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PHYSICAL, DURABILITY AND CHEMICAL CHARACTERIZATION OF *Gmelina arborea* (Roxb.) WOOD TREATED WITH LACTIC ACID

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ABSTRACT

Chemical modification was employed to treat Gmelina arborea wood using lactic acid for property enhancement. The treated wood samples were obtained from two different ages of 15 and 10 years and sawn into (20 x 20 x 60) mm and (20 x 20 x 20) mm for physical, durability and chemical characterization respectively. The impregnated samples were cured for a complete modification process in the oven at a temperature of 140°C at varying durations (3, 6, and 9 hours). The chemical characterization was done using Fourier-infrared spectroscopy (FTIR). The results revealed that wood aged 10 and 15 years recorded density values of 421.83 kg/m³ and 469.24 kg/m³ and had an average value of moisture content, volumetric shrinkage, volumetric swelling, and weight loss due to leaching of 57.32% and 48.39%, 9.32% and 12.52%, 8.50% and 9.97%, and 0.21% and 0.89% respectively. The durability properties of the treated wood showed a reduction in the leaching rate after continuous soaking in water coupled with an increase in the anti-swelling efficiency. The FTIR results revealed that treated wood bands were within 2938 and 2842 cm⁻¹ assigned to CH stretching in aromatic methoxyl groups, and methyl and methylene groups of side chains. The modified wood can be used where considerable dimensional stability is required for structural use.

Keywords: Chemical characterization; *Gmelina arborea;* Impregnation; Modification; Properties enhancement

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INTRODUCTION

Wood is a material with a wide range of applications commonly used in a wide range and various forms, including structures, furniture, and many household items; it has also been applied in high-technology industries such as engineered components for automotive, energy, and aerospace industries (Ansell, 2015). Wood has numerous advantages that make it stand out among engineering materials, some of which include: renewability, versatility, strength-to-weight ratio, ease of fabrication, and aesthetic values.

The problem of dimensional stability in service is imposed by its chemical constituent: polysaccharides (i.e. cellulose and hemicelluloses) responsible for moisture uptake and release in the environments resulting in changes in wood properties (Rowell, 1983; Spear *et al.*, 2021). These notable shortcomings of wood in service necessitate the need for property enhancement. However, wood modification which offers an alternative approach is a relatively new field (Sandberg *et al.*, 2017; Jones and Sandberg, 2020), likely to allow extended applications. Most dominant wood modification systems (chemical modification, thermal modification, and polymer or resin impregnation) have sought to alter the relationship between wood and moisture, and as a result, restrict dimensional change and reduce susceptibility to decay (Hill, 2006; Ormondroyd *et al.*, 2015; Sandberg *et al.*, 2017; Jones and Sandberg, 2020).

The rapid growth in world population is the major cause of the increasing exploitation of matured and durable tree species leading to deforestation which has limited the wood industries to using less durable wood species and fast-growing tree species. Therefore, the plantation with a low rotation of this promising species is of interest to forest investors which has made it imperative to find solutions to achieve the desirable properties in service. Wood properties change with an increase in tree age and are because of cambial activities during tree growth (Owoyemi *et al.*, 2011; Sonderegger *et al.*, 2015). Increasing the range of efficient wood treatments using eco-friendly compounds combined with heat treatment has been recently reported to be a combined approach associating chemical reactions with wood hydroxyls and in-situ polymerization (Grosse *et al.*, 2019; Žigon and Pavlič, 2023). Hence, this study was designed to assess the effects of age and lactic acid treatment on the physical and chemical characterization of *G. arborea* to ascertain the level of property enhancement.

MATERIALS AND METHODS

Preparation of Wood Samples

Gmelina arborea trees with a diameter at breast height of 46 cm and 41.5 cm from two plantation stands of 15 and 10 years respectively were harvested from the Department of Forestry and Wood Technology plantation, FUTA. Three (3) billets 3 meters long were obtained from each tree at 25%, 50%, and 75% of the total height. The samples were converted at the wood workshop to 20 x 20 x 60 mm according to the American Society for Testing and Materials (ASTM) for the assessment of the physical and durability properties and 20 x 20 x 20 mm for chemical characterization. The converted samples were oven-dried at 103±2°C for 24 hours till constant weight was achieved and later transferred into a desiccator to cool to ambient temperature before weighing, only defect-free samples were selected and treated.

Treatment of Wood Samples

In a vacuum-pressure impregnation chamber, 60% of the lactic acid concentration was applied to the oven-dried *G. arborea* wood samples. The process begins with a 5-minute initial vacuum of 2KPa in the impregnation chamber, which is then filled with the prepared lactic acid solution until all the samples are submerged. The impregnation cycle entails applying a pressure of 4 bars for 30 minutes to ensure maximum penetration, and then withdrawing the samples from the chamber.

Curing of the Wood Samples

The withdrawn samples (Fig. 1a) were wrapped in aluminium foil and placed in the oven (Fig. 1b) for the modification process. The curing in the oven was carried out at a temperature of 140°C at varying time regimes (3 hours, 6 hours, and 9 hours) for the treated samples (Fig. 2). All the modified samples were conditioned at atmospheric room temperature for 24 hours before testing was carried out.

Fig. 1: (A) Wood loaded in the Impregnation Chamber (B) Curing Processing in Oven

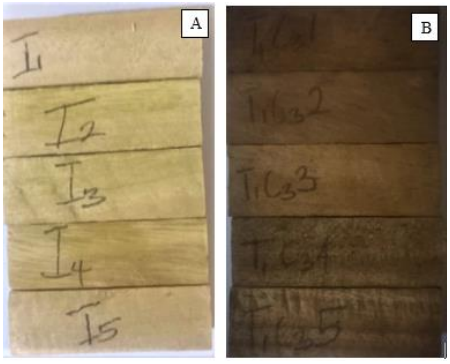

Fig. 2: A: Untreated samples B: Treated samples

Assessment of Basic Physical Properties of *G. arborea* Wood

Moisture Content (MC%) Determination

The green MC% of *G. arborea* wood was determined according to ASTM D4442-16 (2020) using:

MC (%) $= \frac{Wg-Wo}{Wo} X\ 100$ ……………… (1)

Where: W_g is the Weight of green samples (g); W_o is the Weight of oven-dried samples (g).

Wood Density Determination

The density of *G. arborea* wood was calculated by obtaining the weight and volume of the samples after oven drying according to ASTM D2395-17 (2022) using:

Density = $\left(\frac{M}{V}\right)$ kg/m^3 ……………… (2)

Where: M is the mass of the oven-dried sample (g); V is the volume of the samples (mm^3).

Volumetric Shrinkage

The dimensions of the *G. arborea* wood were obtained before and after drying and volumetric shrinkage (VS) was evaluated using:

VS (%) = $\frac{D_1-D_2}{D_1} \times 100$ …………. (3)

Where; VS is the volumetric shrinkage (%); D_1 is green dimensions (mm) while D_2 is the final dimensions after oven-dry (mm)

Chemical Uptake

The rate of chemical uptake during impregnation of the *G. arborea* wood of the two different age groups was determined by calculating the rate of percentage absorption using the following formula:

Absorption (%) = $\left(\frac{T_3-T_2}{T_2}\right) \times 100$ … (4)

Where: T_3 is the weight of the sample after treatment (in grams); T_2 is the weight of the samples before treatment (in grams).

Effect of Lactic Acid Treatment on the Physical Properties of *G. arborea* Wood

The effect of Lactic Acid Treatment on the physical properties of *G. arborea* Wood was determined by assessing the following parameters of both the treated and untreated samples of the two selected age trees.

Wood Density Increment

The density increment of the treated wood samples was determined according to ASTM D2395-17(2022) using:

Volumetric Swelling

The volumetric swelling of *Gmelina arborea* wood treated with lactic acid was determined after immersion in water for 24, 48, and 72 hours using:

$VS\ (\%) = \frac{D_2 - D_1}{D_1} \times \frac{100}{1}$ ………. (5)

Where; VS is Volumetric Swelling (%); D_1 is the Oven-dried Dimensions (mm) while D_2 is the final dimensions after soaking in water (mm).

The Anti-Swelling Efficiency (ASE)

The anti-swelling efficiency of the treated wood was calculated according to Hill (2006) using;

ASE (%) = $\frac{S_u - S_m}{S_u} \times 100$ …… (6)

Where: S_u is the volumetric swelling coefficient of the unmodified wood sample; while S_m is the volumetric swelling coefficient (*S*) of the modified wood samples.

The volumetric swelling coefficient (S) was calculated as follows:

$S(\%) = \frac{V_{ws} - V_{od}}{V_{od}} \times 100$ …… (7)

Where: V_{ws} is the water-swollen volume of the wood sample; while V_{od} is the oven-dried volume.

Weight Loss Due to Leaching

The weight loss of the impregnated wood samples due to leaching after repeated three cycles of water soaking for 24, 48, and 72 hours was done according to Rowell (2005), using:

$$\text{Weight Loss (\%)} = \frac{W_i - W_f}{W_i} \times 100 \quad \text{….. (8)}$$

Where: Wi is the oven-dried weight (g) after treatment; W_f is the oven-dried weight (g) after 72 hours of soaking of treated samples.

Chemical Characterization of Treated *G. arborea* Wood

The Fourier Transform Infrared Spectroscopy (FT-IR) technique was selected to analyze the assessment of chemical changes and to confirm the formation of the chemical bond in the *G. arborea* wood of two different age groups treated with lactic acid. The FTIR was carried out with a modern laboratory equipment model Nicolet iS10 FT-IR Spectrometer, while the IR spectra were analyzed using the spectroscopic software Win-IR Pro Version 3.0 with a peak sensitivity of 2 cm^1.

RESULTS

Physical Properties

Moisture Content Distribution

The percentage moisture content of two different age groups of *G. arborea* wood (**Fig. 3**) showed that the 10-year-old wood had a moisture content value of 57.32%, higher than that obtained from 15-year-old with a value of 48.39%.

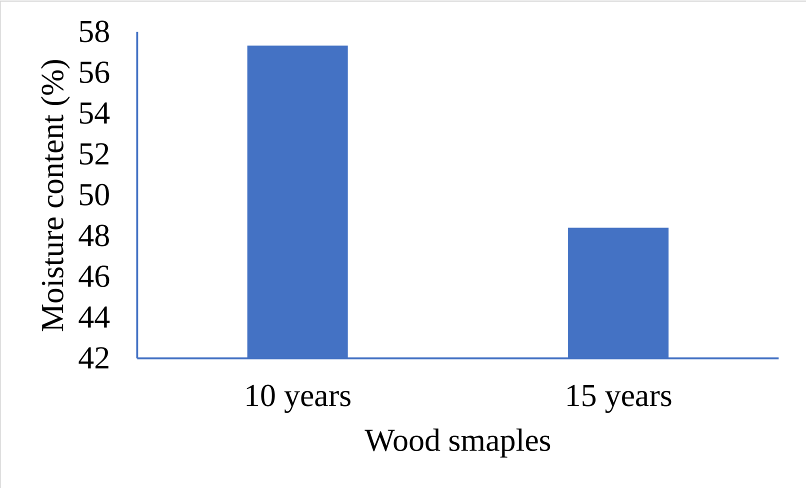

Fig. 3: Moisture content distribution of *G. arborea* wood

Density Distribution of Different Age Groups of Gmelina arborea

The density distribution of the treated *G. arborea* illustrated in Fig. 4 showed that on average the highest density value of 494.07 kg/m^3 was recorded for 15-year-old *G. arborea* wood and higher than that obtained from 10-years having 464.94 kg/m^3. Wood samples obtained from 10 years old tree and cured for 3, 6, and 9 hours after treatment recorded density values of 520.52 kg/m^3, 507.52 kg/m^3, and 509.35 kg/m^3, and those obtained from the 15 years old tree recorded 550.86 kg/m^3, 539.78 kg/m^3, and 537.69 kg/m^3. Duncan's multiple range tests of the density distribution presented in Table 1 revealed that the treated samples significantly differ from the untreated samples.

Chemical Absorption

The chemical absorption for the *G. arborea* wood treated with lactic in **Fig. 5** showed that wood samples obtained from 10 years old tree and cured for 3, 6, and 9 hours after treatment recorded absorption of 15.04%, 13.21%, and 14.49%, and those obtained from the 15 years old tree recorded 13.67%, 13.86%, and 11.98%. On average the 10-year-old has the highest absorption value higher than the 15-year-old. The ANOVA for chemical absorption presented in Table 2 revealed that there was no significant difference at P>0.05 in tree age, curing time, and the interaction between the two factors

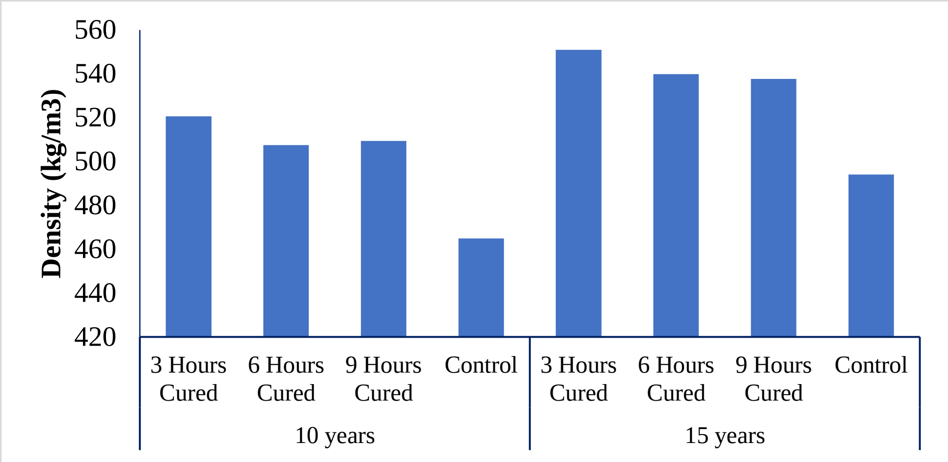

Fig. 4: Effect of treatment on the density distribution of different age groups of *G. arborea* treated with lactic acid

Table 1: Duncan's multiple range tests for density distribution of *G. arborea* wood treated with lactic acid

Treatment	Density (kg/m^3)
Control	479.5015^b
9 Hours	523.5160^a
6 Hours	523.6543^a
3 Hours	535.6931^a

Alphabets with the same letter show that there is no significant difference while alphabets with different letters show that there is a significant difference at P<0.05.

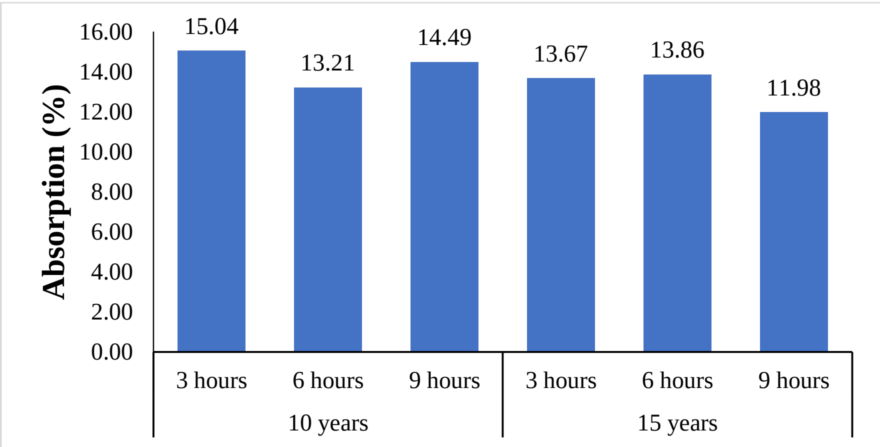

Fig. 5: Absorption of two different age groups of *Gmelina arborea* treated with lactic acid at varying curing time

Table 2: ANOVA Table for absorption of *Gmelina arborea* wood treated with lactic acid

Source	Type III Sum of Squares	df	Mean Square	F	P	Sig.
Tree	10.520	1	10.520	1.146	0.293	Ns
Treatment	8.063	2	4.031	0.439	0.649	Ns
Tree * Treatment	15.366	2	7.683	0.837	0.443	Ns
Error	275.323	30	9.177			
Total	309.271	35				

ns = *Not significant (P>0.05)*

Effect of Lactic Acid Treatment on the Physical Properties of G. arborea Wood

Colour Change

The colour changes of the two different age groups of *G. arborea* wood illustrated in Figures 6A and 6B revealed that the 10 years old *G. arborea* samples creamy-white samples turned dark brown with increased heat intensity as the curing time increased, whereas, the 15 years of *G. arborea* samples the creamy-white samples turned burnt brown with increased heat intensity as the curing time increased. The modification that occurred after the impregnation of the wood samples with lactic acid and cured in the oven at a constant temperature of 140°C at varying times of 3, 6, and 9 hours impacted significant colour changes as the colour of the wood samples turned brown which becomes darken as the curing time increases as shown in Figure 7A and 7B. From the foregoing, the lightness of the two different age groups of Gmelina wood decreased after curing which reduces as the curing time increases.

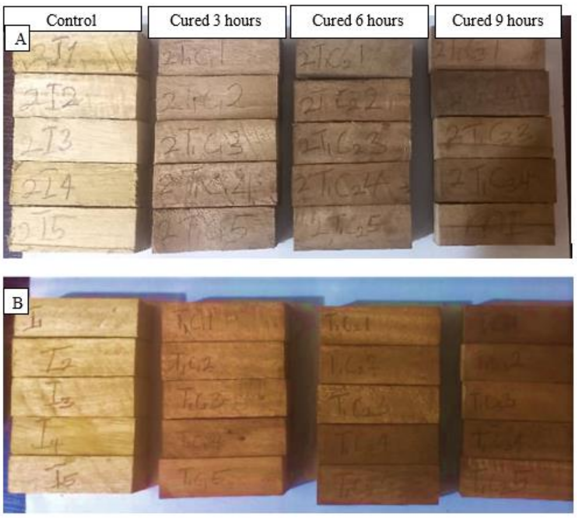

Fig. 6: A: 10 years and B: 15 years *Gmelina arborea* wood impregnated with lactic acid and cured at different time

Volumetric swelling of G. arborea treated with lactic acid

The volumetric swelling (VS) of *G. arborea* wood treated with lactic acid cured at varying times presented in **Fig. 7** showed that the mean VS of the samples obtained from the 10 years old trees with a value of 3.77±2.09% is higher than the wood obtained from the 15 years old trees with VS value of 3.15±1.54%. After prolonged immersion of the treated and untreated samples in water for 24, 48 and 72 hours, the untreated samples had the highest VS value of 5.68% and 4.32%, while those cured at 9 and 3 hours recorded the lowest value of 2.66±1.09% and 2.33±1.57% for 10- and 15-years trees respectively. ANOVA presented in Table 3 revealed that there was a significant difference in the VS at P<0.05 between the two different age groups, curing time, and soaking time, but no significant difference in the interaction. However, Duncan's multiple range test in Table 3 showed that there was no significant difference in the VS of samples cured for 9 and 3 hours which were highly significant from the untreated samples that showed less performance.

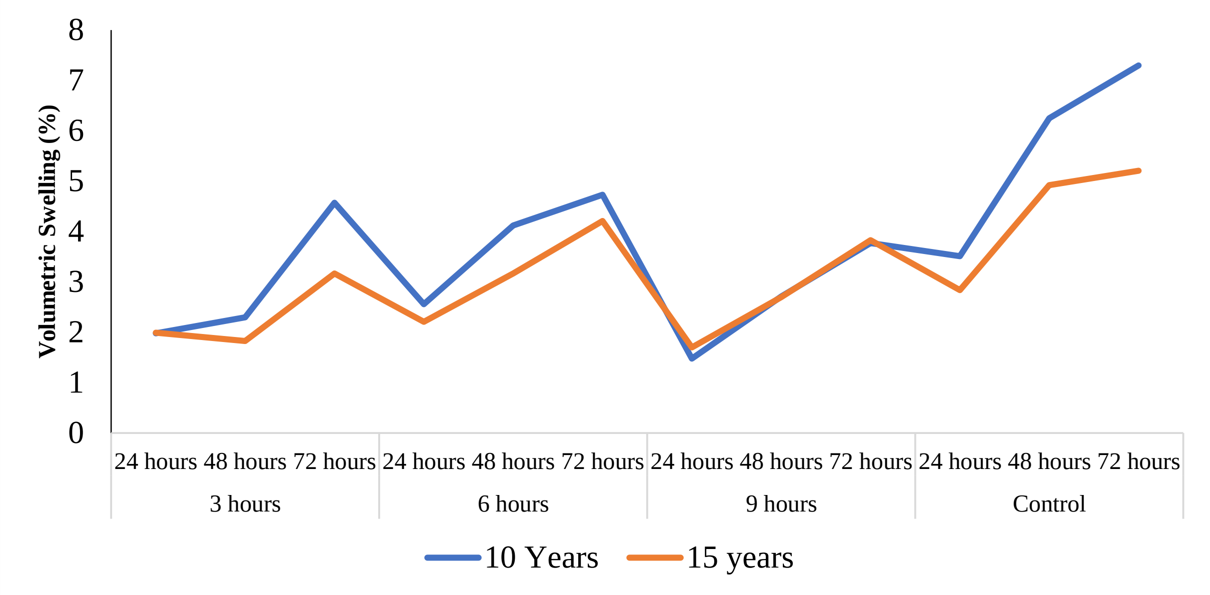

Fig. 7: Volumetric swelling of *G. arborea* treated with lactic acid

Table 3: Duncan's multiple range tests of *Gmelina arborea* wood treated with lactic acid at varying curing times

Curing Time	Volumetric Swelling (%)	ASE (%)	PWL (%)
Control	5.00[a]	54.1749[b]	6.46[b]
9 hours	2.70[c]	74.7641[a]	6.63[b]
6 hours	3.50[b]	61.4845[ab]	8.13[a]
3 hours	2.64[c]	71.3496[a]	8.92[a]

Alphabets with the same letter show that there is no significant difference and alphabets with different letters show that there is a significant difference at P<0.05.

Anti-Swelling Efficiency (ASE)

The ASE (**Fig. 8**) showed that wood samples obtained from 10 years old tree and cured for 3, 6, and 9 hours after treatment recorded ASE values of 66.18%, 71.56%, and 76.48%, and those obtained from the 15 years old tree recorded 76.52%, 51.41%, and 73.05% respectively. The ANOVA for ASE presented in Table 3 showed that there was no significant difference at P>0.05 in tree age and the interaction of the two factors, however, there was a significant difference in the samples' curing time. Likewise, Duncan's multiple range test in Table 3 showed that there was no significant difference in the ASE of wood cured for 9, 6 and 3 hours. However, there was a significant difference in the ASE of wood samples obtained from the untreated (control) and the treated samples.

Weight loss due to leaching

The mean values for percentage weight loss (PWL) due to leaching showed that the 10-year-old trees had the highest value of 7.55±1.68% higher than the wood obtained from the 15-year-old trees with 7.52±1.47% (Figure 9). The *G. arborea* samples cured for 3 and 6 hours had the highest PWL values of 9.42% and 8.78%, while the most negligible value of 6.64% and 6.26% was recorded for those cured for 9 hours and the untreated samples for 10- and 15-years trees respectively.

The ANOVA for PWL presented in Table 3 showed that there was no significant difference in PWL at P>0.05 in tree age while there was a significant difference in the curing time and the interaction in tree age and curing time. However, Duncan's multiple range test in Table 3 showed that there was no significant difference at P<0.05 in the PWL of control samples and those cured for 9 hours which were also significantly different from those cured for 6 and 3 hours.

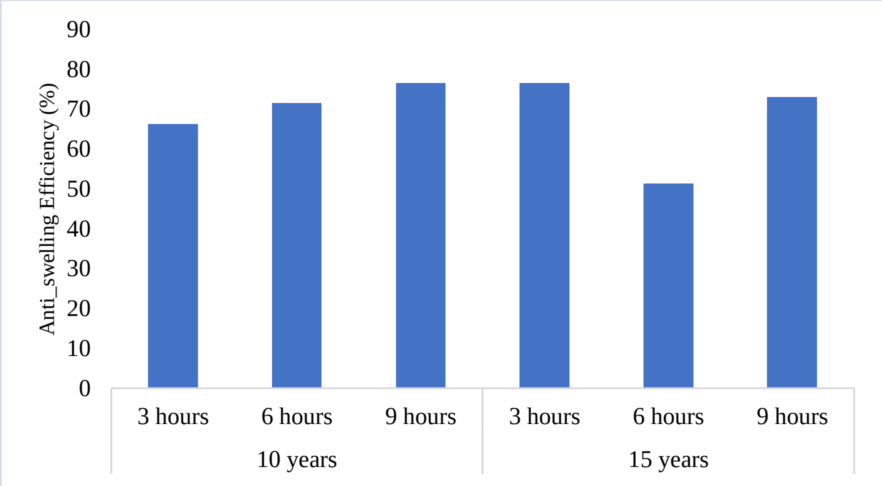

Fig. 8: **The Descriptive of Anti-Swelling Efficiency (ASE) of the two different aged *Gmelina arborea* treated with lactic acid at varying curing time**

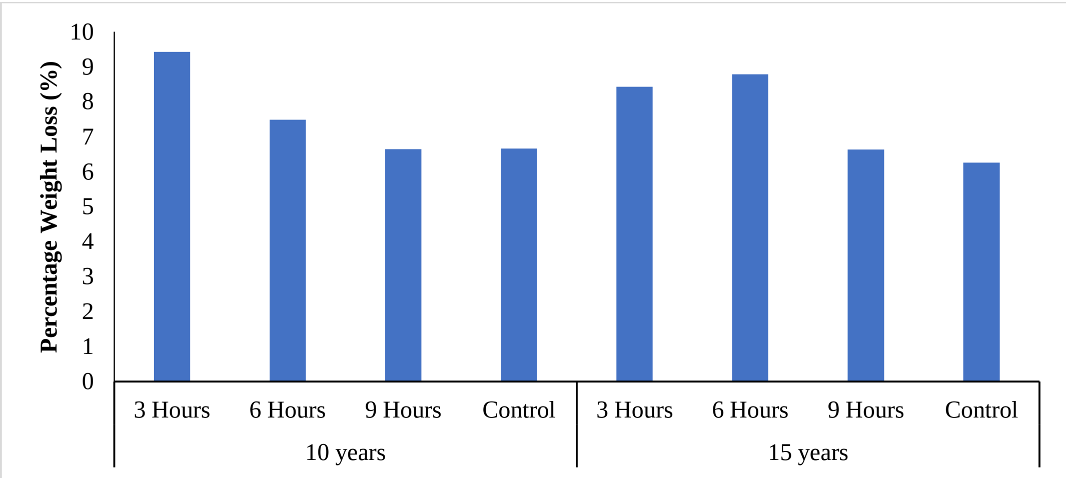

Fig. 9: Percentage weight loss of two different aged Gmelina arborea Wood treated with lactic acid at varying curing time

Chemical Characterization of Treated *G. arborea* Wood

The FT-IR spectrum of the 10 and 15 years *Gmelina arborea* wood illustrated in Table 4 (extracted from Appendix A-H) reflecting the chemical structure showed that the untreated *G. arborea* wood shows strong broadband at 3410–3460 cm^{-1}, attributed to the hydroxyl groups in phenolic and aliphatic structures, while this compound was altered in treated samples. The treated sample bands centred around 2938 and 2842 cm^{-1} primarily arose from CH stretching in aromatic methoxyl, methyl and methylene side chains for both the treated and untreated. Wood samples' strong bands were also noticed around peaks at 2917 and 2847 cm^{-1}, arising from CH stretching in the aliphatic methylene group that can originate from fatty acids in the wood samples. These bands are less intense for the treated samples. In the treated wood samples, this region shows strong bands with peaks at 1654.00-1445.00 cm^{-1} attributed to a weak intensity of C=C aromatic ring functional group stretching in lignin, also shows a strong band at 1153.00 cm^{-1} ascribed to C-O-C vibration in cellulose and hemicellulose. carbonyl/carboxyl region, weak to medium bands are found at 1705–1720 cm^{-1}, originating from unconjugated carbonyl/carboxyl stretching, with a shoulder at around 1680 cm^{-1}, that can be associated with the conjugated carbonyl–carboxyl stretching.

Table 4: FT-IR spectrum of 10- and 15-year *G. arborea* wood modified with Lactic acid

Transmission band (cm^{-1})	Assignment	10 years				15 years			
		Cont.	**3 hrs**	**6 hrs**	**9 hrs**	**Cont.**	**3 hrs**	**6 hrs**	**9 hrs**
4329.00-3395.00	OH, stretching vibration of alcohols, phenols, and acid	+***	-	-	-	+***	-	-	-
3395.00-3228.00	Water OH Stretch	+**	+	-	-	+*	-	-	-
3228.00	Carboxylic acid OH stretching vibration	-	-	+**	-	-	-	+*	-
2924.43	C-H stretching in methyl and methylene groups	+**	+**	+**	+**	+**	+**	+**	+**
2857.57	C=O stretching in unconjugated ketons	+	+	+**	+**	+**	+*	+**	+*
1742.00	Carbonyls	+		+		+	-	-	-
1650	Weak C=C alkene, Syringyl Ring	+	+	+	+	+	+	+	+
1647.00	Aromatic Ring Stretching lignin	-	-	+**	+	+	-	+	+
1457.85	Aldehydes and ester groups	+	+**	+**	+**	+	+**	+**	+**
1450.85	C-O-C vibration in cellulose and hemicellulose	+	+**	+	+	+	+**	+**	+**
1249.00	C-O stretch in lignin and xylan	+***	+	+*	+***	+**	+**	+*	+*
1160.00	C-H deformation	+	-*	+**	+*	+	+**	+**	+***
1153.00	C=C aromatic ring functional group stretching in lignin	+	+	+**	+	+	+**	+**	+**
1028.00	C-H and C-O deformations	+***	+	+**	+**	+**	+**	+**	+**

Control Untreated samples - =*band disappearing; +=weak band; +**=Strong; and +***=strong and broad* wavelength

DISCUSSION

Moisture Content

The moisture content of *G. arborea* wood decreases as the age increases. A transitional stage may influence the variation pattern in the MC%. This supports the findings of Freddy and Roger (2008), who found that the shift from juvenile to mature wood can affect the inflection that occurs in the MC%. In general, the rate of drying is determined by the moisture content of the wood, temperature, and relative humidity of the drying environment (Perré and Keey, 2014; Melin and Bjurman, 2017; Ogunsuyi and Owoyemi, 2022). The fundamental reason for wood drying is properties enhancement thereby making the wood more dimensionally stable and valuable in service (Perré and Keey, 2014; Owoyemi *et al.,* 2015; Melin and Bjurman, 2017; Ogunsuyi and Owoyemi, 2022). Hence, wood users should consider the uneven moisture content distribution of the different age groups of *G. arborea* during seasoning to ensure uniform drying and void of any drying defects. This is in line with the findings of Owoyemi *et al.* (2015) that drying defects can compromise the strength and structural integrity of the wood, making it less useful for building or other applications.

Density

Density is an important parameter contributing to solid wood products' quality, strength, stability, and appearance. The outcomes of the physical property assessment of *G. arborea* wood demonstrated that this wood belongs to the low-density group as defined by Wong (2002) and Falemara *et al.* (2012); low-density wood was defined as having a density of less than 500 kg/m3. When two age groups were examined, it became clear that age had an impact on wood density because the older tree had a higher density. Density significantly affects the strength properties of wood (Ogunsanwo and Akinlade, 2011).

Impregnation of *G. arborea* wood with lactic acid imparted a significant increase in density which varies with curing time ensuring the densification of the wood samples. This corroborates the definition of Sotayo *et al.* (2020) that densification is essentially an increase of the quality and density of timber by decreasing the voids in the material through different techniques, such as compression of the timber, use of heat and steam, impregnation of substances into the lumen, or a combination of all of these. The results showed that the density of wood decreases as the curing time increases. This may be due to the depolymerization reactions of wood polymers that occurred during heat treatment, as the physical characteristics of hemicelluloses (127 to 235°C), lignin (167 to 217°C) and cellulose (231 to 253°C) tend to change as temperature increase during curing time (Boonstra *et al.*, 2007).

Chemical Absorption

The results indicate that the impregnation solution had a relatively uniform impregnation. The high percentage weight gain recorded for the treated *G. arborea* wood showed that the wood was compatible with the lactic acid after curing. The compatibility of the lactic acid treatment and *G. arborea* wood is essential for assuring the treatment's efficacy because incompatible reactions cause chemical deterioration over time, which would lower the treatment's effectiveness. (Kaygin *et al.*, 2009).

Colour Changes

Colour changes were apparent as the treatment curing time increased from 3 hours to 9 hours, and the colour change deepened from pale yellowish to chocolate brown. This colour change in the wood can be attributed to some chemical reactions during the impregnation and curing process. The chemical solution that imparted the colour change may have been formed from degraded carbohydrates, and this could be responsible for the formation of coloured compounds after chemical reactions as this observation is similar to the study reported by McDonald *et al*. (2000). According to Fengel and Wegener (1989), the reason for colour changes is the production of chromospheres as a result of the hydrolytic reactions that occur during curing of the samples after impregnation with lactic acid. In many cases, the extent of thermal degradation is directly related to the extent of the colour changes of the wood (Kawamura *et al.*, 1996).

Dimensional Stability

Wood is a natural and important engineering material because of its attractive physical and mechanical properties and considerably low price compared to other available materials (Wacker, 2010). However, wood is susceptible to dimensional changes attributed to moisture significantly limiting its use in some applications. The reduction in the water-holding capacity after modification is coupled with an increase in the (ASE) and a significant reduction in the volumetric swelling of the treated samples, which quantifies the increase in the dimensional stability of the modified wood (Ormondroyd *et al.*, 2015). These results agreed with the findings of Grosse *et al.* (2019) that the curing temperature and time of treated wood samples impregnated with oligomeric lactic acid (OLA) affect the wood's physical properties after treatment.

After the impregnation of the wood with lactic acid it became more dimensionally stable as the percentage of volumetric swelling reduced for the two different age trees but the curing shows heterogeneous results. This contradicts the findings showing that none of the wood samples impregnated with OLA demonstrated significant improvement in sorption properties (Noel et al., 2015; Grosse et al., 2016). Also, this finding revealed that the water-related properties of the modified wood are significantly improved with heat treatment with the results from a previous study on the strength and durability properties by Owoyemi and Akinwamide (2023) suggesting the wood to be suitable for various applications in construction, furniture, and other industries. Volumetric swelling varies for the two wood of different age groups as the highest value was recorded for the 15 years. This agrees with the previous report of Okon (2014) that the volumetric swelling of wood varies within and between trees. This varying pattern may be due to the ongoing rapid growth of the two tree cells, as physical properties might also differ in different directions due to the influence of wood rays and different arrangements of fibrils on cell walls (Okon, 2014).

The mean value achieved for two separate age groups revealed that *G. arborea* wood treated with lactic acid at various curing times led to a reduction in the dimensional instability of the wood. This agreed with what Korkut *et al.* (2008) discovered that wood treated at high temperatures has less hygroscopicity and improved dimensional stability than untreated wood. Heating wood permanently changes several of its chemical and physical properties which is mainly caused by the thermic degradation of hemicelluloses that host the OH groups which significantly influence the physical properties of wood (Inoue *et al.*, 1993).

The continuous soaking of the *G. arborea* wood samples in water for 24, 48 and 72 hours to ascertain its response to weathering when used for outdoor applications, the estimated results for the percentage weight loss due to leaching revealed that wood obtained from 10 years old trees had the highest percentage weight loss which was significantly different from those value attained by samples obtained from 15 years old trees. This pattern of distribution may be due to the structural arrangement of the cells which is highly dependent on the tree's age. Owoyemi *et al.* (2011), revealed that the wood structure of *G. arborea* is a factor that determines its physical properties which are not arranged in any specific pattern. In materials science, the sorption properties of wood affect its dimensional stability, mechanical strength, and electrical conductivity. Understanding and controlling these sorption properties is crucial for ensuring the quality and durability of materials and structures.

Chemical Characterization

The weak absorptions were discovered around 1650 cm^{-1} in both the treated and untreated wood samples, resulting in the asymmetry and broadening of the more intense bands at 1705 and 1600 cm^{-1}, respectively. Boeriu *et al.* (2004) suggested that this reaction might have originated from both protein impurity and water associated with lignocellulosic material. The aromatic skeleton vibrations and the C–H deformation combined with aromatic ring vibration were observed and assigned to the pronounced peaks in the treated wood samples. These compound groups are common for all lignocellulosic substances, although the intensity of the bands may differ, while, the aromatic C–H deformation appears as a complex vibration associated with the C–O, C–C stretching and C–OH bending in polysaccharides (Boeriu *et al.,* 2004). The results revealed that some pronounced compound classes in the control samples of *Gmelina arborea* disappeared. This confirmed that the wood sample is a cellulosic fibre and has undergone chemical modification (Salémn and Bergstrom, 2009; Dai and Fan, 2011). There are more similarities in the characterization of samples cured for 6 and 9 hours.

The results of the FT-IR showed the chemical changes that occurred in the wood after treatment with lactic acid. The noticeable bands in the FT-IR results established that the wood sample is a cellulosic fibre, and it was observed that some pronounced compound classes in the control samples of *Gmelina arborea* disappeared in treated samples. This confirmed that the wood sample has undergone chemical modification (Salémn and Bergstrom, 2009; Dai and Fan, 2011). There are more similarities in the characterization of samples cured for 6 and 9 hours. Understanding the chemical composition of the two age groups of wood will help in determining the most appropriate use of this wood, such as in construction, furniture making, or paper production, combined with its properties and performance.

CONCLUSION

Age is an important factor when considering the maturity of wood for construction and other purposes. The *G. arborea* wood of 15- and 10-year-old trees revealed little difference in tested properties, however, 15 years is more durable as revealed in the study. The wood classified as low density also showed considerable improvement in its physical properties and changes in chemical structure revealing its treatability capacity: using lactic acid will require variation in the curing time for maximum results as 9 hours of curing time had the best performance. This established the possibility of using lactic acid as a chemical in wood modification. This further development will help in solving the inherent problem of a dwindling supply of durable species and long gestation periods in forest plantations. Hence, expanding the scope of using the commonly available less durable young plantation-grown wood for structural and furniture purposes is made possible.

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