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RESEARCH ARTICLE

DETERMINATION OF MECHANICAL AND THERMAL PROPERTIES OF INSULATING RAFFIA LEAVES PARTICLEBOARD MADE WITH TANNIC POWDER OF AFRICAN LOCUST BEEN POD SHELL (PARKIA BIGLOBOSA)

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ABSTRACT

Sustainable development finds its full meaning in the sense that it promotes the use of renewable resources, available in sufficient quantity to meet the diverse needs of a society in the present and in the future. This concept includes social, economic and environmental factors which must all be taken into account because they are decisive in the absolute availability of the resource. The cob is the part of the maize which bears its seeds and which, after shelling, is thrown away as vegetable waste. Corn is a food grain of the Gramineae family, whose tight kernels on a long cob are rich in sugar and gluten. This plant grown in Africa and around the world whose use of its different parts is varied. Corn was probably domesticated in southern or central Mexico. In recent years and in the context of the need to use renewable resources, the use of locally available raw materials has literally exploded, particularly in the field of construction. At the origin of the research, we find first of all the desire to valorize the corn cob. It is dried and then reduced to a powder whose particle size is determined before use.It is also a question of appreciating the mechanical and thermal properties of the Compressed Earth Block (BTC) with the reinforcement of vegetable fiber by valuing the cob of corn which is a biodegradable natural product as reinforcement in the manufacture of the ecological BTC which meets the standards. international. The composite material obtained was characterized mechanically and thermally. The mechanical properties comply with the values of the standards in force. Similarly, the results show that thermal conductivity and diffusivity decrease with the introduction of corn cob flour while effusivity increases. This particleboard could be used for thermal isolation

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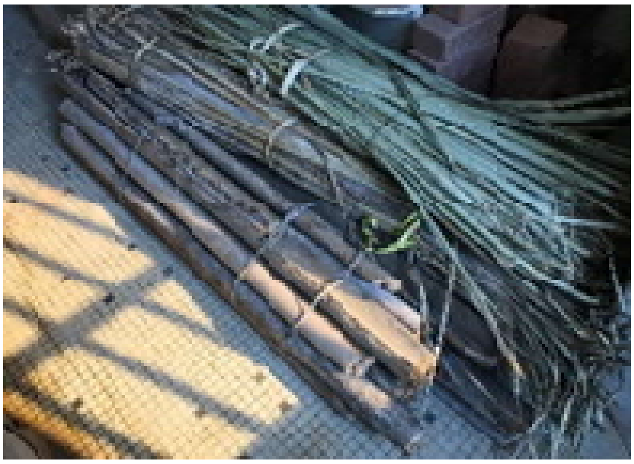
INTRODUCTION

Sustainable development finds its full meaning in the sense that it promotes the use of renewable resources, available in sufficient quantity to meet the diverse needs of a society in the present and the future. This concept includes social, economic and environmental factors which must all be taken into account because they are decisive in the absolute availability of the resource. The raffia palm is an African palm which originates from the tropical Regions of Africa, particular in the island of Madagascar. The name raffia comes from the Greek word ''*Raphis*'' which means sting, and is an allusion to the scaly and pointed fruits of this tree which belongs to the botanical family of *Palmaceae.* The raffia palm has the scientific name: *« Raphia Farinifera » figure 1*. In recent years and in the context of the need to use renewable resources, the use of locally available raw This has the direct consequence of expanding research and various studies on the multi-faceted raffia palm. At the origin of the research, we find first of all the desire to valorize in addition to the ligneous material of the branch of raffia, the leaves. It is also a question of recovering the waste from the pod of African locust been which is a biodegradable natural product as a binder in the manufacture of ecological particleboards which meet international standards. The composite material obtained will be characterized mechanically ant thermally.

Experimentations

Preparation of the particle of raffia leaves: The raffia leaves are harvested from Sokodé (Central Region of Togo), in Lomé, they are natural drying and then to steaming where they become dry, devoid of any moisture.Then they are transformed into particles in the RETSCH cutting mill equipped with a 2 mm diameter sieve (figure 2).

a



b

Fig.1. Raffia: Raffia palm (a); leaves et branch (b)

Fig. 2: The particles of the leaves of raffia

Preparation of the African locust been pod tannic powder: The pod of African locust been is also harvested in the central region of Togo.It is dried in an oven at a temperature of 72°C for three days, devoid of any humidity.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 and the second with a diameter between 0.8 and 1.6 mm 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 have the tannic powder. The figure 3 describe the process of obtention on the tannic powder of African locust been.

Preparation of the raffia leaves panel: The dry powder (Fig. 2) of the raffia branch leaves is mixed with the tannic powder of African locust been pod (Figure 3c) at levels of 10, 15 and 20%. The mixture is kneaded for 10 minutes and pressed at a temperature of 160°C to obtain the panels.The figure 4 shows the successive stages in the preparation of a particleboard of leaves from raffia branches with the tannic powder of African locust been pod.

Fig. 3. Process of obtention of tannic powder of African locust been: pods (a); fibre of the pods (b); powder (c).

Characterization of raffia branch leave panels: The elaborated panels are characterized to have the physical, mechanical and thermal properties

Physical characterization of raffia branch leave panels: It is made according to standard ANSI A208.1– 2016 (1) on specimens measuring 50 x 50 mm.

The density: It consists to take weigh ten (10) specimens of each panel, calculate the density and take the average to obtain the density of the six panels

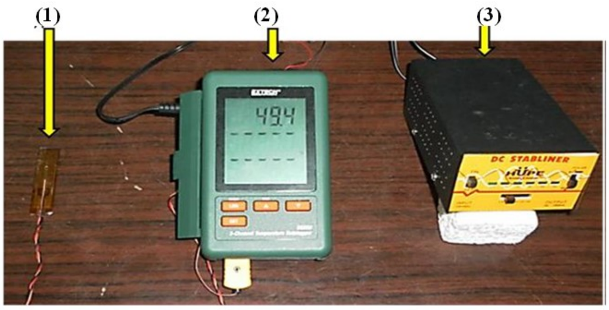
The rate of thickness swelling : The rate of swelling in thickness is between 43 and 68% after 2 hours and 66 to 73% after 24 hours of immersion.

Fig. 4. Particleboard of leaves from raffia branches before (a), and after (b, c) thermal pressing

Water immersion : It consists to immerse twelve (12) specimens of each panel in water after measuring the thickness and weight. and then repeat these measurements after 2 hours on the six first and 24 hours on the six others. This gives the rate of the thickness swelling (TS) and water absorption (WA).

Mechanical characterization of raffia branch leave panels: It is made from the three-point bending test on six 50 x 150 mm specimens of each panel produced according to the ANSI A208.1 standard. The test consists of placing the specimen on two supports and applying a bending force in the middle until it breaks. The modulus of elasticity (MOE) and the modulus of rupture (MOR) are then determined.

Thermal characterization of raffia branch leave panels: It is carried out according to the RT 2000 standard by the heating plate kept on the test specimens of dimension 50 x 30mm. The figure 5 below shows the experimental setup.



(1): heating plate between two specimens; (2): central acquisition; (3) power supply stabilization

Fig. 5. Hot plate experimental device

RESULTS

Physical properties: These properties are the density, the rate of swelling of thickness after immersion in water.

Density: The density of the particleboards from the leaves of raffia branches prepared with the tannic powder of African locust been pod varies between 700 kg/m^3 to 738 kg/m^3. The results are grouped in Table 1. These panels are therefore in the category of medium density panels (MD) according to the American standard ANSI A208.1-2016 (1).

Table 1: Density of the panels according to the binder rate

Binder rate (%)	Density (kg/m^3)
10	700.78
15	723.49
20	738.89

The ANSI A208.1-2016 standard (1) has set a water thickness swelling threshold for panels at 20% for floor panels and 8% for roof panels. The results are grouped in Table 2. The panels produced have swelling rates that are clearly higher than that fixed by this standard. The swelling rate decreases with that of the binder. These results confirm those of Kadja 2012 (2), Drovou 2022.

Table 2. The thickness swelling rate of the panels according to the binder rate

Binder rate (%)	TS%	
	2 hours	24 hours
10	68.87	73.33
15	55.75	70.00
15	43.67	66.60
Recommendations of ANSI A208.1, 2016	20	50

The rate of water absorption: The rate of swelling in thickness is between 21 and 55% after 2 hours and 45 to 64% after 24 hours of immersion. The ANSI A208.1-2016 standard (1) has set a water absorption threshold for panels at 20% for floor panels and 8% for roof panels. The results are grouped in Table 3. The panels produced have absorption rates that are clearly higher than that fixed by this standard. The absorption rate decreases with that of the binder. These results confirm those of Drovou 2022 (3).

Table 3. The water absorption rate of the panels according to the binder rate

Binder rate (%)	TS%	
	2 hours	24 hours
10	55.57	64.25
15	39.15	57.21
15	21.76	45.62
Recommendations of ANSI A208.1, 2016	20	50

Mechanical properties: These properties are determined by three-point bending tests. These are the modulus of elasticity (MOE) and the modulus of rupture (MOR).

The bending modulus of elasticity (MOE): The MOE of the panels is grouped in Table 3. It appears that the MOE increases with the binder content. It complies with the ANSI A208.1 2009 (1) standard, the value of which is set at 1225 MPa. These results show that the particleboards made from leaves of raffia leaves produced with the tannic powder of African locust bean pod shell are of medium density class 1 (MD-1) by the ANSI A208.1 2016 standard (1). They confirm those of Drovou in 2015 (2) who worked on kapok sawdust particle boards with tannic powder from African locust been pod and Nénonéné in 2009 (4) who explored kenaf stem panels with the same binder.

The bending modulus of rupture (MOR): We notice that the MOR increases with the binder rate, between 13 and 15 MPa for the particle boards of the leaves of the raffia branch Table 4 groups together the variation in the modulus of rupture as a function of the binder content.

Table 4. Variation of the bending modulus of elasticity (MOE) and rupture (MOR) according to binder rate

Binder rate (%)	MOE (MPa)	MOR (MPa)
10	1523.54	13.21
15	1667.49	14.64
20	1777.92	15.72
Recommendations of ANSI 208.1, 2016	1125	11

These results show that the particleboards of raffia branch leave produced with the tannic powder of African locust been pod are of medium density class 1 (MD-1) by the ANSI A208.1 2016 standard (1).They are similar to the results of the modulus of elasticity, thus confirming those of Drovou in 2015 (2), and Nénonéné in 2009 (4).

Thermal properties: These determined properties are effusivity, conductivity and diffusivity. The property averages are summarized in Table 5. The results show that thermal conductivity and diffusivity decrease with increasing binder content while effusivity increases.These results confirm those of Drovou et al 2019 (5) who characterized the teak sawdust panels with the tannic powder of African locust been pod.They are therefore classic insulators according to the RT 2000 standard.

Table 5. Variation of thermal properties according to binder rate

Binder rate (%)	Eff. ($J.m^{-2}. K^{-1}. s^{-0,5}$)	λ ($W.m^{-1}. K^{-1}$)	Diff. ($m.s^{-2}$)
10	497.746	0.44667	$7.308E^{-07}$
15	599.497	0.43467	$5.309E^{-07}$
20	745.,469	0.42967	$3.374E^{-07}$

CONCLUSION

This study demonstrates that tannic powder from African locust bean pod pods can replace conventional binders with no effect on the environment.All raffia branch leaves panels have mechanical property that meets ANSIA208.1 – 2016 standard.

The values of the mechanical properties are:

- *Bending modulus of elasticity (MOE) is between:*1523 to 1777 MPa
- *Bending modulus of rupture (MOR) is between:*13 to 15 MPa

The values of the thermal properties are:

- *Effusivity grows from: 497 to 745 ($J.m^{-2}. K^{-1}. s^{-0,5}$)*
- *conductivity decrease from: 0.44667to 0.42967 ($W.m^{-1}. K^{-1}$)*
- *Diffusivity decrease from:$7.308E^{-07}$to $3.374E^{-07}$($m.s^{-2}$)*

They are classic insulators according to the RT 2000 standard.
The values of thephysical properties

- *The medium density:*

The panels density is between 700 to 738 (kg/m^3).They are medium density (MD1) according to the ANSIA208.1 – 2016 standard.

- *The high thickness swelling (TS) rate:*
- over 21% to 55 % after 2 hours and
- over 45% to 64% after 24 hours
- *the high-water absorption (WA) rate:*
- over 21% to 55 % after 2 hours and
- over 45% to 64% after 24 hours

The high rate of thickness swelling and water absorption prove that these panels will be used in a dry environment.

It will be very good to determinate the phonic absorption to know if these particleboards can be used for insulating.

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