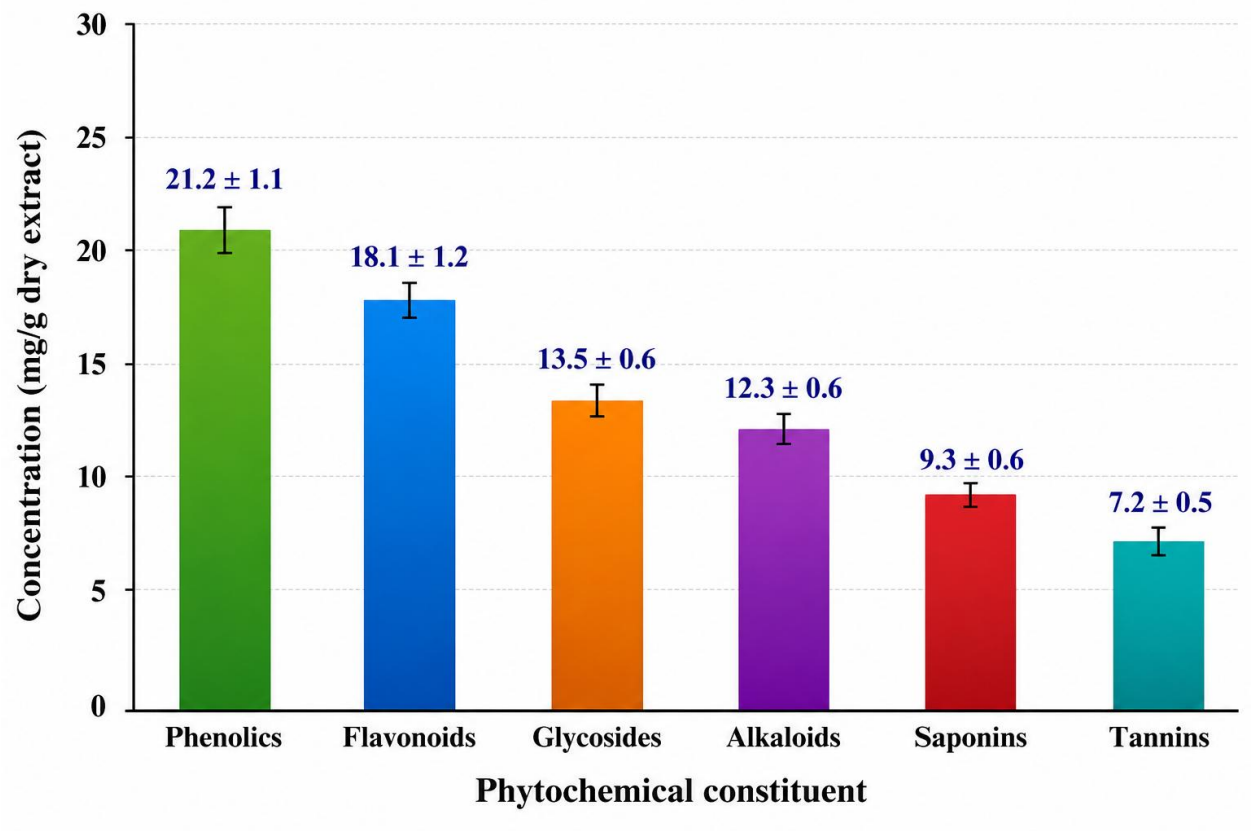

Figure 1 shows the quantitative phytochemical constituents of the aqueous leaf extract of *Morinda lucida* Benth. Phenolic compounds were present at the highest concentration (21.2 ± 1.1 mg/g dry extract), followed by flavonoids (18.1 ± 1.2 mg/g dry extract). Glycosides and alkaloids were detected at concentrations of 13.5 ± 0.6 mg/g and 12.3 ± 0.6 mg/g dry extract, respectively. Saponins (9.3 ± 0.6 mg/g dry extract) and tannins (7.2 ± 0.5 mg/g dry extract) were present at lower concentrations, with tannins being the least abundant phytochemical constituent quantified.

DISCUSSION

The phytochemical profile obtained in the present study demonstrates that the aqueous leaf extract of *Morinda lucida* is a rich source of bioactive secondary metabolites, particularly phenolic compounds and flavonoids. These phytochemicals were detected alongside alkaloids, glycosides, saponins, and tannins, indicating that the aqueous extract contains multiple classes of compounds associated with diverse biological activities. Previous studies have similarly identified *M. lucida* as a reservoir of polyphenols and other pharmacologically important secondary metabolites, supporting its widespread use in African traditional medicine for the management of malaria and other infectious diseases (Babangida et al., 2021; Gboeloh et al., 2021).

The predominance of phenolic compounds and flavonoids observed in the present study can be attributed primarily to the extraction efficiency of water. Because water is a highly polar solvent, it preferentially dissolves hydroxyl-rich polyphenolic compounds, resulting in greater extraction of phenolics and flavonoids than relatively non-polar phytochemicals (Oladeji et al., 2022). Akande et al. (2022) similarly reported appreciable concentrations of phenolic compounds and flavonoids in aqueous extracts of *M. lucida*, demonstrating the suitability of aqueous extraction for recovering these phytochemicals. Variations in phytochemical composition reported among different studies are expected because secondary metabolite

production is influenced by geographical location, climatic conditions, soil characteristics, seasonal variation, plant age, harvesting period, drying methods, extraction techniques, solvent polarity, and analytical procedures. Genetic variability among plant populations may further contribute to differences in phytochemical accumulation.

Phenolic compounds constituted the dominant phytochemical group in the present study, while flavonoids were the second most abundant constituents. The predominance of these polyphenolic compounds is pharmacologically important because both groups possess well-documented antioxidant, anti-inflammatory, antimicrobial, and antiplasmodial properties (Oladeji et al., 2022; Akande et al., 2022). During malaria infection, excessive generation of reactive oxygen species contributes to oxidative stress, erythrocyte destruction, lipid peroxidation, and tissue injury. Phenolic compounds counteract these pathological processes through free radical scavenging, hydrogen atom donation, metal ion chelation, and inhibition of oxidative chain reactions, thereby reducing oxidative damage to host tissues. Flavonoids complement these protective effects by interfering with multiple biochemical pathways required for *Plasmodium* survival, including inhibition of nucleic acid synthesis, disruption of mitochondrial function, interference with fatty acid biosynthesis, inhibition of heme detoxification, and modulation of parasite-specific enzymes. The abundance of phenolic compounds and flavonoids in the aqueous extract therefore provides a plausible phytochemical explanation for the traditional use of *M. lucida* in malaria management.

In addition to polyphenolic compounds, the aqueous extract contained appreciable quantities of alkaloids, glycosides, saponins, and tannins. Although these phytochemicals occurred at lower concentrations than phenolics and flavonoids, they remain important contributors to the biological activity of medicinal plants. Plant alkaloids have long been recognized as valuable antimalarial agents, with quinine representing one of the earliest successful examples of plant-derived antimalarial drugs. Alkaloids inhibit parasite development through disruption of DNA replication, protein synthesis, metabolic pathways, and heme detoxification. Glycosides have been associated with antioxidant, antimicrobial, immunomodulatory, and cytoprotective activities that may strengthen host defence during infection. Saponins possess membrane-modifying and immunostimulatory properties and may improve the bioavailability of coexisting phytochemicals, whereas tannins inhibit microbial and parasitic growth through enzyme inhibition, protein precipitation, and disruption of essential metabolic processes. Babangida et al. (2021) and Gboeloh et al. (2021) similarly identified these phytochemical classes in *M. lucida*, emphasizing their contribution to the medicinal value of the plant. Collectively, these constituents may act synergistically to enhance the overall pharmacological activity of the extract.

Terpenoids, steroids, and anthraquinones were not detected in the aqueous leaf extract. Their absence should be interpreted cautiously because qualitative phytochemical composition is strongly influenced by solvent polarity and extraction methodology. Water generally exhibits lower extraction efficiency for relatively non-polar constituents, including many terpenoids and steroidal compounds, which are more readily extracted using organic solvents such as ethanol, methanol, acetone, or chloroform (Oladeji et al., 2022). Consequently, the absence of these phytochemicals in the present study most likely reflects solvent selectivity rather than their complete absence in *M. lucida*. Comparative studies employing solvents of different polarities would provide a broader understanding of the phytochemical diversity of the plant.

The coexistence of phenolics, flavonoids, alkaloids, glycosides, saponins, and tannins suggests that the medicinal potential of *Morinda lucida* is unlikely to depend on a single bioactive constituent. The pharmacological activities of medicinal plants often result from synergistic interactions among multiple phytochemicals acting through complementary mechanisms. Such interactions have been reported to enhance antioxidant activity, inhibit parasite development, modulate host immune responses, and improve overall therapeutic efficacy. However, these mechanisms were not investigated in the present study and therefore remain speculative with respect to the aqueous leaf extract of *M. lucida*. Consequently, the phytochemical profile established in this study provides chemical support for the traditional use of *M. lucida* in malaria management but should not be interpreted as direct evidence of antimalarial efficacy. Confirmation of these pharmacological properties requires complementary investigations, including bioactivity-guided fractionation, isolation and structural characterization of active constituents, in vitro and in vivo antiplasmodial evaluation,

comprehensive toxicity assessment, and mechanistic studies to elucidate the biological pathways underlying the observed medicinal potential.

The present study was limited to the qualitative and quantitative phytochemical characterization of the aqueous leaf extract of *Morinda lucida* and did not include direct evaluation of its antiplasmodial or other biological activities. Consequently, the findings establish the phytochemical composition of the extract but do not independently demonstrate its biological activity against malaria parasites. Furthermore, plant materials were collected from a single geographical location during one harvesting period; therefore, possible geographical and seasonal variations in phytochemical composition were not assessed. Although standardized analytical procedures were employed, advanced chromatographic profiling and analytical method validation parameters, including limits of detection (LOD), limits of quantification (LOQ), accuracy, precision, and method robustness, were beyond the scope of the present investigation.

Despite these limitations, the present study provides a comprehensive phytochemical baseline for the aqueous leaf extract of *Morinda lucida*. The predominance of phenolic and flavonoid compounds, together with the presence of other bioactive phytochemicals, contributes to the scientific understanding of the chemical composition of this medicinal plant and supports its continued investigation as a potential source of plant-derived therapeutic agents. The findings provide a robust foundation for future pharmacological, toxicological, and mechanistic studies aimed at identifying the specific bioactive constituents responsible for the reported medicinal properties of *M. lucida* and establishing their therapeutic relevance through rigorous biological validation.

CONCLUSION

The aqueous leaf extract of *Morinda lucida* contains diverse phytochemicals, with phenolic compounds and flavonoids occurring in the highest concentrations, alongside appreciable amounts of alkaloids, saponins, tannins, terpenoids, glycosides, and anthraquinones. These bioactive constituents provide scientific support for the widespread traditional use of the plant in malaria management and other oxidative stress-related conditions. Although the phytochemical composition indicates promising pharmacological potential, the present findings should not be interpreted as direct evidence of antimalarial efficacy. Rather, this study establishes a comprehensive phytochemical foundation for subsequent pharmacological, toxicological, and mechanistic investigations. Overall, the findings contribute valuable baseline data that may facilitate future drug discovery and the scientific validation of *Morinda lucida* as a medicinal plant.

RECOMMENDATIONS

Future investigations should focus on:

Isolation, purification, and structural characterization of the major bioactive constituents responsible for the phytochemical profile of *Morinda lucida*.

Bioactivity-guided fractionation to identify and characterize the specific compounds responsible for the plant's antiplasmodial activity.

In vitro antiplasmodial evaluation against *Plasmodium falciparum*, including determination of inhibitory concentrations (IC_{50}) and assessment against both drug-sensitive and drug-resistant parasite strains where feasible.

Cytotoxicity and safety evaluation using appropriate mammalian cell lines to determine the selectivity index (SI) and establish the therapeutic window of the active fractions or isolated compounds.

In vivo pharmacological and toxicological studies to confirm efficacy, establish dose–response relationships, and evaluate acute and sub-chronic safety profiles.

Mechanistic investigations to elucidate the molecular targets and pathways underlying the observed pharmacological activities.

Advanced metabolite profiling and chemical fingerprinting using chromatographic and spectroscopic techniques such as HPLC, LC–MS/MS, GC–MS, and NMR to facilitate compound identification, quality control, and standardization.

Evaluation of seasonal, geographical, and environmental variations in phytochemical composition to support consistency, reproducibility, and sustainable utilization of *Morinda lucida*.

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