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IN-VITRO AND IN-VIVO EVALUATION OF *Adansonia digitata* AND *Azadirachta indica* WOOD ASH AS NATURAL REPELLENTS AND ACARICIDES AGAINST LICE INFESTATION IN POULTRY FARMS IN KADUNA

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ABSTRACT

Poultry production supports food security and economic growth, yet infestations by wing lice (*Lipeurus caponis*) and chicken body louse (*Menacanthus stramineus*) threaten productivity. Synthetic insecticides/acaricides raise safety concerns, prompting the search for eco-friendly alternatives. The study evaluated the acaricidal (insecticidal) and repellency efficacy of wood ash from *Adansonia digitata* (baobab) and *Azadirachta indica* (neem) against poultry lice collected in a selected poultry farm located in Kaduna metropolis, Kaduna state Nigeria. The selected stem-barks of the trees were collected, authenticated, vouchered and processed to wood-ash at the Department of Biological Sciences, Kaduna State University; Geochemical analysis assessed metal content and pH (9.01–10.75). In-vitro repellency and kill-time assays (0.25–1.0 g/cm³) used 20–25 lice per trial, while in-vivo assays and hematological evaluations (50–150 g/kg) determined physiological effects. *A. digitata* (baobab) showed higher repellency (84.4% at 0.25 g/cm^2) and faster mortality (40 min at 1.0 g/cm³) than *A. indica*. Acaricidal / Insecticidal bioassay reveals *A. digitata* (1.0 g/cm²) achieved 93.3% mortality by 48 hours, while *A. indica*. (neem) reached 78.3%. Wood ashes, particularly from *A. digitata*, offer eco-safe, effective alternatives for sustainable poultry lice management.

Keywords: *Adansonia digitata, Azadirachta indica,* Wood-Ash, Poultry Lice, Eco-Acaricide

INTRODUCTION

Poultry production represents a fundamental pillar in ensuring food security and bolstering economic stability across numerous developing countries (Bello *et al*., 2024). It plays a critical role in supplying high-quality animal protein in the form of meat and eggs, while simultaneously offering a dependable and sustainable source of livelihood for smallholder farmers, especially those residing in rural and peri-urban areas (Ifabiyi *et al*., 2024). Among livestock species, chickens are frequently the initial choice for farmers due to their relatively low input requirements, ease of management, and remarkable adaptability to a wide range of environmental and climatic conditions. However, despite its socio-economic and nutritional significance, the poultry sector is beset by a multitude of constraints, with ectoparasitic infestations ranking among the most damaging and persistent challenges (Bamidele *et al*., 2020; Peter *et al*., 2022).

There are two common chicken lice that are common in Nigeria; especially northern Nigeria which are *Lipeurus caponis* (wing louse) and *Menacanthus stramineus* (chicken body louse). They are ectoparasites of poultry, but they differ in location on the bird's body, feeding behavior, and impact (Mohammed *et al.,* 2021). A particularly prevalent and deleterious ectoparasite afflicting domestic poultry generally is the chicken body louse, scientifically identified as *Menacanthus stramineus* (Opeyemi *et al*., 2021). These ectoparasites are obligate hematophages, deriving sustenance by feeding on the blood and tissue exudates of their avian hosts. They predominantly inhabit the skin surface and feather shafts, where they inflict considerable irritation and discomfort. The infestation leads to extensive feather degradation, heightened physiological stress, and behavioral disturbances, all of which collectively impair feed conversion efficiency, suppress egg-laying capacity, and retard overall growth performance. Moreover, the structural compromise of plumage integrity renders affected birds more vulnerable to opportunistic pathogens, thereby increasing the risk of secondary infections and compounding health-related complications, ultimately resulting in a marked decline in flock productivity and economic returns (Abubakar and Aliyu, 2024). Recently, in Kaduna, a market-based study involving 250 chickens examined in Kaduna metropolis reported an overall ectoparasite prevalence of 54.0%. *Menacanthus stramineus* was the most frequently encountered ectoparasite, present in 18.4% of all birds examined and accounting for 34.1% of ectoparasite infestations (Jibril *et al.*, 2025). Also, a local surveillance in Tarauni LGA (Kano State) sampled chickens from markets and farms and reported multiple lice species with 61.70% of birds infested with *M. stramineus* being the dominant species. Thus, underlining its wide occurrence across North-West Nigeria and the need for targeted control at the LGA level (Shah, 2021).

In efforts to mitigate the adverse impacts of ectoparasitic infestations in poultry production systems, farmers have historically depended on the application of synthetic chemical insecticides, notably those belonging to the organophosphate, carbamate, and pyrethroid classes (Natala and Ochoje, 2009; Da-Silva Soares *et al.*, 2020). These chemical agents are typically administered through topical application or formulated into dusting powders and aerosol sprays for direct use on birds and their housing environments. Although these compounds have demonstrated considerable efficacy in the immediate suppression of ectoparasite populations, their prolonged and repeated use has revealed a series of significant limitations and unintended consequences. Foremost among these concerns is the emergence of resistance within parasite populations, a phenomenon driven by genetic selection and adaptive mechanisms that render the pests increasingly unresponsive to standard treatment regimens (Oyeniyi *et al.*, 2024; Pumnuan *et al.*, 2024). This resistance not only compromises the effectiveness of existing insecticidal protocols but also necessitates the deployment of higher concentrations or alternative chemical formulations, thereby escalating both the financial and ecological costs of pest control (Martínez-García *et al.*, 2022).

In addition to resistance, the use of chemical insecticides (acaricide) introduces substantial health risks to both poultry and humans. Misapplication, excessive dosing, or lack of protective measures during handling can result in acute or chronic toxicity in birds, farm workers, and even end consumers through contaminated meat or eggs (Adekunle *et al*., 2017; Ekundayo, 2022; Amuda-Kannike, 2023). Furthermore, residual traces of these chemicals can leach into surrounding soil and water bodies, leading to bioaccumulation in non-target organisms and contributing to broader environmental degradation. This ecological impact is particularly pronounced in regions where regulatory frameworks are weak or poorly enforced, increasing the likelihood of misuse, accidental exposure, and poisoning incidents (Obidike *et al*., 2020).

Economic constraints also play a pivotal role in limiting the accessibility and sustainability of chemical acaricide/insecticide use. Commercially available insecticidal products are often prohibitively expensive for smallholder farmers, especially those operating in remote or underserved areas with limited market access and financial resources (Ivase *et al*., 2017; Anaduaka *et al*., 2023). As a result, many producers are compelled to seek alternative pest control strategies that are both cost-effective and environmentally benign. In light of these challenges, there has been a growing interest among researchers, agricultural extension agents, and rural communities in the revival and scientific validation of traditional pest management practices (Martínez-García *et al.*, 2022). One such practice is the utilization of wood ash—a residual byproduct of biomass combustion—which has been employed for generations in indigenous settings for its multifaceted utility (Fontem and Edison, 2018). Wood ash is abundantly available, economically viable, and has historically served diverse functions, including household cleaning, soil pH regulation, and the deterrence of insect pests. Its alkaline nature and abrasive texture make it a promising candidate for ectoparasite control, offering a low-risk, locally sourced alternative to synthetic chemicals (Bang-Andreasen *et al*., 2017).

The pesticidal/acaricidal properties of wood ash are attributed to its chemical composition and physical characteristics. It is highly alkaline, with a pH often exceeding 10, which creates an inhospitable environment for many parasites and pathogens. Additionally, wood ash contains trace elements such as calcium, potassium, magnesium, and zinc, which may contribute to its antimicrobial and insecticidal effects (Akter & Amin, 2017; Ibrahim *et al*., 2019a). The fine particulate nature of ash allows it to adhere to the skin and feathers of birds, potentially disrupting the respiratory and reproductive systems of ectoparasites. Although anecdotal evidence supports the use of wood ash for pest control, systematic scientific studies on its efficacy against poultry ectoparasites remain limited (Sileshi *et al*., 2009; Okutu *et al*., 2013). Farmers in various regions have reported reduced parasite loads and improved bird health following the use of ash, but these observations have yet to be validated through controlled experiments (Ibrahim *et al*., 2019a). Field trials involving different breeds of chickens, varying levels of infestation, and diverse climatic conditions would provide valuable insights into the practical applicability of wood ash. Laboratory analyses could help elucidate the biochemical interactions between ash components and ectoparasite physiology, shedding light on the mechanisms of action. Moreover, interdisciplinary research involving veterinarians, entomologists, chemists, and rural development experts could facilitate the development of integrated pest management strategies that incorporate wood ash alongside other natural remedies (Mazarin *et al*., 2016)

Wood ash, with its unique chemical and physical properties, offers a promising avenue for natural pest control (Maphumulo *et al*., 2023). Its traditional use in rural communities, combined with emerging scientific interest, underscores the need for systematic research to validate its efficacy and safety (Martinez-Garcia *et al*., 2022). By integrating wood ash into sustainable poultry management practices, farmers can reduce costs, protect the environment, and improve the health and productivity of their flocks (Chuku & Chuku, 2016; Muhammad & Kashere; 2021). As global demand for safe, affordable, and environmentally friendly agricultural practices continues to grow, innovations rooted in traditional knowledge, such as the use of wood ash, deserve renewed attention and investment (Wahedi *et al*., 2017). Through collaborative efforts and evidence-based approaches, it is possible to harness the full potential of this humble material and contribute to the advancement of poultry farming in resource-limited settings. This study compared the physicochemical properties, repellent effects, and insecticidal activity of *Azadirachta indica* (neem) and *Adansonia digitata* (baobab) wood ashes against chicken feather lice.

MATERIALS AND METHODS

Study Area and Plant Material Processing

The study was conducted at Kaduna State University and Udoye Agro Farms Ltd., Sabon-Tasha, Kaduna State, Nigeria. The study aimed at evaluating the acaricidal (insecticidal) and repellency efficacy of wood ash from *Adansonia digitata* (baobab) and *Azadirachta indica* (neem) against poultry lice collected in a selected poultry farm located in Kaduna metropolis. Stem bark of *A. digitata* and *A. indica* were collected from the Forest Reserve of Ahmadu Bello University, Zaria, authenticated (voucher numbers KASU/BSH/942 and KASU/BSH/1213), air-dried under room temperature of 25°C to 27°C on botanical work-bench within the botanical laboratory of Department of biological Sciences, Kaduna State University to constant weight, and combusted under controlled laboratory conditions to obtain ash. The ash was sieved through a 0.4-mm mesh and stored at 4°C in sealed jars to prevent moisture absorption (Mazarin *et al*., 2016).

Geochemical Analysis

Ash samples were analyzed for pH and electrical conductivity by dissolving 20 g in 100 ml distilled water and homogenizing for 30 minutes. Measurements were taken using a calibrated pH meter. Trace metals (Ba, Ni, Co, Cs, Ga, Sr, Mo, Cu, Pb, Zn) were quantified via atomic absorption spectrophotometry after solubilization in aqua regia (1/3 HNO_3 + 2/3 HCl) at 150°C (Ajavon *et al*., 2024).

Lice Collection and Identification

Adult *Lipeurus caponis* (wing louse) and *Menacanthus stramineus* (body lice) were collected from infested chickens at Udoye Agro Farms using a soft brush and transferred to Petri dishes containing feathers and skin scrapings. Identification was performed using light microscopy with permanent mounts in Canada balsam (Lawal *et al*., 2017; Opeyemi *et al*., 2021).

Acaricidal Experimental / Research Design

In vitro assays were conducted to evaluate the repellent and insecticidal properties of wood ash from *Adansonia digitata* and *Azadirachta indica* against chicken feather lice. Repellent activity was assessed using filter paper bioassays, where ash was applied to half of a Petri dish and lice distribution after 4 hours was recorded to calculate percent repellency. Insecticidal activity was determined through contact toxicity assays in Petri dishes treated with varying ash concentrations (0.25–1.0 g), with lice mortality monitored at intervals up to 48 hours. Negative controls without ash were included, and all treatments were replicated to ensure reproducibility. This design allowed for systematic evaluation of both behavioral avoidance and lethal effects of the wood ash under controlled laboratory conditions.

Repellent Bioassay

Repellency was tested (invitro) using 8.5 cm Petri dishes lined with Whatman filter paper split into two halves. Ash was applied at 0.25, 0.5, and 1.0 g/cm^2 to one half. Twenty to twenty-five adult lice were released at the center, and after 4 hours in darkness, lice distribution was recorded. Percent repellency (PR) was calculated as PR = 100 × (C - T) / C, where C and T are the number of lice in untreated and treated halves, respectively (Chaubey, 2021). Three replicates were performed per concentration.

Acaricidal Bioassay

Acaricidal/insecticidal activity was assessed (in-Vivo) in 13.5 cm Petri dishes with ash applied at 0.25, 0.5, and 1.0 g/cm^2. Twenty to twenty-five adult lice were released per dish and incubated at room temperature (25 - 28°^{c}). Mortality was recorded at 20-minute intervals for 1 hour, then at 2, 4, 24, and 48 hours. Lice unresponsive to stimulation were considered dead. Controls used clean dishes with feathers and skin scrapings (Bohinc *et al*., 2018; Lakyat *et al*., 2024).

Data Analysis

Repellency and mortality data were expressed as mean ± SD, with LC_{50} and LC_{90} determined by probit analysis.
Differences were analyzed using one-way ANOVA, with significance set at $p < 0.05$.

RESULTS AND DISCUSSION

Yield of Wood Ash

These results confirm the presence of bioactive elements and high alkalinity, both of which are known to affect parasite physiology. *Azadirachta indica* had a higher yield of ash than *A. digitata*. The yield of *Azadirachta indica* was 26.8% as 2050g of the dried stem bark yielded 549g of ash. The dried stem bark of *A. digitata* (1480g) produced 286g of wood ash, thus giving a percentage yield of 19.3% (Table 1).

Table 1: Percentage Yield of Wood Ash from Stem Barks of *Azadirachta indica* and *A. digitata*

Name of plant	Weight of dried stem bark (g)	Weight of ash (g)	Percent yield (%)
Azadirachta indica	2050	549	26.8
Adansonia digitata	1480	286	19.3

Repellency and Trace Metal Profiles of Wood Ash.

Repellency was concentration-dependent for both species. Baobab ash showed strong repellency even at the lowest concentration (84.4% at 0.25 g/cm^2), while neem showed no repellency at that level, LC_{50} and LC_{90} values were lower for baobab, indicating higher potency (Figure 1). Geochemical analysis showed *Azadirachta indica* ash had a higher pH (10.75) than *Adansonia digitata* (9.01), with similar electrical conductivity (1.565 and 1.562 for *Azadirachta indica* and *Adansonia digitata*, respectively). *A. indica* ash contained higher copper, iron, manganese, and nickel levels (Figure 1).

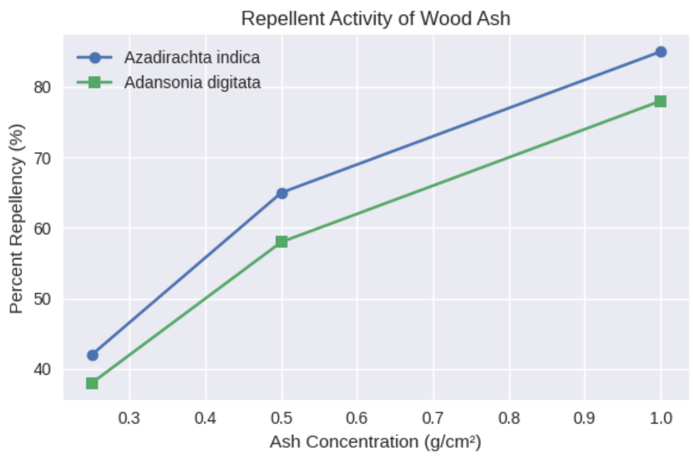

Figure 1: *In vitro* Repellent Effects of *Adansonia digitata* (Baobab) and *Azadirachta indica* (Neem) Wood Ash against Chicken Feather Lice

Acaricidal Activity of *Adansonia digitata* (Baobab) and *Azadirachta indica* (Neem) in Time

Baobab ash caused faster and higher mortality than neem ash. At 1.0 g/cm², baobab achieved 93.3% mortality by 48 hours, while neem reached 78.3%. Baobab showed early mortality (38.3% at 60 min), while neem showed negligible effects until 2 hours. LC_{50} and LC_{90} values again favored baobab, confirming its superior insecticidal potency (Figure 2). LC_{50} and LC_{90} values confirmed greater potency of baobab (0.232 and 0.612 g/cm^2, respectively) compared to neem (0.588 and 0.974 g/cm^2).

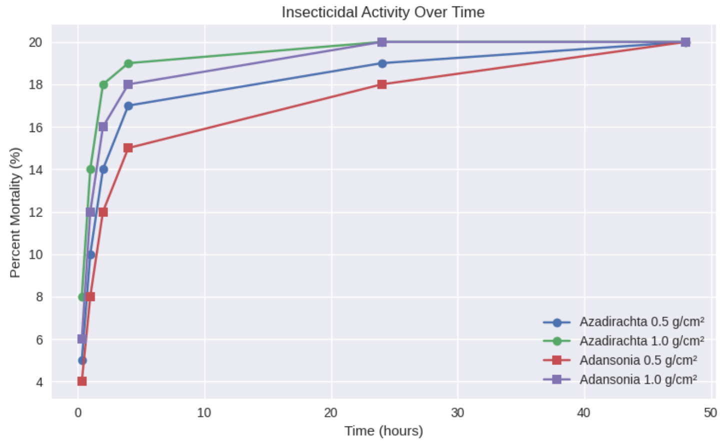

Figure 2: Percentage Mortality Insecticidal Activities of the Two Wood-ash against Chicken Feather Lice at Different Concentrations with Time

Discussion

The geochemical composition of wood ash derived from *Adansonia digitata* (baobab) and *Azadirachta indica* (neem) trees reveals promising potential for their use as natural pest control agents in poultry farming. These ashes, rich in mineral constituents and characterized by distinct pH profiles, offer an eco-friendly alternative to synthetic insecticides, particularly in resource-constrained rural settings across Africa (Martínez-García *et al.,* 2022). The pH values of the two ashes for *A. indica* (10.75) and for *A. digitate* (9.01) highlight a significant difference in alkalinity, which plays a crucial role in their bioactivity. This observation aligns with findings by Bang-Andreasen *et al*. (2017), who emphasized that the alkalinity of wood ash, primarily driven by the presence of oxides and hydroxides, enhances its pesticidal properties. Alkaline conditions are known to disrupt the structural integrity of insect exoskeletons and interfere with their chemical signaling pathways, thereby contributing to both repellent and insecticidal effects (Gao *et al*., 2020). The higher pH of *A. indica* ash suggests a greater potential for metal solubility, which may amplify its toxicity against ectoparasites. Manan and Abdullah (2020) reported that increased alkalinity facilitates the release of trace metals, thereby enhancing the bioavailability of toxic elements. However, the relatively lower pH of *A. digitata* did not compromise its efficacy, indicating that other factors such as unique phytochemicals, synergistic interactions among trace elements, or ash particle morphology may contribute to its potent bioactivity.

Trace metal analysis further supports the pesticidal potential of these ashes. *A. indica* ash exhibited higher concentrations of copper, iron, manganese, and nickel, elements known for their toxic effects on insect physiology. Deighton et al. (2021) documented similar metal profiles in wood ash, reinforcing its role as a natural pest deterrent. Copper, in particular, has been widely recognized for its ability to disrupt enzymatic functions and cellular respiration in ectoparasites (Khan *et al*., 2020). Iron and manganese contribute to oxidative stress within insect systems, impairing metabolic pathways and leading to mortality (Kumari & Yadav, 2020). Interestingly, despite its lower metal content, *A. digitata* ash demonstrated superior efficacy at reduced concentrations. This paradox suggests the presence of other bioactive compounds or structural features that enhance its pesticidal action. Ibrahim et al. (2019b), in their study on indigenous pest control methods in northern Nigeria, highlighted the role of plant-derived ashes in disrupting pest behavior through both chemical and physical mechanisms. The porous nature and abrasive texture of *A. digitata* ash may facilitate mechanical damage to lice exoskeletons, thereby accelerating mortality.

The concentration-dependent repellent activity observed in both ashes corroborates earlier findings by Salifou et al. (2013), who demonstrated the effectiveness of wood ash in repelling poultry lice in West African settings. At a concentration of 0.25 g/cm², *A. digitata* achieved an impressive repellency rate of 84.4±8.82%, while *A. indica* showed no significant effect. This disparity suggests that *A. digitata* possesses a lower threshold for repellency, potentially due to the presence of secondary metabolites or finer ash particles that enhance surface coverage and contact with ectoparasites. At higher concentrations (1.0 g/cm²), both ashes exhibited strong repellent effects 93.3% for *A. digitata* and 82.2% for *A. indica*. These results may be attributed to the combined influence of alkalinity and trace metal toxicity, which have been shown to disrupt the chemosensory systems of lice, impairing their ability to locate hosts and reproduce (Navajas et al., 2021). The LC_{50} and LC_{90} values further validate the superior potency of *A. digitata*, indicating that smaller quantities are required to achieve comparable effects, thereby enhancing its practicality for field applications.

In terms of acaricidal (insecticidal) activity, both ashes followed a similar concentration-dependent trend, with *A. digitata* consistently outperforming *A. indica* across all tested doses. After 48 hours of exposure, *A. digitata* achieved a mortality rate of 93.3% at 1.0 g/cm², compared to 71.7% for *A. indica*. Notably, *A. indica* failed to induce any mortality at the lowest concentration (0.25 g/cm²), suggesting a higher toxicity threshold. These findings are consistent with the work of Muhammad & Kashere (2021) in Katsina where the results revealed that Azadirachtin in particular interferes with chemoreception and exerts direct negative effects on many insect tissues such as muscles and digestive epithelial cells as well as insect mortality. The study also agrees with Mazarin et al. (2016), who reported the efficacy of wood ash against *Callosobruchus maculatus*, and Bohinc and Trdan (2017b), who observed similar effects on granary weevils. The rapid onset of mortality observed with *A. digitate* in 40 minutes at 1.0 g/cm² compared to 60 minutes for *A. indica* indicates a more immediate toxic effect. This may be due to the physical abrasion of the lice exoskeletons or the swift induction of oxidative stress by trace metals. Gao et al. (2020) emphasized that such mechanisms are critical in determining the speed and extent of insecticidal action. The absence of mortality at lower concentrations for *A. indica* reinforces the need for higher doses to achieve lethal outcomes, which may limit its cost-effectiveness and environmental sustainability (Martínez-García *et al.*, 2022).

These findings underscore the potential of wood ash, particularly that derived from *A. digitata*, as a viable and sustainable alternative to synthetic insecticides in poultry farming. The superior efficacy of *A. digitata* at lower concentrations offers several advantages, including reduced input costs, minimized environmental impact, and enhanced safety for both poultry and handlers. In rural Nigerian communities, where access to commercial insecticides is limited and regulatory oversight is minimal, the use of locally sourced wood ash presents a practical solution to ectoparasite management. Wahedi et al. (2017), in their study conducted in Mubi, Nigeria, demonstrated the effectiveness of neem and wood ash as biopesticides against vegetable crop pests, further supporting the broader applicability of these materials in agricultural pest control. Similarly, Agbede and Adekiya (2017) reported improvements in soil health and crop yield following the application of wood ash and poultry manure in southwestern Nigeria, highlighting its multifunctional benefits.

Despite these promising results, the variability in efficacy between *A. digitata* and *A. indica* ashes suggests that plant-specific factors warrant further investigation. Secondary metabolites, ash particle size, and combustion conditions may all influence the bioactivity of wood ash. Future research should focus on characterizing these variables and optimizing application methods to maximize efficacy while ensuring safety (Egbaji *et al.*, 2021). Long-term field trials are essential to assess the persistence of ash effects, potential accumulation of trace metals, and impacts on poultry health and productivity.

CONCLUSION

Wood ash from *A. digitata* and *A. indica* exhibits significant repellent and insecticidal activity against chicken feather lice, actions which may be related to their alkaline pH and trace metal content. *A. digitata* demonstrated superior efficacy, achieving 84.4% repellency and 68.3% mortality at 0.25 g/cm^2, with an LC_{50} of 0.232 g/cm^2 compared to an LC_{50} of 0.588 g/cm^2 for *A. indica*. Both ashes offer a sustainable, cost-effective approach to poultry lice control, with *A. digitata* showing greater potential due to its effectiveness at lower doses. These findings support the use of wood ash as a natural pesticide, particularly in resource-limited settings, and highlight the need for further research to optimize its application.

RECOMMENDATIONS

i. Encourage and support poultry farmer and their cooperatives to standardize tested or known plants-wood ash preparation for its repellency efficacy and share best practices across communities.
ii. Include wood ash pest control methods in agriculture, livestock farming and projects to showcase the efficacy of wood ash in poultry and other livestock farming settings.
iii. Explore the development of ash-based formulations (e.g., dusts, sprays) for easier application and improved efficacy.

STUDY LIMITATIONS

The study was limited by its in vitro design, which does not fully replicate natural poultry environments, host factors, or long-term parasite dynamics. It also tested only adult lice under controlled ash application and short observation periods, reducing ecological validity and generalizability of the findings.

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APPENDIX

Plate I: Lice Infested Broiler Feather

Plate II. In-vitro Experimental Set up