

Research Article

This article is published by Jozac Publishers in the *African Social Science and Humanities Journal (ASSHJ)*. Volume 5, Issue 2, 2024.

ISSN: 2709-1309 (Print)
2709-1317 (Online)

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Article detail

Received: 05 April 2024


Accepted: 15 April 2024

Published: 19 April 2024

Conflict of Interest: The author/s declared no conflict of interest.



Recycling Cocoa Pod Particleboards for furniture in Ghana

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 <https://dx.doi.org/10.4314/asshj.v5i2.1>

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Abstract: Ghana is the second leading producer of cocoa in the world after Cote d'Ivoire. Cocoa production has been the mainstay of the Ghanaian economy and today cocoa continues to be Ghana's main agricultural export commodity and an important contributor to Ghana's foreign exchange earnings and GDP. Greater volumes of waste are however generated annually resulting from these annual high yields and pose serious environmental challenges to the farmers and other inhabitants in the cocoa growing areas. The study investigated the possibilities of using these cocoa pod husk that usually go waste, to produce particleboard as a substitute of solid wood for furniture in Ghana by mixing cocoa pod particles (4,500ml) with polyvinyl acetate (1,500ml), cassava starch (2,500ml) and water (1000ml). The researchers adopted a qualitative research approach for the study to probe the participants' knowledge about particleboards. A combination of exploratory, descriptive, and experimental methods was employed in the study. Purposive and snowball sampling techniques were used to interview 25 respondents who comprised 15 cocoa farmers and 10 particle board users. Findings revealed that adequate mixtures of the materials in the right proportions can produce low density boards that support the furniture industry.

Keywords – Cocoa pods, Furniture, Particleboard, Recycled art, Woodwork

1. INTRODUCTION

Cocoa production in Ghana has been of immense benefit. It has been the major source of livelihood for a lot of Ghanaian farmers. 800,000 smallholder farmers rely on cocoa as their main source of livelihood (Peprah, 2015: 3). Surveys conducted in 1991, 1999 and 2005 indicated a reduction in poverty levels among cocoa farming households in Ghana (Ghana Business News, 2015). Statistics have shown that, Ghana is the second largest exporter of cocoa beans after Cote d'Ivoire. It has been estimated that in 2010/2011 Ghana's exports of cocoa reached its 1,004, 000 MT (GAIN, 2012). In terms of world cocoa exports, Ghana has maintained its position as the 2nd largest exporter of cocoa beans for the period of 2005 – 2011. Historically, cocoa production has been the mainstay of the Ghanaian economy and today cocoa continues to be Ghana's main agricultural export commodity and an important contributor to Ghana's foreign exchange earnings and GDP. Today, cocoa cultivation has spread across six regions

of Ghana namely Eastern, Ashanti, Brong-Ahafo, Central, Volta and the Western region. Due to fluctuating rainfall patterns and decreasing soil fertility, production has moved westward to the point where the Western region is now Ghana's main producer of cocoa. Being the main source of livelihood for most Ghanaian farmers, the majority of the lands in these areas are used for cocoa farming. For this, lots of cocoa pod husks keep piling on the farm lands to decay.

Cocoa pod husk forms about 70% of the cocoa fruit and is generated after opening the pod for removing the cocoa beans (Yusof et al., 2016). While the cocoa seeds which contain fat are used to produce cocoa butter and the cocoa butter is used to produce chocolates for human consumption, volumes of these cocoa pod husks are usually left as unexploited waste to rot on the cocoa plantations producing foul odor and propagating diseases such as black pod rot (Opoku et al., 2007). Only a handful it is usually burnt into ashes and used mainly for manufacturing soft soap locally. That aside, huge volumes of this cocoa waste are burnt on the open farms and this field burning of cocoa pod husk and the remains from other agricultural produces, does not only result in serious environmental problems, but could also be considered as a waste of precious resources for other industries (Li et al., 2010). An environmentally friendly alternative for handling these volumes of waste is imperative so as to ensure the safety of our environment and health. These cocoa pod husks when ground into particles will not only be of a greater benefit such as fertilizer to the farmers for cocoa, vegetables and food crops (International Cocoa Organization, 2003), but will benefit the furniture industry as well. Timber which is regularly cut as result of high demand for furniture has left humanity with among other consequences, global warming.

As the world is faced with shortages of forest resources coupled with environmental pollution and waste of biological resources emanating from the burning agricultural remains (Li et al., 2010), there is a growing awareness and amplified calls for stronger policies around the globe to have intensified researches into the use of field crop residues such as rice husk, coconut husk, corn stalk, coffee hulls, cereal straw, peanut shell, flax straw, cassava stem, castor bean meal, sugarcane, soybean, among others (Elisabeth et al., 2018; Ma & Nasir, 2011) as alternative materials for the production particleboard for the furniture industry. The need for alternative resources in many spheres of life has arisen and the cocoa pod particles therefore come in handy as an alternative material for the experimentation to produce particleboards. A particleboard is an engineered wood product made from fine wood chips, fibers or even small scraps of wood under intense heat and pressure with suitable a binding agent (Mamza et al., 2014). The production and use of particleboards is on the increase in recent times (Elisabeth et al., 2018). Solid wood from the forest has been the primary material for the production of these types of boards but in recent times however, several field-crop remains such as rice husk, coconut husk among others have been sourced as substitutes. Numerous experiments have been carried out using these agricultural residues from fields and lots of these materials have yielded significant results.

The use of particleboards emerged in Germany in the early 1940s, as a result of the shortage of good quality wood (Elisabeth et al., 2018) and its benefits cannot be over emphasized. The first commercial mass manufacture of medium density fiberboard (MDF) took place in Deposit, New York, in 1965 (Muhammed et al., 2017). The advantages of particleboards and MDF are numerous. They serve as cost-effect and versatile substitutes for solid wood products such as furniture, cupboards, cabinets, musical instruments, door panels etc., ensures proper environmental sustainability and preserves natural resources (Mamza et al., 2014; Elisabeth et al., 2018). According to (Benthien & Ohlmeyer, 2020), the use particleboard does not only bring the benefit of the reduction in the use of solid wood but also a reduction in the board's weight. With the help of a series of experiments, the focus of this paper is (a) test feasibility of processing cocoa pod into particleboards. (b) to design and construct bed side cabinet using cocoa pod particle boards.

2. METHODS

The researchers adopted a qualitative research approach which is designed to reveal a target audience's range of behavior and the perceptions that drive it with reference to specific topics or issues. This research approach enabled

the researchers to probe beyond initial responses and rationales to understand the knowledge of the target population have about particleboards or low density fiberboard. Exploratory, descriptive, and experimental research designs were employed for the study. An exploratory study can potentially save time and other resources by determining at the earlier stages the types of research that are worth pursuing (Dudovskiy, 2018). This method enabled the researchers to merely explore the research topic with varying levels of depth in order to state the facts about the study conducted. The researcher agreed with Shuttleworth (2008), that descriptive research as a scientific method involves observing and describing the behavior of a subject without influencing it in any way. As such, this method allowed the researchers to describe the properties of cocoa particles that makes it an efficient raw material for the production of particleboards which will be used for the production of furniture. A simple random sampling technique was used to avoid bias in the information seeking and interview and observation were used for collecting the data for the study since many of the respondents were illiterates and could not write. Some of the questions also demanded further probing hence the choice of these data collection tools.

2.1. Population and sample size

The targeted population of the study was 25 cocoa farmers from Dunkwa-Ofinso in the Ashanti region of Ghana. The accessible population was 15 cocoa farmers from Dunkwa-Offinso and 10 particle board users at the Roman Hill in Kumasi, Ghana. Simple random sampling technique was used the researchers to avoid been bias in the information seeking.

2.2. Ethics committee approval

This research was approved by the Industrial Art Department Ethics Committee of the Kwame Nkrumah University of Science and Technology on November 14th, 2019 with approval number RuralArt201904-04.

2.3. Mixing procedure

Two different experiments were performed in almost the same procedure. The difference lies in the addition of cassava starch to the mixture in the second experiment. Tools and materials used include; wooden mold, manual pressing machine, white transparent polythene, mixing bowl, measuring cup, gloves, water, polyvinyl acetate (white glue) and cassava starch.

Figure 1: Ratios of mixtures

EXPERIMENT	MATERIAL	RATIO
1 st	Cocoa pod particles	5,000ml
	Water	2,500ml
	polyvinyl acetate (white glue)	3,500ml
2 nd	Cocoa pod particles	4,500ml
	Water	1000ml
	polyvinyl acetate (white glue)	1,500ml
	Cassava starch	2,500ml

Experiment 1

- Fill six (6) cups of powdered cocoa pod particles into a mixing bowl.
- Add three cups of acetate (white glue) into the powdered cocoa pods particles.
- Add four cups of water gradually into the mixture to aid in the mixing process.
- With your hand gloves on, mix the content toughly to obtain a uniform mixture. The end result of the mixture should be in a pasty form.
- Fill the mixture required into the wooden mold.
- Place the wooden mold with the content on the pressing machine.
- Remove the board and place it under the shade for drying.

Experiment 2

- Fill six (6) cups of powdered cocoa pod particles into a mixing bowl.
- Add three cups of acetate (white glue) into the powdered cocoa pods particles.
- Add four cups of water gradually into the mixture to aid in the mixing process.
- Add two cups of cassava starch into the mixture.
- With your hand gloves on, mix the content toughly to obtain a uniform mixture. The end result of the mixture should be in a pasty form.
- Fill the mixture required into the wooden mold.
- Place the wooden mold with the content on the pressing machine.
- Remove the board and place it under the shade for drying.

Working Process (Preparing cocoa pods into particleboards/low density particleboards)

Step one: Collection of cocoa pods from the farms

The researchers collected the material from Dunkwa-Offinso cocoa farms. The collection lasted for about 4 to 5 hours which gave the researcher the opportunity to have first-hand information from the farmers. The collection was basically handpicking which enable the researcher to avoid pods that are infected with insects. The researchers were of the view that insect infected pods can affect the strength of the board hence the need for the circumspection.

Step two: Drying of the cocoa pods

For about 5 to 7 hours of collection, the researchers dried the pods under the sun which lasted for about five (5) days. This process was monitored by the researchers to obtain uniform dryness for effective grinding process.

Step three: Grinding the cocoa pods

At this stage the dried pods were then ground into smaller particles. The grinding process could be done by using a milling machine or by manual mortar and pestle and crush the pods. To make the project less costly and practical to the cocoa farmers the researchers used manual mortar and pestle to do the crushing. This enables the researchers to obtain the required sizes of the particles which can be used to produce the boards.

Step four: Construction of a Wooden Mold

Plywood and wooden buttons (measuring 1inch x 1 inch) were used for the construction of the mold for the board casting process. The mold took take the form of a modelling or sack board. The inner surface area of the mold measured 20 inches by 20 inches due to the surface area of the pressing machine.

Step five: Mixing the particles with binders to obtain a uniform mixture

The required quantities of the cocoa pod powder are mixed with the binder and water to achieve an even consistency. In the second experiment, the cassava starch (2,500ml) was then added to the mixture.



Figure 1: Collection and preparation of cocoa pod husk

Step Six: spreading the mixed content into a mold

After the researchers obtained a uniform mixture, the researchers spread the mixed content into a wooden mold to allow the pressing machine evenly press it for a flat and smooth boards. The white transparent polythene was first spread in the mold to allow for easy removal of the boards. The researchers used hand to effectively fill all spaces to avoid gaps or spaces.

Step Seven: Place the mold on the pressing machine

The pressing machine is a tool that effectively presses the boards to make them compact and strong. The pressing machine is manual for which reason the researchers were are not able to produce many boards which made the process very slow. Moreover, the surface area for pressing was small that did not give the researcher the opportunity to press larger boards. The surface area for pressing is 20 by 20 inches.

Step Eight: Remove the mold from the pressing machine for drying

The researchers with all consciousness, removed the molds from the pressing machine so as for drying to take place.



Figure 2: Particleboard formation

Step Eight: The drying of the boards

The researchers used three techniques in drying the boards. This included sun drying that is allowing the boards under the sun to dry for about two weeks, shade drying that is allowing the boards under the shade to dry while heat drying the researchers used hair drier to dry the boards which lasted for about one hour. All the three drying techniques were tried on different boards and the researchers observed that, the heat drying and the shade drying were appropriate because cracks and warping which are the challenges in cocoa pods particles boards construction are eliminated.

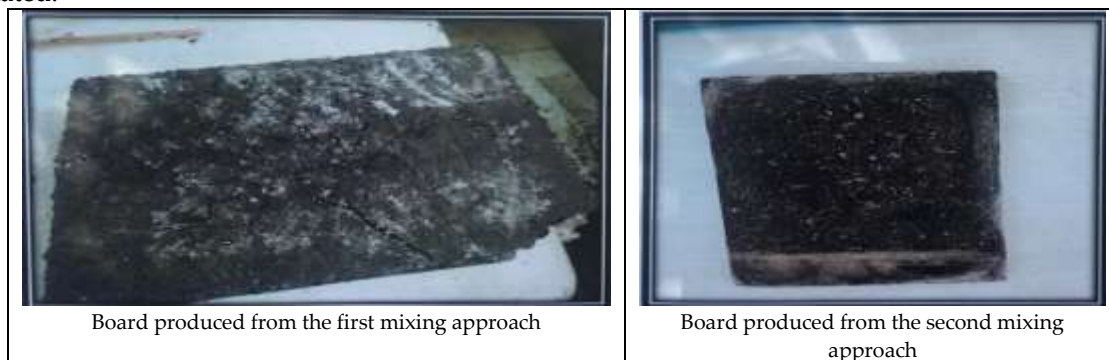


Figure 3: Formed Particleboards

The process of using cocoa particleboards (low density particleboards) to construct bed side cabinet.

In response to the second objective of the study, the cocoa particleboards were used to construct a bedside to ascertain the boards appropriateness for furniture construction. A cabinet is a cupboard with shelves or drawers for

storing or displaying articles. The importance of a bedside cabinet cannot be over emphasized particularly in contemporary times as it allows for necessary item accessibility just before sleeping and immediately after sleep. Among others uses, the bedside cabinet serves as a pedestal or a nightstand for lamps, electronic gadgets, documents, medicines, a bottle of water, personal jewelry and also improves the general bedroom aesthetics.

Design concept

After a series of preliminary sketches, the researchers arrived at a final design for the bedside cabinet construction. Several joints have been in existence for decades for the construction a cabinet. Some of which include; widening joints, angle or joint and Farming joint. The researchers used the simple butt joint under the angle joints for box-like constructions.



Figure 4: Sketch for the cabinet construction



Figure 5: Processing particleboards for cabinet construction



Figure 6: Cabinet construction

DATA ANALYSIS AND DISCUSSIONS

Observations made from Experiment one (1)

The researchers observed that, the drying process was very slow. Moreover, the boards were warping while drying. The researchers also noticed that the boards were having deeper cracks on them which made them weaker and not durable.

Observations made from Experiment two (2)

The researchers observed some changes on the boards. Although the drying was slow, there were no cracks and warping compared to the boards in experiment (1). This was due to the fact that regular turning of the boards and the addition of cassava starch binder to the polyvinyl acetate made it compact. This resulted in durable and strong boards. The observation made on both experiments shows that the addition of cassava starch into the mixture reduced the amount of polyvinyl acetate. Moreover, the starch made the boards more compact and durable to work with compared to the mixing approach used in experiment (1). What this suggests is that the ratio of the cassava starch to the cocoa particles is a strong determiner of the properties of cocoa particle board.

Testing the boards through the cabinet construction process

To ascertain the durability and workability of the boards, the researchers conducted the appropriate manual test on the boards by the cabinet construction process to prove that the cocoa pods particleboards were durable for the production of furniture.

- **Sanding**

As part of the testing process, the researchers used grade 60 sanding paper and with the help of a machine, a good surface was achieved. In addition, the researchers used the surface sanding machine to help attain smooth surface and perfect edges. The sanding process further eliminated the odor of the boards. Moreover, it was observed that the boards were not producing dust compared to the solid wood which produces intense dust during sanding.

- **Sawing/Cutting**

To understand whether the cocoa pod particle boards can be cut like other fiberboards or the solid wood, the researchers carried out a demonstration to ascertain the ability of the boards to undergo cutting. The researchers observed that the cocoa particle boards can be sawn like any other fiberboards without any challenges.

- **Drilling/Nailing**

The researchers used a drill bit and a drilling machine to drill holes on the boards. The researchers noticed that the drill bit was able to create holes on the boards. Also, the researchers tested the ability of the cocoa pod particleboards to hold nails. It was noticed that the boards had good ability to allow nails through them and to hold firm just like any other particleboards or solid wooden boards.

- **Joining**

This was to ascertain whether the boards could effectively be joined together to produce an article in wood. The researchers used simple butt joint and held in place by means of glue. The ends or edges of the boards were butted together at right angles and nailed or fixed with glue. However, the researchers noticed that different kinds of joints like rebated, tongued or dado joints could also be applied on the boards with no difficulty.

- **Finishing process**

The researchers further applied paint on the boards to protect the surface of the cabinet. It was observed that the boards could absorb different kinds of finishes which protected the surfaces from moisture.

The success of the second experiment may be attributed to how efficient the cellulosic fibres in the cocoa pod husks bonded with the cassava starch and polyvinyl acetate because of its high index of crystallinity making it an important reinforcing ingredient as similarly noted by other researchers (Herrera-Barrios et al., 2022). The absence of the binder (herein cassava starch) in the first experiment led to its failure. Similar bonding characteristics of

cocoa pod husks were noted in a laboratory experiment to produce from it compressed earth bricks (Manu et al., 2015).

Also, the high moisture absorption property we observed in our studio-based research on the particleboards were similarly observed by Manu et al. (2015) as they tried producing earth bricks from the cocoa pod husks. Lu et al. (2018) affirms that studies such as our own that tries to make good use of the lignocellulosic components of cocoa pod husks will help farmers in gaining additional income. While various studies have explored for its bioproducts, nutraceuticals, antioxidant compounds, theobromine, and functional food properties (Ouattara et al., 2021; Indiarito et al., 2021; Siegert, 2021), the novelty of this study is developing particleboards for furniture production, an area of research on cocoa pod husks that has not been explored in current studies.

3. CONCLUSION

This study was carried out with the focus of testing the feasibility of processing cocoa pod into particleboards and subsequent to that, design and construct a bed side cabinet using the cocoa pod particle boards via studio-based research approaches. The use of cocoa pod husk to produce particleboards proved successful with the addition of cassava starch binder to the polyvinyl acetate which made the boards compact. This indicates that the properties of the particleboard depend on the ratio of the cassava starch. Therefore, variation in the percentage composition alters the properties of the particleboard proportionately. The ability of the boards to absorb finishes makes the boards moisture resistant to withstand the rigorous process of sanding, cutting, drilling and nailing has proven its durability. Large-scale production of cocoa particleboard should be encouraged in Ghana by the various governments and industry players as it has proven to be cost-effective, environmentally friendly and reduces the pressure on solid wood from the already depleted forest resources. This will go long way to boost the country' wood product exports to attract more foreign exchange earnings. While these experimentation were studio-based, this study recommends that future research should investigate through scientific laboratory experiments to explain the studio-based experiments.

4. FUNDING

This research paper received no internal or external funding.

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