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Evaluation of Plant-Based Extracts for the Control of *Anopheles gambiae* Mosquitoes under Laboratory Conditions

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Abstract *Anopheles gambiae* is one of the principal vectors of malaria and remains a major target in mosquito control programs. However, the widespread development of insecticide resistance has reduced the effectiveness of conventional chemical interventions, creating an urgent need for alternative control agents. This review summarizes laboratory-based evaluations of plant extracts for the control of *A. gambiae*, with emphasis on their larvicidal, adulticidal, and repellent activities. It also examines the chemical composition of these extracts, including the identification of major bioactive compounds, and discusses their possible mechanisms of action at physiological, enzymatic, and cellular levels. In addition, the review considers safety issues, such as toxicity to non-target organisms and environmental persistence, and compares plant-derived products with synthetic insecticides. Overall, plant extracts show considerable promise as eco-friendly and sustainable tools for mosquito management, although further studies are needed to standardize formulations and validate their field efficacy.

Keywords *Anopheles gambiae*; Plant extracts; Mosquito control; Larvicidal activity; Insecticide resistance

1 Introduction

Anopheles gambiae mosquitoes are the primary vectors responsible for malaria transmission in sub-Saharan Africa, where the disease remains a major public health challenge. Their capacity to transmit Plasmodium parasites is influenced by factors such as their abundance, biting behavior, and longevity, which enable effective parasite development and spread among human populations. Understanding the biology and ecology of *An. gambiae* is crucial for developing targeted interventions to reduce malaria incidence, as these mosquitoes predominantly feed indoors at night and breed in aquatic habitats, making them accessible to control measures (Takken et al., 2024; Simoni et al., 2025).

Current mosquito control strategies largely rely on synthetic insecticides applied through insecticide-treated nets (ITNs) and indoor residual spraying (IRS). While these methods have significantly reduced malaria burden, their effectiveness is increasingly compromised by the rapid emergence of insecticide resistance in *An. gambiae* populations, as well as behavioral adaptations that reduce mosquito contact with treated surfaces. Additionally, concerns about environmental toxicity and sustainability highlight the limitations of chemical-based approaches, necessitating alternative or complementary vector control tools that can overcome resistance and minimize ecological impact (Paton et al., 2022; Simoni et al., 2025).

Plant-based extracts have gained attention as promising alternative agents for controlling *An. gambiae* due to their eco-friendly nature and diverse bioactive compounds with repellent, larvicidal, and adulticidal properties. Various studies have demonstrated that essential oils and phytochemicals from plants such as *Croton macrostachyus*, *Cymbopogon* species, *Azadirachta indica*, and *Ocimum* spp. exhibit significant efficacy against different life stages of *An. gambiae* under laboratory conditions. These natural products offer potential advantages including reduced risk of resistance development and lower environmental toxicity, positioning them as valuable candidates for integrated malaria vector management strategies (Lamuntani et al., 2025; Tadesse et al., 2025).