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Physico-mechanical characterization of fiberboards made from African locust bean pod fiber using two ecological tannic binders

Soviwadan DROVOU [1, 2, 3, 5], Kokouvi Happy N'TSOUAGLO [1, 2, *], Sinko BANAKINAO [1, 3], Komlan Assogba KASSEGNE [1, 2], Antony PIZZI [5, 6], Komla SANDA [3, 4] and André DL BATAKO [7]

[1] *Polytechnical School of Lomé in University of Lomé (EPL – UL), 01Po. Box 1515 Lomé 01, Togo.*
[2] *Laboratory of Structure and mechanic of materials (LaS2M), (EPL – UL), 01Po. Box 1515 Lomé 01, Togo.*
[3] *Laboratory of Recherche on Agricultural resources and Environmental Health (LARASE), University of Lomé, 01Po. Box 20131 Lomé 01, Togo.*
[4] *University of Kara, Kara, Togo.*
[5] *Laboratory of Study and Recherche on Wood Materials, University of Lorraine (LERMAB – UL), Épinal, 88000, France*
[6] *Department of Physics, King Abdulaziz University, Jeddah, Saudi Arabia.*
[7] *Liverpool John Moores University, Byrom Street, Liverpool, L3 3AF, UK.*

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Abstract

This study explores the valorization of agricultural residues, specifically African locust bean pod fibers and tannic powders extracted from their husks and Indian tamarind peels, for the development of eco-friendly fiberboards. Two fiber size ranges (0.8–1.6 mm and 1.6–2 mm) were used to produce panels with different binder types and tannin contents. The physical properties (density, thickness swelling and water absorption) and mechanical properties (modulus of elasticity, modulus of rupture and tensile strength) of the fiberboards were evaluated. Results revealed that the fiberboards can be classified as Medium Density Fiberboards (MDF) according to the ANSI A208.1–2022 standard. While the water resistance did not meet the standard requirements, the mechanical performance significantly exceeded the thresholds, particularly in terms of stiffness and strength. These findings highlight the potential of underutilized agricultural residues and natural tannin-based binders in the development of sustainable bio-based panels for future material applications.

Keywords: African locust bean pod; Indian tamarind peels; Fiber size; Fiberboards; Tannin-based binders; Physical and mechanical properties

1. Introduction

The construction, industrial, and furniture manufacturing sectors are facing increasing pressure to transition toward sustainable and environmentally friendly materials in response to the challenges of climate change and the depletion of natural resources. These sectors contribute significantly to global CO_2 emissions; for instance, construction activities and building operations alone account for approximately 40% of total emissions, with around 15% specifically linked to the manufacture of building materials [1]. To reduce the environmental impact of these activities and preserve non-renewable resources, the development and use of alternative materials have become essential. The integration of agricultural biomass and waste into panel production represents a viable solution to this challenge, while also aligning with key principles of the circular economy [2], [3]. As a result, innovative alternatives to conventional materials such as plywood, fiberboards, and particleboards are emerging [4], [5], [6], [7].

* Corresponding author: Kokouvi Happy N'TSOUAGLO

Among these bio-based solutions, materials derived from agricultural residues, including rice straw [8], coconut shells [9], hemp fibers [10], [11], and other crops, have attracted growing attention [12], [13], [14], [15]. Numerous studies have demonstrated that these bio-composites exhibit favorable physical and mechanical properties, providing significant potential for a wide range of applications [16], [17], [18]. These findings provide a foundation for continued innovation in the field of sustainable materials.

With this perspective, the exploration of new bio-based raw materials is a promising avenue. The husks of African locust bean (*Parkia Biglobosa*), an abundant by-product in West Africa [19], [20], have interesting properties for the manufacture of composite fiberboards [21]. This renewable resource offers a dual opportunity: to provide an environmentally-friendly alternative to traditional materials, and to valorise an often-under-utilized agricultural waste product.

The aim of the present study is to investigate the physical and mechanical properties of fiberboards made from African locust bean husks, using natural tannic binders extracted from *Parkia Biglobosa* husk and *Pithecellobium Dulce* bark.

2. Materials and methods

2.1. Raw materials

The materials used for the production of fiberboards from African locust bean husks were locally sourced in Togo. The African locust bean husks were collected in the Sokodé region (Figure 1). Two types of tannin-based binders were selected to evaluate their influence on the properties of the produced fiberboards. These include tannins extracted from *Parkia Biglobosa* (African locust bean) and *Pithecellobium Dulce* (Indian tamarind).

Figure 1 Tannic based elements, (a) African locust bean pods; (b) Indian tamarind peel

2.2. The preparation of tannic powders

The pod of African locust bean was dried in an oven at a temperature of 72°C for three days to eliminate all moisture. Then, it is transformed into powder in the RETSCH knife mill with a 2 mm diameter sieve. The material resulting from the grinding is sieved successively with a sieve of 1.6 mm and 0.8 mm. Thus, two fibers are obtained; the first with a diameter between 1.6 and 2 mm (G_1) and the second with a diameter between 0.8 and 1.6 mm (G_2) to separate the fiber from the husk. The material that has passed through the 0.8 mm sieve is again sieved with a 0.125 mm sieve to obtain the tannic powder.

The peels of Indian tamarind were also dried in an oven of MEMMENT type, from the LARASE (Laboratory of Research on Agro resources and Environmental Health) at the University of Lomé. The drying temperature is 72 ∘ C and the drying time is three days. These peels are then cut into small pieces and crushed. The grinder has knives and is of RETSCH SK 1000 type. It is equipped with a sieve with the diameter of the mesh of 0.125 mm to obtain tannic powder. The powders obtained from African locust bean pods and Indian tamarind peels were then mixed with the African locust bean pod fibers at different proportions.

The chemical composition of these two ecological tannic binders, previously characterized by Nénonéné [22], is presented in Table 1.

Table 1 Chemical composition (%) of African locust bean pods and Indian tamarind peel

Parameter (%)	African locust bean pods	Indian tamarind peel
Moisture Content	8.32	5.88
Ash content	2.9	4.97
Crude fat	0.9	0.99
Crude protein	4.69	15.50
Cellulose	49.76	44.61
Hemicellulose	2.52	20.96
Lignin	32.95	13.30

2.3. Fibreboards preparation

The granulometries G_1 ($1.6 < g \leq 2$ mm) and G_2 ($0.8 < g \leq 1.6$ mm) are mixed with the both tannic powders (African locust bean (AL) and Indian tamarind (IT) in the proportion shown in Table 2. Water was added at 20% of the total mixture weight (i.e., 80 g for 400 g). The mixture is kneaded for five (5) minutes. In Table 2, the binder content (%) refers to the weight percentage of binder relative to the total dry weight (binder + fiber). For instance, a 5% binder content means 20 g of binder and 380 g of fiber, totaling 400 g, with the binder making up 5% of the dry mixture.

Table 2 Binder and fiber proportions in fiberboard production

Binder content (%)	Binder weight (g)	Fibre weight (g)
5.0	20	380
7.5	30	370
10.0	40	360
12.5	50	350
15.0	60	340

2.4. Fibreboards thermal pressing

The homogenized mixture is poured into a square mould with dimensions of 36 cm x 36 cm x 12 cm preheated to the required thermal pressing temperature of 160 °C. The mold is sealed with a top plate (31cm x 31 cm x 10 cm) and placed between the heated plates of a Carver hydraulic thermal pressing, with the lower plate being movable and the upper plate fixed.

Figure 2 Thermal pressing process: a) Fibers in the mould before thermal pressing, b) the mould out of the pressing machine and c) Demolded fiberboard.

The thermal pressing process is carried out at a temperature of 160 °C under a pressure of 11 bars. After the temperature stabilizes, the fiberboards are demolded and allowed to cool at ambient air temperature. The thermal pressing time is about 15 minutes. Once cooled, the materials are ready for characterization.

2.5. Physical properties determination

The physical properties are performed according to the ANSI A208.1-2022 standard on the samples of dimensions 50 cm x 50 cm.

2.5.1. Density

The density of the materials was determined by calculating the ratio of the weight of each sample to its volume, following the method described in [23]. It is determined according to ANSI A208.1-2022 on 10 specimens of each of the six fibreboards produced. The density is calculated using the following Equation 1:

$$\rho = \frac{M}{V} \tag{1}$$

Where ρ is the density of the material (kg/m^3), M is the mass of the specimen (kg), and V is its volume (m^3).

The weight was measured using a high – precision digital scale, while the volume was determined by measuring the dimensions of the sample after pressing.

2.5.2. Determination of water absorption and thickness swelling

Water absorption and thickness swelling tests are essential for evaluating the ability of materials to absorb water and undergo dimensional changes when exposed to humid environments [24], [25], [26]. The water absorption test measures the amount of water absorbed by a material after immersion for a defined period, while the thickness swelling test quantifies the variation in the sample's thickness after immersion for a specific duration.

In this study, the tests were conducted in accordance with the ANSI A208.1-2022 Standard. Twelve (12) specimens with dimensions of 50 mm x 50 mm were used. Before immersion, the initial weight and thickness of each sample were carefully measured. The specimens were then immersed in water, and the weights and thicknesses of six specimens were recorded after 2 hours and other six after 24 hours of immersion. It should be noted that after immersion, the specimens were left at room temperature for 15 to 20 minutes to allow excess surface water to drain before final weighing and thickness measurement.

These measurements enabled the calculation of water absorption and thickness swelling, providing key indicators of the materials performance in humid conditions.

The thickness swelling (TS) is determined using Equation 2:

$$TS\ (\%) = \frac{t_i - t_0}{t_0} \times 100 \tag{2}$$

Where:

TS: is the thickness swelling (%),

t_0: is the thickness before immersion in water (mm),

t_i: is the thickness after immersion in water (mm) 2 or 24 hours.

The water absorption (WA) was calculated using Equation 3:

$$WA\ (\%) = \frac{W_i - W_0}{W_0} \times 100 \tag{3}$$

Where:

WA: is the water absorption (%),

W_0: is the weight before immersion in water (gr),

W_i: is the weight after immersion in water (gr) 2 or 24 hours.

2.6. Mechanical properties determination

The mechanical properties of the samples were determined using a mechanical testing bench equipped with accessories specifically designed for three-points bending and tensile tests. The tests were conducted under controlled conditions, maintaining a relative humidity of 65% and a temperature of $20^{\pm 3}$ °C.

2.6.1. Three point bending test

The samples dimensions were 150 mm x 100 mm for bending test. The mechanical tests were performed according to the standards EN 312-2 2004 and EN 310 [27], [28]. The standards NF B51-124:1993 and NBN EN 310:999 [29], [30] were used to calculate the mechanical properties such as elasticity modulus (MOE), the modulus of rupture in bending (MOR). The values of MOE and MOR were giving by the following expressions:

$$MOE = \frac{F.l^3}{4be^3y} \quad (4)$$

With $F = (F_2 - F_1)$ and $y = (y_2 - y_1)$, leading to the expression:

$$MOE = \frac{(F_2 - F_1).l^3}{4be^3(y_2 - y_1)} \quad (5)$$

The modulus of rupture (MOR) was calculated using Equation 6:

$$MOR = \frac{3Fl}{2be^2} \quad (6)$$

In these equations, l is the distance between supports, e is the thickness of the specimen, and b is the width of the specimen. F represents the strength at break, while F_1 and F_2 correspond to 10% and 40% of F , respectively. y_1 and y_1 are the deflections corresponding to F_1 and F_2.

2.6.2. Tensile test

The tensile test was performed on specimens with dimensions of 150 mm × 20 mm. The Young's modulus (E) and the tensile modulus of rupture (MOT) of the fiberboards are determined using the Equations 7:

$$\mathbf{E} = \frac{\sigma}{\varepsilon} = \frac{\frac{F}{S_0}}{\frac{\Delta l}{L_0}} = \frac{F \times L_0}{\Delta l \times S_0} \quad (7)$$

The modulus of tensile rupture (MOT) was determined using Equation 8:

$$\mathbf{MOT} = \frac{\mathbf{F_m}}{\mathbf{b \times e}} \quad (8)$$

In these equations, F represents the elastic limit load, $\mathbf{F_m}$ is the maximum tensile load applied to the specimen, and l_0 is the initial length of the specimen. Δl denotes the elongation during the test, while $\mathbf{S_0}$ is the initial cross-sectional area of the specimen. The parameters **b** and **e** correspond to the width and thickness of the specimen, respectively.

3. Results and discussion

3.1. Density

The density results of the different materials, based on binder content and fiber size, are presented in Figure 3.

AL G1: Fiberboards made from African locust bean fibers, with a fiber size of 1.6–2 mm, bonded using tannin extracted from African locust bean pod husks. Densities range from 788 kg/m^3 (at 5% binder content) to 798 kg/m^3 (at 15% binder content).

AL G2: Similar fiberboards using smaller fibers (0.8–1.6 mm) show densities ranging from 793 kg/m^3 (5% binder) to 800 kg/m^3 (15% binder).

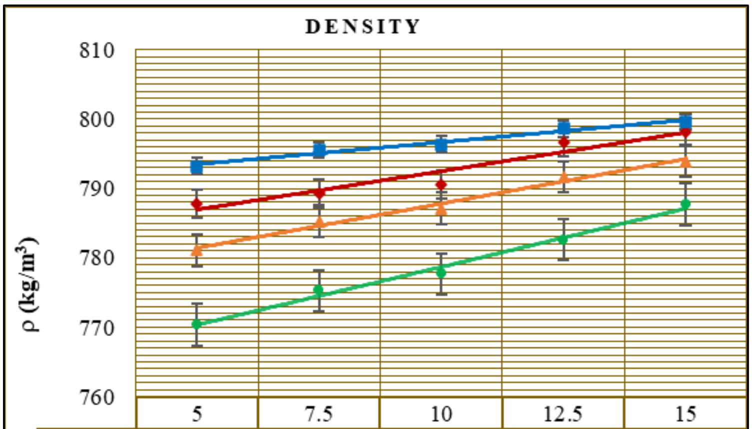
IT G1: Fiberboards using African locust bean fibers (1.6–2 mm) and tannin derived from Indian tamarind bark. Densities range from 770 kg/m^3 (5% binder) to 788 kg/m^3 (15% binder).

IT G2: The same formulation with smaller fibers (0.8–1.6 mm) results in densities between 781 kg/m^3 (5% binder) and 794 kg/m^3 (15% binder).

It is also important to note that density variation is more pronounced at lower binder contents. For instance, the standard deviation reaches ±8 kg/m^3 at 5% binder content, compared to only ±5 kg/m^3 at 20%.

All fiberboards have a density between 640 and 800 kg/m^3, classifying them as medium-density fiberboard according to ANSI A208.1-2022. These results align with those of Kadja [31], who developed cotton and Kenaf tree fiber fiberboards using pearls bone glue, and Drovou et al. [32], who used tannic powders from *Parkia biglobosa* pod husk and *Pithecellobium dulce* peels to bind Antiaris Africana sawdust, creating formaldehyde-free environmental fiberboards. The granulometry significantly impacts fiberboard density; finer fibers are denser . Given the same weight, finer fibers occupy less volume, pack more efficiently, and reduce porosity, leading to thinner, more compact fiberboards [32], [33].

In general, the density increases with the binder content in the fiberboard, as higher binder ratios enhance fiber adhesion and reduce void spaces, which is consistent with some results presented in the literature [9], [32]. Additionally, African locust bean husk tannin-based fiberboards systematically exhibit higher densities compared to Indian tamarind bark tannin-based fiberboards, suggesting a stronger binding effect. This effect has already been demonstrated in the literature, where fiberboards made with tannic powder from African locust bean pod husks are denser than those manufactured with other binders [7].



	5	7.5	10	12.5	15
AL G1	788	789	791	797	798
AL G2	793	796	796	799	800
IT G1	770	775	778	783	788
IT G2	781	785	787	792	794

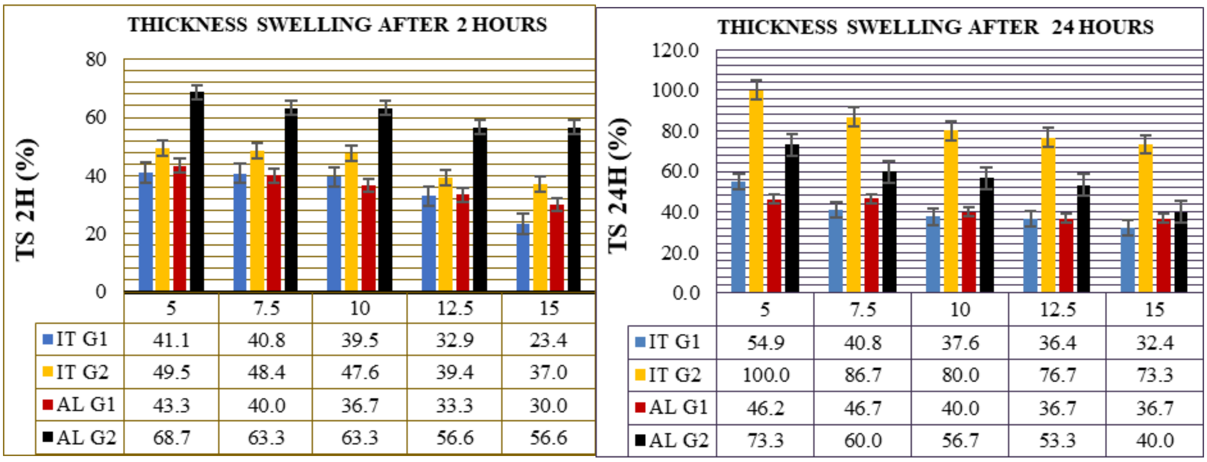
AL: African locust bean pods, IT: Indian Tamarind, G1: 1.6 < g ≤ 2, G2: 0.8 < g ≤ 1.6

Figure 3 Variation of density according to granulometry and binder

3.2. Thickness Swelling

Figure 4 shows the thickness swelling of the fiberboards after 2 hours and 24 hours immersion in water. After 2 hours of immersion, all tested fiberboards exceed the 20% threshold defined for floor fiberboards. Surprisingly, fiberboards with smaller fiber sizes exhibit particularly high swelling rates, reaching up to 68% when using the tannin binder from Indian tamarind bark. Conversely, fiberboards with larger fiber sizes show more moderate and consistent swelling rates, regardless of the type of binder used.

After 24 hours of immersion, there is no significant variation in the swelling rate of fiberboards with larger fibers compared to the swelling observed after 2 hours. This suggests that absorption is very high at the beginning but stabilizes over time. On the other hand, for fiberboards with smaller fibers, swelling remains significant, reaching up to 100% when using the tannin binder derived from African locust bean at 5%. In contrast to the results observed after 2 hours, where the tannin binder from Indian Tamarind bark led to a higher swelling rate, it is now the fiberboards made with the tannin binder derived from African locust bean that show the highest swelling rate after 24 hours. Overall, it is also observed that the swelling rate decreases with the binder content.



	5	7.5	10	12.5	15
IT G1	41.1	40.8	39.5	32.9	23.4
IT G2	49.5	48.4	47.6	39.4	37.0
AL G1	43.3	40.0	36.7	33.3	30.0
AL G2	68.7	63.3	63.3	56.6	56.6

	5	7.5	10	12.5	15
IT G1	54.9	40.8	37.6	36.4	32.4
IT G2	100.0	86.7	80.0	76.7	73.3
AL G1	46.2	46.7	40.0	36.7	36.7
AL G2	73.3	60.0	56.7	53.3	40.0

AL: African locust bean pods, IT: Indian Tamarind, G1: 1.6 < g ≤ 2, G2: 0.8 < g ≤ 1.6

Figure 4 Thickness swelling variation according to the granulometry and binder after 2- and 24-hours immersion

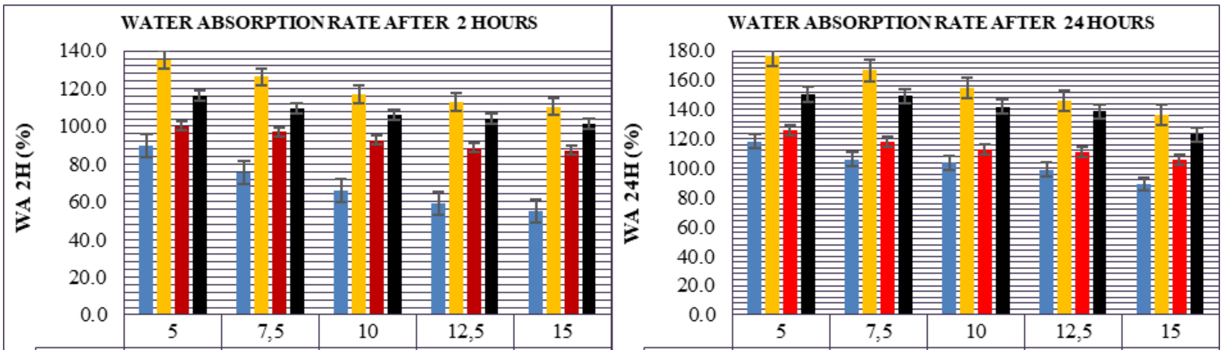
It is important to note that, according to the ANSI A208.1 – 2022 standard, the acceptable thresholds for thickness swelling are defined as follows: 20% for flooring fiberboards, 8% for roofing fiberboards after 2 hours of immersion, and 50% for general applications after 24 hours. However, the swelling values recorded in this study remain significantly higher than those prescribed by the more stringent EN 317 standard [34].

3.3. Water absorption

The water absorption test revealed significant variations depending on fiber size and immersion duration. Figure 5 shows the evolution of water absorption under different configurations. After 2 hours of immersion, all fiberboards absorbed more than 50% of their weight in water. The values ranged from 55.0% (IT G1, 15% binder content) to 135.3% (IT G2, 5% binder content). It was observed that fiberboards with smaller fiber sizes exhibited the highest water absorption. Similar to the swelling trends, the difference between water absorption at 2 and 24 hours is not substantial, as one might have expected. After 24 hours, water absorption ranged from 89.2% (IT G1, 15% binder content) to 176.7% (IT G2, 5% binder content). This suggests that water absorption is very high during the initial phase but tends to stabilize over time as the internal pores become saturated.

The water absorption values obtained in this study are comparable to those reported by Diop et al. [35], who found absorption ranging from 120% to 160% in fiberboards made from thermomechanical pulp and lignocellulosic nanofibrils. In contrast, our results differ markedly from the findings of Rodríguez et al. [36] and Boran and Torun [37], who evaluated fiberboards made from medium-density fiberboard residues and from microcrystalline cellulose combined with antimony trioxide, respectively. In Rodríguez et al.'s work, water absorption ranged from 18% to 60% after 24 hours, while Boran and Torun reported values between 20% and 25% over the same duration.

Overall, it was also observed that the water absorption decreased as the binder content increased.



WA 2H (%)	5	7,5	10	12,5	15
IT G1	89.8	75.4	66.2	59.2	55.0
IT G2	135.3	126.2	116.9	112.7	110.4
AL G1	100.0	97.0	92.6	88.7	87.3
AL G2	116.4	109.7	105.9	103.9	101.1

WA 24H (%)	5	7,5	10	12,5	15
IT G1	118.4	105.9	103.8	98.9	89.2
IT G2	176.7	166.6	154.7	145.9	136.6
AL G1	126.2	118.0	113.0	110.7	105.7
AL G2	150.5	149.2	141.8	138.9	123.0

AL: African locust bean pods, IT: Indian Tamarind, G1: 1.6 < g ≤ 2, G2: 0.8 < g ≤ 1.6

Figure 5 Water absorption (WA) variation according to fiber size and binder after 2 and 24 hours immersion

3.4. Three-point bending test properties

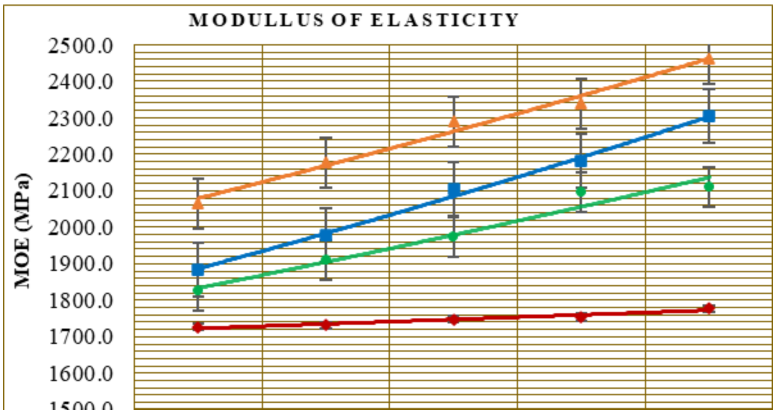
This section presents the results related to the moduli of elasticity (MOE) and rupture (MOR) of the fiberboards.

3.4.1. Moduli of elasticity (MOE)

Figure 6 shows the evolution of the MOE as a function of binder. The results show that fiberboards manufactured with tannin extracted from Indian Tamarind bark (IT) exhibit MOE values ranging from 1825.0 MPa to 2462.2 MPa. Similarly, fiberboards produced with tannin extracted from African locust bean husk (AL) display MOE values between 1726.4 MPa and 2303.1 MPa. It is also noteworthy that fiberboards made with smaller fiber particles exhibit higher MOE values than those made with larger particles. This trend is consistent with previous studies, which have shown that finer particles contribute to improved mechanical strength due to better compaction and reduced porosity. Moreover, MOE values increase with higher binder content, confirming findings reported in the literature [32], [38].

All tested fiberboards meet or exceed the minimum requirements defined by the ANSI A208.1 – 2022 standard. The MOE values obtained in this study are comparable to those reported by Rodríguez et al. [36] and Jazayeri et al. [39], who developed fiberboards incorporating modified graphene as an additive in urea-formaldehyde (UF) adhesive. Their results showed a progressive increase in MOE with higher additive content.

Although not strictly equivalent in terms of formulation, a comparison was made with Sellers [40] and Xu et al. [41], who studied fiberboards manufactured without any binder. This comparison was included to highlight the significant improvement in mechanical performance achieved through the use of tannin-based binders in our study. The MOE values observed in our boards are considerably higher than those without binder, underscoring the effectiveness of tannin adhesives in enhancing the stiffness and reliability of fiberboards.



	5	7.5	10	12.5	15
AL G1	1726.4	1732.2	1747.5	1753.6	1777.9
AL G2	1884.1	1978.1	2104.4	2180.2	2303.1
IT G1	1825.0	1908.3	1972.3	2094.6	2109.5
IT G2	2065.5	2177.6	2289.8	2339.2	2462.2

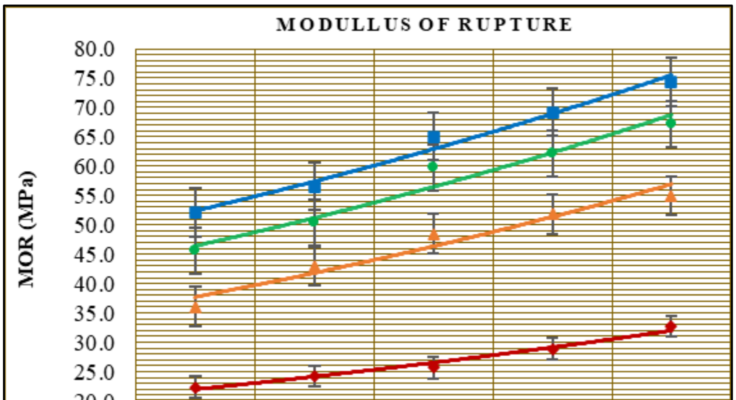
AL: African locust bean pods, IT: Indian Tamarind, G1: 1.6 < g ≤ 2, G2: 0.8 < g ≤ 1.6

Figure 6 Variation of modulus of Elasticity (MOE) according to binder content and fiber size

3.4.2. Moduli of rupture (MOR)

Figure 7 shows how the modulus of rupture (MOR) of the fiberboards varies depending on the type and amount of binder used. Fiberboards made with tannin from Indian Tamarind peels (IT) have MOR values ranging from 36.1 MPa to 67.2 MPa. Those made with tannin from African locust bean husk (AL) show MOR values between 22.4 MPa and 74.4 MPa. In general, as observed for MOE, fiberboards made with smaller particles have higher MOR values than those made with larger particles. However, in the case of tannin from IT, an opposite trend is observed: fiberboards with smaller particles have lower MOR values than those with larger particles.

As concluded in the previous subsection for the MOE, all MOR values obtained in this study meet or exceed the minimum requirements specified by the ANSI A208.1–2022 standard. Furthermore, these values are significantly higher than those reported by other authors in the literature who also developed natural fiberboards [40], [41], [42]. These results confirm the mechanical strength and reliability of the manufactured fiberboards, regardless of the binder type or fiber particle size used.



	5	7.5	10	12.5	15
AL G1	22.4	24.2	25.7	28.8	32.7
AL G2	52.1	56.5	65.0	69.2	74.4
IT G1	45.7	50.4	59.8	62.2	67.2
IT G2	36.1	42.9	48.5	51.8	54.9

AL: African locust bean pods, IT: Indian Tamarind, G1: 1.6 < g ≤ 2, G2: 0.8 < g ≤ 1.6

Figure 7 Variation of modulus rupture (MOR) according to binder content and fiber size

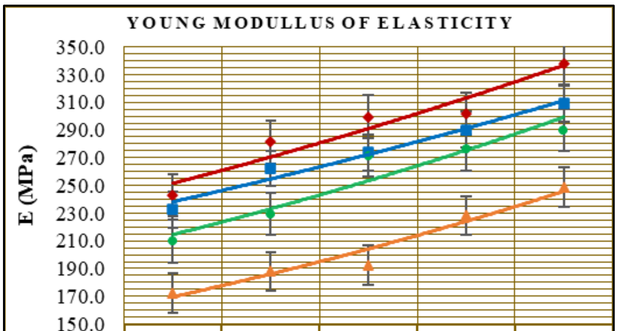
3.5. Tensile test properties

This section presents the results for the Young's modulus of elasticity (E) and the tensile modulus of rupture (MOT).

3.5.1. Young's Modulus of Elasticity (E)

Figure 8 shows the variation of E of the fiberboards as a function of binder content and fiber size. The results indicate that E values are higher in fiberboards manufactured with tannin powder derived from African locust bean husks (AL). Specifically, E values for AL-based fiberboards range from 232.7 MPa to 337.9 MPa, while those produced with tannin extracted from Indian tamarind peels (IT) range from 172.5 MPa to 289.8 MPa. For all types of fiberboards, it is also noteworthy that specimens made with larger fiber particles exhibit higher E values than those made with smaller particles. This trend highlights the role of fiber size in improving the tensile stiffness of the boards.

To the best of our knowledge, no previous studies in the literature have specifically reported the Young's modulus of fiberboards manufactured from similar natural fibers and tannin-based binders, which makes a direct comparison with existing data difficult.

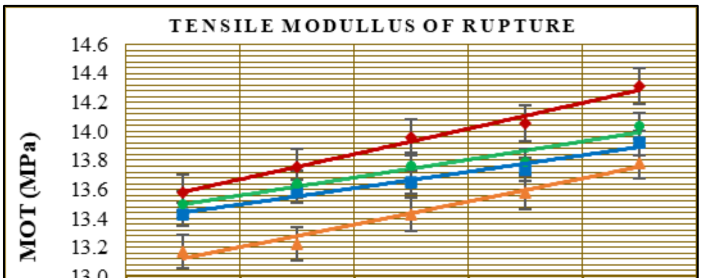


	5	7.5	10	12.5	15
◆ AL G1	242.9	281.4	299.5	301.7	337.9
■ AL G2	232.7	262.2	273.6	290.3	308.9
● IT G1	209.7	229.2	271.4	276.2	289.8
▲ IT G2	172.5	187.9	192.7	228.3	248.9

AL: African locust bean pods, IT: Indian Tamarind, G1: 1.6 < g ≤ 2, G2: 0.8 < g ≤ 1.6

Figure 8 Variation of tensile modulus of elasticity according to binder and fiber size

3.5.2. Tensile Modulus of Rupture (MOT)



	5	7.5	10	12.5	15
◆ AL G1	13.6	13.8	14.0	14.1	14.3
■ AL G2	13.4	13.6	13.7	13.7	13.9
● IT G1	13.5	13.6	13.8	13.8	14.0
▲ IT G2	13.2	13.2	13.4	13.6	13.8

AL: African locust bean pods, IT: Indian Tamarind, G1: 1.6 < g ≤ 2, G2: 0.8 < g ≤ 1.6

Figure 9 Variation of tensile modulus of rupture according to binder and fiber size

Figure 9 shows the variation of the tensile modulus of rupture (MOT) of the fiberboards as a function of binder content and fiber particle size. The results indicate that, overall, MOT values are slightly higher in fiberboards manufactured with tannin powder derived from African locust bean husks (AL). The MOT of fiberboards made with AL tannin ranges from 13.4 MPa to 14.3 MPa, while for those manufactured with IT tannin, values range from 13.2 MPa to 14.0 MPa. As observed for Young's modulus, both E and MOT values increase with the binder content, confirming that a higher amount of binder improves tensile performance [32], [38].

4. Conclusion

This study demonstrates the feasibility and potential of ecological fiberboards made from African locust bean pod fibers and tannic powders derived from their husks and Indian tamarind peels.

Physical properties: The produced fiberboards exhibited densities ranging from 770 to 800 kg/m^3, classifying them as Medium Density Fiberboards (MDF) according to the ANSI A208.1–2022 standard. Density increased with binder content, with the highest values obtained for fiberboards made with African locust bean tannin and finer fiber particles (AL G2: 793–800 kg/m^3). However, thickness swelling and water absorption emerged as critical limitations, since the required specifications for these properties were not met. This restricts their use in humid environments and highlights the need for optimized binder formulations or hydrophobic treatments to improve moisture resistance.

Mechanical properties: The bending modulus of elasticity (MOE) increased with binder content and fiber size, ranging from 1726.4 MPa to 2462.2 MPa, with the highest values achieved using Indian tamarind tannin and smaller particles (IT G2). All boards met or exceeded ANSI A208.1–2022 specifications. The bending modulus of rupture (MOR) varied from 22.4 MPa to 74.4 MPa, with higher values recorded for finer African locust bean particles (AL G2) and higher binder content. All fiberboards were classified as Grade 2 MDF according to ANSI A208.1–2022. The tensile modulus of elasticity ranged from 172.5 MPa to 337.9 MPa, with superior results for AL binders and larger fibers. The tensile modulus of rupture (MOT) varied between 13.2 MPa and 14.3 MPa, with the best performance observed in boards with higher binder content and larger particles.

In terms of future prospects, these ecological fiberboards show strong potential for applications such as furniture manufacturing, interior design elements, and insulation materials in environments with limited moisture exposure. Their fully plant-based composition aligns well with the growing demand for sustainable in both local and international markets. Although their current sensitivity to moisture limits certain uses, their mechanical performance is comparable to that of conventional MDF panels. To compete effectively with traditional products, further improvements, such as hydrophobic treatments will be essential.

Moreover, African locust bean, a tree that grows abundantly in the Sudano-Sahelian zones of West Africa, provides a renewable and locally available resource. Combined with the widespread availability of agricultural residues and the emerging demand for green building solutions in these regions, this offers strong potential for commercialization and local value creation. Importantly, the pressing process and raw materials used are compatible with existing MDF production technologies, suggesting realistic prospects for scale-up.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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