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PHYSICAL AND MECHANICAL PROPERTIES OF WOOD PLASTIC COMPOSITE PARTICLE BOARDS PRODUCED FROM THE COMBINATION OF *Gmelina arborea* and *Khaya senegalensis* SAWDUST AND POLYETHYLENE TEREPHTHALATE

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ABSTRACT

The study investigated the properties of wood-plastic composite (WPC) boards produced from a combination of G. arborea and K. senegalensis sawdust with Polyethylene Terephthalate (PET). G. aborea and K. Senegalensis sawdust and PET were collected and prepared. The experiment design was 2 x 2 x 10 (2 types of plastic, 2 types of sawdust and 10 types of composite mixture) factorial in Completely Randomized Design (CRD). A composite board was produced using a rectangular mould size of 2x17x16 cm. Sample mixtures were in the ratio of 100%, 50:50, 70:30, 60:40, 30:70 mixed thoroughly with a thermo setting adhesive and poured in a flat mould of 2 cm and pressed using pressing machine for 5 minutes to allow proper curing of the adhesive. Data was collected on density, shattered index, shattered resistance, compressive strength parallel to grain modulus of elasticity, and modulus of rapture and analyzed using analysis of variance (ANOVA) with Multiple Range Test as follow up test. The results showed that the density of boards ranged from 0.34 to 0.55 g/cm^3, with the highest density observed in the treatment containing PET and G. arborea (30:70). Shattered index ranged from 5.00% to 6.99%, with the lowest index observed in the treatment containing G. arborea and K. senegalensis (60:40) and the highest index in the treatment containing 100% PET. The shattered resistance ranged from 93.01% to 95.00%, with the highest resistance observed in the treatment containing G. arborea and K. senegalensis (60:40). Modulus of Elasticity (MOE) ranged from 1.88 N/mm^2 to 8.16 N/mm^2, with the highest value in the treatment containing 100% G. arborea. Similarly, the Modulus of Rupture (MOR) ranged from 2.68 N/mm^2 to 10.43 N/mm^2, with the highest value in the treatment containing 100% G. arborea. Compressive strength ranged from 135.63 N/mm^2 to 153.19 N/mm^2, highest value in the treatment containing PET and G. arborea (70:30). There were no significantly different among WPC boards treatments. It was concluded that the combination of G. arborea and K. senegalensis sawdust with PET produced composites with higher MOE, MOR, and compressive strength compared to the treatment containing only PET.

Keyword: Board, Chemical Properties, Physical Properties, Wood Plastic Composite, Sawdust

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INTRODUCTION

Wood-plastic composites (WPCs) are materials that combine the properties of wood and plastics, offering a versatile and dynamic product range for various industries. WPCs are not a novel concept, but their potential for design innovation continues to drive interest in the plastic industry (Faruk and Bledzki, 2012). These composites are typically made by integrating wood fibers or flour with a plastic matrix, resulting in a material that exhibits characteristics of both constituents (Harničárová *et al*., 2017; Ravivarman, *et al*., 2018).

Despite the advantages of WPCs, such as resistance to corrosion and plasticity, challenges persist in terms of weather ability, life cycle costs, and mechanical properties like tensile and flexural strength (Faruk and Bledzki 2012; Jian *et al*., 2022). Research has focused on optimizing these properties through various means, including the use of coupling agents, surface pretreatment, and the addition of nano-fillers to improve interface compatibility and mechanical performance (Fang *et al*., 2020; Jian *et al*., 2022).In terms of processing technology, WPCs can be manufactured using compounding, extrusion, injection molding, and compression molding, with recent advancements aimed at enhancing production efficiency and product quality (Faruk and Bledzki, 2012). Additionally, the mechanical properties of WPCs have been a subject of extensive study, with finite element analysis being used to optimize composite structures for specific applications like outdoor decking (Ravivarman *et al*., 2018).

Surface quality is another critical aspect of WPCs, with machining processes such as drilling affecting the surface topography and, consequently, the material's aesthetic and functional properties (Mitaľová *et al*., 2022). Moreover, the physical properties of WPCs can be influenced by the composition of the polymer matrix and the type of wood reinforcement used (Bhaskar *et al*., 2020). The physical and mechanical properties of particle board produced from a combination of *G. arborea* and *K. senegalensis* sawdust with polyethylene terephthalate (PET) can be inferred the studies on similar composites. Aisyah *et al*. (2021) demonstrates that steam treatment of *G. arborea* strands improves the dimensional stability and mechanical properties of oriented strand board (OSB) when bonded adhesives such as methylene diphenyl diisocyanate (MDI) andol-formaldehyde (PF) (Aisyah *et al*., 2021). Mascarenhas *et al*. (2021) indicates that *K. senegalensis* wood has high dimensional stability and good mechanical performance, suggesting its potential for use in composite materials (Mascarenhas *et al*., 2021).

Interestingly, while not directly addressing the combination of *G. arborea* and *K. senegalensis* , several studies have investigated the properties of wood-plastic composites (WPCs) using wood sawdust and PET. Rahman *et al*. (2013) found that increasing sawdust content in the PET matrix decreased density and increased water absorption and thickness swelling, while the best mechanical properties were achieved at a lower sawdust content (Rahman *et al*., 2013). Javier *et al*. (2015) optimized the tensile and flexural strength of WPCs made from PET and sawdust, indicating the potential for achieving desirable properties through careful control of processing conditions.

G. arborea sawdust has been identified as a versatile by-product with multiple applications in sustainable energy production, construction materials, and wood product manufacturing. Research indicates that sawdust from *G. arborea* can be effectively used in the pyrolysis process to produce bio-oil with favorable physicochemical properties and low sulfur content, suggesting its potential as an environmentally friendly alternative fuel (Adegoke *et al*., 2021). Additionally, the sawdust has been utilized in the production of storage structures for harvested rainwater, with varying mix ratios of cement to sawdust affecting the engineering properties and dimensional stability of the resulting structures (Aladenola *et al*., 2007).

Contradictorily, while *G. arborea* sawdust contributes positively to the production of bio-oil and construction materials, its use in cement-bonded boards shows that an increase in the proportion of *G. arborea* sawdust can lead to improved mechanical properties and reduced water absorption and thickness swelling, indicating its suitability for manufacturing such boards (Adelusi *et al*., 2019). Furthermore, thermal modification of *G. arborea* wood, which includes sawdust as a by-product, affects its basic chemical composition and mechanical properties, with certain temperatures yielding materials suitable for structural or non-structural purposes (Minkah *et al*., 2021).

Khaya senegalensis, also known as African mahogany, dry zone mahogany, Gambia mahogany, Khaya wood, or Senegal mahogany, is a species of tree that belongs to the Meliaceae family. It is native to Africa and has been evaluated for its wood quality in various contexts, including its suitability for use in wood composites. The form trees grown in agroforestry systems (AFS) has been found to possess medium density and high dimensional stability, with mechanical properties comparable to other mahogany species from monocultures and natural forests (Mascarenhas *et al*., 2021). These characteristics are indicative of its potential for use in wood composite materials, where dimensional stability and mechanical strength are important.

Wood plastic composites (WPCs) incorporating polyethylene terephthalate (PET) have been explored for their improved mechanical properties and potential applications. The integration of PET sub-micro-fibrils into high-density polyethylene (HDPE) has been shown to enhance the tensile and flexural properties of the composites significantly (Lei and Wu, 2011). Similarly, finite element simulations and experimental tests on WPCs with Chilean Radiate pine wood flour have confirmed that higher wood flour content and particle size can increase the elastic modulus, although these properties are highly dependent on particle orientation (Pesante *et al*., 2021). Contradictorily, while increasing PET content generally improves mechanical properties such as compressive strength and hardness, the addition of silica was found to adversely affect these properties, despite reducing water absorption (Chotikhun *et al*., 2022).

Therefore, the objective of this study was to determine the physical and mechanical properties of wood plastic composite particle board produced from the combination of *G. arborea* and *K. senegalensis* sawdust and PET for the purpose of reducing their wastes and their harmful in effect in the environment.

MATERIALS AND METHODS

Study Area

The experiment was carried out at the Department of Civil Engineering Laboratory, Joseph Sarwuan Tarka University Makurdi, Benue State, Nigeria. It is located in North Central of Nigeria (Federal Republic of Nigeria Official Gazette, 2007). Makurdi is the State capital of Benue State. It is the largest urban area in the State. The geography of the town I between latitudes 7^{o}20' and 8^{o}10' North and longitudes 8^{o}4' and 9^{o}40' East (Ancha *et al*, 2011).

Sample Collection and Preparation

Sawdust of wood species of *(G. aaborea* and *K. Senegalensis*) was collected from North bank Timber Shade along old bridge in Makurdi, Benue State Nigeria. Polyethylene Terephthalate (PET) single used plastic water bottles were collected from Benue Hotels and Resorts, Makurdi Benue State was collected from Mechanic village Kanshio Makurdi, Benue State. The sawdust samples collected was sun-dried for 6 days to evaporate excess moisture. Thereafter, the wood sawdust was sieved out by using 1-2 mm seive which help to remove some undesirable materials such as pieces of plastic, metals and wood particles and to keep the samples in uniform sizes. A cold setting adhesive formalin formaldehyde resin (Top bond) was applied to the sieved wood samples and crushed plastic samples as binder.

Experimental Design

The experiment design was 2 x 2 x 10 factorial (2 types of plastic, 2 types of sawdust and 10 types of composite mixture) in Completely Randomized Design (CRD).A composite board was produced using a rectangular mould of 2cm x 17cm x 16cm.The sample mixtures were in the ratio of 100%, 50:50, 70:30, 60:40, 30:70, which was mixed thoroughly with a thermo setting adhesive (Top bond) and poured in a flat mould of 2 cm and pressed using pressing machine for 5minutes to allow proper curing of the adhesive.

Plate 1: Drying of Sawdust

Plate 2: Sieving of Sawdust

Plate 3: Sieved *Khaya senegalensis*

Plate 4: *Sieved Gmelina arborea*

Plate 5: Polyethylene Terephthalate (PET)

Plate 6: Adhesive (Top Bond)

Plate 7: Mould

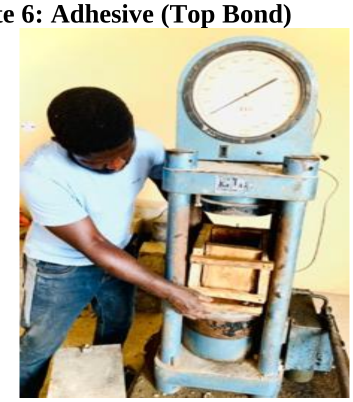

Plate 8: Compression

Plate 9: Determination of MOE and MORUTM)

Plate 10:Determination of Compressive Strength

Data Collection

Data was collected through the investigation of the physical properties of density, shattered index, shattered resistance, and mechanical properties such as compressive strength parallel to grain modulus of elasticity, and modulus of rapture.

Physical Properties

Determination of density

The density of produced wood plastic composite (WPC) boards was evaluated by randomly selecting four boards from each production batch. The mean compressed density of the boards was immediately determined after removal from the mold, calculated as the ratio of the measured weight to the calculated volume, following the method described by Olorunnisola (2007). The weights of the boards were measured using a digital weighing balance, while the average diameters and heights were taken at two positions using calipers to determine the volume. The volume was calculated by subtracting the outer volume from the inner volume to obtain the actual volume. The compressed and relaxed densities of the boards were then determined at 0 minutes, 30 minutes, 1 hour, 24 hours, and 7 days, using the die dimensions and the ASTM (2004) standard method, with the density calculated as the ratio of the board's weight to its volume.

D= M/V (Kg/m^3)……………… (1)

Where,
D = Density
M = Weight of the test sample;
V = Volume of the sample.

Determination of shattered index and shatter resistance

The durability of the WPC boards was evaluated using the Shattered index method described by Suparin *et al*. (2008). This involved repeatedly dropping the WPC board samples from a height of 1.5 m onto a solid base, and the fraction of the boards retained was used as an index of their breakability. The percentage weight loss of the WPC boards was calculated as the percentage of the initial weight of the material remaining on the solid base, and the shatter resistance was determined by subtracting the percentage weight loss from 100, as described by Ghorpade (2006) and Sengar *et al*. (2012).

$\%WL =$ IWBS – WS/IWBS ………… (2)

Where:
P=%WL = percentage weight loss, WS = Weight of shattering, IWBS = Initial weight before shattering, IWBS = Initial weight before shatter,

Shatter resistance = 100 - % weight loss .. (3)

Plate 11: Boards Produced

Plate 12: Test of Density

Plate 13: Shattered indextest

Plate 14: Wood plastic boards produced *K. senegalensis* and *G. arborea*spread to dry

Determination of Mechanical Properties of Composite Board

a. Modulus of Elasticity (MOE)

Modulus of Elasticity (MOE) was calculated using the load to deflection curve plotted on the graph by the Hounsfield Tensiometer testing machine as expressed in the equation below:

MOE = ΔPL3 /4bd3Δs …................(4)

Where:

MOE = modulus of elasticity (N mm-2),
P = increment in load (N),
L = the span of the sample between the machine support (mm),
b = width of the sample (mm),
d = thickness of the sample (mm),
Δs = increment in deflection corresponding to increment in load

b. Modulus of Rupture

The Modulus of Rupture (MOR) test was carried out using test samples measuring 50 mm x 150 mm on a Hounsfield Tensiometer Machine according to British Standard 373 (1989). The test samples were supported by two rollers at both ends and loaded at the middle of the span until failure occurs. MOR was calculated from the maximum load at which each sample failed.

MOR = 3PL/2bd2 ……………….….... (5)

Where:

MOR = modulus of rupture (N mm-2),
P = the ultimate failure load (N),
L = the wood sample span between the machine support (mm),
b = width of the wood sample (mm),
d = thickness of the wood sample (mm).

c. Determination of Compressive Strength parallel to grain

The tensile strength in the parallel-to-face orientation is the resistance of a composite board material to be pulled apart parallel to its surface.

Four composite board samples were randomly picked from each of mixing ratio or treatment and tests were conducted on strength parallel to grain, as the load was applied vertically on the composite boards from the California Bearing ratio test machine (CDI machine).
Mathematically, compressive strength (parallel to grain) (N/mm^2) is expressed as;

Compressive strength = (Length ×1000)/Area (6)

Data Analysis
Data collected was analyzed using analysis of variance (ANOVA); a follow up test was done with Multiple Range Test.

RESULTS
Table 1 presents results on the mean density values from wood-plastic composite (WPC) boards produced from combination of *G. arborea*and *K. senegalensis*sawdust with Polyethylene Terephthalate (PET). The results show that the density of the boards ranged from 0.34 to 0.55 g/cm^3, with the highest density observed in the treatment containing PET and *G. arborea* (30:70) and the lowest density in the treatment containing 100% PET. The density of the boards was not significantly different among the treatments, indicating that the combination of wood sawdust and PET can produce boards with similar densities.

The results of shattered index and shattered resistance of wood plastic composites produced from the combination of *G. arborea*, *K. senegalensis* sawdust and PET were presented in Table 2. The results show that the shattered index ranged from 5.00% to 6.99%, with the lowest index observed in the treatment containing *G. arborea* and *K. senegalensis* (60:40) and the highest index in the treatment containing 100% PET. The shattered resistance ranged from 93.01% to 95.00%, with the highest resistance observed in the treatment containing *G. arborea* and *K. senegalensis* (60:40) and the lowest resistance in the treatment containing 100% PET. The shattered index and resistance were not significantly different among the treatments, indicating that the combination of wood sawdust and PET can produce composites with similar shattered properties.

Table 1: Density of wood plastic/composite board produced from the combination of *G. arborea, K. senegalensis*sawdust and Polyethylene Terephthalate (PET)

S/No.	Treatment	Density Mean±Sdv (g/cm^3)
1.	Polyethylene Terephthalate (100%)	0.34±0.15[a]
2.	Polyethylene Terephthalate and *G. arborea*(30:70)	0.55±0.15[a]
3.	*G. arborea*(100%)	0.53±0.18[a]
4.	*G. arborea*and *K. senegalensis*(60:40)	0.54±0.18[a]
5.	Polyethylene Terephthalate and *G. arborea*(70:30)	0.46±0.23[a]
6.	Polyethylene Terephthalate and *K. senegalensis*(70:30)	0.45±0.24[a]
7.	Polyethylene Terephthalate and *G. arborea*(50:50)	0.51±0.29[a]

Note: Mean with the same alphabets show no significant difference

Table 2: Shattered Index and Shattered Resistance of wood plastic composites with combination of *G. arborea, K. senegalensis*sawdust and Polyethylene Terephthalate (PET)

S/No.	Treatment	Shattered Index (%)	Shattered Resistance (%)
1	*G. arborea* and *K. senegalensis*(60:40)	5.00[a]	95.00[a]
2	*G. arborea*(100%)	5.01[a]	94.99[a]
3	Polyethylene Terephthalate and *G. arborea* (30:70)	5.05[a]	94.95[a]
4	Polyethylene Terephthalate and *G. arborea*(50:50)	5.08[a]	94.92[a]
5	Polyethylene Terephthalate and *G. arborea*(70:30)	6.92[a]	93.08[a]
6	Polyethylene Terephthalate and *K. senegalensis*(70:30)	6.57[a]	93.43[a]
7	Polyethylene Terephthalate (100%)	6.99[a]	93.01[a]

Note: Mean with the same alphabets show no significant difference

Results of MOE and MOR of wood plastic composites produced from the combination of *G. arborea*, *K. senegalensis* sawdust and PET are shown in Table 3. The results show that the MOE ranged from 1.88 N/mm^2 to 8.16 N/mm^2, with the lowest value observed in the treatment containing 100% PET and the highest value in the treatment containing 100% *G. arborea*. Similarly, the MOR ranged from 2.68 N/mm^2 to 10.43 N/mm^2, with the lowest value observed in the treatment containing PET and *G. arborea* (70:30) and the highest value in the treatment containing 100% *G. arborea*. The results indicate that the combination of *G. arborea* and *K. senegalensis* sawdust with PET can produce composites with higher MOE and MOR compared to the treatment containing only PET. Which implies that the addition of *G. arborea* and *K. senegalensis* sawdust can improve the mechanical properties of the wood plastic composites compared to the use of PET *al*one

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Table 3: Modulus of Elasticity and Modulus of Rapture of wood plastic composites produced from the combination of *G. arborea, K. senegalensis*sawdust and Polyethylene Terephthalate (PET)

S/No.	Treatment	Modulus of Elasticity Mean±Sdv (N/mm^2)	Modulus of Rapture Mean±Sdv (N/mm^2)
1	Polyethylene Terephthalate (100%)	1.88±1.09[a]	3.90±2.14[a]
2	*G. arborea* (100%)	7.22±4.67[b]	10.43±7.62[b]
3	Polyethylene Terephthalateand *G. arborea* (70:30)	2.73±1.49[a]	2.68±2.43[a]
4	Polyethylene Terephthalate and *G. arborea* (30:70)	6.85±2.39[b]	6.41±4.51[b]
5	Polyethylene Terephthalate and *K. senegalensis* (70:30)	2.98±1.72[a]	3.80±1.44[a]
6	Polyethylene Terephthalate and *G. arborea* (50:50)	3.19±2.07[a]	3.48±1.91[a]
7	*G. arborea* and *K. senegalensis* (60:40)	8.16±3.56[b]	8.66±7.00[b]

strength parallel to grain of the wood plastic composites produced from the combination of *G. arborea*, *K. senegalensis* sawdust and PET. The results show that the compressive strength ranged from 135.63 N/mm^2 to 153.19 N/mm^2, with the lowest value observed in the treatment containing 100% PET and the highest value in the treatment containing PET and *G. arborea* (70:30). The treatments containing 100% *G. arborea*, PET and (30:70 and 70:30) had significantly higher compressive strength compared to the treatments containing 100% PET, PET and *K. senegalensis* (70:30), and *G. arborea* and *K. senegalensis* (60:40). This indicates that the addition of *G. arborea* sawdust can improve the compressive strength of the wood plastic composites compared to the use of PET or *K. senegalensis* sawdust alone.

Table 4: Compressive Strength Parallel to Grain of the wood plastic composites produced from the combination of *G. arborea, K. senegalensis*sawdust and Polyethylene Terephthalate

S/No.	Sample Combination	Compressive Strength parallel to grain Mean±Sdv(N/mm^2)
1.	Polyethylene Terephthalate (100%)	135.63±83.59[a]
2.	Polyethylene Terephthalate and *K. senegalensis*(70:30)	135.72±85.00[a]
3.	*G. arborea* and *K. senegalensis*(60:40)	136.89±85.04[a]
4.	*G. arborea* (100%)	143.61±41.71[b]
5.	Polyethylene Terephthalate and *G. arborea* (50:50)	144.68±41.46[b]
6.	Polyethylene Terephthalate and *G. arborea* (30:70)	150.11±40.05[c]
7.	Polyethylene Terephthalate and *G. arborea* (70:30)	153.19±108.30[c]

Note: Mean with the same alphabets show no significant difference

The colour and surface appearance of the wood plastic composites produced from *G. arborea*, *K. senegalensis* sawdust and PET were investigated. The results show that the colour of the composites varied from black to milky, cream, and reddish brown, depending on the combination of materials used. The surface appearance ranged from very rough to very smooth, with the composites containing 100% Polyethylene Terephthalate and Polyethylene Terephthalate and *G. arborea* (50:50) having the roughest surfaces, while the composites containing 100% *G. arborea* and *G. arborea* and *K. senegalensis* (60:40) had the smoothest surfaces. The composites containing higher proportions of *G. arborea* sawdust generally had smoother surfaces compared to those with higher proportions of PET or *K. senegalensis* sawdust.

Table 5: Colour and Surface Appearance of the wood plastic composites produced from *G. arborea, K.senegalensis*sawdust and Polyethylene Terephthalate (PET)

S/No.	Sample Combination	Colour	Surface
1	Polyethylene Terephthalate (100%)	Black	Very Rough
2	*Gmelinaarborea* (100%)	Milky	Very Smooth
3	Polyethylene Terephthalate and *G. arborea*(70:30)	Milky	Rough
4	Polyethylene Terephthalate and *G. arborea* (30:70)	Cream	Smooth
5	Polyethylene Terephthalate and *K. senegalensis*(70:30)	Reddish Black	Rough
6	Polyethylene Terephthalate and *G. arborea* (50:50)	Cream	Very Rough
7	*G. arborea* and *K. senegalensis*(60:40)	Reddish Brown	Very Smooth

DISCUSSION

Density of Wood Plastic Composites

The density of wood plastic composites produced from the combination of *G. arborea*, *K. senegalensis* sawdust and PET ranged from 0.34 to 0.55 g/cm^3, with the highest density observed in the treatment containing PET and *G. arborea* (30:70). Bol a *et al*., (2020) reported densities of WPCs at different plastic-wood ratios of 40-60, 50-50 and 60-40 for 0.53, 0.79, and 0.59 g/cm^3, respectively. Durmaz (2022) reported the density values of WPC to vary between 0.931 to 0.959 g/cm^3 as Oladejo and Omoniyi (2017) reported 0.77 – 1.14 g/cm3 for WPCs made with varying wood-plastic ratios of sawdust and recycled PET. In a related study, Flores-Hernández *et al*., (2014) recorded density 1.05 g/cm^3 to 1.15 g/cm^3 for polystyrene-based WPCs with varied contents of wood flour. The density of the boards was not significantly different among the treatments, indicating that the combination of wood sawdust and PET can produce boards with similar densities. The study revealed that the density of WPCs generally decreases as the plastic content increases and wood content decreases and WPCs with higher wood content tend to have higher densities which agree with Durmaz (2022).

Shattered index and shattered resistance of wood plastic composites

The shattered index of the wood plastic was highest in the treatment containing 100% PET. The shattered resistance was highest resistance (6.99%) observed in the treatment containing *G. arborea* and *K. senegalensis* (60:40). Kristoffer (2012) reported shatter indices from 0.2 to 0.8 for WPCs made with varying wood-plastic ratios of sawdust and recycled PET. Composites with higher wood content had higher shatter indices. The shatter index of WPCs is a measure of their impact resistance and brittleness. A higher shatter index indicates more brittle behaviour. From this study, shattered resistance ranged from 93.01% to 95.00%, with the highest resistance observed in the treatment containing *G. arborea* and *K. senegalensis* (60:40) and the lowest resistance in the treatment containing 100% PET. Shatter resistance is the ability of a material to resist fracturing or shattering under impact. Higher shatter resistance is desirable and it decreased with increasing wood flour content as obtained in this study. The shattered index and resistance were not significantly different among the treatments, indicating that the combination of wood sawdust and PET can produce composites with similar shattered properties.

Modulus of Elasticity (MOE) and Modulus of Rupture (MOR)

The MOE of the wood plastic composites had highest value in the treatment containing 100% *G. arborea*. Similarly, the MOR had lowest value in the treatment containing PET and *G. arborea* (70:30) and the highest value in the treatment containing 100% *G. arborea*. The MOE of WPCs is generally higher when the wood content is increased compared to the plastic content. Adelusi *et al*. (2021) reported MOE values from ranged from 6804.88 N/mm^2 -14,617.35 N/mm^2 and 10,797.18 N/mm^2 - 21,285.50 N/mm2 for mixing ratios 2.5:1 and 3:1 respectively of corn cob particles and *G. arborea* Sawdust boards. Adefisan, (2012) reported MOE values from 1,254.0 N/mm² to 3,346.7 N/mm² for WPCs made with varying wood-plastic ratios of *G. arborea* and Khaya ivorensis sawdusts with PVC. The MOE increased with higher wood content.

This study had highest MOR (Flexural strength) value of 10.43 ± 7.62 N/mm² observed in the treatment containing 100% *G. arborea* wood and the lowest MOR value of 2.68 ± 2.43 N/mm² obtained from treatment containing PET plastic and *G. arborea* in a 70:30 ratio. Combining *G. arborea* and *K. senegalensis* sawdust resulted in WPCs with higher MOR (8.66 ± 7.00 N/mm²) compared to treatments containing only PET plastic. The study of Oladejo and Omoniyi (2017) found that increasing the wood content in WPCs made from recycled PET and sawdust (SD) resulted in higher MOR values. Gulitah and Liew (2018) reported WPCs with 100% polypropylene (PP) had the highest MOR of 25.10 N/mm² which means MOR decreased as the plastic content decreased which agrees with finding of this study. Higher MOR values indicate stronger materials that can withstand greater bending forces before breaking. It is the critical measure of a material's resistance to bending failure, providing insights into its strength and load-bearing capacity for applications like construction and furniture making.

Compressive Strength

The compressive strength of the wood plastic composites had lowest value (135.63 N/mm2) observed in the treatment containing 100% PET and the highest value (153.19 N/mm^2) in the treatment containing PET and *G. arborea* (70:30). The treatments containing 100% *G. arborea*, PET and *G. arborea* (50:50), and PET and *G. arborea* (30:70 and 70:30) had significantly higher compressive strength compared to the treatments containing 100% PET, PET and *K. senegalensis* (70:30), and *G. arborea* and *K. senegalensis* (60:40). This indicates that the addition of *G. arborea* sawdust can improve the compressive strength of the wood plastic composites compared to the use of PET or *K. senegalensis* sawdust alone as reported by Xu *et al*. (2022). Finding from this study shows that the compressive strength of WPCs was highest in the treatment containing 70% PET and 30% *G. arborea* (153.19 N/mm²) and lowest in the treatment with 100% PET (135.63 N/mm²) is consistent with related studies on the effect of wood content on the compressive properties of WPCs. A study by Li *et al*. (2022) on PVC-based WPCs found that compressive strength decreased by 34.39% from 20°C to 50°C, indicating that increasing temperature reduces compressive strength more than tensile strength. Li *et al*. (2022) also reported that WPCs had higher compressive properties compared to tensile properties, with compressive strength about 10 times the tensile strength, suggesting WPCs have stronger compressive resistance. These findings support the current result that optimizing the wood-plastic ratio, in this case using 30% *G. arborea*, can enhance the compressive strength of WPCs compared to using 100% PET or a different wood species like *K. senegalensis*. In related studies by Akinfiresoye *et al*. (2018)

reported that wood plastic composites have been produced from various combinations of wood species and recycled plastics, with similar findings on the effects of the wood-plastic ratio on the physical and mechanical properties of the composites. Xu *et al*. (2021) reported the use of wood fillers, such as sawdust, has been shown to improve the strength and dimensional stability of the composites compared to using plastic alone. Atowon, 2022) noted that the particle size and distribution of the wood fillers also play a role in the properties of the final composite.

CONCLUSION

The study investigated the properties of wood-plastic composite (WPC) boards produced from a combination of *G. arborea* and *K. senegalensis* sawdust with Polyethylene Terephthalate. Highest density was observed in the treatment containing PET and *G. arborea* (30:70). The lowest shattered index was observed in the treatment containing *G. arborea* and *K. senegalensis* (60:40) while shattered resistance was highest in the treatment containing *G. arborea* and *K. senegalensis* (60:40). MOE and MOR were highest in100% *G. arborea* and compressive was highest value in the treatment containing PET and *G. arborea* (70:30). The color and surface appearance of the WPC boards varied depending on the combination of materials used, with the composites containing higher proportions of *G. arborea* sawdust generally having smoother surfaces. Although density, shattered index, and shattered resistance of the WPC boards were not significantly different among the treatments. However, the combination of *G. arborea* and *K. senegalensis* sawdust with PET produced composites with higher Modulus of Elasticity (MOE), Modulus of Rupture (MOR), and compressive strength compared to the treatment containing only PET.

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