



EVALUATION OF THE POTENTIAL OF MORINGA FIBRE AS A FIRE RESISTING COMPOSITE

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Abstract

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The Production of a fire resisting composite Ceiling Board from Moringa wood was carried out basically using moringa sawdust, PVA, CaCO₃, nitrosol etc which was sourced locally and in the chemical stores in Uturu, Abia State. The quantity of each material used, was weighed out in their adequate proportion as contained in the formulation table respectively so as to evaluate the potential of the moringa wood dust fire resistance. The deflection and fire resistance test shows that the produced ceiling boards are better in terms of rigidity and fire resistance ability. It was then recommended that the cultivation of this moringa wood can help in the production of fire resistance ceiling board and as such should be encourage to create job opportunities for Nigerians.

Keywords: Moringa, fire resistance, ceiling board, formulation, PVC

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1.0 INTRODUCTION

Ceiling boards have a long history of application in the house construction for a long period of time. It has been put in use in recent years to improve its aesthetics and reduces sound and heat transmission in the house. It is an essential part in the building process, where it plays a key role in the thermal comfort of a building (Ataguba, 2016). Ceiling as one of the main building elements is very important and has the main function of thermal conductivity and thermal resistivity which reduces or increases excessive heat in the room, they are produced from different materials such as plastics, saw dust etc. There are different types of ceiling boards; these include: gypsum ceiling boards, acoustical ceiling boards, gypsum fiber ceiling boards and cement fiber ceiling boards etc. These types of ceiling boards are grouped in accordance to the raw materials used for the production (Ajayi and Fuwape, 2005). Gypsum ceiling boards are produced from gypsum, acoustical ceiling boards are obtained from mineral wool, gypsum, small amount of paper and starch.

Earlier model incorporate the use of gypsum and mineral fiber sandwiched in between paper covering. The aim being to keep away the heat and hence maintain normal room temperature. The choice of material for the ceiling boards have always been one with low heat conductivity and resistance to fire. With time materials such as the use of rice husk (*Oladele et al.*, 2009; *Suleiman et al.*, 2013; *Madu et al.*, 2018), banana fibres (*Stephen et al.*, 2014), jatropha curcas seedcake material (*Olorunmaiye and Ohijeagbon*, 2015), water melon peels (*Idris et al.*, 2011), bamboo (*Chibudike et al.*, 2011), corn cobs and cassava stalks (*Amenaghawon et al.*, 2016) as well as other wastes like sawdust (*Idehai*, 2012; *Akinyemi et al.*, 2016; *Atuanya and Obele*, 2016; *Isheni et al.*, 2017; *Olufemi et al.*, 2012) and waste paper (*Ekpunobi et al.*, 2015) have been experimented upon for cheap and local substitute. Most of these materials are agro-waste and readily available but are decomposable when subjected to fire. The need for readily available substitute informed this research proposal. It has been observed that the moringa wood does not burn when subjected to open fire as other wood would do. It then became a thing of curiosity that this wood if processed could make an excellent substitute for use in the production of ceiling boards.

Elemental Analysis Of Moringa Dust:

The untreated *Moringa oleifera* wood dust sample and the alkali prehydrolysis liquor (PHL) were analyzed in terms of their contents of minerals, such as Fe, Si, Ca, Mg, K, P, Na, Al and Co, by Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). The findings of elemental analysis performed on *Moringa oleifera* wood and alkali prehydrolysis liquor (PHL) samples are given in Table 2.1. The alkali prehydrolysis liquor shows the presence of some useful ingredients, which may be further valorized in many ways. The possibility to turn it into value added products needs to be analysed. Alkali prehydrolysis degrades the low molecular weight carbohydrates, along with the minerals from the materials. In this study, the alkali

prehydrolysis liquor contains 50.9 mg/kg calcium, 5140 mg/kg potassium and 312 mg/kg iron content.

Table 1: Elemental analysis of moringa oleifera wood and Alkali prehydrolysis liquor sample

Elements	<i>Moringa oleifera</i> wood sample, mg/kg	Alkali prehydrolysis liquor sample, mg/kg
Fe	1270	312
Si	97.0	32.2
Ca	56.0	50.9
Mg	3806	97.4
K	7587	5140
P	44.6	3.84
Na	1577	61.0
Al	-	50.0
Co	18.4	4.32

(Arvid Sharma *et al.*, 2020)

Fire Performance Of Wood

Ignition

Wood, like other cellulosic materials, undergoes thermal degradation at elevated temperatures. This phenomenon, pyrolysis, follows a low-temperature pathway (below 300°C (570°F)) and a high-temperature pathway (above 300°C) (Shafizadeh, 1984). At low temperatures, the pyrolysis of wood favors the formation of char and evolution of noncombustible gases such as H₂O and CO₂. At high temperatures, tars and combustible gases are produced. These combustible volatiles combine with oxygen to “burn”. In the presence of a pilot flame, the volatiles can ignite with a minimum rate of heating of 13 kW/m² (1.1 Btu/ft²•s). When no pilot flame is present, spontaneous ignition can occur, although roughly twice the heat flux is required—about 25 kW/m² (2.2 Btu/ft²•s) (Lawson and Simms, 1952). The surface temperature for the rapid spontaneous ignition of wood has been determined to be between 330° and 600°C (626° and 1,112°F) (Beall and Eickner, 1970; Kanury, 1972). Forest Products Laboratory (FPL) is currently using ASTM Test Method E1321-90.

Fire Resistance

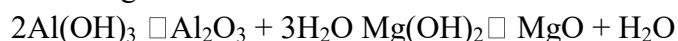
Wood has excellent natural fire resistance as a result of low thermal conductivity and the fact that char is formed as wood burns. This layer of char prevents further fire penetration, while the wood beneath the char retains most of its original strength properties. In the standard fire conditions for ASTM E119 (ASTM, 1988), a thick piece of wood is exposed to fire conditions between 815°C and 1,038°C (1,500°F and 1,900°F). The outermost layer of wood is charred, but deeper into the wood, the temperature drops. The active char area is found to correspond to the

depth at which the wood temperature reaches 290°C (550°F). Beyond that depth, the temperature drops further; at the depth at which the temperature falls to 175°C (347°F), the wood is no longer darkened. At a depth of 13 mm (0.5 in.) from the active char zone, the wood is only 105°C (220°F). Table 2 contains some typical values of char rates for various softwoods and hardwoods under ASTM E119 testing conditions.

FUNDAMENTALS OF VARIOUS FLAME RETARDANTS

Alumina Tri-Hydrate (ATH) and Magnesium Hydroxide

Like ATH ($\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$), magnesium hydroxide ($\text{Mg}(\text{OH})_2$), is an acid- and halogen-free flame retardant for various plastics. Both hydroxides decompose endothermically when heated according to the reactions:



The gaseous water phase is believed to envelop the flame, thereby excluding oxygen and diluting flammable gases. Similar to the function of char formed by phosphorous-containing flame retardants, a heat insulating material may form on the surface of the plastic in contact with the flame, reducing the flow of potentially flammable decomposition products to the gas phase where combustion occurs. In both of the reactions, the decomposition products are non-toxic and the mineral phases, especially MgO, are alkaline, reducing the likelihood of acidic, corrosive gases exiting.

Phosphorous-Containing Flame Retardants

Phosphorous-containing flame retardants mainly influence flame retardancy in the condensed phase. They are particularly effective in materials having a high oxygen content, such as cellulose and some oxygen-containing plastics. The basic flame retarding mechanism involves thermal conversion of the phosphorous-containing flame retardant to phosphoric acid in the condensed phase of the plastic. The phosphoric acid extracts water from the burning plastic, causing it to char. The char insulates the plastic from flame and heat, preventing volatile, combustible gases from exiting the bulk. Since phosphoric acid is formed in the burning plastic, there is increased likelihood that the smoke will be corrosive. Halogenated organophosphates are sometimes used as a flame retardant.

3.0 METHODOLOGY

The under listed method was adopted for this research work in order to meet the set of aim and objectives.

- i. Material sourcing
- ii. Equipment used
- iii. Determination of Ash temperature
- iv. Production of ceiling board / manufacturing process
- v. Test on produced ceiling and available ceiling board

MATERIAL SOURCING

The approach to manufacture moringa fire resistant ceiling boards is premised on the possible synergetic combinations of the moringa dust (fibre) and polyvinyl acetate. This is due to the fact that both products have comparable production procedures, differing only in constituents and bonding materials. The moringa wood is collected from Uturu forest Isiukwuato Abia state. The bonding agent was sourced from the chemical stores at Aba Ariaria Market, Abia States while the laboratory equipment were gotten from Chemical engineering laboratory, Gregory University, Uturu.

EQUIPMENT AND TOOLS

Equipment and Tools, used for this research work include:

- i. Electronic weighing balance: used to determine the mix ratio of the materials.
- ii. Hand Trowel: used for mixing of the materials.
- iii. Measuring cylinder: For measuring the volume of liquids that were used during the manufacturing process.
- iv. Grinding machine: this was used for reducing the particle size of the material.
- v. Bags or Polythene bags: was used for conveying the materials to the laboratory
- vi. Paraffin oil: was placed on the mould before the casting of the ceiling board for easy removal.
- vii. Reactor: this is the container in which all the materials used for the production will be added together.
- viii. Stirrer: for stirring all the materials in the reactor.
- ix. Roller: this is a metallic pipe (Rammer). This to be used to compress the mixture in the mould and also used to smoothen the surface of the mixture, Other equipment used include Local sieve, cylindrical plastic container, meter rule, vernier caliper.
- x. Wooden mould: Was used for casting the ceiling board in other to ascertain the required shape.

DETERMINATION OF THE ASH TEMPERATURES

This is the process taken to a certain the combustion temperature of moringa dust. The following steps were taken in other to achieve this temperature, and they are;



Measuring of the dust sample of 100g into a crucible

- a. Put the sample into the oven take the time interval of 15mins and check.
- b. Measuring of the temperature at which the dust becomes ash which is at 260°C



CEILING BOARD PRODUCTION PROCESS

The Production process was achieved through different process.

- i. **Material Collection:** Moringa wood was collected in the farm in Uturu Abia State, Nigeria.
- ii. **Debarking:** The moringa log was debarked thereby removing all the external cover of the wood.
- iii. **Drying:** This is the process of putting the wood out the sun for a duration of 5-6 days so as to remove moisture for easy grinding of the wood into dust.
- iv. **Grinding:** The wood log was then blended with the grinding machine to achieve a smooth finish.
- v. **Sorting:** The sawdust was sieved to remove every large wooden particles in other to a certain a very small particle size.
- vi. **Mixing:** Various components for the production of ceiling board were then mixed in their right proportion according to the formulation table. These components include; (i) Water (ii) nitrosol (iii) moringa dust (vi) Calcium carbonate (CaCO_3), (v) PVA. They were all mixed together thoroughly with a Stirrer to enhance proper blending. The chemical additive (CaCO_3) of 3% concentration in water dilution was used for a particular formulation sample, and the water containing the additives was added to the mixture while blending in the mix. The fibre (moringa dust) was used because it was the structural back bone of the product. It contributes to the strength, optics, stiffness and

smoothness of the ceiling board. CaCO₃ was added to improve the texture and opacity, brightness of the board. It also contributes to the smoothness and more uniform surface of the board. Finally, the addition of water enables easy mixing of the slurry and to make the mixture mouldable.

Table 1: Composition formulation table.

Material composition	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	Sample G
PVA	500	500	500	500	500	500	500
NITROSOL	Nil	100	100	100	100	100	100
WATER	300	300	300	300	300	300	300
FIBRE	40	40	50	60	70	70	100
CaCO₃	Nil	Nil	Nil	Nil	Nil	50	Nil

Mould: The mixed component was then poured into a 400mm by 400mm square mould designed for the production of ceiling board. The mix component was then spread across the mould in order to take the shape of the mould. It must fill every part of the mould, vibrated and the levelled using a roller.



Drying: The board was then allowed to set and to dry in the mould for about two days after which is removed from the mould and dried naturally in conducive environment usually it is dried with solar energy. They are stacked under a controlled laboratory environment to allow for 7 days curing.

Trimming: The sheets formed from the mould undergo trimming to get rid of the rough edges.

FLAME TEST

In this process the fire resistance test was carried out in other to determine the rate of burning in the produced samples A, B, C, D, E, F, G, respectively. 20 grams of the sample was measured out in a weighing balance, then put into the furnace in a constant temperature of 490°C which is the Ash temperature of the sample A(only a ratio of the dust and PVA) where the weight loss reading is taken against time respectively.

Table 2: induced burning of sample inside a furnace

Time (mins)	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	Sample G
1	19.72	19.67	19.40	19.79	19.89	19.70	19.95
2	19.01	18.87	18.93	18.76	19.50	19.10	19.67
3	17.96	18.12	18.31	18.74	18.89	18.50	19.01
4	16.95	16.67	17.66	17.74	18.73	18.00	18.89
5	15.42	15.36	17.13	17.30	18.60	17.60	18.76
6	14.42	14.91	16.49	17.00	17.99	17.03	18.50
7	13.12	14.50	16.20	16.70	17.70	16.90	18.00

4.0 RESULTS AND DISCUSSION

MATERIAL COMPOSITION

From all the samples A, B, C, D, E, F, G Composition respectively, it is observed that sample F and sample E were one of the best mixture with enough resistance effect. Table 3 shows the composition in grams.

Table 1: Material composition of Sample E and F respectively.

Material composition	Sample E	Sample F
PVA	500	500
NITROSOL	100	100
WATER	300	300
FIBRE	70	70
CaCO₃	Nil	50

SAMPLE DRYING PERIOD

Table 2, present the rate of drying for each sample composition. It was observed that the composition of sample E, F and G dries faster than other samples, from this, we can deduce the information, the more the fibre the faster the drying period.

Table 2: Sample drying period

Drying period (days)	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	Sample G
Number of days	3	5	5	4	2	2	4

4.3 FIRE RESISTANCE TEST

All the samples were subjected to fire test, it was clear that the rate of burning reduce progressively at constant temperature of 485°C. Table 5 shows the reduction in weight of a sample against time.

Table 3: Effect of fire on Sample at furnace temperature of 460°

Time (mins)	Sample A (g)	Sample B (g)	Sample C (g)	Sample D (g)	Sample E (g)	Sample F (g)	Sample G (g)
1	19.72	19.67	19.40	19.79	19.89	19.70	19.95
2	19.01	18.87	18.93	18.76	19.50	19.10	19.67
3	17.96	18.12	18.31	18.74	18.89	18.50	19.01
4	16.95	16.67	17.66	17.74	18.73	18.00	18.89
5	15.42	15.36	17.13	17.30	18.60	17.60	18.76
6	14.42	14.91	16.49	17.00	17.99	17.03	18.50
7	13.12	14.50	16.20	16.70	17.70	16.90	18.00

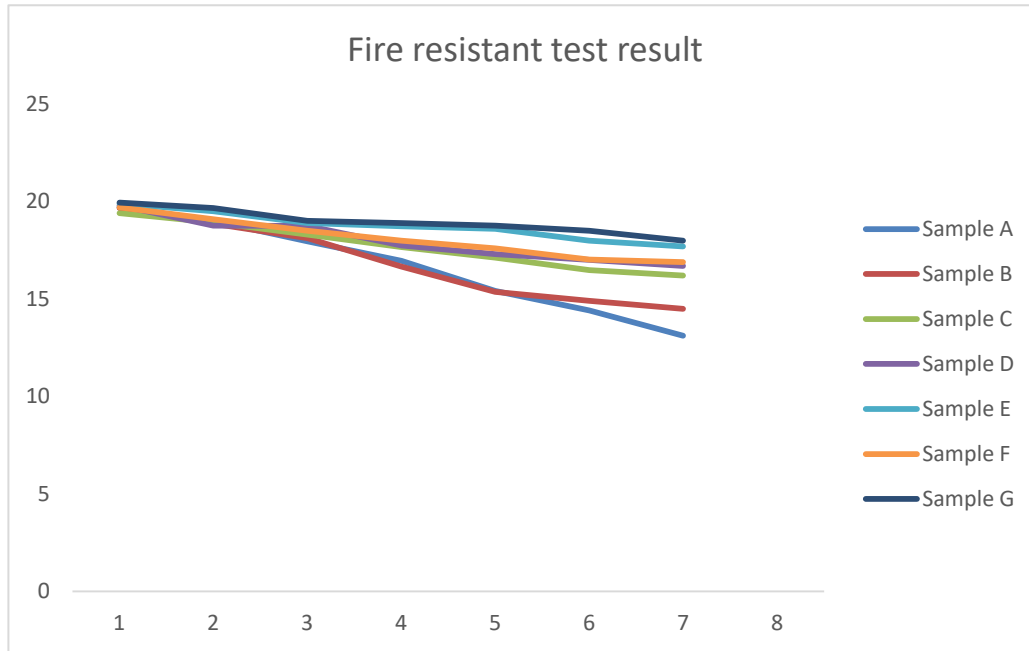


Fig 1: Effect of fire on Sample at furnace temperature of 460°C

It was observed that the primary composition sample of only PVA burnt so easy when subjected to fire. And from table 3 we can say that with the increase in quantity of fibre we observed a reduction in the burning rate of the composite. From table 4.3 we induced a high temperature of 460°C in the furnace due to the resistance of the composite to low temperature and as such making ignition very difficult and causing the composite not to burn. In this process the various samples were weighed to achieve 20g weight of sample which was further put into the furnace of 460°C and the weight loss reading was taken against time in order to determine its burning rate. It was observed that Sample A weighs 19.72g at the first minute, 16.95g at 4 mins, 13.12 at 7mins of burning in the furnace, while Sample E weighs 19.89g at the first minute, 18.73g at 4 minutes, and 17.70g after 7 minutes of burning in the furnace at constant temperature of 460°C. Here it was also observed that Sample G with the highest moringa fibre composition was also resistant to fire and as such reduces the rate of burning in the sample. Sample F which contained 50g CaCO₃ weighed 19.70g at the first minute, 18.0g after 4 minutes and 16.90g after 7 minutes when subjected to flame in the furnace respectively, from here we can say that the CaCO₃ masked the effect of the fibre thereby adding more strength to the fire retardance of the sample.

5.0 CONCLUSION

From the results which were derived from the study of this experiment, it is very clear to us the potential of moringa fibre as a fire resisting wood, which can now be converted into so structural materials like the fire resisting ceiling boards.

Also it was derived from the experiment that's the more the fibre composition the more effect of its fire retardance.

RECOMMENDATION

This study is an eye opener to researchers of potentials in some woods, and as such is advice to go into the cultivation of the tree moringa and also is advice to evaluate other woods potentials.

REFERENCES

- A. G. Adeniyi, J. O. Ighalo, and D. V. Onifade, "Banana and plantain fiber-reinforced polymer composites," *Journal of Polymer Engineering*, vol. 39, no. 7, pp. 597–611, 2019.
- A. G. Temesgen and O. Sahu, "Process ability enhancement of false banana fibre for rural development," *Cellulose*, vol. 67, no. 67.89, p. 67.63, 2014.
- Achebe C.H., Obika E.N., Chukwunke J.L. Vol. 233. SAGE Publications; 2019. Optimisation of hybridised cane wood-palm fruit fibre frictional material; pp. 1–8. (Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications). [Google Scholar]
- Adinarayana, M. (2015) Construction and building materials Retrieved from [www.vigyanprasal.gov.in> brief>building.pdf](http://www.vigyanprasal.gov.in/brief/building.pdf).
- Akinyemi A.B., Afolayan J.O., Oluwatobi E.O. Some properties of composite corn cob and sawdust particle boards. *Constr. Build. Mater.* 2016;127:436–441. [Google Scholar]
- Amenaghawon N.A., Osayuki-Aguebor W., Okieimen C.O. Production of particle boards from corn cobs and cassava stalks: optimisation of mechanical properties using response surface methodology. *J. Mater. Environ. Sci.* 2016;7(4):1236–1244. [Google Scholar]
- Amit B.D., Ipshita S. Sustainable application of agro-waste as substitute for construction materials: a review. *IJSART.* 2015;1(9):30–34. [Google Scholar]
- Arvind Sharma, Gunjan Dhiman, Priti S. Lal, Ravi D. Godiyal AAN Bipin P. 2020 Thapliyal Characterization of Moringa Oleifera (Drumstick Family) wood for pulp and paper making.
- Arvind Sharma, Gunjan Dhiman, priti s. Lal, ravi d. Godiyal andbipin p. Thapliyal

- Ataguba C.O. Properties of ceiling boards produced from a composite of waste paper and rice husk. *Int. J. Adv. Sci. Eng. Technol.* 2016;2:117–121. [Google Scholar]
- Atuanya C.U., Obele C.M. Optimization of process parameter for sawdust/recycled polyethylene composites. *J. Miner. Mater. Charact. Eng.* 2016;4:270–277. [Google Scholar]
- Chibudike H.O., Anyakora A.N., Suleiman M.A. Utilization of baamboo in the production of ceiling board. *J. Eng. Res.* 2011;16(1):1–10. [Google Scholar]
- Ekpunobi U.E., Ohaekenyem E.C., Ogbuagu A.S. The mechanical properties of ceiling board produced from waste paper. *Br. J. Appl. Sci. Technol.* 2015;5(2):166–172. [Google Scholar]
- Fahey, J. W. (2005). *Moringaoleifera: A Review of the Medical Evidence for Its Nutritional, Therapeutic, and Prophylactic Properties. Part1.* *Trees for Life Journal.* www.TFLJournal.org
- Fanger, P Ole (1970). *Thermal Comfort: Analysis and applications in environmental engineering.* McGraw-Hill.
- Idehai O.O. Retrofitting composite ceiling tiles with sawdust introduction. *Cuvillier.* 2012:291–295. [Google Scholar]
- Idris U.D., Aigbodion V.S., Atuanya C.U. Eco-friendly (water melon peels): alternatives to wood-based particleboard composites. *Tribology Indus.* 2011;33(4):173–181. [Google Scholar]