COIR FIBRE SOURCED PROJECTS: ELEVATED ADINKRA WALL HANGINGS

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ABSTRACT

This project extracted coconut fibres via low technology processes and converted the fibres into useful hand-made functional Adinkra themed wall hangings. Some of the major properties (chemical and physical) and application of the coir fibres are utilised and discussed in the process. The Adinkra wall hangings include symbols such as *Anansi Ntontan, Boa Me Na Me Mmoa Wo, Gye Nyame, Mate Masie, Nkyinkyim* and *Nsaa.* This project is one of many that is seeking to address the problem of managing coconut husk and for that matter other natural by-products and waste in Ghana. Coconuts abound from the coast through the forest regions to the middle belt of the country. Coconut juice sellers and coconut oil producers are known for dumping coconut shells and husks at unauthorized places after close of business or production each day. Even though coconut husks are biodegradable, if not properly disposed they contribute to the waste problem in many prime areas in Ghana. This is so because solid waste management in Ghana is a huge challenge affecting the lives of every ordinary person of the country as well as the environment. This project conjectures that there is a huge economic potential of coconut and its waste products which has remained largely untapped in Ghana. The potential of the coconut crop has been grossly under-utilized in Ghana, hence there is the need to research and explore the many potentials of coconut fibres that includes utilitarian products. In this study, coir fibres are mixed with glue as binders to produce elevated wall hangings for decoration.

Keywords: Coir Fibres; Wall Hanging; Adinkra; Coconut

1.0 INTRODUCTION

The scientific name and plant family of coconut fibre is Coir, Cocos nucifera and Arecaceae (Palm), respectively (Ali, 2011). In Ghana, they are available in large quantities in the southern part of the country. Coir is an important product of coconut, giving income to the coconut growers and employment to many. Coconut fibre is extracted from the outer shell of coconut by separating it from the pithy material of the fibrous mesocarp by a process of retting. As the consumption of coconut fruit is at its utmost important to mankind, there is the need for proper disposal of the husk, thus coir fibres can be extracted from the coconut husks and made into seats, cushions, mattresses for the manufacture of brushes, brooms, ropes, yarns, mats, mattings, carpets, rugs etc. In industrial practice the extraction of coir fibre is undertaken manually or by mechanical means depending on the age of husks used in the manufacture of coir fibre.

Coconut fibres are stiff and tough and have low thermal conductivity (Asasutjarit et al., 2005). Coconut fibres are commercially available in three forms, namely bristle (long fibres), mattress (relatively short) and decorticated (mixed fibres). These different types of fibres have different uses depending upon the requirement. There are many general advantages of coconut fibres e.g., they are moth-proof, resistant to fungi and rot, provide excellent insulation against temperature and sound, not easily combustible, flame-retardant, unaffected by moisture and dampness, tough and durable, resilient, springs back to shape even after constant use, totally static free and easy to clean (Ali, 2011). Coconut plants exist in many parts of the world. They are widely available in the southern parts of Ghana. Coconut fibre contains cellulose, hemi-cellulose, and lignin as major composition (Ali, 2011). These compositions affect the different properties of coconut fibres but also affected by pre-treatments depending on the end use. There is coconut fruit at almost every corner in Ghana, hence disposing the husk off is a challenge. There are various uses of the coconut husks such as charcoal, coconut fibres for agricultural purposes, construction and many more. In the textile's environment, the Coconut fibres can be used in producing clothes, carpets, amongst others. Also, in construction, coconut husk can be made into tiles, blocks, composite materials etc.

Coconut fibre is extracted from the outer shell of a coconut. The common name, scientific name and plant family of coconut fibre is Coir, Cocos nucifera and Arecaceae (Palm), respectively. There are two types of coconut fibres, a brown fibre extracted from matured coconuts and white fibres extracted from immature coconuts. Brown fibres are thick, strong and have high abrasion resistance. White fibres are smoother and finer, but also weaker. Coconut fibres are commercially available in three forms, namely bristle (long fibres), mattress (relatively short) and decorticated (mixed fibres).

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These different types of fibres have different uses depending upon the requirement. In engineering, brown fibres are mostly used (Ali, 2011).

The coir fibre is relatively waterproof and is one of the few natural fibres resistant to damage by saltwater. Freshwater is used to processing brown coir, while seawater and fresh water are used in the production of white coir. In the form in which it is taken from the coconut husk, coir fibre is composed of several reddish-brown, strong, elastic filaments of different lengths, which are thickest in the middle of their length and taper towards the ends; in cross-section, they are round or elliptical. The diameter in the middle varies from 0.002 to 0.012 inches. These filaments, however, are each made up of several irregularly–thickened ultimate fibre cells which vary in length from about 0.4 to 1 mm and have a diameter of 5 to 8 microns (Textile Value Chain, 2021).

Coconut husk represents the entire fibrous material enveloping the fruit constituting both the inner endocarp (liquid and solid food part) and outer mesocarp (fibrous part). The mesocarp, which is an assemblage of fibres and elastic cellular cork-like parenchymatous cells cementing the fibrous materials dispersed throughout the mass. Retting is the water of this material causes separation of the leathery exocarp (thin outer slippery cover) from spongy fibrous mesocarp. The fibrous strands are composed of a highly lignified form of cellulose, hence are harsh and rigid. These nonfibrous parenchymatous cells of husk are referred to as coconut pith and account for as much as 50%–70% of the total weight of husk. There are about 300 eco-types of coconut and there are variations in the quality and quantity of the fibre. Even in the same variety, the fibres vary in length and thickness (Mishra, Leena & Basu, 2020). According to Sackey (2002) the husk is then separated from the inner hard shell and conditioned for retting. It is then retted for several weeks, and then fibres are separated by hand beating or machine squeezing and hackling into fine strands. Although stiff, coir is strong, and does not decay in damp surroundings, quite elastic and resembles horsehair.

1.1 Types of Coconut Fibres

The fibres are divided into two main types namely white fibres and brown fibres. The white fibres are produced from fresh green husks of ten- to eleven-month-old coconuts. The husks are allowed to undergo retting and the fibres are extracted manually. These fibres possess good elasticity and colour. The brown fibres, on the other hand are produced from the dried brown husks of about twelve-month-old coconuts. The husks are soaked for 2-3 weeks and the coir is extracted mechanically. These fibres are more brittle and brownish in colour (Meenatchisunderam, 1980). Brown coir fibre is harvested from fully ripened coconuts. It is thick, strong and has high abrasion resistance. It is typically used in mats, brushes, and sacking. Mature brown coir fibres contain more lignin and less cellulose than fibres such as flax and cotton and so are stronger but less

flexible. They are made up of small threads, each about 1mm long and 10 to 20 micrometres in diameter (Textile Value Chain, 2021). Brown fibres are thick, strong and have high abrasion resistance. The long bristle fibres are separated from the shorter mattress fibres underneath the skin of the nut through a process known as wet milling. The longer bristle fibres are washed in clean water and then dried. The fibres are then wrapped into bundles or hanks. They can be cleaned and hackled by steel combs to straighten the fibres and remove any shorter fibres. Brown fibre can also be bleached and dyed to obtain hanks of different colours. The white coconut fibres on the other hand are extracted from the coconuts before they are ripe. These fibres are white and are smoother and finer, but also weaker. The immature husks are suspended in a river or water-filled pit for up to ten months. During this time, microorganisms break down the plant tissues surrounding the fibres to loosen them- this process is known as retting. The husks are beaten, with iron rods to separate the long fibres, which are subsequently dried and cleaned. The cleaned fibres are ready for spinning into yarn using a simple onehanded system or a spinning wheel.

1.3 Structure and Property of Coir Fibres

The coconut, scientifically known as *Cocos Nucifera*, is a fibrous drupe fruit as shown in figure 1. Usually ovoid, it comes in various sizes and colours. In general, a coconut takes about 12 months to mature, weighing up to 1.2-2kg. Under ideal conditions, the coconut palm produces one leaf and one inflorescence, or better known as male and female flowers within a spathe, every month. After the inflorescence opens and fertilization of the flowers take place, coconuts begin to form. They start to grow, and the cavity inside the nut differentiates itself in the second month, reaching its maximum size by the seventh month, filled with coconut water. It is also during this time that a thin and soft layer of raw kernel forms. As the nuts ripen, their hardness and quantity increase at a declining rate. The thickness of the kernel also increases, while the internal cavity reduces in size. There is also a progressive decrease in the quantity of coconut water as the nut ripens (TetraPack, 2021).

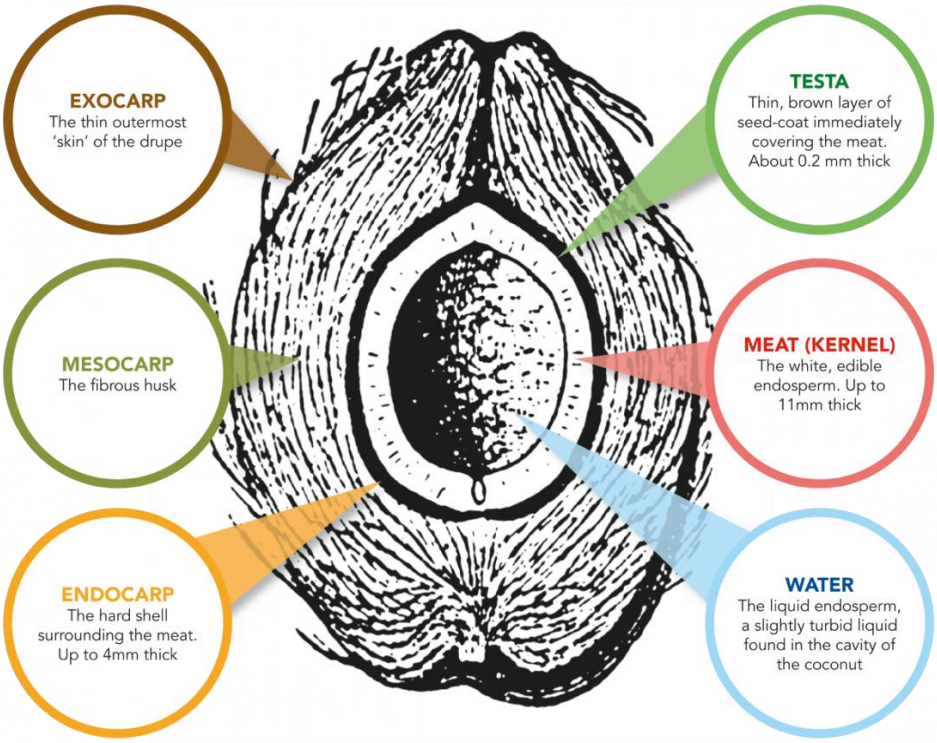


Figure 1. Parts of a coconut
Source: TetraPack, 2021

The property of coconut fibre can be manipulated by initiating pre-treatment over it as they are filled with cellulose, lignin and hemicellulose. Continue immersion for 60 days, with alternate wetting and drying can show a variation in tensile strength and chemical composition. During testing, this organic fibre has shown a good percentage of retaining the original tensile strength as well (Sethy & Panda, 2020). Many researchers have investigated coconut fibres for different purposes. There is a huge difference in some properties, for example, the diameter of coconut fibres is approximately the same and magnitudes of tensile strength are quite different, for example, compare tensile strength of coconut fibres mentioned by Ramakrishna and Sundararajan (2005) and Toledo et al. (2005). In addition, the range shown for a particular property is quite wide; Toledo et al. (2005) mentioned the density of coconut fibre as 0.67-10.0 g/cm3.

The structure and property in fibre are determined by the quantity of cellulose and non-cellulose constituents and this influences the crystallinity and moisture regain. Properties such as tensile strength, density and young modulus are related to the composition by the internal structure of the fibre. Fibres that have high cellulose content, with the degree of polymerisation that is high and low microfibrillar angle gives better mechanical properties while those with higher contents of lignin, lower mechanical strength and young modulus but have better and higher extensibility. The

composition, structure, and number of defects in a coir fibre influence mechanical properties such as young modulus, stress and strain of a fibre. When tensile strength failure occurs under stress by intercellular of intracellular modes, the fibres with high cellulose crack causing intercellular fracture without the removal of microfibrils and those with low cellulose crack causing intracellular fracture with the removal of microfibrils (Eng et al., 2008). The factors that affect the elongation of a fibre can be attributed to orientation, high degree of crystallization and the angle of the microfibrils to the axis of the fibre (Eng et al., 2008). Coconut fibre properties are influenced by the structure and composition.

1.4 Extraction of Coir Fibres

Both state-of-the art and conventional technologies used for fibre extraction are available. The traditional extraction of fibres from the husks is a laborious and time consuming process. After separating the nut, the husks are processed by various retting techniques generally in ponds of brackish waters (for three to six months) or backwaters or lagoons. This requires 10-12 months of anaerobic (bacterial) fermentation (Coir Board of India, 2014). Traditional practices of this kind yield the highest quality of (white) fibre for spinning and weaving. Retted fibres from green husks are the most suitable fibres for dyeing and bleaching. Alternatively, mechanical processing using either defibring or decorticating equipment can be used to process the husks after only five days of immersion in water tanks. Crushing the husk in a breaker opens the fibres. By using revolving “drums” the coarse long fibres are separated from the short woody parts and the pith. The stronger fibres are washed, cleaned, dried, hackled and combed. The quality of the fibre is greatly affected by these procedures (Central Coir Research Institute, 1997). By this, it is established that traditional fibre extraction is the process of obtaining fibres through retting of the fibres to make them soft, and can be decorticated and extracted by beating, which is usually done by hand. After hackling, washing and drying the fibres are loosened manually and cleaned. To produce more coarse brown yarns, shorter periods of retting may be applied.

Technology has made the extraction process more efficient and eco-friendlier. It is hoped that further developments can also enhance the properties of the coir fibres themselves. The microbial enzymes used in the retting process allow the fibres to be bleached or dyed. To sum up, mechanical extraction of fibre is more efficient, environmentally friendly, speeds up the extraction process and produces fewer quality yarns. It also affects some properties of the product (fibre). Besides, there are various ways of extracting fibres, which are according to the source.

1.5 Application of Coconut Fibres

There is a breadth of products that can be prepared with the coconut fibre. They are coir yarn, coir ropes, coir mats, coir matting, coir tiles, coir mattings for cricket pitches, coir rugs, coir *mourzouk*, coir belts for factories, coir mattings for roof surface cooling, acoustic barriers, coir geotextiles, cocologs, coir fibre beds (cocobeds), coir composite boards, coir fenders, plant climbers or coco poles (gardening coir grow stick), coir baskets, coco pots (moulded coir pots), coir fibre discs (tree cover), coco chips (husk chips), coco peat, coir pith as briquettes, coco lawn and much more (Dinesh, 2016).

Coir is often used in gardening and landscaping projects. For example, coco coir peat looks and feels like traditional soil, but retains more moisture, thus keeping your plant roots from drying out. Coir also repels most insects, creating a natural pest management system for your garden. Coco chips are often used in places where you would traditionally use bark chips. Because they help retain water, coco chips are great for mulching around trees. Coir woven textiles are applied to the ground in areas prone to erosion. The textile absorbs water, helps seed germination, and promotes new vegetation growth. White coir fibres are typically used for rope because of its strength and flexibility. White coir fibre also has a strong resistance to salt water, making it the perfect medium for making fishing nets, nets for shellfish harvesting and marine rope for boats. In an attempt to use renewable resources, the use of coir fibre in concrete instead of sand has proven beneficial in some circumstances. In addition to being a renewable resource, concrete made with coir offers thermal conductivity, permeability, and low drying shrinkage. These characteristics make it ideal for drainage applications. It does have a lower strength level than sand concrete but is strong enough for secondary structural use. Coir ply is a substitute for traditional plywood and is made by combining coir fibres with resin and pre-treated timber veneer. It creates a plywood alternative that offers abrasion resistance. Coir ply is more temperature stable than traditional plywood and resists contracting and expanding with extreme temperature changes.

Coir is also commonly used for rough, bristle welcome mats. This natural fibre is strong and helps remove dirt from shoes. In addition, coir fibre is rot resistant, making it excellent for outdoor use. Brown coir fibres are also used to make household brushes, such as toilet brushes and brooms. In addition to welcome mats, coir fibres are woven to make indoor and outdoor rugs. Brown coir fibre can also be bound together with natural latex and is layered in between the foam and polyester wadding to make mattresses (TetraPack, 2021). Although Ghana consumes more coconut for its edible parts, there needs to be a way of making use of the husk and other residue.

2.0 GENERAL PROCEDURE 2.1 Adinkra Symbols

The evolution of symbols dates to the prehistoric periods when men drew images on walls in caves for visual communication. In Ghana, the most prominent among traditional symbols are the Adinkra symbols. There are many stories as to the origin of the Adinkra symbols. It is unfortunate that the exact date and origin of the symbols cannot be traced because it dates back many generations. There is strong evidence to suggest that the more abstract ones may have been of the Islamic religion, hence older than Ashanti state. The crescent moon and star symbol which means faithfulness is classic example and this came because of the contact with Islamic traders by the Asantes (Kuwornu-Adjaottor & George, Appiah & Melvin, 2016). Adinkra symbols are ideographical representations of proverbs, philosophies, thoughts, and values of the Akans of Ghana. The symbols encapsulate the worldviews and keen observations of human behaviour, and the interactions between nature and humanity. Adinkra symbolic expressions may be carried through gestures or performance, verbal and/or visual representations and are thus very versatile. While each symbol has a basic meaning, it assumes expansive interpretations in different contexts of its applicability (Commons et al., 2019). Table 1 is a selection of Adinkra symbols, their literal meanings and symbolism. These symbols served as design resource for this project.

Table 1: Selected Adinkra symbols and their meanings (Source: Ntoso et al., 2006)

Image	Twi Name	Literal Translation	Symbolic Meaning
	ADINKRAHENE	"Chief of adinkra symbols"	Greatness, Charisma, Leadership
	AKOBEN	"War horn"	Vigilance, Wariness
	AKOFENA	"Sword of war"	Courage, Valour

	ANANSE NTONTAN	"spider's web"	Wisdom, Creativity
	BOA ME NA ME MMOA WO	"Help me and let me help you"	Cooperation, Interdependence
	DUAFE	"Wooden comb"	Beauty, Hygiene, Feminine Qualities
	GYE NYAME	"Except for God"	Supremacy of God
	MATE MASIE	"I have heard and kept it"	Wisdom, Knowledge, Prudence
	NKONSONKONSON	"Chain links"	Unity, Human Relations
	NKYINKYIM	"Twistings"	Initiative, Dynamism, Versatility
	NSAA	Type of handwoven cloth	Excellence, Genuineness, Authenticity
	OSRAM NE NSOROMMA	"The moon and the star"	Love, Faithfulness, Harmony

	OWO FORO ADOBE	"Snake climbing the raffia tree"	Steadfastness, Prudence, Diligence
 or 	SANKOFA	"Return and get it"	Learn from the past

2.2 Selection of the Symbols

Even though all the adinkra symbols has the characteristics needed for wall hangings, six were selected for the final presentation. The six are:

- Anansi Ntontan: Spider's web; it represents wisdom and creativity.
- Boa Me Na Me Mmoa Wo; Help me and let me help you; it represents cooperation and interdependence.
- Gye Nyame: Except for God; it represents the supremacy of God.
- Mate Masie: I have heard and kept it; it represents wisdom, knowledge and prudence.
- Nkyinkyim: Means twistings; it represents initiative, dynamism and versatility.
- Nsaa: A type of hand-woven cloth; it represents excellence, genuineness and authenticity.

2.3 Preliminary Sketches

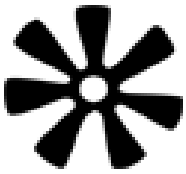


Figure 2. Ananse Ntontan.

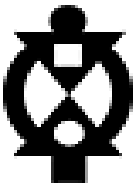


Figure 3. Boa Me Na Me Mmoa Wo



Figure 4. Gye Nyame



Figure 5. Mate Masie



Figure 6. Nkyinkyim

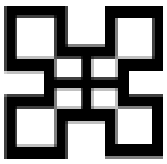


Figure 7. Nsaa

2.4 Materials and Steps for the Project

Coir fibre was the main material for the project; there is also Perspex board, self adhesive vinyl, white glue, wooden shadow boxes and glass frames in various quantities as shown in Table 2.

Table 2. Materials for the project

MATERIALS	SIZE/QUANTITY	UNIT
Coconut Fibre	Apx. 0.5 kg	1
Perspex Board	15" × 15"	6
Self-Adhesive Vinyl	11" × 11"	6
White Glue	750 ml	2
Wooden Shadow Box Glass Frame	17" × 17"	6

The wall hanging pieces were executed through the following steps:

- Gathering and sorting of coconut husks from coconut vendors
- Defibring of the coconut husks using the traditional hammer mill machine
- Sieving the fibres to get rid of the coconut peat and dust and separation of the matt fibres
- Digital outlines print out of the selected Adinkra symbols on self-adhesive vinyl.
- Pasting the outlined Adinkra symbol designs on white Perspex board to cut the mould
- Stuffing of the coconut fibres into the mould using white glue as a binder, and cutting out after drying
- Fitting the Adinkra symbol moulds into wooden glass frames.

2.5 Gathering and sorting of Coconut Husks

Coconut husks are gathered from various coconut juice sellers and assembled at the processing plant. The husks are then sorted out before they were fed into the hammer mill. The sorting is done to separate the smaller husks, wet and dry husks. The wet husks are allowed to sun dry for further processing to avoid it getting stack in the machine during the process.



Figure 8. Gathering and Sorting of coconut husks
Source: Field Studies

2.6 Defibring of the Coconut Husks Using the Traditional Hammer Mill Machine

The coconut husks are sorted out and fed into the hammer mill machine in smaller quantities to prevent the machine from getting chocked. The machine crushes and opens the husks to separate the fibres individually. The coconut husks are struck by the rectangular pieces of hardened steel which rotates at high speed inside the chamber. These radically swinging hammers (from the rotating central shaft) move at a high angular velocity causing brittle fracture of the feed material.



Figure 9. Sorting
Source: Field Studies



Figure 10. Hammer Mill Machine
Source: Field Studies



Figure 11. A Grinding machine that was built by Kmoy Cocopeat Company
Source: Field Studies

2.7 Sieving the Fibres and Separation of the Matt Fibres

After grinding the coconut husks, the out product is sieved using a wired mesh. This separates the coconut shell chips, coconut peat and the coconut fibres. The main product of interest to this project is the coconut fibre. Apart from the coconut fibre obtained, there are two (2) other by- products of this process and they are coconut shell chips and the coconut peat. These two are largely used in horticulture as a base

or soil supplement for planting garden crops, generally fruits, vegetables and ornamental plants.



Figure 12. Sieving the Grinded Husks
Source: Field Studies



Figure 13. Grinded Husk in the Hammer Mill Machine
Source: Field Studies

2.8 Digital designing of the outline and cutting of the moulds of the selected Adinkra symbols

With the aid of a computer and the CorelDraw software, an outline of the selected Adinkra symbols each was created to be printed on self-adhesive vinyl. The stickers were then pasted on the white Perspex board. The board was then put on a cutting surface and with the assistance of a cutter and metal ruler, the mould was cut out. This procedure was repeated for the six (6) selected Adinkra symbols.

2.9 Procedure for making the Moulds

The moulds were placed on a transparent polythene bag laid on the working board, and was secured using the shoemakers' nails. This was to avoid any movement during the process. White glue was mixed with water proportionately to achieve a desired consistency. The consistency is not too thick or too light. The fibres were being stuffed into the mould, the white glue mixture was applied onto the fibres and tucked with the ice cream stick. This was repeatedly done until the desired thickness of the mould is achieved, and the procedure was repeated to complete all the selected Adinkra symbols. The drying of the moulds was quick dried by using an electric hand dryer. The moulds were then cut out to achieve the desired shapes.

Figure 14 to 18 illustrate the various stages of production.

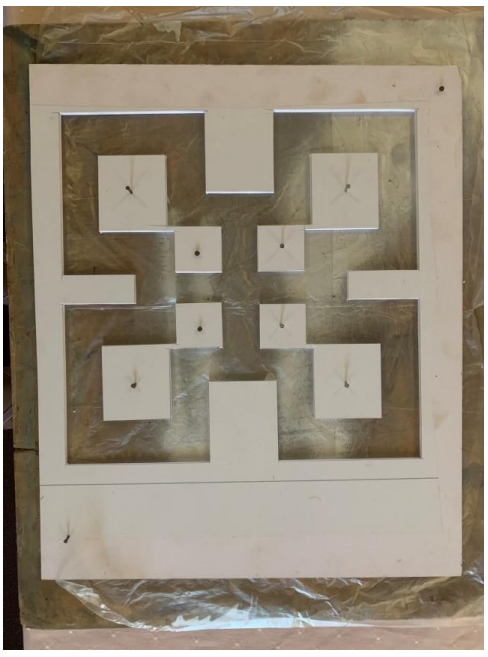


Figure 14.



Figure 15.

Figure 14 and 15. Cut out moulds on white plastic bag secured with nails on the working board

Source: Field Studies



Figure 16. Stuffing the fibres into the adinkra mould
Source: Field Studies



Figure 17. Adinkra symbol after stuffing the mould with the coconut fibres
Source: Field Studies



Figure 18. Cutting out the Adinkra symbol after drying
Source: Field Studies

2.10 Fitting the Adinkra symbol moulds into Shadow wooden frames

The symbols were finished and fitted into 17 by 17 inches wooden shadow glass frames each. The frames have hooks at the back of each to enable them to be hanged on wall surfaces. Figure 19 to 24 are the finished and mounted wall hangings.

2.11 Finished Wall Hangings

The colours are the natural brown colour of the coconut fibres against an off-white background with a complimentary gold and black frames to add some sophistication to overall outlook. The fibre colour was maintained to achieve a rustic look considering the origin of the Adinkra symbols, though the symbols may be executed in other colours for innovative products.



Figure 19. Boa Me Na Me Mmoa Wo
Source: Field Studies



Figure 20. Nsaa
Source: Field Studies



Figure 21. Gye Nyame
Source: Field Studies



Figure 22. Mate Masie
Source: Field Studies



Figure 23. Ananse Ntontan
Source: Field Studies



Figure 24. Nkyinkyim
Source: Field Studies

3.0 CONCLUSION

The main aim of the project was to extract coconut fibres and use the fibres to produce Adinkra Symbols in the form of framed wall hangings as functional artefacts for the purpose of beautification of spaces. The final presentations include symbols such as Anansi Ntontan, Boa Me Na Me Mmoa Wo, Gye Nyame, Mate Masie, Nkyinkyim, and Nsaa. After the coconut fibre extraction, the symbols were rendered in four stages, that is, digital outline print out of Adinkra symbols on self-adhesive vinyl, pasting the outlined symbols on white Perspex board to cut the mould; stuffing of the coir fibres into the mould using white glue as a binder and cutting out after drying and; fitting the moulds into wooden glass frames of specified dimensions. The interesting rustic look of the wall hangings make them a perfect feature for every sophisticated interior spaces.

This project reinforces the fact that coconut fibres can be utilized in a breadth of art projects in addition to the wide range of application of the by-products from the husk in construction, horticulture and general agricultural practices. As the coconut fruits are consumed on regular basis in Ghana, there must be creative ways of reducing how the husks litter the environment. Converting them into functional artifacts as part of the

many uses of the coconut plant is a sure sustainable posture. Low tech machines and gadgets were used to extract and process the coir fibres and the rest of the processes were mainly manual. This is phenomenal because to make these top-class wall hangings with a relatively cheaper installation capacity and at a minimal energy cost means a good profit margin. It is also environmentally sustainable as gathering the husks also doubles as clearing 'coconut juice waste' which may hitherto end up in drains and other spots creating water stagnation and causing pollution. Beyond the outstanding results it is also fun working with coir fibres to create these elevated adinkra reliefs. It is, therefore, recommended that, textile artists explore and develop creative and utilitarian products from sustainable and biodegradable materials such as coir fibres from the coconut husks as demonstrated in this study. Making functional artifacts such as table runners, place mats, pen holders, flower vases and several others could be a good source of income. It is further recommended that more research is done with regards to coconut husks waste management to explore and develop new products of economic value.

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