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COMPARATIVE ASSESSMENT ON THE RETENTION CAPACITY OF BORON AND ACQ WOOD PRESERVATIVES IN LESSER-KNOWN TIMBER SPECIES IN SRI LANKA BY THE DIPPING TREATMENT

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Abstract:

This study explores lesser-known wood species (LKS) from the southern region of Sri Lanka, focusing on their unique characteristics and potential applications in woodworking, construction, and decoration. These species, often overlooked in commercial markets, possess distinctive visual qualities and durability that make them suitable for specific uses. The research investigates twenty such species, assessing their response to two wood preservatives-Alkaline Copper Quaternary (ACQ) and boron-at the Kaldemulla Timber Complex, Sri Lanka. Boron was selected for its ease of use, high chemical penetration, minimal color change, and low environmental impact, while ACQ was chosen for its versatility and eco-friendliness. The study employed a dipping treatment method with a 6-hour duration, using an 8% (w/v) solution strength and temperatures ranging from 60°C to 80°C. Chemical uptake was measured by weight differences, and penetration was assessed using Chrome Azurol S (CAS) and turmeric solutions. The results revealed comparable chemical uptake for both preservatives, with a notable inverse relationship between wood density and chemical uptake. Species like Rukkattana (Alstonia scholaris) and Arawkeriya (Araucaria columnaris) exhibited high chemical penetration despite their low density, whereas species with high density, such as Diya Na (Mesua thwaitesii) and Kahamilla (Vitex altissima), showed lower uptake. The average moisture content of the samples ranged from 10% to 20%, with densities varying from 400kg/m³ to 1350kg/m³. Diya Na (Mesua thwaitesii) had the highest density, while Wanasapu (Cananga odoraya) had the lowest but exhibited the highest chemical uptake. This inverse correlation between density and chemical uptake highlights the potential of these lesser-known species in the field of wood preservation and their suitability for various industrial applications.

Key words*: ACQ, Boron, Chemical penetration, Chemical uptake, Dipping method, Lesser-known species, Wood preservations.*

INTRODUCTION

Sri Lanka is an island full of natural resources that can be utilized for many purposes and privileges to cover income within the country. Timber is a naturally found construction material that has been used since ancient times and is worth other uses too. Except for construction works, it is used as a decoration agent, furniture, strengthening items, parts of domestic pieces of equipment, roofing material, railway coaches and wagons, and houses in some areas (Pushpakumara et al. 2023; Zoysa 2022).

The distinctive structural and chemical properties of wood, a natural, cellular, composite material of botanical origin, make it ideal for a wide range of end purposes. The wood's reaction to enforced physical and chemical treatments frequently determines its level of acceptability for a certain end use (Lou et al.

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2023). However, in addition to these standards, wood quality is frequently determined by how wood reacts to environmental factors, including weather, fire, and decay. All of these performance standards are connected to the chemistry of wood and the microscopic and macroscopic organizational structure of the wood, either directly or indirectly (Zhang et al. 2022).

In Sri Lanka, there are two types of timber resources: forest-derived and non-forest-derived. The forest timber resources are made up of wood that has been taken from both natural and artificial plantations. The non-forest timber resources are made up of wood taken from individual and community gardens, rubber and coconut plantations, and lumber mills (Himandi et al. 2021; Muthumala et al. 2022). In Sri Lanka, there are about 400 timber species; among them, 250 are already in use, and the remaining species are not frequently in use which are called Lesser Known Species (LKS) in Sri Lanka. Lesser-known timber species also bear many valuable wood properties like density, moisture content, colour, texture, and urability. But there is no proper timber classification system available for this lesser-known timber category. The natural wood properties of each species are more or less different from one another. Timber is categorised into two groups: hardwood and softwood. Coniferous belongs to softwood, and deciduous is hardwood (Muthumala et al. 2022).

“Wood preservative” refers to the substance of treating wood with chemicals or any other biochemical compounds that can aid in preventing or slowing down the deterioration of wood brought on by either environmental conditions or by creatures like fungi, insects, and wood borers (Wijayaboparathne et al. 2024). Boron wood preservatives are a type of wood treatment that utilizes borate compounds to protect wood against decay, insects, and other organisms. Boron is a natural element that has been used for decades as an effective wood preservative due to its low toxicity to humans and animals, as well as its ability to penetrate wood fibers and provide long-lasting protection (Hewage et al. 2024). Boron compounds disrupt the metabolic processes of fungi and insects by interfering with enzyme systems. They also inhibit the ability of insects to digest wood. Boron has the ability to deeply penetrate wood, which helps in providing protection against decaying organisms. The penetration depth depends on factors like wood species, moisture content, and treatment method (Vipushnan et al. 2022). Alkaline Copper Quaternary (ACQ) is a wood preservative used to protect wood from decay, insects, and other environmental factors. The mode of action of ACQ wood preservative involves its chemical properties interacting with the wood’s structure and the organisms that cause deterioration. Penetration and Binding, Insect Resistance, Quaternary Ammonium Compounds, Longevity, and Environmental considerations are the works of ACQ (Janin et al. 2021). One significant drawback is its potential to accelerate the corrosion of certain metals, such as steel and Aluminium, when in contact with ACQ-treated wood. This can pose challenges in construction projects where metal fasteners and connectors are utilized. Another concern lies in the potential leaching of copper ions from ACQ-treated wood, which can impact surrounding soil and aquatic environments, especially in areas with sensitive vegetation or aquatic life. ACQ-treated wood’s suitability for specific applications can be limited due to its alkalinity and the potential for localized ecological impacts. Furthermore, the coloration of ACQ-treated wood, albeit temporary, might not align with desired aesthetics, potentially affecting the visual appeal of projects. Additionally, while ACQ is regarded as environmentally friendly, there are still considerations around its initial cost, especially when compared to untreated wood (Evans et al. 2022). Impregnation is a wood preservation method that involves saturating wood with a preservative substance to enhance its resistance to decay, insects, and other forms of deterioration. This process ensures that the preservatives penetrate deep into the wood’s cellular structure, providing comprehensive protection. There are several methods of impregnation used in wood preservation, including pressure treatment, vacuum treatment, dipping and soaking, vacuum-pressure treatment, diffusion treatment and incising (Järvinen et al. 2022).

The timber classification of Sri Lanka has been developed based on demand, supply, and availability over time. The State Timber Corporation introduces eight categories for Sri Lankan timber classification: Supper Luxury Class, Luxury Class, Special Class Upper, Special Class, Class I, Class II, Class III, and Class III Lower Grade. However, high-quality timber represents the uppermost classes in the classification. Trees are biological materials, and with time, they get degraded and affected by insect attacks. Timber deterioration refers to the process of wood gradually losing its structural integrity, aesthetic appeal, and other desirable properties due to various factors. Wood is a natural material and is susceptible to degradation over time. Several factors contribute to timber deterioration, including biological, environmental, chemical, and mechanical factors. As a solution, wood preservation involves applying various treatments to wood in order to protect it from decay, insects, and other forms of deterioration. Preserving wood extends its lifespan, making it suitable for a wide range of applications, from construction and furniture to outdoor structures. There are several methods and techniques for wood preservation, like chemical treatments (pressure treatment, dipping and soaking, brush-on application, surface coatings), chemical preservatives (copper-based preservatives, borate preservatives, organic-based preservatives), heat treatment (thermal modification), wood modification, and natural resistance (Van Acker et al. 2023). Lesser-known species (LKS) are commercially less accepted species left in the forest after a logging operation. Nonetheless, as stated by Hansom (1982), a better definition is that it is a species not being put to the best advantage (although many commercial species are not being put to the best advantage either). However, as timber resources become scarcer and the real prices of dominant species rise, LKS will gain wider acceptance and value. The absence of information regarding the retention capacity of Boron and ACQ wood preservatives in lesser-known timber species poses a challenge in determining suitable, cost-effective wood treatment methods and their viability for commercial use.

MATERIALS AND METHODS

Timber preparation

This study was conducted at the State Timber Corporation, Battaramulla, and Kaldemulla Timber Complex from March 2024 to July 2024. Timber samples were collected by State Timber Corporation and Forest Department, Sri Lanka.

Selection of timber species

This investigation was undertaken with 20 lesser-known timber species (Table 1) which can be used in furniture. ACQ treatment and Boron treatment were done for all 20 species and 04 replicates were represented for each treatment. Samples were prepared in sizes of approximately 4cm×4cm×2cm.

Measuring initial mass of samples

Electrical balance was used to take initial mass of samples. Initial mass of a sample contains dry matter and moisture content.

Measuring volume

Venire caliper was used to get measurements of volume. Three values from each height, length and breadth were taken to obtain accurate average value.

Moisture test for samples

Both oven dry method and moisture meter methods were used to get accurate moisture values of timber samples.

Density test

Both densitometer values and water displacement method were used to compare and take accurate final output.

Measuring final mass (mass after treatment)

Same electrical balance was used to get final mass of samples. Average final weight was calculated by final masses of four replicates.

Labelling the samples

Both ACQ and Boron treatment samples were labelled according to a scientific order.

Moisture test

Moisture content was measured by a moisture meter as well as the oven dry method to get an accurate output.

Table 1

Selected lesser-known timber species

No	Species common name	Scientific name	Family
1	Acasia auriculiformis	*Acasia auriculiformis*	Fabaceae
2	Acasia mangium	*Acasia mangium*	Fabaceae
3	Aladu	*Allenthus zeylanicus*	Moraceae
4	Arawkeriya	*Araucaria columnaris*	Araucariacea
5	Bora damaniya	*Grewla helicterifolia*	Malvaceae
6	Diya na	*Mesua thwaitesii*	Calophyllaceae
7	Dunumadala	*Stereospermum personatum*	Bignoniaceae
8	Halamba	*Mitragyna parvifolia*	Rubiaceae
9	Kahamilla	*Vitex altissima*	Lamiaceae
10	Karaw	*Margaritaria indica*	Phyllanthaceae
11	Katu andara	*Dichrostachys cinerea*	Fabaceae

12	Katuboda	*cullenica ceylanica*	Malvaceae
13	Korakaha	*Memecylon umbellatum*	Melastomataceae
14	Kurumbattiya	*Syzygium rubicundum*	Myrtaceae
15	Maha nuga	*Flecus benghalensis*	Moraceae
16	Na imbul	*Harpullia arborea*	Sapindaceae
17	Path kalla	*Bridelia mooni*	Euphorbiaceae
18	Pelan	*Bhesa ceylanica*	Centroplacaceae
19	Rukkanttana	*Alstonia scholaris*	Apocynaceae
20	Wanasapu	*Cananga odoraya*	Annonaceae

PRESERVATION TREATMENTS

Dipping treatment method

A half-cut barrel was used to conduct two wood preservations. 100L of water and 8% (w/v) of wood preservatives were consumed to complete the treatment.

Chemical penetration - Boron treated samples

Turmeric A, B solutions were applied cross surface of samples to check whether any color change happened.

Chemical penetration -ACQ treated samples

Chrome Azurol S was applied cross surface of samples to check ant color changes were happened.

Determination of chemical uptake

$$CU = \{(W2 - W1) / V1\} \times C. \quad \text{Equation 2}$$

where:

CU = Chemical Uptake (kg/m^3)
W2 = Final mass of the timber sample after treatment (g)
W1 = Initial mass of the timber sample (g)
V1 = Volume of the conditioned wood sample before immersion (cm^3)
C = Solution concentration as percentage

TREATING PROCEDURE

Preparation of timber specimens to ACQ and Boron treatment

ACQ treatment

ACQ treatment was done through the Dipping method in a half-cut barrel. The heat was supplied by burning fuel wood and from consecutive time intervals, the temperature was maintained in between 60°C to 90°C. Other requirements were as follows. The treatment was conducted on May 24, 2024, beginning at 11 a.m. The dipping process lasted for a total of 6 hours, with the procedure concluding at 5 p.m. The solution strength used for the treatment was 8% (w/v). After 06 hours, samples were taken out of the solution and gently wiped to remove the preservative solution from the surface. The final masses of the samples were measured.

Identification of ACQ

Chrome Azurol S (CAS) was used to determine the visible penetration level of ACQ. Penetrated potions were converted to a dark blue color after applying CAS. Color difference was observed after applying CAS.

Method for determining ACQ uptake

This research was reflected the methodical analysis (dipping) to evaluate Chemical uptakes of two wood preservatives and the quantitative measures of ACQ uptake in LKS were calculated by following Equation 1.

$$CU = (W2 - W1) \times C \qquad \text{Equation 1}$$

where: CU = Chemical (ACQ) Uptake (kg/m3)
W2 = Final mass of the ACQ timber sample after treatment (g)
W1 = Initial mass of the ACQ timber sample (g)

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C = Solution concentration as percentage
V = Volume of the conditioned ACQ wood sample before immersion (cm^3)

Boron treatment

Boron treatment was done through Dipping method in a half-cut barrel. Heat was supplied by burning fuel wood and time to time temperature was continued in between 60°C to 90°C.
The treatment was carried out on May 25, 2024, starting at 10 a.m. The dipping process lasted for 6 hours, with the procedure finishing at 4 p.m. The solution strength used for this treatment was also 8% (w/v). After 06 hours samples were taken out from solution and gently wiped to remove the preservative solution on the surface. Final masses of samples were measured.

Identification of Boron

First Turmeric A solution was applied on cross surface of Boron treated samples and on which Turmeric B solution was applied. Within few minutes color was changed according to chemical penetration of each sample. Color differences after the application of Turmeric A, B solutions.

Method for determining Boron uptake

The quantitative measures of Boron uptakes in LKS were calculated by following Equation 1 as above.

Results and Discussion

The highest and lowest boron uptakes were observed in the Wanasapu (*Cananga odoraya*) and Diya Na (*Mesua thwaitesii*) species, respectively, as shown in Table 2, which presents the boron uptake data for all 20 samples. Similarly, the highest and lowest ACQ uptakes were also recorded for the Wanasapu (*Cananga odoraya*) and Diya Na (*Mesua thwaitesii*) species, with the ACQ uptake data for all 20 samples presented in Table 2 and Fig. 1.

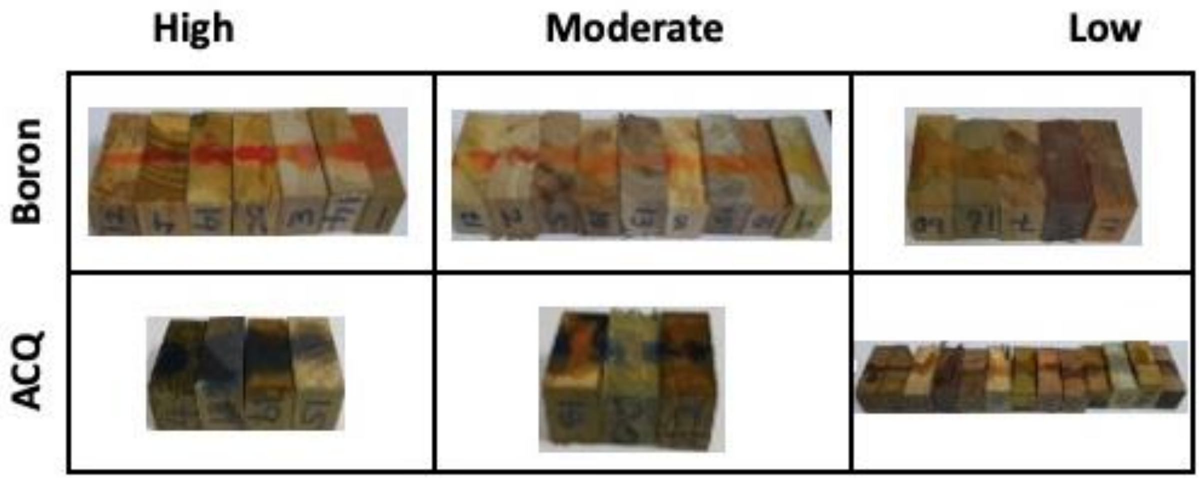

Fig. 1.
Comparison of Boron and ACQ uptake.

Table 2

Comparison between chemical uptakes of samples in two wood preservatives

Group	ACQ	Chemical uptake of ACQ wood preservative (Kg/m3)	Boron	Chemical uptake of Boron wood preservative (Kg/m3)
Difficult to treat	Diya na	2.5	Diya na	2.24
	Dunumadala	3.14	Dunumadala	4.31
	Aladu	3.73	Aladu	2.97

	Path kalla	3.77	Kahamilla	4.28
	Acasia auriculiformis	3.99	Katu andara	3.7
Moderate to treat	Na imbul	9.09	Na imbul	7.26
	Karaw	9.5	Karaw	8.42
	Korakaha	7.03	Path kalla	6.45
	Katu andara	5.35	Acasia auriculiformis	4.5
	Kahamilla	6.89	Korakaha	5.45
Easy to treat	Acasia mangium	10.1	Acasia mangium	8.46
	Kurumbattiya	17.22	Kurumbattiya	15.4
	Halamba	18.19	Halamba	24.95
	Bora damaniya	19.64	Bora damaniya	18.65
	Pelan	26.95	Maha nuga	29.74
Very easy to treat	Katuboda	41.99	Katuboda	43.19
	Arawkeriya	38.82	Arawkeriya	32.61
	Rukkanttana	40.84	Rukkanttana	32.16
	Wanasapu	47.26	Wanasapu	48.42
	Maha nuga	29.92	Pelan	33.6

*replicates = 3

Table 3

Relationship between ACQ uptake and Density

Species common name	Density (kg/m^3)	Chemical uptake of ACQ wood preservative (kg/m^3)
Acasia auriculiformis	900.86	3.99
Acasia mangium	585.26	10.10
Aladu	915.26	3.73
Arawkeriya	465.00	38.82
Bora damaniya	764.26	19.64
Diya na	1321.36	2.50
Dunumadala	1065.95	3.14
Halamba	743.11	18.19
Kahamilla	662.55	6.89
Karaw	738.22	9.50
Katu andara	935.57	5.35
Katuboda	441.70	42.99
Korakaha	1028.32	7.03
Kurumbattiya	711.12	17.22
Maha nuga	582.90	29.92
Na imbul	565.50	9.09
Path kalla	809.75	3.77
Pelan	766.62	26.95
Rukkanttana	331.42	40.84
Wanasapu	272.86	47.26

*replicates = 3

The Table 3 shows the relationship between the density of various wood species and their chemical uptake of the ACQ wood preservative. Generally, the data illustrates a wide range of density values and corresponding preservative uptake amounts across the 20 species listed. The Table 3 presents the relationship between the density of various wood species and their uptake of the ACQ wood preservative. It shows a diverse range of density values and ACQ uptakes, with no clear, linear correlation between the two. For instance, species like Diya Na (*Mesua thwaitesii*) (density 1321.36kg/m³) and Dunumadala (*Stereospermum personatum*) (1065.95kg/m³) have relatively high densities but exhibit low ACQ uptakes of 2.50 and 3.14kg/m³, respectively. In contrast, species with lower densities, such as Wanasapu (*Cananga odoraya*) (272.86 kg/m³) and Rukkanttana (*Alstonia scholaris*) (331.42kg/m³), demonstrate very high ACQ uptakes of 47.26 and 40.84kg/m³, respectively. These species with lower density appear to absorb significantly more preservative. Similarly, other species like Arawkeriya (*Araucaria columnaris*) (465.00kg/m³, ACQ uptake 38.82kg/m³) and Katuboda (*Cullenica ceylanica*) (441.70kg/m³, ACQ uptake 42.99kg/m³) also show high uptake despite their relatively low densities.

The chemical uptake of the ACQ wood preservative observed in this study aligns with global literature on wood preservative absorption, where lower density species typically show higher uptake. Studies have consistently shown that wood species with lower density tend to have more porous structures, which facilitates the penetration of preservatives like ACQ. For example, research by White et al. (2021) and Gonzalez-Benecke et al. (2021) found that less dense wood species, such as *Pinus radiata* and *Eucalyptus species*, exhibited higher absorption rates for wood preservatives due to their greater porosity and larger capillary spaces. Conversely, higher-density species such as *Quercus robur* and *Pinus sylvestris*, with their more compact cell structures, tend to limit preservative penetration, as observed in species like Diya Na and Kahamilla in this study. This inverse relationship between wood density and preservative uptake highlights the importance of considering wood structure in selecting species for preservative treatments. It suggests that, in line with global findings, species with lower density are more likely to benefit from ACQ treatments, making them more suitable for applications requiring deeper preservative penetration.

On the other hand, some species with moderate densities, such as Bora Damaniya (*Grewla helicterifolia*) (764.26kg/m³, ACQ uptake 19.64kg/m³) and Pelan (*Bhesa ceylanica*) (766.62kg/m³, ACQ uptake 26.95kg/m³), exhibit moderate levels of ACQ uptake. This pattern suggests that while there may be a weak tendency for species with lower densities to have higher ACQ uptake, the relationship is not absolute. Factors such as the wood's porosity, cell structure, and species-specific characteristics likely play a more significant role in determining the amount of preservative uptake than density alone. Thus, while density may influence the absorption of ACQ to some extent, it is clear that other anatomical factors must be considered to fully understand preservative uptake.Significant negative relationship between chemical uptake (ACQ) and density was represented in Fig. 1.

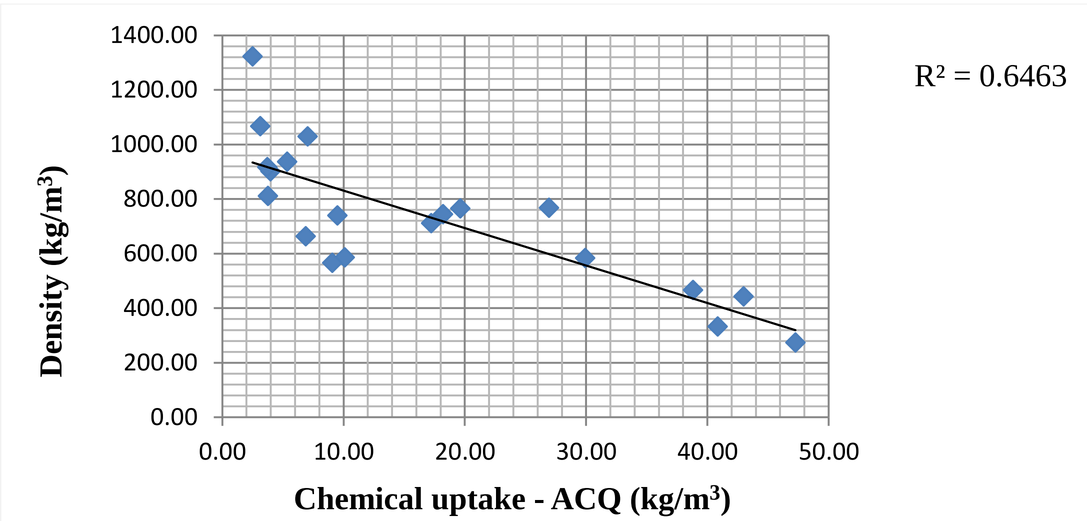

Fig. 2.
Relationship between ACQ uptake and Density.

Timber samples were treated with ACQ wood preservative and chemicals were absorbed into wood fibers through dipping treatment method. The chemical uptake increased was with declination of density value of samples. Depending on the chemicals used, species and treatment process also can influence the chemical uptake. Species density and chemical uptake amount were included in Table 3 and relationship between two parameters was described in Fig. 2.

Relationship between Boron uptake and Density

Timber samples were treated with ACQ wood preservative and chemicals were absorbed into wood fibers through dipping treatment method. Species density and chemical uptake amount were included in Table 4 and relationship between two parameters was described in Fig. 2.

Table 4

Relationship between Boron uptake and Density

Species common name	Density (kg/m^3)	Chemical uptake of Boron wood preservative (kg/cm^3)
Acasia auriculiformis	900.86	4.50
Acasia mangium	585.26	8.46
Aladu	915.26	2.97
Arawkeriya	465.00	32.61
Bora damaniya	764.26	18.65
Diya na	1321.36	2.24
Dunumadala	1065.95	4.31
Halamba	743.11	24.95
Kahamilla	662.55	4.28
Karaw	738.22	8.42
Katu andara	935.57	3.70
Katuboda	441.70	43.19
Korakaha	1028.32	5.45
Kurumbattiya	711.12	15.40
Maha nuga	582.90	29.74
Na imbul	565.50	7.26
Path kalla	809.75	6.45
Pelan	766.62	33.60
Rukkanttana	331.42	32.16
Wanasapu	272.86	48.42

*replicates = 3

The Table 4 illustrates the relationship between the density of various wood species and their chemical uptake of boron wood preservative. It shows that there is no clear, direct correlation between wood density and boron uptake. For example, Diya Na (*Mesua thwaitesii*) (with a density of 1321.36kg/m^3) and Aladu (*Allenthus zeylanicus*) (915.26kg/m^3) have relatively high densities but exhibit low boron uptake values of 2.24 and 2.97kg/cm^3, respectively. In contrast, species with lower densities such as Wanasapu (*Cananga odoraya*) (272.86kg/m^3), Katuboda (*Cullenica ceylanica*) (441.70kg/m^3), and Rukkanttana (*Alstonia scholaris*) (331.42kg/m^3) show very high boron uptake values of 48.42, 43.19, and 32.16kg/cm^3, respectively. This suggests that wood density alone does not determine boron absorption. Some species with moderate densities, such as Bora Damiya (*Grewla helicterifolia*) (764.26kg/m^3, boron uptake of 18.65kg/cm^3) and Halamba (*Mitragyna parvifolia*) (743.11kg/m^3, boron uptake of 24.95kg/cm^3), also show moderate uptake, indicating that a balance of factors, likely including porosity and cell structure, influences preservative absorption. Therefore, while density may play a role, it is clear that other anatomical and species-specific characteristics are crucial in determining the level of boron uptake. Significant negative relationship between chemical uptake (Boron) and density was represented in Fig. 3.

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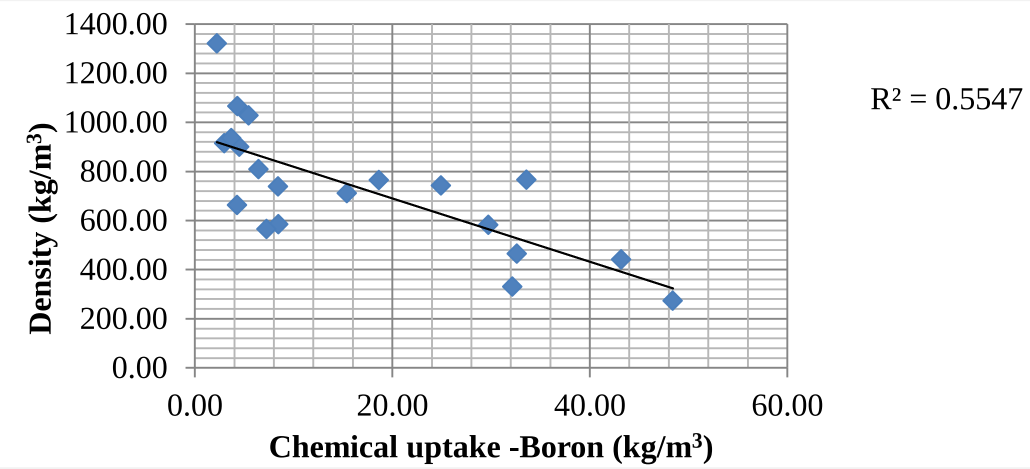

Fig. 3.
Relationship on Boron uptake and Density.

Comparison between chemical uptake of Boron, ACQ wood preservatives and Density

Table 5

Comparison between chemical uptake of Boron, ACQ wood preservatives and Density

Species common name	Density (kg/m^3)	Chemical uptake of Boron wood preservative (kg/m^3)	Chemical uptake of ACQ wood preservative (kg/m^3)
Acasia auriculiformis	900.86	4.50	3.99
Acasia mangium	585.26	8.46	10.10
Aladu	915.26	2.97	3.73
Arawkeriya	465.00	32.61	38.82
Bora damaniya	764.26	18.65	19.64
Diya na	1321.36	2.24	2.50
Dunumadala	1065.95	4.31	3.14
Halamba	743.11	24.95	18.19
Kahamilla	662.55	4.28	6.89
Karaw	738.22	8.42	9.50
Katu andara	935.57	3.70	5.35
Katuboda	441.70	43.19	42.99
Korakaha	1028.32	5.45	7.03
Kurumbattiya	711.12	15.40	17.22
Maha nuga	582.90	29.74	29.92
Na imbul	565.50	7.26	9.09
Path kalla	809.75	6.45	3.77
Pelan	766.62	33.60	26.95
Rukkanttana	331.42	32.16	40.84
Wanasapu	272.86	48.42	47.26

*replicates = 3

The chemical uptake of a wood and its density were interrelated factors that can influence each other, particularly when wood was treated with chemicals like preservatives. The chemical uptake process can affect the density of wood due to the addition of the chemical substances within the wood's cellular structure. According to available data, inverse relationship between density and chemical uptake was identified. The added mass from the chemicals can increase the overall density of the treated wood compared to untreated wood. Density of species and chemical uptakes of two wood preservatives were showed in Table 5.

The table 5 compares the chemical uptake of two wood preservatives-boron and ACQ-across various species, alongside their wood density. It reveals both similarities and differences in how these two preservatives are absorbed by wood species with varying densities.

One notable observation is that, for many species, the boron uptake tends to be higher than the ACQ uptake. For instance, Katuboda (*Cullenica ceylanica*) (density 441.70kg/m³) has a boron uptake of 43.19kg/m³, which is slightly higher than its ACQ uptake of 42.99kg/m³, while Arawkeriya (*Araucaria columnaris*) (465.00kg/m³) shows a significant difference with a boron uptake of 32.61kg/m³ compared to 38.82kg/m³ for ACQ. This indicates that while both preservatives are absorbed by the wood, the species may have different affinity levels for each, influenced by factors like porosity and chemical interactions.

On the other hand, species such as Diya Na (*Mesua thwaitesii*) (density 1321.36kg/m³) and Dunumadala (*Stereospermum personatum*) (1065.95kg/m³) show low uptakes of both boron (2.24 and 4.31kg/m³, respectively) and ACQ (2.50 and 3.14kg/m³). This suggests that denser species may not necessarily absorb preservatives in high quantities, regardless of the type of preservative used.

Wanasapu (*Cananga odoraya*) (272.86kg/m³), with the lowest density, shows exceptionally high uptake values for both preservatives, with 48.42kg/m³ for boron and 47.26kg/m³ for ACQ, indicating that species with lower density may have higher absorption capacities for both types of chemicals. Similarly, Rukkanttana (*Alstonia scholaris*) (331.42kg/m³) demonstrates high uptake for both preservatives (32.16kg/m³ for boron and 40.84kg/m³ for ACQ), further suggesting a trend where lower density species tend to absorb more preservative, though the exact relationship is not always consistent.

Overall, while there is some overlap, the data suggests that density does not strictly determine the uptake of either boron or ACQ preservatives. Rather, other factors—such as wood structure, porosity, and chemical interactions with the preservatives—play a significant role in influencing absorption. In general, lower density species tend to absorb higher amounts of both preservatives, but exceptions do exist, indicating the complexity of wood preservative absorption across different species.

Identification of penetration of Boron wood preservative

Three groups were classified to evaluate Boron wood preservative uptake as high, moderate, low and they were showed in the Table 6.

Table 6

Identification of penetration levels of Boron wood preservative

High	Moderate	Low
T19 – Rukkanttana	T17 – Path kalla	T9 – Kahamilla
T20 – Wanasapu	T2 – Acasia mangium	T16 – Na imbul
T4 – Arawkeriya	T5 – Bora damaniya	T7 – Dunumadala
T14 – Kurumbattiya	T18 – Pelan	T6 – Diya na
T12 – Katuboda	T13 – Korakaha	T11 – Katu andara
T3 – Aladu	T8 – Halamba	
T1 – Acasia auriculiformis	T15 – Maha nuga	
	T10 – Karaw	

The Table 6 categorizes the penetration levels of boron wood preservative into three distinct groups: High, Moderate, and Low. These groups represent the relative effectiveness of boron penetration across different species of wood, with the species listed under each category showing varying levels of preservative absorption.

High Penetration: Species such as Rukkanttana (*Alstonia scholaris*) (T19), Wanasapu (*Cananga odoraya*) (T20), and Arawkeriya (T4) exhibit high penetration levels of boron, meaning they absorb the preservative most effectively. This suggests that these species have a structure, porosity, or other anatomical features that allow for deeper or more thorough penetration of boron.

Moderate Penetration: Species like Path Kalla (*Bridelia mooni*) (T17), Bora Damaniya (*Grewla helicterifolia*) (T5), and Pelan (*Bhesa ceylanica*) (T18) fall into the moderate penetration category. These species show a more moderate level of boron uptake, indicating that their wood structure allows for some absorption but not as deeply as those in the high penetration group.

Low Penetration: Species such as Kahamilla (*Vitex altissima*) (T9), Na Imbul (*Harpullia arborea*) (T16), and Diya Na (*Mesua thwaitesii*) (T6) show low penetration levels, meaning that they either have a denser or less permeable structure, which limits the depth or amount of boron preservative that can penetrate the wood.

This classification of penetration levels reflects the relationship between wood structure (such as density, cell arrangement, and porosity) and the ability to absorb and retain preservatives. The species in the high penetration group likely have characteristics that allow for greater preservative movement into the wood, whereas those in the low penetration group may have denser or more compact fibers, which restrict preservative uptake. The moderate group falls somewhere in between. Understanding these penetration levels can help in selecting the right wood species for treatments requiring deep preservative penetration.

CONCLUSION

There is an inverse relationship between chemical uptake and density of woods for both Boron and ACQ treatments under the dipping treatment method. For both wood preservatives, Rukkattana (*Alstonia scholaris*) and Arawkeriya (*Araucaria columnaris*) species showed higher chemical penetration while Pelan (*Bhesa ceylanica*) showed moderate penetration. Kahamilla (*Vitex altissima*), Na imbul (*Harpullia arborea*), Dunumadala (*Stereospermum personatum*), Diya Na (*Mesua thwaitesii*), and Katu andara (*Dichrostachys cinerea*) species show the lowest chemical penetration for both ACQ and Boron wood preservatives. Fifteen lesser-known timber samples (Rukkanttana, Wanasapu, Arawkeriya, Kurumbattiya, Katuboda, Aladu, Acasia auriculiformis, Path kalla, Acasia mangium, Bora damaniya, Pelan, Korakaha, Halamba, Maha nuga, Karaw) of Boron treatment were shown color difference and five (Kahamilla, Na imbul, Dunumadala, Diya na, Katu andara) are not respond for Turmeric A, B treatment in the dipping method while thirteen samples (Kurumbattiya, Diya na, Aladu, Karaw, Acasia auriculiformis, Halamba, Kahamilla, Na imbul, Dunumadala, Katu andara, Path kalla, Acasia mangium) of ACQ treatment were not shown any color difference and seven samples (Arawkeriya, Korakaha, Rukkanttana, Maha nuga, Pelan, Wanasapu, Katuboda) were shown color difference for Chrome Azurol S. The Chemical uptake of a species is mainly affected by its density value, and it has an inverse relationship. Considering that the dipping treatment method is the most suitable for boron wood preservative for lesser-known timber species.

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