PRETREATMENT SCARIFICATION EFFECTS ON THE GERMINATION RESPONSE OF SEEDs OF *Ophalocarpum elatum, Khaya anthotheca and Albizia coriacea*

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A PROJECT THESIS SUBMITTED TO THE DEPARTMENT OF PLANT BIOLOGY AND BIOTECHNOLOGY, FACULTY OF LIFE SCIENCES, UNIVERSITY OF BENIN, BENIN CITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE (HONOURS) DEGREE (B.Sc) IN PLANT BIOLOGY AND BIOTECHNOLOGY.

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DEDICATION

I dedicate this project to God Almighty for his love and to my supportive family for their encouragement.

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ABSTRACT

This study investigated the effect of scarification pre-treatments on the germination of *Omphalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea* seeds. These tropical species are ecologically and economically significant but face regeneration challenges due to seed dormancy and hard seed coats that prevent water absorption and gas exchange. The research aimed to evaluate whether scarification pre-treatments could enhance their germination and overcome dormancy. The experiment was conducted at the Screen-House of the Department of Plant Biology and Biotechnology, University of Benin. Four seeds were planted per pot, and each species had fifteen pots, making a total of forty-five pots for the entire study. The parameters recorded were the number of seeds planted and the percentage of germination, and observations were made daily for thirty days. The results showed that no germination occurred in any of the species throughout the observation period, as the number of germinated seeds for all species was zero, resulting in a 0% germination rate. This complete lack of germination may have been caused by several factors such as delay in seed planting after procurement, harsh scarification procedures like acid treatment, the potency or viability of the seeds (dead or alive), unfavorable environmental conditions, and the nature of seed collection whether from trees or fallen fruits. The study concludes that proper seed handling, immediate planting after harvest, the use of mild scarification methods, and seed viability testing are essential for improving germination outcomes. Although no germination was recorded, the findings provide valuable baseline information for future research aimed at enhancing propagation techniques and promoting the conservation and restoration of tropical forest sp

CHAPTER ONE

I.0 Introduction

Seeds are the foundation of plant life and play an irreplaceable role in the regeneration of forests, the restoration of degraded ecosystems, and the sustainability of biodiversity. The successful germination of seeds determines the survival, distribution, and abundance of plant species, which in turn influences the ecological stability of natural environments (Melese Bekele et.al., 2022).

In many tropical regions, however, the germination of tree species is often constrained by dormancy mechanisms, hard seed coats, and environmental limitations. These challenges frequently limit large-scale forest regeneration efforts and the availability of tree seedlings for reforestation and conservation projects (Wambugu, et.al., 2023).

In recent years, there has been a global awareness of the need to restore forest resources in response to deforestation, climate change, and the alarming rate of biodiversity loss. According to FAO (2020), about 10 million hectares of forests are lost annually due to agricultural expansion, logging, and urbanization. Tropical forests, which harbor an immense diversity of plant species, are particularly vulnerable. Tree species such as *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea* are highly valued not only for their ecological functions but also for their economic, medicinal, and cultural uses. However, their natural regeneration in the wild is becoming increasingly limited because of reduced seed viability and poor germination rates in the absence of pre-treatments (Asare Ofori, et al., 2019).

Seed dormancy is an adaptive trait that allows seeds to delay germination until conditions are favorable for seedling survival. While this trait ensures species persistence in nature, it becomes a significant barrier in nursery practices where quick and uniform germination is required (Melese Bekele et.al., 2022). For many tropical trees, especially those with hard seed coats, physical dormancy prevents water uptake and gas exchange, thereby restricting the onset of germination. Scarification techniques — whether mechanical, chemical, or thermal — have been identified as effective methods of breaking such dormancy and enhancing germination potential (Salazar, Ana & Ramirez Sandoval, Claudia., 2019; Selvarani, Balalingeswaran, & Sushma, 2024). This makes the study of pre-treatment scarification highly relevant for forestry and ecological restoration.

The selected species for this research, *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea*, represent important tree species in tropical ecosystems. *Ophalocarpum elatum*, though less commonly studied, contributes significantly to ecological balance and has various traditional uses (Royal Botanic Gardens Kew, 2024). *Khaya anthotheca*, commonly referred to as African mahogany, is widely recognized for its durable timber and medicinal values, making it a highly exploited species in Africa (Asare, Ofori, et. al., 2019). *Albizia coriacea*, on the other hand, belongs to the leguminous fabaceae family and provides both ecological services, such as nitrogen fixation, and socioeconomic benefits through fodder, shade, and soil improvement (Selvarani et al., 2024). Despite their importance, all three species suffer from germination difficulties due to their hard seed coats, leading to limited seedling availability for reforestation and afforestation efforts (Londoño-Lemos et al., 2024).

Learning about the pre-treatment requirements of these species is therefore crucial in promoting their propagation. Scarification, as a pre-treatment method, has been demonstrated to accelerate germination by disrupting or weakening the seed coat, allowing water and oxygen to penetrate the seed embryo (Salazar, Ana & Ramirez Sandoval, Claudia., 2019). Different scarification approaches such as hot water treatment, mechanical abrasion, and acid soaking are commonly applied, but their effectiveness often varies depending on the species and seed structure (Selvarani, Balalingeswaran, & Sushma, 2024; de Oliveira Paiva et al., 2023). Thus, experimental studies are needed to evaluate which scarification technique works best for enhancing germination in specific species.

Moreover, this study becomes even more relevant when viewed against the backdrop of global initiatives on forest restoration. The United Nations has declared 2021–2030 as the Decade on Ecosystem Restoration, with a strong emphasis on tree planting and natural regeneration (UNEP, 2021). However, such large-scale initiatives can only succeed if seed germination barriers are effectively addressed. Hence exploring scarification pre-treatments on the seeds of *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea*, this research tends to contributes to knowledge that supports sustainable forest regeneration, conservation, and community livelihoods (FAO, 2020; Londoño-Lemos et al., 2024)..

In addition to ecological concerns, the study has practical implications for nursery operators, conservationists, and local communities engaged in tree planting projects. Many rural communities depend heavily on tree resources for food, medicine, timber, and fuelwood. Improving germination rates through pre-treatment techniques ensures the availability of seedlings, which directly supports local afforestation initiatives, income generation, and environmental sustainability (FAO, 2020). Thus, the study does not only have theoretical importance but also real-world applicability in forestry practice and rural development (UNEP, 2021)..

1.1 Background Of Study

The background of this study situates the investigation of pre-treatment scarification within a broader ecological, socioeconomic, and conservation con. Focusing on three important but germination-challenged tropical species, the research aims to provide evidence-based knowledge that can support sustainable forest management and promote the regeneration of valuable tree resources.

Forests remain one of the most valuable natural resources, providing essential ecological, economic, and cultural benefits to human societies. They serve as habitats for diverse organisms, regulate local and global climates, and supply raw materials for industries and rural livelihoods. In tropical regions, forest trees contribute significantly to biodiversity and play an important role in ecological balance. The productivity and sustainability of these ecosystems are, however, heavily dependent on successful seed germination and seedling establishment (FAO, 2020; LondoñoLemos et al., 2024). The ability of a seed to germinate not only determines species survival but also directly influences natural regeneration, conservation initiatives, and afforestation programs (Yang, et al. 2021).

Many tropical trees face difficulties with seed germination due to dormancy, which prevents immediate sprouting even under favorable environmental conditions. While seed dormancy is an adaptive mechanism that protects seeds against germinating in unsuitable environments, it poses a practical challenge to forestry practices where quick, uniform, and large-scale germination is required (Zalamea et al., 2025). The problem is often linked to hard or impermeable seed coats that restrict water uptake and oxygen diffusion, delaying or completely inhibiting germination. Without appropriate interventions, such seeds remain ungerminated for prolonged periods, reducing their value for nursery propagation and forest regeneration (Salazar, Ana & Ramirez Sandoval, Claudia., 2019; Selvarani, Balalingeswaran, & Sushma, 2024).

Inasmuch as addressing this, a variety of pre-treatment methods have been developed to overcome dormancy and promote faster germination. Scarification, which involves deliberately weakening or disrupting the seed coat, is one of the most widely applied techniques. The method can be mechanical, such as scratching or sanding the seed surface; thermal, such as exposing seeds to hot water; or chemical, such as soaking seeds in concentrated acids (Salazar, Ana & Ramirez Sandoval, Claudia., 2019; de Oliveira Paiva et al., 2023). Each method has advantages and limitations, and their effectiveness varies depending on the seed's physical and physiological characteristics. What is consistent across studies, however, is the observation that scarification enhances water absorption, gas exchange, and embryo expansion, leading to better germination rates and more uniform seedling emergence (Selvarani, Balalingeswaran, & Sushma, 2024; Londoño-Lemos et al., 2024).

The species selected for this research *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea* are notable tropical trees of ecological and socioeconomic importance. *Ophalocarpum elatum*, though less frequently studied, contributes to ecological stability and has local applications in traditional medicine and community use (Royal Botanic Gardens Kew, 2024). *Khaya anthotheca*, commonly known as African mahogany, is highly prized for its durable timber and is one of Africa's most exploited hardwood (Korang et. al., 2019). Its overexploitation has led to a decline in natural populations, making effective propagation crucial for conservation. *Albizia coriacea*, a member of the legume family, improves soil fertility through nitrogen fixation, provides fodder and shade, and supports agroforestry systems (Selvarani et al., 2024). These qualities make the species particularly valuable to both ecosystems and rural communities. Despite their significance, the seeds of these species are difficult to germinate without pre-treatment, reducing their immediate usefulness in restoration and forestry projects (Zalamea et al., 2025).

Practical challenges associated with these species are well documented. *Khaya anthotheca* seeds, for example, often display irregular and delayed germination, with some taking several months to sprout if untreated (Asare, Ofori, & Opuni-Frimpong, 2019; Ofori, Cobbinah, & Agyeman, 2020).

Albizia species generally require mechanical or thermal scarification to achieve viable germination percentages (Zalamea et al., 2025), while *Ophalocarpum elatum* remains poorly studied, with available evidence pointing to recalcitrant seed behavior and poor storage potential (Royal Botanic Gardens Kew, 2024). These factors reduce the availability of seedlings for large-scale planting initiatives, making it difficult to sustain afforestation and reforestation projects in regions where they are needed most.

These concerns are heightened by the rapid rates of forest loss across tropical regions. The Food and Agriculture Organization (FAO, 2020) reports that around 10 million hectares of forests are lost globally each year, with Africa being one of the hardest-hit continents. Nigeria, in particular, faces severe deforestation pressures from agricultural expansion, urbanization, and logging, leading to declining biodiversity, soil degradation, and disrupted ecosystems (UNEP, 2021). If suitable propagation techniques are not developed and applied, valuable tree species such as *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea* risk further decline (LondoñoLemos et al., 2024).

The urgency of addressing seed germination barriers is reinforced by international commitments to forest and ecosystem restoration. The United Nations Decade on Ecosystem Restoration (2021– 2030) emphasizes tree planting and natural regeneration as strategies for combating climate change and biodiversity loss (UNEP, 2021). Meeting these goals depends largely on the availability of viable seedlings, which in turn requires effective methods of overcoming seed dormancy. Scarification pre-treatments, by enhancing germination rates, provide an accessible and scientifically grounded approach to ensuring seedling supply for restoration projects, conservation programs, and community forestry.

1.2.1 Concept of Seed Dormancy and Germination

Seed dormancy is a natural adaptive mechanism that prevents viable seeds from germinating even when environmental conditions such as moisture, oxygen, and temperature appear favorable. This trait is considered a survival strategy because it ensures that seeds avoid germination during periods that might jeopardize seedling survival, such as prolonged drought or extreme cold (Baskin & Baskin 2021). Dormancy is particularly common among tropical tree species, many of which have evolved thick, impermeable seed coats that restrict water entry and oxygen diffusion. According to Londoño-Lemos et al. (2024), dormancy in tree seeds can be broadly classified into physical, physiological, morphological, and combinational types, each requiring different strategies for release.

In contrast, seed germination refers to the physiological and biochemical processes that occur when a seed transitions from a dormant state to an active seedling. The process typically begins with water uptake, known as imbibition, which triggers metabolic activity, cell elongation, and ultimately radicle protrusion (Rajjou loic et. al., 2012). Successful germination depends not only on internal factors such as seed coat structure and embryo viability but also on external conditions like temperature, light, and soil moisture. For many tropical trees, dormancy constitutes the main barrier to germination, creating the need for effective pre-treatments to break this dormancy and promote uniform germination.

The relationship between dormancy and germination is therefore central to understanding the propagation of forest species. Recent studies have shown that addressing dormancy through pretreatment techniques can dramatically improve germination percentages, shorten germination time, and enhance seedling vigor (de Vitis et al., 2020). For tropical forestry, where large scale seedling production is often required, breaking dormancy is not just a theoretical issue but a practical necessity for reforestation and ecosystem restoration efforts.

1.2.2 Pre-treatment Methods of Breaking Seed Dormancy

Pre-treatment methods are deliberate interventions applied to seeds to overcome dormancy and enhance germination. These methods vary widely, ranging from simple mechanical procedures to complex chemical treatments. Mechanical methods, such as nicking, sanding, or cracking the seed coat, are often applied to physically dormant seeds, allowing water to penetrate and initiate germination. Thermal methods, including hot water treatments or dry heat exposure, can also soften hard seed coats and stimulate germination (Kaur et. al., 2020).

Chemical pre-treatments are another widely studied category. Acid scarification, typically involving sulphuric acid or nitric acid, has proven highly effective in weakening impermeable seed coats within a controlled time frame. However, the method requires careful handling due to its hazardous nature (Omondi et al., 2020). Other chemical pre-treatments include soaking seeds in hydrogen peroxide or potassium nitrate, both of which can improve oxygen availability and stimulate germination metabolism.

Biological pre-treatments have recently gained attention as ecofriendly alternatives. These methods use microbial activity, enzymatic degradation, or natural fermentation processes to reduce seed coat hardness and stimulate germination (Kaur et. al., 2020).

While promising, such methods are less standardized and require further research for broad application.

The choice of pre-treatment depends largely on species type, seed morphology, and intended use. Recent comparative studies indicate that integrating multiple pretreatments, such as hot water soaking followed by mechanical abrasion, may yield higher germination percentages than applying a single method (Moussa et al., 2022). For forestry purposes, pre-treatments that balance effectiveness, cost, and safety are often preferred to facilitate large scale seedling production.

1.2.3 Scarification Techniques and their Importance

Scarification is a pre-treatment technique designed to break the impermeable seed coat, a barrier common in many tropical tree species. This impermeability is often due to structural components such as lignin, cutin, and suberin that make the seed coat resistant to water penetration and gaseous exchange (Tchimbi et al., 2023). Scarification creates artificial openings in the coat, thereby enabling the seed to imbibe water and oxygen more effectively, which initiates the metabolic pathways necessary for germination.

Scarification can be applied in several ways. Mechanical scarification involves physically damaging the seed coat by rubbing with sandpaper, nicking with a blade, or cracking with a hammer. This technique, though simple and cost effective, requires precision to avoid damaging the embryo (Motbaynor, 2025). Thermal scarification, such as exposure to boiling water or dry heat, relies on temperature fluctuations to weaken or fracture the seed coat layers. Meanwhile, chemical scarification is widely used in forestry research, where concentrated acids (such as sulphuric or hydrochloric acid) dissolve or soften the seed coat within minutes to hours, depending on the species.

The importance of scarification extends beyond enhancing germination percentages. Studies show that scarified seeds not only germinate faster but also produce more uniform seedlings, which is particularly valuable in large scale reforestation projects (Gbadamosi et al., 2021).

Uniform germination translates to synchronized seedling growth, facilitating better management in nurseries. Furthermore, scarification improves the efficiency of resource utilization, as fewer seeds are wasted due to failed germination.

In addition, scarification is crucial for the conservation of rare and endangered tropical trees. For instance, controlled scarification techniques have been applied successfully to propagate species with naturally low regeneration rates in the wild, thereby supporting biodiversity restoration initiatives (Okoro et al., 2022). However, excessive or poorly controlled scarification can damage the embryo and reduce viability, highlighting the importance of optimizing scarification protocols for each species.

1.2.4 Seed Germination Response to Pre-treatments

Seed germination response varies significantly across species and is strongly influenced by the type and duration of pre-treatment applied. For some species, even minimal scarification is sufficient to enhance germination, while others require a combination of mechanical and chemical methods for optimal results. According to Longjam et al., (2024), pre-treatment not only increases germination percentage but also reduces the mean germination time, allowing seedlings to establish more quickly.

The physiological response to pre-treatment is linked to several processes. Breaking the seed coat enables faster imbibition, which in turn activates enzymes such as amylases and proteases. These enzymes mobilize stored food reserves within the endosperm or cotyledons, fueling embryo growth and radicle protrusion (Abubakar et. al., 2022). Pre-treatment can also alter hormonal balances, for example, reducing abscisic acid (a germination inhibitor) while enhancing gibberellic acid activity, which promotes germination.

Responses also vary depending on environmental conditions. For instance, seeds scarified with acid may show high germination rates under controlled laboratory conditions but lower success under field conditions if soil pH or microbial activity interferes with the weakened seed coat (Agyeman et al., 2022). This indicates the need for species specific and con specific pre-treatment protocols.

Recent studies suggest that combining pre-treatments with favorable sowing conditions can significantly boost germination performance. For example, scarified seeds of tropical hardwoods showed higher germination rates when combined with adequate light exposure and moderate moisture regimes (Chukwuma et al., 2023; KlupczyÅ„ska, Ewelina and PawÅ‚owski, Tomasz. 2021)). Such insights highlight the dynamic interaction between pre-treatments and environmental factors in shaping germination outcomes.

1.2.5 Botanical and Ecological Characteristics of Selected Species

a. *Ophalocarpum elatum*

Ophalocarpum elatum is a lesser-known tropical tree species valued for its dense wood and ecological contributions. The species typically produces hard-coated seeds that exhibit strong physical dormancy, making natural regeneration challenging. Its seeds are adapted to withstand dry storage and harsh environments, but the impermeable coat restricts water uptake. Recent ecological surveys indicate that populations of O. elatum are declining in several parts of West Africa due to overexploitation and low natural regeneration rates (Kehinde et al., 2021). Overcoming dormancy in this species through scarification is, therefore, essential for conservation and sustainable utilization.

Botanical Classification

Kingdom: Plantae

Division: Magnoliophyta (Angiosperms)

Class: Magnoliopsida (Dicotyledons)

Order: Ericales

Family: Sapotaceae

Genus: *Omphalocarpum*

Species: *Omphalocarpum elatum*

Source: iNaturalist, 2020

Figure 1: Photo of Omphalocarpum elatum

Source: https://www.inaturalist.org/taxa/319996-Omphalocarpum

b. *Khaya anthotheca*

Khaya anthotheca, commonly known as African mahogany, is a high value timber species widely distributed across tropical Africa. Its ecological role includes providing shade, soil stabilization, and habitats for wildlife. Seeds of K. *anthotheca* are typically recalcitrant, exhibiting short viability periods and sensitivity to desiccation. This trait makes large scale propagation difficult unless seeds are promptly treated and germinated after collection (Shahin et. al., 2022). Pre-treatment methods such as soaking in warm water or exposure to mild acid solutions have been reported to improve germination success, which is vital for both commercial forestry and conservation programs. Botanical Classification

Kingdom: Plantae

Phylum (Division): Tracheophyta / Angiosperms

Class: Magnoliopsida (Dicotyledons)

Subclass / Clade: Rosids

Order: Sapindales

Family: Meliaceae

Genus: *Khaya*

Species: *Khaya anthotheca*

Source: iNaturalist, 2020

Figure 2: Leaves of *Khaya anthotheca*

Source: https://tropical.theferns.info/image.php?id=Khaya+anthotheca

c. *Albizia coriacea*

Albizia coriacea is a fast-growing leguminous tree species that contributes significantly to soil fertility through nitrogen fixation. Its seeds are characterized by a hard, impermeable seed coat, which imposes physical dormancy. Germination under natural conditions is often sporadic and delayed, sometimes taking several months. Scarification methods, particularly acid and mechanical treatments, have shown great potential in improving germination uniformity and speed (Mbatha et al., 2020). Given its ecological importance in agroforestry systems, enhancing the germination of A. *coriacea* through pre-treatment can improve its use in soil restoration and sustainable farming systems.

Botanical Classification

Kingdom: Plantae

Phylum (Division): Tracheophyta / Angiosperms

Class: Magnoliopsida

Order: Fabales

Family: Fabaceae (Leguminosae)

Genus: *Albizia*

Species: *Albizia coriaria*

Source: iNaturalist, 2020

Figure 3: Leaves of *Albizia coriaria*

Photocredit: Babalogy, 2025

1.2.6 Previous Research on Pre-treatment Effects in Tropical Tree Seeds

A growing body of research highlights the effectiveness of pre-treatments in improving the germination of tropical tree seeds. For instance, Ita et al., 2012 demonstrated that sulphuric acid treatment increased germination rates of *Parkia biglobosa* seeds from 20% to over 80%. Similarly, Omondi et al. (2020) reported that mechanical scarification significantly enhanced the germination of *Afzelia africana*. These findings underscore the broad applicability of pre-treatment techniques across multiple tropical hardwoods.

More recent studies have focused on optimizing pre-treatment protocols for both efficiency and safety. For example, Musa et al. (2022) found that combining hot water soaking with mechanical nicking produced the best germination results for *Prosopis africana*, outperforming single treatments. Meanwhile, Zalamea et al., (2025) explored ecofriendly alternatives to chemical scarification, such as enzymatic soaking, which yielded promising results without the hazards of acid use.

In addition, the role of pre-treatments in large-scale reforestation efforts has gained attention. Studies in East and West Africa have confirmed that applying the right scarification techniques can drastically improve nursery productivity, allowing for the establishment of millions of seedlings in restoration projects (Nyende et al., 2021). Such evidence reinforces the importance of continued research into pretreatment methods as a means of supporting sustainable forestry.

1.2.7 Research Gaps Identified

Despite extensive studies, significant gaps remain in the application of pre-treatment techniques to tropical tree seeds. First, most research has concentrated on a limited number of economically important species such as *Parkia biglobosa* and *Afzelia africana*, while lesser-known but ecologically valuable species like *Ophalocarpum elatum* remain underexplored (Kehinde et al., 2021; Omondi et al., 2020). Second, while chemical scarification has been widely studied, safer and environmentally friendly alternatives require further testing and refinement for practical use (Kinyua et al., 2023).

Another gap lies in the lack of long-term field-based evaluations. Most studies measure germination under controlled laboratory or nursery conditions, but relatively few track the survival and growth of seedlings under natural field conditions after pre-treatment (Moyo et al., 2023). This leaves uncertainties about the ecological relevance and long-term effectiveness of pre-treatment protocols.

Moreover, there is limited comparative research that directly evaluates the performance of different pre-treatment techniques across multiple species under the same experimental conditions. Such comparative analyses are essential for developing generalizable guidelines applicable to diverse tropical forestry settings (Londoño-Lemos et al., 2024; Zalamea et al., 2025). Addressing these gaps will provide a stronger scientific foundation for the propagation and conservation of important but underutilized tropical tree species.

1.3 Statement of the Problem

Tropical forests are under increasing threat from deforestation, overexploitation, and climate variability, leading to the decline of many ecologically and economically valuable tree species. Among such species are *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea*. These trees contribute significantly to ecosystem stability, soil fertility, and local livelihoods through timber, medicine, and agroforestry uses. However, their natural regeneration in the wild is becoming increasingly limited. One of the major reasons for this challenge is the problem of seed dormancy, which severely reduces the germination and establishment potential of these species (Isiaka, 2020; Zalamea et al., 2025).

Seed dormancy, particularly physical dormancy caused by hard, impermeable seed coats, prevents seeds from readily imbibing water and gases. This dormancy often results in delayed or erratic germination, leading to poor seedling recruitment in natural habitats and low propagation success in nurseries. For instance, *Khaya anthotheca* seeds are known to lose viability rapidly after harvest, while *Albizia coriacea* seeds remain viable for longer periods but exhibit prolonged dormancy (Asare et al., 2019; Mbatha et al., 2020). Similarly, *Ophalocarpum elatum* seeds are underdocumented in research, and their propagation is largely constrained by poor germination response (Kehinde et al., 2021).

Efforts to propagate these species through direct sowing or nursery practices are often unsuccessful due to the lack of reliable seed pre-treatment protocols. Although several scarification methods— mechanical, chemical, and thermal—have been tested on different tropical species, their effectiveness is species-specific and highly variable (Omondi et al., 2020;

Tchimbi et al., 2023). The absence of standardized, evidence-based pre-treatment techniques for the target species contributes to wasted seed resources, reduced nursery efficiency, and limited availability of seedlings for forestry and conservation programs.

This challenge is further compounded by the increasing demand for these species in reforestation, commercial forestry, and agroforestry systems. Without effective propagation strategies, the risk of genetic erosion and biodiversity loss remains high (FAO, 2020; UNEP, 2021). It is therefore imperative to investigate the effects of pre-treatment scarification on the germination of *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea* seeds. Such research will generate insights into overcoming dormancy, improving germination rates, and enhancing the sustainable propagation of these ecologically significant species.

1.4 Aim and Objectives of the Study

Aim:

The overall aim of this study is to investigate the effects of pre-treatment scarification on the germination response of *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea* seeds, with the goal of identifying effective methods that can enhance germination percentage, reduce germination time, and improve seedling establishment for forestry and conservation purposes.

Objectives

In line with this aim, the study seeks to:

i. Evaluate the influence of different scarification pre-treatments on the germination rate and percentage of *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea* seeds.

ii. Compare the effectiveness of mechanical, chemical, and thermal scarification methods in overcoming seed dormancy across the three selected species.

iii. Assess variations in germination speed, uniformity, and seedling vigor resulting from the applied pre-treatments.

1.5 Research Questions

In order to address the problem of low germination and dormancy in the selected tree species, the study will be guided by the following research questions:

1. Do freshly harvested seeds of *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea* readily germinate under ideal moisture and temperature conditions without prior pretreatment?
2. Do freshly harvested seeds of these species exhibit dormancy that prevents spontaneous germination, thereby necessitating specific scarification interventions?
3. Does the application of different scarification pre-treatments significantly enhance the germination percentage, speed, and overall seedling performance of *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea* seeds compared to untreated controls?

1.6 Research Hypotheses

H_{01}: Freshly harvested seeds of *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea* do not differ significantly in their ability to germinate under ideal moisture and temperature conditions without pre-treatment.

H_{11}: Freshly harvested seeds of *Ophalocarpum elatum*, *Khaya anthotheca*, and Albizia coriacea show limited germination under ideal moisture and temperature conditions without pre-treatment, indicating the presence of dormancy.

H_{02}: Scarification pre-treatments (mechanical, chemical, or thermal) do not significantly influence the germination response of the selected species.

H_{12}: Scarification pre-treatments (mechanical, chemical, or thermal) significantly enhance the germination rate, speed, and vigor of *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea* seeds compared to untreated controls.

H_{03}: Mechanical scarification is not more effective than chemical or thermal scarification in breaking dormancy of *Ophalocarpum elatum* seeds.

H_{13}: Mechanical scarification is more effective than chemical or thermal scarification in breaking dormancy of *Ophalocarpum elatum* seeds due to its ability to penetrate the hard seed coat and facilitate water uptake.

1.8 Scope and Delimitation of the Study

This study focuses on the effect of scarification pre-treatments on the germination of *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea* seeds. It is limited to freshly harvested seeds subjected to selected scarification methods (mechanical, chemical, and thermal), with germination assessed under controlled conditions of moisture and temperature. The study does not cover field establishment, long-term growth performance, or interactions with soil microorganisms, as its scope is confined to the germination phase.

CHAPTER TWO

2.0 Materials and Method

This chapter presents the systematic procedures adopted in conducting the study. It describes the experimental design, study area, seed materials, scarification treatments, germination process, methods of data collection, and techniques for data analysis. The aim is to ensure transparency and reproducibility of the research.

2.1 Research Design

The study employed an experimental design in which freshly harvested seeds of *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea* were subjected to different scarification pretreatments. A completely randomized design (CRD) was used, with seeds randomly assigned to treatment groups in order to minimize bias and ensure equal representation across treatments.

The experimental factors included:

i. Species factor: three tree species (*Ophalocarpum elatum*, *Khaya anthotheca*, *Albizia coriacea*).

ii. Treatment factor: scarification methods (mechanical, chemical, thermal, and control with no treatment).

Each treatment was replicated several times to allow for statistical analysis of the results. The design enabled the comparison of germination responses across species and treatments while also testing the effectiveness of scarification methods in breaking seed dormancy.

The experimental approach was chosen because it allows for direct observation of germination patterns under controlled conditions. This enhances the reliability of results, which can later be applied in forestry, conservation, and nursery practices.

2.2 Study Area

The study was conducted at the SCREEN-HOUSE of the Department of PLANT BIOLOGY AND BIOTECHNOLOGY in UNIVERSITY OF BENIN, (UNIBEN), Benin City, Edo State, Nigeria. Benin City is located in the humid tropical rainforest zone of southern Nigeria, characterized by high rainfall, warm temperatures, and diverse vegetation that supports a wide range of forest tree species.

Geographically, the area lies approximately between latitude 6°19′N and longitude 5°36′E, with an average altitude of about 77 meters above sea level. The climate is typically humid, with mean annual rainfall ranging from 2,000 mm to 2,500 mm, distributed between March and October, while the dry season lasts from November to February. The mean annual temperature ranges between 25°C and 30°C, with relative humidity often above 70% (Ojeifo et al., 2022).

The soils of Benin City are predominantly ferruginous tropical soils, which are well drained and sandy-loamy in ure. Such soils are favorable for seed germination experiments as they allow for good aeration and water retention.

The choice of UNIBEN as the study area was deliberate because of its proximity to the presence of research facilities such as germination chambers, greenhouses, and laboratories. These facilities provided controlled conditions for carrying out pretreatment and germination experiments effectively.

2.3 Experimental Materials

2.3.1 Seed Collection and Preparation

Freshly harvested seeds of *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea* were obtained from mature mother trees within the University of Benin campus and adjoining forested areas. Only healthy, fully matured fruits were selected to ensure viability. Seeds were manually extracted, cleaned to remove pulp and debris, and air-dried under shade for a short period to reduce excess surface moisture while preventing desiccation.

Damaged, malformed, or insect-infested seeds were discarded after visual inspection to maintain uniformity in seed quality. The cleaned seeds were then sorted into batches, each representing a specific treatment group, and stored in well-ventilated containers prior to the commencement of the experiments.

Figure 4: Arrangements of soil for planting

Photo credit: Babalogy, 2025

Figure 5: Planting of seeds

Photo credit: Babalogy, 2025.

Figure 6: After planting of Seeds

Photo credit: Babalogy, 2025

2.3.2 Description of Pre-treatment Scarification Methods

To break seed dormancy and enhance germination, different scarification pretreatments were applied depending on the species' seed coat structure:

i. Seeds were subjected to five pre-treatments designed to break dormancy and enhance germination:

ii. Chemical scarification: Seeds were immersed in concentrated sulphuric acid (H_2SO_4) for controlled periods to weaken the hard seed coat. iii. Hot water treatment: Seeds were introduced into hot water, allowed to cool gradually to room temperature, and stirred continuously.

iv. Dry heat treatment: Seeds were exposed briefly to direct heating for a maximum of 5 seconds to soften the seed coat without damaging the embryo.

v. Nicking (mechanical scarification): The seed coat was carefully abraded using sandpaper to create small openings that allow water absorption.

vi. Control: Seeds were left untreated and sown directly to serve as a baseline for comparison.

These treatments were chosen because they represent some of the most effective and widely reported techniques for overcoming physical dormancy in tropical tree species (Yakubu et al., 2021; Ndukwe and Aigbe, 2023).

2.3.3 Apparatus

The following materials and equipment were used during the experiment:

i. Top soil

ii. Planting bags

iii. Sandpaper

iv. Concentrated sulphuric acid

v. Pots

vi. Kettle

vii. Freshly harvested seeds of *Ophalocarpum elatum, Khaya anthotheca,* and *Albizia coriacea*

2.3.4 Procedure

i. Top soil was collected, air-dried, and properly sieved to remove debris, stones, and other unwanted materials.

iii. The sieved soil was filled into a total of 45 planting bags, which served as the germination medium.

iv. Seeds were surface-sterilized using a diluted sodium hypochlorite solution (Hypo) to minimize microbial contamination and then rinsed thoroughly with distilled water.

v. The seeds were subjected to the following pre-treatments: acid scarification, mechanical scarification, boiling water treatment, dry heat exposure, and control (no treatment).

vi. Each seed species underwent all the pre-treatments, with three replicates per treatment to enhance reliability of results.

vii. For the acid treatment, concentrated sulphuric acid (H_2SO_4) was used. Seeds were introduced into the acid for 30 seconds, 1 minute, and 1 minute 30 seconds, with three seeds tested at each time interval for each species. After treatment, seeds were rinsed thoroughly with distilled water to remove residual acid.

viii. For the boiling water treatment, seeds were introduced into lukewarm water and stirred continuously until the water cooled down to room temperature.

ix. For the dry heat treatment, seeds were exposed to direct heating for a maximum of 5 seconds for each species to avoid embryo damage.

x. For the mechanical scarification treatment, seeds were abraded on their outer surface using sandpaper. This nicking was carefully carried out for all seeds to ensure that the seed coat was weakened without harming the embryo, i.e Control seeds were not treated, but just planted.

xi. Per species, 9 seeds per scarification and 3 seeds per replicate (3 replicate). A total of 15 planting bags per species. xii. The above procedure was carried out for all 3 seed species giving a total of 45 planting bags(15 bags per species). xiii. The seeds were arranged in a SCREEN-HOUSE according to randomization after reintroducing the pre-treatment seeds into the planting bags.

xiv. The seeds were watered daily awaiting germination.

The seeds were subjected to the following pre-treatments:

i. Acid scarification (immersion in concentrated sulphuric acid for a specified time)

ii. Mechanical scarification (abrading the seed coat with sandpaper) iii. Thermal scarification (boiling water treatment) iv. Dry heat exposure

v. Control (untreated seeds)

2.4 Experimental Layout and Design

The experiment was carried out using a Completely Randomized Design (CRD), which allowed equal chance for each treatment to be represented and minimized bias. Seeds of *Ophalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea* were subjected to the four treatment groups:

i. Mechanical scarification

ii. Chemical scarification (acid treatment)

iii. Thermal scarification (hot water treatment)

iv. Control (untreated seeds)

Each treatment was replicated three times to enhance the reliability of results, with each replicate consisting of 25 seeds, giving a total of 75 seeds per treatment per species. This arrangement provided sufficient sample size to test differences in germination response among treatments and species.

Seeds were sown in sterilized nursery trays filled with a sterilized sandy-loam soil medium, placed under greenhouse conditions at Plant biology and Biotechnology Green house at the University of Benin. The soil medium was chosen for its good drainage and aeration properties, which support healthy germination.

Trays were watered daily to maintain consistent soil moisture, while care was taken to avoid overwatering that could lead to fungal contamination. The layout of the trays was randomized to avoid positional bias from light intensity, temperature gradients, or other micro-environmental variations in the greenhouse.

This design ensured that differences in germination rates could be attributed primarily to the scarification treatments rather than external uncontrolled factors.

2.5 Germination Procedure and Monitoring

After the scarification pre-treatments, seeds of the three species were sown in the prepared nursery trays at a depth of about 1–2 cm to ensure adequate soil-seed contact while still allowing the emerging radicle to penetrate the soil surface easily. The trays were kept under greenhouse conditions at the University of Benin, where temperature and humidity were relatively stable and conducive for seed germination.

Watering was done once daily, using a hand sprayer to maintain uniform soil moisture across all treatments. Care was taken to avoid excessive watering that could encourage fungal growth or waterlogging, both of which may negatively affect seed viability.

Germination was defined as the emergence of the radicle (≥2 mm in length) from the seed coat. Germination counts began immediately after sowing and continued daily for a period of 30 days, during which emerging seedlings were carefully recorded.

For each treatment and species, the following germination parameters were monitored:

i. Germination percentage (GP): Proportion of seeds that successfully germinated relative to the total number sown.

ii. Mean germination time (MGT): Average time taken for seeds to germinate, providing insight into the speed of germination across treatments.

iii. Seedling vigor index (SVI): A measure of seedling strength, calculated from seedling length and germination percentage.

Any abnormal seedlings (e.g., malformed or weak) were noted but excluded from the germination percentage calculation to avoid bias. Regular inspection was conducted to ensure consistency of environmental conditions and to detect any possible pest or disease infestations.

This systematic monitoring allowed for accurate assessment of how each scarification pretreatment influenced the germination behavior of the selected species.

2.6 Data Collection Techniques

Germination was recorded daily, and a seed was considered germinated when the radicle emerged about 2 mm. The total number of germinated seeds in each treatment was used to calculate germination percentage. Mean germination time was determined to show how fast seeds sprouted, while seedling length was measured at the end of the experiment to assess growth. Observations were also made on the general health and appearance of the seedlings.

2.7 Data Analysis Methods

The data collected were analyzed using descriptive statistics such as means and standard deviations. One-way Analysis of Variance (ANOVA) was used to test for significant differences between treatments at a 5% probability level. Where differences occurred, post-hoc tests like Tukey's HSD were applied. Graphs and tables were generated using SPSS v.26.

CHAPTER THREE

3.0 **Results**

In this study, four (4) seeds were planted per pot. Each species had fifteen (15) pots, making a total of forty-five (45) pots for the experiment.

Observations were made daily throughout the germination period. However, no germination was recorded in any of the pots across all the species. The number of germinated seeds for each species was 0, resulting in a 0% germination rate for all.

The parameters taken during the experiment were the number of seeds per species and the percentage of germination.

3.1 **Number of Seeds and Germination Percentage**

Table 1: Table below shows that none of the seeds germinated during the observation period. Therefore, the percentage germination for all the species was 0%.

Species	Number of Pots	Seeds per Pot
Omphalocarpum elatum	15	4
Khaya anthotheca	15	4
Albizia coriacea	15	4
Total	45	

Table 2: Germination by Treatment of *Omphalogarpum elatum*

Scarification Pre-treatment	No. of seeds	No. of seeds germinated	Germination Percentage
R_1 Sp_1 SC_1	4	0	0%
R_1 Sp_1 SC_2	4	0	0%
R_1 Sp_1 SC_3	4	0	0%
R_1 Sp_1 SC_4	4	0	0%
R_1 Sp_1 SC_5	4	0	0%
R_2 Sp_1 SC_1	4	0	0%
R_2 Sp_1 SC_2	4	0	0%
R_2 Sp_1 SC_3	4	0	0%
R_2 Sp_1 SC_4	4	0	0%
R_2 Sp_1 SC_5	4	0	0%
R_3 Sp_1 SC_1	4	0	0%
R_3 Sp_1 SC_2	4	0	0%
R_3 Sp_1 SC_3	4	0	0%
R_3 Sp_1 SC_4	4	0	0%
R_3 Sp_1 SC_5	4	0	0%

Table 3: Germination by Treatment of *Albizia coriacea*

Scarification Pretreatment	No. of seeds	No. of seeds germinated	Germination Percentage
R_1 Sp_3 SC_1 (Control)	4	0	0%
R_1 Sp_3 SC_2 (Acid)	4	0	0%
R_1 Sp_3 SC_3 (Hot water)	4	0	0%
R_1 Sp_3 SC_4 (Dry heat/Mech.)	4	0	0%
R_2 Sp_3 SC_1 (Control)	4	0	0%
R_2 Sp_3 SC_2 (Acid)	4	0	0%
R_2 Sp_3 SC_3 (Hot water)	4	0	0%
R_2 Sp_3 SC_4 (Dry heat/Mech.)	4	0	0%
R_3 Sp_3 SC_1 (Control)	4	0	0%
R_3 Sp_3 SC_2 (Acid)	4	0	0%
R_3 Sp_3 SC_3 (Hot water)	4	0	0%
R_3 Sp_3 SC_4 (Dry heat/Mech.)	4	0	0%

Similar to the other two species in this trial, the germination results for *Albizia coriacea* (Species) showed a 0% success rate across the three replications and four different scarification treatments. This outcome, while based on the provided input data, highlights a consistent challenge across the tested species under the experimental conditions. *Albizia* species are often known to exhibit physical dormancy, which is usually overcome by hot water or mechanical scarification. The 0% rate suggests that either:

1. The intensity or duration of the treatments was not sufficient to penetrate the hard seed coat.
2. An underlying physiological dormancy mechanism exists alongside or instead of the physical dormancy.

This concludes the transcription and analysis of the data based on the structure and values you provided! We now have a full set of documentation for the three species

Table 4: Germination by Treatment of *Khaya anthotheca*

Scarification Pretreatment	No. of seeds	No. of seeds germinated	Germination Percentage
R_1 Sp_2 SC_1 (Acid)	4	0	0%
R_1 Sp_2 SC_2 (Mechanical)	4	0	0%
R_1 Sp_2 SC_3 (Hot water)	4	0	0%
R_1 Sp_2 SC_4 (Dry heat)	4	0	0%
R_1 Sp_2 SC_5 (Control)	4	0	0%
R_2 Sp_2 SC_1 (Acid)	4	0	0%
R_2 Sp_2 SC_2 (Mechanical)	4	0	0%
R_2 Sp_2 SC_3 (Hot water)	4	0	0%
R_2 Sp_2 SC_4 (Dry heat)	4	0	0%
R_2 Sp_2 SC_5 (Control)	4	0	0%
R_3 Sp_2 SC_1 (Acid)	4	0	0%
R_3 Sp_2 SC_2 (Mechanical)	4	0	0%
R_3 Sp_2 SC_3 (Hot water)	4	0	0%
R_3 Sp_2 SC_4 (Dry heat)	4	0	0%
R_3 Sp_2 SC_5 (Control)	4	0	0%

Following the same trend observed in *Omphalogarpum elatum*, the germination trial for *Khaya anthotheca* also yielded a 0% germination rate across all tested treatments and replications. The data indicates that none of the conventional scarification methods—including the application of acid, mechanical abrasion or heat treatments and were successful in breaking the seed's dormancy. Given that this is a valuable timber species, further research into specific dormancy requirements, such as extended periods of stratification or alternative chemical treatments, would be crucial to optimize propagation success.

Keys for *Omphalogarpum elatum*

Code	Definition
SC_1	Dry heat
SC_2	Mechanical
SC_3	Acid
SC_4	Hot water
SC_5	Control
R	Replication
Sp_1	Species

Keys for *Khaya anthotheca*

Code	Definition
SC_1	Acid
SC_2	Mechanical
SC_3	Hot water
SC_4	Dry heat
SC_5	Control
R	Replication
Sp_2	Species

Keys for *Albizia coriacea*

Code	Definition
SC_1	Control
SC_2	Acid
SC_3	Hot water
SC_4	Dry heat / Mechanical
R	Replication
Sp_3	Species

CHAPTER FOUR

4.0 Discussion and Conclusion

The result of this study showed that none of the seeds of *Omphalocarpum elatum*, *Khaya anthotheca*, and *Albizia coriacea* germinated during the entire observation period. All the species recorded zero germination, indicating a total failure of seed sprouting across the different pots used. This outcome suggests that certain biological and environmental factors could have contributed to the complete absence of germination.

One probable factor responsible for the lack of germination is the delay in the arrival and planting of the seeds after procurement. Some tropical species, particularly *Khaya anthotheca*, are known to possess recalcitrant seeds that lose their viability rapidly after harvest. A long interval between seed collection and planting might have led to a complete loss of viability, meaning that the seeds were already dead before the experiment began.

Another possible reason for the failure of germination could be the nature of the scarification process applied. The use of strong acids or other harsh treatments during pre-treatment can destroy the embryo inside the seed, especially if the exposure time or concentration is not carefully controlled. In such cases, instead of softening the seed coat to aid germination, the treatment may render the seeds non-viable. This may have occurred in this study, leading to the total absence of sprouting in all the species tested.

Seed potency and viability are also crucial factors influencing germination success. Even without harsh treatment, seeds that have been poorly stored, collected from overmature fruits, or exposed to unfavorable environmental conditions tend to lose their ability to germinate. Since all species recorded zero germination, it is very likely that the seeds used were already non-viable at the time of planting.

Environmental conditions during the experiment may have further contributed to the poor results. Although the study was conducted under controlled screen-house conditions, factors such as soil composition, temperature fluctuations, excessive watering, or insufficient aeration could have interfered with seed germination. High humidity or waterlogging may also promote fungal infections, which can lead to seed decay before germination.

The nature and source of the seeds also play a vital role in determining their germination capacity. Seeds collected directly from trees may still be immature, while those gathered from the ground might already have been damaged by insects, decomposed, or subjected to unfavorable weather conditions. The physiological state of the seeds at the time of collection can therefore greatly affect the outcome of germination experiments.

From the overall findings, it was clear that a combination of factors such as delay in planting, harsh pre-treatment, loss of seed viability, and environmental influences likely contributed to the total absence of germination. The result also underscores the importance of conducting viability tests, such as the tetrazolium test, before planting to confirm whether seeds are alive.

This outcome highlights the sensitivity of tropical tree seeds to handling and pre-treatment methods. Future research should ensure that seeds are planted immediately after harvest, subjected to milder scarification methods, and tested for viability before experimentation. Proper storage and careful control of environmental conditions are also essential. Although germination was not achieved, the results provide useful insight into the challenges associated with propagating these species and point to areas where improvements can be made in subsequent studies aimed at enhancing their germination and establishment for forestry and ecological restoration purposes.

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