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Original Article

Evaluation of selected Nigerian wood species treated with creosote and *Occimum gratissimum* Linn. extract against fungal infestation

OPEN ACCESS

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ABSTRACT

The study focuses on the resistance of Pterocarpus soyauxii and Celtis zenkeri treated with creosote and Occimum gratissimum against fungal infestation. Wood samples were obtained from a sawmill and processed into 30mm × 30mm × 70mm in three replicates and dried at a temperature of 103±20°C for 8 hours and soaked in 500 ml of Occimum gratissimum and creosote for 24 hours. Absorption, retention, and visual assessment tests were carried out. Data were subjected to descriptive statistics using a two-sample T-test to test for significant difference. Pterocarpus soyauxii had the highest percentage moisture content of 17.85% among other wood samples that were tested, followed by Celtis zenkeri. Pterocarpus soyauxii had a higher absorption rate, ranging from 52.17% to 54.69% for the two treatment methods. Celtis zenkeri had the least absorption rate when treated with creosote (42.35%). The result proved that there is an interaction effect between the treatment and wood species. Creosote had the highest retention rate of 50.92 kg/m³. There is a significant difference between the wood species and the treatment methods. Celtis zenkeri had the least retention rate of 39.23 kg/m³ (Occimum gratissimum). The extent of protection varied with different treatment methods. Findings show that creosote is more effective in treating wood than Occimum gratissimum. Extension education should be increased towards educating wood users on the importance of organic preservatives as wood preservatives.

KEYWORDS: *Celtis zenkeri, Preservation, Preservatives, Pterocarpus soyauxii*

INTRODUCTION

In forestry and construction, wood preservation is crucial because fungus attacks can seriously impair the durability and structural integrity of wood (Wang *et al.*, 2018). According to Gonzalez & Morrell (2012), several types of fungi that can infest wood include Brown rot fungi (*Gloeophyllum trabeum* and *Postia placenta*) that break down the cellulose and hemicellulose in wood, leading to a brownish discoloration and a decrease in wood strength, White rot fungi (*Trametes versicolor* and *Phanerochaete chrysosporium*) that break down the lignin in wood, leading to a whitish discoloration and a decrease in wood strength and Soft rot fungi (*Chaetomium globosum* and *Aspergillus niger*) that breaks down the cellulose

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and hemicellulose in wood, leading to a softening of the wood surface. (Gonzalez & Morrell, 2012).

Species including *Khaya senegalensis*, *Mansonia altisiima*, *Pterocarpus soyauxii*, and *Celtis zenkeri* are frequently employed in tropical locations due to their advantageous qualities, however they are also vulnerable to fungal infestations. Therefore, effective treatment techniques are crucial to increasing their durability. Since the most common wood species in Nigeria, such as *Milicia excelsa, Celtis zenkeri* and *Pterocarpus soyauxii*, are prized for their high-quality timber, adequate preventive measures are necessary due to their vulnerability to fungi that damage wood (Olorunnisola, 2018).

Effective protection measures are necessary due to their vulnerability to fungi that degrade wood (Olorunnisola, 2018). Because of their shown effectiveness, chemical preservatives like creosote are employed extensively (Annamalai *et al.*, 2017). When assessing these treatments, it's critical to consider both how well they work to stop fungal infestations and how well they work with various types of wood. The density, porosity, and natural extractive of wood can affect how well preservatives are absorbed and work.

Comparative study is essential to gaining a thorough grasp of how each treatment interacts with various wood kinds (Schubert et al., 2022). Researchers can determine the best treatment combinations that improve the sustainability and durability of wood products by examining the effectiveness of various preservatives on diverse wood species.

MATERIAL AND METHODS

Study Area

The general laboratory of the School of Agriculture and Agricultural Technology (SAAT), Federal University of Technology, Owerri (FUTO) in Imo State, Nigeria, was used during the period of the research. Federal University of Technology, Owerri (FUTO) is located between the latitudes 5.47630N and longitudes 7.17580E in Imo State, Nigeria, in the Owerri West Local Government Area. Federal University of Technology, Owerri is a premier institution of higher learning in Nigeria, established in 1980. The university is known for its strong programs in science, technology, engineering, and agriculture. Federal University of Technology Owerri is a leading research institution in Nigeria, with a strong focus on innovation, entrepreneurship, and community development. Owerri West is one of the 27 local government areas in Imo State. It is a significant urban center, serving as the administrative headquarters of the local government. Owerri West is known for its bustling markets, commercial activities, and educational institutions, including FUTO.

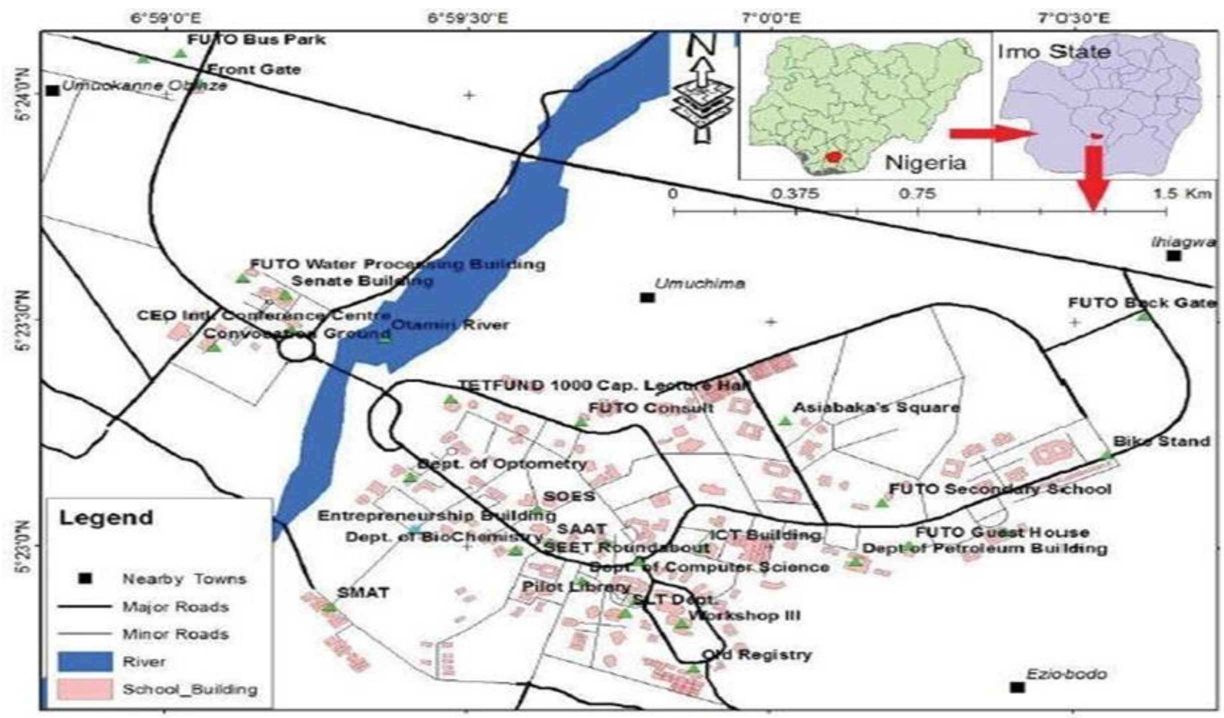

Figure 1: Map of the study area. *Source: Eke and Emelue (2020).*

Procurement and processing of Experimental Materials

The two wood species were procured from Naze Allied and timber market in Owerri, Imo State. These wood samples were converted into 30mm x 30mm x 70mm dimensions at the saw mill. Creosote and Potato Dextrose Agar (PDA) were obtained from chemical and laboratory shops in Owerri respectively, while O. gratissimum extract was prepared by the following method:

The extraction process was done according to Zhang (2018). O. gratissimum leaves were harvested, dried and blended into powdered form. Five hundred milliliters (500ml) of ethanol solution was added into 45grams of the blended *O. gratissimum*. This was later filtered to remove any remaining plant material. The extracted preservative was stored in an enclosed container.

All samples were carefully labelled for easy identification using combination of the wood species name and preservatives to be used. The initial weights (W_0) of each of the wooden blocks was determined using a weighing balance before it is oven dried after which they were dried for 8-10 hours at a temperature of 103 ± 2°C until a constant weight was attained. The samples were thereafter weighed again (W_1) to determine the weight after oven drying.

The preservatives were divided into 3 equal parts for each wood species. Two samples each from the wood species were soaked in the preservatives for a period of24 hours representing 3 replicates for each wood and preservative used together with the control (untreated sample). The samples were weighed after treatment and recorded as W_2. The samples were kept in the laboratory for 72 hours for conditioning before exposure to fungi attack. Aspergillus fumigatus was cultured in the laboratory using PDA. The treated wood samples were inoculated with the cultured Aspergillus fumigatus in an enclosed transparent container for 8 weeks. Untreated samples (control) were also exposed to fungi attack. After the 8 weeks exposure, the test blocks were removed, cleaned and then weighed. The final weight after exposure was obtained and recorded as W_3.

Data Collection

Data collected on preservative absorption by the two (2) wood species in three (3) replicates were obtained through the initial mass and the final mass of samples after 12 hours dipping; which represent the data obtained both before and after the application of chemical on the wood sample and their chemical retention level. According to Owoyemi *et al*. (2020), the assessment of test samples was carried out using equations below.

Before treatment

Determination of moisture content

The moisture content of the wood samples was determined using the weight of the samples before and after oven drying of it (American Society for Testing and Materials (ASTM, 2016).

$$\text{Moisture content (\%)} = \frac{W0-W1}{W1} \times 100 \qquad (1)$$

After treatment:

These are the tests that were carried out on the wood samples after the period of the experiment (ASTM, 2014).

a. Preservative Absorption: This is the amount of preservation chemical that the wood samples absorb. The percentage absorption was calculated by using:

$$\text{\% Absorption} = \frac{W2-W1}{W1} \times 100 \qquad (2)$$

b. Preservative retention: this is the amount of each preservative retained in the wood after treatment period or cycle. This was calculated using the equation below;

$$\text{Retention} = \frac{GC}{V} \times 100 \qquad (3)$$

G = W_3-W_1, C = is the quantity of the treating solution, V = volume of the wood samples (cm^3)

c. Weight Loss due to fungi infestation: The weight of the wood samples after exposure to the fungi species was calculated using:

$$\text{\% Weight loss} = \frac{W2-W3}{W2} \times 100 \qquad (4)$$

Where; W_2 = Conditioned weight after preservative treatment (g), W_3 = Final weight after fungi exposure (g)

Statistical Analysis

The data on absorption and weight was subjected to descriptive statistics using Two-sample T-test to test for significant difference between the species and treatment method. Results are presented in tables and charts.

RESULTS AND DISCUSSIONS

Results

Moisture content

Among the two selected wood species, Figure 2 revealed that *Pterocarpus soyauxii* exhibited the highest moisture content at 17.85 ± 3.87%**,** followed closely by *Celtis zenkeri* with 16.16 ± 2.09%**.** The observed differences suggest that *Pterocarpus soyauxii* and *Celtis zenkeri* retain moisture. This may indicate variations in their cellular structure, density, and hygroscopic properties. These differences in moisture content can influence the wood's performance in applications requiring dimensional stability, drying characteristics, or resistance to decay. This suggests that the inherent properties of each wood species contribute to their distinct moisture retention capacities.

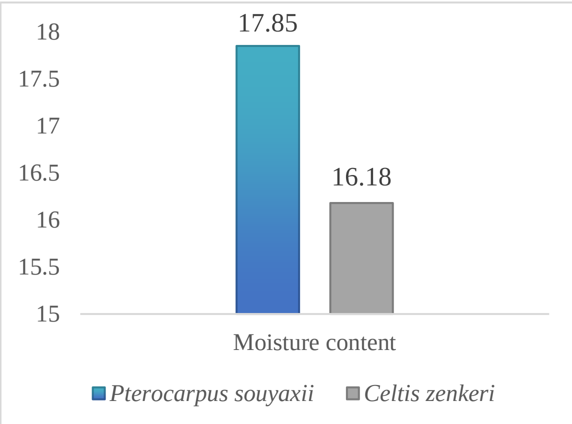

Figure 2: Percentage moisture content of wood samples

The Percentage Absorption

The results presented in Table 1 illustrate the percentage absorption of two preservatives, Creosote and *Occimum gratissimum* across two wood species: *Pterocarpus soyauxii*, and *Celtis zenkeri*. For *Pterocarpus soyauxii* wood, the absorption percentage was slightly higher for Creosote (54.69±0.90) compared to Occimum (52.17±2.27), with an overall mean absorption of 53.43±2.05. This suggests that *Pterocarpus soyauxii* a wood has a moderate absorption capacity, with Creosote being marginally more effective. In contrast, *Pterocarpus soyauxii* wood exhibited significantly higher absorption rates for both preservatives, with Creosote at 54.69±0.90 and Occimum at 52.17±2.27. This indicates that *Perocarpus soyauxii* wood has a notably higher affinity for preservatives, particularly creosote, which may be attributed to its inherent porosity or chemical composition.

Celtis zenkeri wood, however, showed the lowest absorption rates among the two species, with Creosote at 42.35±0.75 and Occimum at 44.33±0.30, resulting in a total mean absorption of 43.33±1.18. This suggests that *Celtis zenkeri* wood is less permeable to preservatives compared to *Pterocarpus soyauxii*. The relatively small standard deviations across all measurements indicate consistent absorption rates within each wood species, highlighting the reliability of the data. Overall, these findings underscore the variability in preservative absorption across different wood species, with *Pterocarpus soyauxii* demonstrating the highest potential for preservative treatment followed by *Celtis zenkeri*. This information is crucial for selecting appropriate wood-preservative combinations for specific applications in construction or preservation. The two sample T-test carried out in Occimum extract absorption shows that p-value (0.000002) is less than the significant difference between the means of *Pterocarpus soyauxii* and *Celtis zenkeri*. While for the creosote absorption, p-value (0.000006) is less than the significant level (0.05) indicating a statistically difference between the means of the wood samples.

Table 1: Descriptive statistics for percentage absorption

Wood species	Preservatives	% Absorption
	Control	52.24±1.27
P. soyauxii	Creosote	54.53±0.90
	Occimum	52.22±2.27
	Control	41.09±0.32
Zenkeri	Creosote	42.31±0.75
	Occimum	44.34±0.30

Values are means± Standard deviation

The Percentage Retention

The results in Table 2 provide insights into the percentage retention of preservatives (Creosote and *Occimum gratissimum*) compared to untreated controls across three wood species (*Pterocarpus soyauxii* and *Celtis zenkeri*). For *P. soyauxii* wood. Creosote-treated samples showed a higher retention of 50.92±0.82, and Occimum-treated samples had a retention of 49.11±0.62. The results indicate that Creosote was more effective in enhancing retention compared to Occimum. This suggests that *P. soyauxii* wood responds well to preservative treatment, particularly with Creosote, which may improve its durability and resistance to decay. The p-value (0.00014) is less than significant level (0.05) indicating a significant difference between means of *Pterocarpus soyauxii* treatment with creosote and occimum extract. *Pterocarpus soyauxii* wood exhibited the highest retention percentages among the two species. *Celtis zenkeri* wood had the lowest retention values, with Creosote treatment at 42.17±1.21, and *Occimum gratissimum* at 39.21±1.24, resulting in a total mean retention of 40.69±2.02. This indicates that *C. zenkeri* wood has limited capacity for preservative retention, regardless of the treatment used. These findings emphasize the variability in preservative retention across wood species, with *P. soyauxii* showing the greatest potential for effective treatment, followed by *C. zenkeri*. This information is valuable for selecting appropriate wood-preservative combinations to enhance durability and longevity in practical applications. This suggests that *P. soyauxii* has a higher capacity for absorbing and retaining treatment compared to *Celtis zenkeri*, which could be attributed to variations in their anatomical structures and porosity.

The use of preservatives enhanced moisture retention, as indicated by the significant differences between the treated and untreated samples.

Table 2: Descriptive statistics for percentage retention

Wood species	Preservatives	Percentage Retention
P. soyauxii	Control	50.11±0.71
	Creosote	49.91±0.82
	Occimum	49.11±0.62
C. zenkeri	Control	39.51±2.15
	Creosote	42.09±1.21
	Occimum	39.23±1.24

Values are means± Standard deviation

Percentage weight loss of wood species

Results on percentage weight loss (Figure 3) revealed that untreated wood species had highest weight loss than those treated with *Occimum gratissimum* and creosote. *C. zenkeri* had highest percentage weight loss of 22.2% (control sample) and 11.52% when treated with *Occimum gratissimum*. *Pterocarpus soyauxii* had 4.61% (control), 4.18% (Occimum) and 2.14% (creosote). Wood species treated with creosote had least percentage weight loss ranging from 2.14% in *Pterocarpus soyauxii* and 0.52% in *Celtis zenkeri*.

Results presented in figure 4a and 4c showed the visual ratings of *Pterocarpus soyauxii*, and *Celtis zenkeri*. It was observed that untreated samples (control) had higher rating among the three wood species. In figure 4a, *Pterocarpus soyauxii* exhibited high fungal stain with molds that appear fuzzy and slimy in samples treated with *O. gratissimum* than those treated with creosote. In Figure 4b, from week 3, *Celtis zenkeri* treated with *Occimum gratissimum* had higher fungal growth than those treated with creosote.

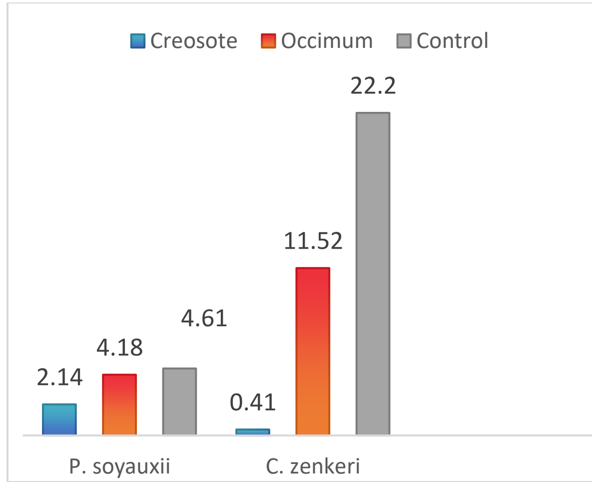

Figure 3: Percentage weight loss of wood species

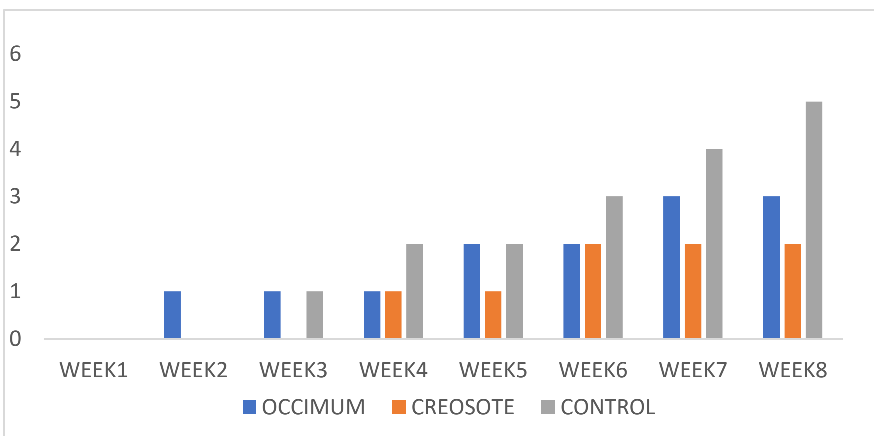

Figure 4a: Visual rating of *Pterocarpus soyauxii*.

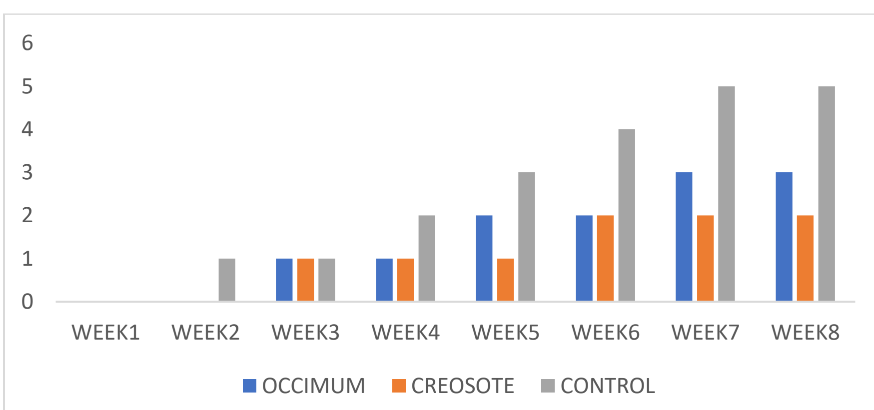

Figure 4b: Visual rating of *Celtis zenkeri*.

Discussion

The measured values indicate variability in the moisture levels among the different species analyzed. These variations in moisture content can be attributed to differences in the cellular structure and hygroscopic properties of the wood species. *Pterocarpus soyauxii* and *Celtis zenkeri*, with their higher moisture content, may have more porous or less dense structures, allowing them to absorb and retain more water. (Bowyer *et al.,* 2007). The higher moisture content in *Pterocarpus soyauxii* and *C. zenkeri* suggests that these species may be more prone to dimensional changes, such as swelling and shrinkage, when exposed to varying environmental conditions.

Pterocarpus soyauxii wood exhibited moderate absorption rates, with Creosote showing slightly higher absorption compared to Occimum. This suggests that *P. souaxii* wood has a moderate capacity for preservative absorption, with Creosote being marginally more effective. The higher absorption of Creosote may be due to its chemical properties, which allow it to penetrate wood fibers more effectively than Occimum (Rowell & Winandy, 2012).

Creosote outperformed Occimum in the moderate retention of *Pterocarpus soyauxii* wood, indicating that Creosote improves the wood's durability and resistance to decay more successfully (Rowell & Winandy, 2012). *Pterocarpus soyauxii* exhibited the highest retention, particularly with Creosote, indicating its superior ability to retain preservatives, likely due to its porous structure and chemical compatibility (Bowyer *et al*., 2007). Additionally, *Celtis zenkeri* had the lowest retention values (Creosote: 42.09±1.21; Occimum: 39.23±1.24), suggesting limited preservative uptake, possibly due to its denser structure (Simpson & TenWolde, 1999). This variability in retention emphasizes the need for tailored wood-preservative combinations to optimize performance in practical applications (De Ligne *et al.,* 2022).

CONCLUSIONS AND RECOMMENDATIONS

This study examined the moisture content, absorption, and retention properties of two selected wood species, *Pterocarpus soyauxii* and *Celtis zenkeri*, in response to preservative treatments with Creosote and *Occimum gratissimum*. The results revealed significant differences in moisture content, with *P. soyauxii* retaining higher moisture levels compared to *Celtis zenkeri*, which exhibited superior dimensional stability. Absorption and retention rates varied among species, with *P. soyauxii* demonstrating the highest capacity for preservative uptake, followed by *Celtis zenkeri* showing the lowest values. Creosote was more effective than Occimum in improving both absorption and retention, suggesting its suitability for enhancing wood durability. The significant variations in absorption and retention indicate that *P. soyauxii* is the most promising candidate for preservative treatment, making it suitable for applications requiring enhanced durability and resistance to decay. *P. soyauxii*, with moderate absorption and retention, may also benefit from preservative treatments, while *Celtis zenkeri`s* limited uptake suggests the need for alternative preservation techniques. The effectiveness of Creosote over Occimum further underscores its role in prolonging wood lifespan in construction and industrial applications. These insights contribute to the knowledge of wood preservation and can guide material selection for improved longevity and performance in various industries.

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Authors' Contributions

IED & VOU designed the research idea, methodology experiments and data collection. IDU and JAO revised and edited the manuscript.

Ethical Statement

The authors declare that the research was conducted in accordance with the standards of American Society for Testing and Materials (ASTM). All participants provided written informed consent before taking part in the research.

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