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Reducing cost and ensuring environmental sustainability: Palm kernel expeller as an alternative sculpture material for casting in Ghana

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Abstract: The materials for sculpture in Ghana have always been clay, wood, cement, resin, and silicon. These materials have their limitations. Also, some students do not have the financial strength to purchase them because they are expensive. This situation slows down the pace in the teaching and learning of practical activities in the Sculpture discipline in most Ghanaian educational institutions. Owing to this, the researchers explored the possibility of experimenting with local materials in the home regions of students which could have otherwise been a nuisance in the environment as alternative sculptural materials. The researchers adopted the Double Helix of Praxis Exegesis Model, which is an arts-based method undergird in the eco-innovation theory to investigate the possibility of using palm kernel which is abundant in the Anloga Sobolo community, Kumasi, Ghana as an alternative material for modeling, casting, and carving. The palm kernel expellers were prepared by collecting the kernel, cracking, firing, milling, and cooking to extract the oil, and then the expeller. The palm kernel expellers were mixed with selected binders to produce aesthetically pleasing modeled, cast, and carved works. Findings revealed that palm kernel expeller is non-toxic, environmentally friendly, and cost-effective alternative material for sculpture. The study contends that teachers and students in the sculpture discipline in the various Senior High and tertiary educational institutions in Ghana should constantly explore waste local materials as alternative materials for practical activities in sculpture to reduce cost and to serve as a tool for ensuring environmental sustainability.

Keywords: Casting, Environmental sustainability, Ghana, Modelling, Palm kernel expeller, Recycled art, Sculpture

1. Introduction

Sculpture is one of the disciplines studied in art education in both secondary and tertiary institutions in Ghana. Materials come second to the skill of a sculptor and therefore play an important role in the process of sculpturing (Droth, 2018). Many of the materials used to make sculpture are imported, expensive, or inaccessible, making studio work difficult for students in second-cycle and tertiary institutions where Visual Arts are studied. This has reduced visual arts teachers' and students' access to resources, resulting in fewer and uninteresting practical works, depriving students of the opportunity to learn sculpture production techniques successfully and effectively. Clay, cement, and Plaster of Paris (P.O.P) have been the primary materials utilized for sculpting by teachers and students for modeling and casting objects at most second-cycle schools and colleges across the country. For their studio practices, students must acquire these materials on their own, which has proven to be challenging for many of them due to the items' high cost. As a result, students turn to alternatives that are accessible and inexpensive, such as palm kernel expeller (PKE). The Palm Kernel Expeller is derived from palm kernels. The kernel is transferred to expeller factories, where it is ejected twice to produce higher-quality oil. In a drum machine, the kernels are crushed and ground. The residue after oil extraction from palm kernels is known as palm kernel expeller (PKE). Processing of palm oil fruits has been done in Africa for a long period.

The palm oil fruit, when processed, yields palm oil, palm fiber, and palm nuts; and the nut, when cracked, yields palm kernel and shell. It contains approximately 46 to 57 percent oil on a dry matter basis. It consists of an endosperm that is white and translucent in its fresh state, enclosed in a light brown testa. During the process of heating, both the endosperm and testa turn dark (Jayalekshmy & Mathew, 1991; Atil, 2009). The palm nut shell can also be used as a replacement material for concrete production. It is also an economically and environmentally sustainable raw material for renewable energy. The economic value of palm kernel is derived from its byproducts, which are palm kernel oil (PKO) and palm kernel cake (PKC). Palm Kernel Oil as food is a source of concentrated energy. The oil could be used as a lubricant. It is an ingredient in paint making as a drying base and the manufacture of candles and soaps. It is a good medium for molding and casting in sculpture. It can be mixed with resin to get a paste for casting and also be used as a paste for molding and casting boards for carving. However, certain specific factors also seem to be specific for that palm kernel processing (Hartley, 1988). For instance, 60 percent of palm kernels are produced in the country are produced bytraditional palm oil millers. Also, the majority of palm kernel consumers reside in the villages and consumers are mostly familiar with the kernel oil as the main by-product from the palm kernel.

Makafui (2015) posit that most of the factories that produce instructional materials for teaching art-based courses are few. Materials coming from these factories are very expensive to buy, and they are either produced here or imported. Since they are done in the concept of foreign production, so is their pricing. The use of palm kernel expeller could minimize the importation of some of these materials in the field of art as a whole. This necessitated an inquiry into palm kernel expeller, which is abundant at AnlogaSobolo and could be used as an alternative sculpture material but is disposed of by dumping, with consequent environmental pollution. However, producers have other economic benefits from it when they make sales off of it. The researchers, therefore, seek to explore the use of palm kernel expeller, a less expensive, available, and readily accessible option as an alternative sculpture material for modeling, carving, and casting to foster creativity, teaching, and learning. The study siught answer the following questions:

1. How is the palm kernel expeller produced from the palm nut?
2. Which binders will be suitable for modeling, casting, and carving?
3. How can the palm kernel expeller be used as an alternative sculptural material for students at the Department of Painting and Sculpture to model, carve and cast objects to improve their skills, creativity, and knowledge?

2. Literature review

2.1. Palm kernel expeller

Palm kernels are becoming the most popular tropical fruit in Africa, garnering interest from all around the continent (Okpala, 2015). The edible seed of the palm fruit, the palm kernel, comes from the palm tree, and the fruit is noted for its oil production. It is well-known for producing two types of oil: palm kernel oil from palm kernels and palm fruit oil from palm fruit. Palm kernel expeller is a by-product that is generated from the processed fruit of palm kernel. African palm oil is a member of the Arecaceae family of plants (Jayalekshmy & Mathew, 1991).

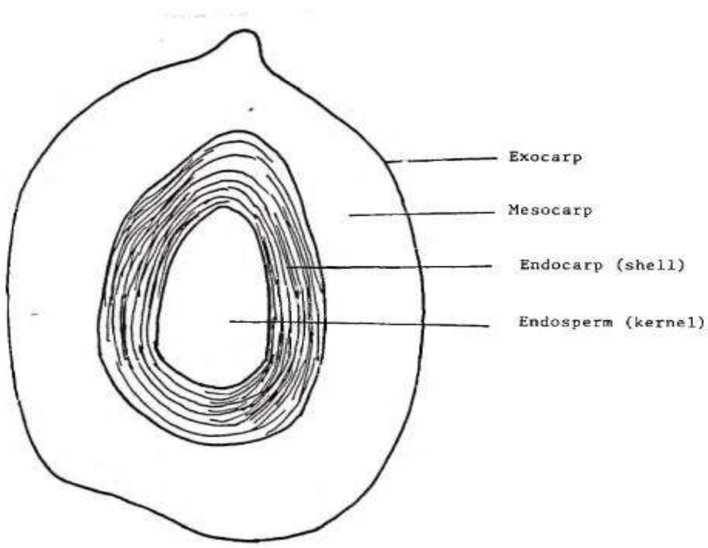


Figure 1: A typical Palm fruit structure (Okpala, 2015)

Palm kernel expeller is abundant in many West African countries. It is easily accessible for animal feed and inexpensive to purchase. As a result, the researchers aimed at using it as an alternative for sculpture casting as well as to help students broaden their knowledge of materials available to them. This may assist the learner in becoming aware of its richness around the country. Because of lack of information, nutritional qualities, and improvement methods, palm kernel expeller is currently being used for animal feed across the country, such as pig farming, poultry farming, and so on. As an alternative for sculpting, palm kernel expeller will be a suitable choice. Abdeltawab and Khattab (2018) mention that the chemical composition of palm kernel expeller varies based on the source of the samples, soil type, oil extraction technique (mechanical or solvent), and amount of endocarp left, and oil extraction efficiency from the kernel. The quantity of moisture in the palm kernel expeller is referred to as dry matter (Hartley, 1988). The dry matter content is significant when buying palm kernel expeller in bulk and storing it. More than 14% moisture content could not be stored in bulk, and it is the ideal culture for molds to grow on it. Akinyeye et al. (2011) have pinned several investigations that found that the dry matter of palm kernel expeller ranged from 89.00 to 95.00 percent. When compared to soybean meal and groundnut cake, palm kernel expeller has a low crude protein concentration. Atil (2009) opined that the crude protein concentration of palm kernel expeller varies between 14-20%. The amino acid balance in palm kernel expeller protein was poor, with lysine, methionine, tryptophan, threonine, and histidine being the primary limiting amino acids (Ezieshi & Olomu, 2004). The primary components of crude fiber are cellulose, hemicellulose, and lignin. Crude fiber is a nutrient digestibility measure that may be used to estimate the feeding value and digestibility of feeds (Alimon, 2004).

Table 1: Chemical component of palm kernel expeller

Chemical components in Palm Kernel Expeller	**Percentage (%).**
Calcium	0.276 %
Phosphor	0.645 %
Magnesium	0.158 %
Zinc	0.214 %

Sodium	0.187 %
Potassium	0.365 %
Copper	0.25 %
Manganese	1.3 ppm
Iron	0.75 Pm

Akinyeye et al. (2011)

2.2. Binders

Binders are the most crucial materials to employ when putting together an artifact (Pizzi & Mittal, 2003). Binders are liquid and solid substances that may solidify through a chemical process and bind anything with which they come into contact (Sakoalia, Adu-Agyem & Amenuke, 2019). Fibers propelled metals, and other particles are among the materials used. Binders have been employed in the production of numerous works, as well as for binding works together, from the prehistoric to the twenty-first century. Cement, gum, glue, resins, and other materials were utilized in the early days. In Ghana, several materials have been used as binders. These include cassava starch, white glue, and resin. These binders have been discussed below.

2.3. Cassava starch as binder

Starch is the most frequent binder in the tablet formulation is starch, which comes from a variety of sources including cassava tubers. Chitedze et al. (2012) opine that cassava roots are mostly grown in tropical nations, and it has been identified as a crop with the potential to boost rural industrial development and increase revenue for growers, processors, and merchants. Cassava is the most common source of starch binders. Starch is a renewable and limitless material that comes from grain or root crops and is used to glue particles together. Cassava is chemically, physically, and biologically transformed into a variety of adhesives through the removal of the coat, cleaning, grinding, sieving, rinsing, dehydration, finalizing and curing.

2.4. White glue as binder

White glue, also known as polyvinyl acetate woodworking adhesive, is a high-strength, long-lasting adhesive that works well on porous materials like wood and cardboard. Wood and porous substrates such as paper, cardboard, leather, and fabric, among others, can be bonded using white glue. White glue is a non-flammable, non-toxic, water-based adhesive. Pizzi and Mittal (2003) assert that Polyvinyl acetate was first used as a solvent-based adhesive in the 1930s, but it was not widely utilized until the 1940s when it was introduced as an emulsion adhesive for bonding paper and wood. It is now the most extensively used thermoplastic adhesive in the world, in emulsion form as white glue.

2.5. Resin as binder

A resin is a heat-reactive viscous substance that is effective at attaching particles and is not influenced by the weather (Spurgeon, 2016). Resin binder is chosen for casting sculptural works. The resin was defined as any natural or synthetic organic substance with a non-crystalline or liquid component. Resins are clear or translucent flammable organic compounds that range in color from yellowish to brown. The resin dissolves in a wide range of organic liquids but not in water. Inorganic materials such as plastics and rubber can also be bonded using resin. Polymerization, or the creation of long molecular chains, is the process that transforms the material into a solid with sticky characteristics during the transition. Resins include superglue, fiberglass bonding chemicals, and epoxy glues.

3. Research methodology

This study adapted the procedural steps in the Arts-based research approach known as the Double Helix of Praxis Exegesis Model by Marshall (Marshall, 2010). The model allows for the smooth transition between creative processes both in theory (exegesis) and practice (praxis).This study is rooted in the eco-innovation theory (Kemp and Foxon, 2007) that aims at the production of innovative projects that impact positively on the environment by re-using and/or recycling waste materials that would have been a menace in the environment. This project contributes directly to an improvement in the environment by re-using palm kernel waste as an alternative sculptural material.The procedural steps in this model include observation, reflection, creation, and analysis. The total population of students in the department of Paintinng and Sculpture were 379. However, the study participants who were purposively selected for this project included Eight (8) solvent workers and all the 22 third-year sculpture students in the Department of Painting and Sculpture in the Kwame Nkrumah University of Science and Technology, Ghana, totaling a sample size of 30. The final products were evaluated by stakeholders in the Sculpture discipline, namely teachers and students.

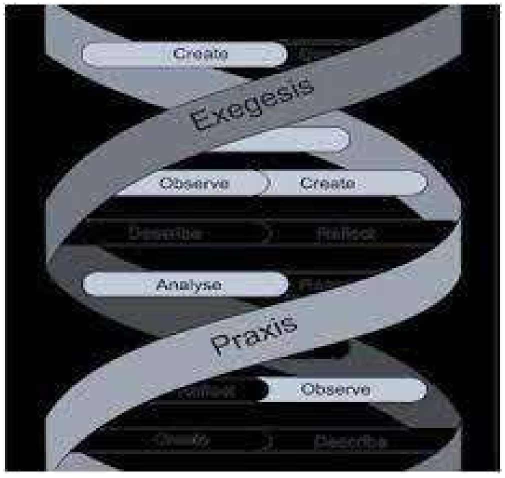


Figure 2: Double Helix of Praxis Exegesis Model. **Source:** Marshall (2010).

4. Results and discussion

4.1. Acquisition and treatment of palm kernel expeller (Solvent extraction)

The first objective of the work was to find out how the palm kernel expeller is produced from the palm nut. The palm kernel expeller was acquired from the expellers after they have finished with the oil extraction. The material was then broken down and sieved for the project. The procedures are as follows. The expellers will start by buying palm nuts from various homes and palm oil manufacturers. They remove all impurities from the palm nut, such as stones, leaves, feathers, and other unwanted materials that are found in them. After drying them under the sun for some time, the palm nuts are sent to the electronic cracking machine for cracking of the nuts for easy separation of the shell from the seed. The palm kernel will go through various processes before the extraction of the kernel oil, which is the palm kernel expeller. The first process is called palm nut drying, kernel breaking, winding, separation of shell and seed, and extraction of palm kernel oil is the last thing to do.

Dry Cracking Cracked Nut

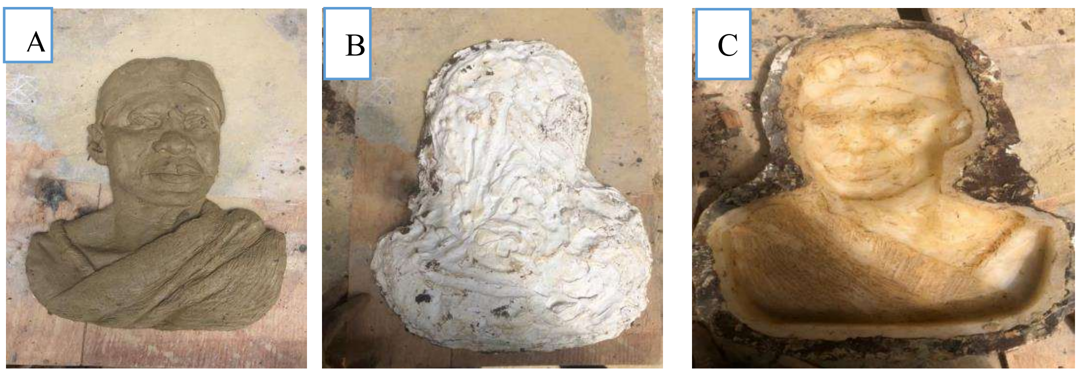
Washing of the Palm Kernel   Separation of Palm Kernel   Fried Palm Kernel

Cooking of Milled Palm Kernel   Palm Kernel Expeller (Solvent Extracted)

Figure 3: A-H- Treatment and Processing of Palm Kernel

4.2. Obtaining moulds for the experiments

The second objective was to find out through experiment which binders will be suitable for modeling, casting, and carving. The researchers with the participants broke the lumps into smaller forms and loosens them into powdery forms. After these were done, there was a need for sieving of the material to get the unwanted materials from it and also to get the fine and smooth palm kernel expeller from which the researchers and students would use to cast a bust and relief work. The students were grouped in three sections and each was to model and cast, modeling with the material and carve a work from the palm kernel expeller and the selected binders. The researchers guided the students to model a bust and soft clay relief model depicting a traditional chief.



Modeling   Mould Making   Mould

Bust Modelling

Bust Mould

Figure 4: A-E-production of moulds for the experiments

4.3. Experimenting with palm kernel expeller with selected binders

With the desired quantity, the researchers with the students mixed the binder with the palm kernel expeller with selected binding materials which include resin with accelerator and hardener, white glue (top bond), konkote, and Fante kenkey. The material was grinded into a powdery form and mixed with all the selected binders and poured into each mould. After hardening of the cast material, the mould was removed leaving the cast pieces. This process was repeated until all the binders were tested with the material.

4.4. Casting with resin and palm kernel expeller

The resin was mixed in a small plastic gallon. Some quantity was fetched and mixed with the palm kernel expeller. The hardener was added and stirred. After stirring, it was poured and spread in the mould. It sets within some minutes. The set cast is reinforced with fiberglass and then separated from the mould. The bust figure was joined together.

Crushing the lumps

Sieving the Expeller

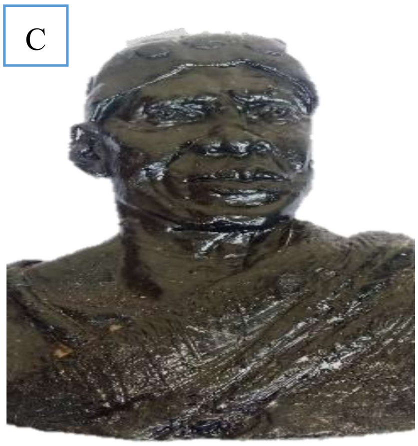
Mixing Resin

Applied Resin and Expeller

Figure 5: A-D-experimenting with resin palm kernel expeller and resin

Laying of Fibreglass

Dabbing of Resin



Relief Cast Piece

Bust

Figure 6: A-D-experimenting with resin palm kernel expeller and resin

4.5. Casting with white glue

Water was added to the white glue (top bond) or carpenter glue to dilute it before the researcher and the participants added the palm kernel expeller to the glue for stirring. The participants stirred it until a uniform paste was achieved. The Palm Kernel Expeller was first of all sieved before being added to the white glue.

White glue mixed with expeller   Casting

Cast piece

Figure 7: A-C-experimenting with palm kernel expeller and white glue

4.6. Casting with *Konkonte* and palm kernel expeller

The students were introduced to the*Konkonte* powder. This cooked *Konkonte*was mixed with the palm kernel expeller (PKE), which gave a good paste as to that of the clay. The solution was poured into the mold in two ways. The first one was made of a little leather hard for it to pick all the details. The second was looser for it also to depict the details.

Cooked *Konkonte*

***Mixed Konkonte* and Expeller**

Cast Piece

Figure 8: A-C- experimenting with palm kernel expeller and *Konkonte*

4.7. Casting with Fante kenkey and palm kernel expeller

A sum of 350 milligrams was added to the two balls of kenkey and was mixed very well and also kneaded to get a uniform paste. This gave a good paste for the casting of the relief. This was kind of solid so was pressed the mold to take all the details.

Kenkey Cast Piece

Figure 9: A-B- experimenting with palm kernel expeller and kenkey

4.8. Experimenting with palm kernel expeller with selected binders

Observation of experiment one: *The reactions of palm kernel expeller with resin*

It was observed that the resin reacted well with the palm kernel expeller which changes color when mixed with the chemical. The work was set within 30 minutes and the mold was removed. It picked all the details in the mold. The cast piece is stronger and tougher than the other binders. Its works perfectly for both the round bust and relief bust.

Observation of experiment two: *The reactions of palm kernel expeller with white glue*

The researchers observed that the material cracks after it has been removed from the mold. After curing, the cast piece got broken. There was a recast with a different mold which was a relief model of self-portraiture done by one of the students. After curing, it was strong. The researchers observed that the first cast had enough water mixed with it but the second cast did not have enough water in it and came out well and strong but had cracks.

Observation of experiment three: *The reactions of palm kernel expeller with Konkonte*

Two types of casting were made to try both controlled and uncontrolled drying. The uncontrolled drying was cast and removed. When left in the open and under a shield for three days, it grew mold. Under the controlled drying process, the researchers used the heat gun to blow heat unto the work. It began to melt on the spot. It was observed that the binder could bind well for the material but will melt under controlled drying. As a result, the work was hard enough to move around.

Observation of experiment four: *The reactions of palm kernel expeller with kenkey*

Controlled and uncontrolled air drying was been experimented with. Controlled and uncontrolled air drying was been experimented with. Uncontrolled air-dried which took a week to properly dry very well. After drying it was very strong and hard. This has to be kept indoors and saved from mice and ants since they both are organic. The students were divided based on the sculptural techniques used. Six students handled the casting with the various selected binding material with the palm kernel expeller. All the respondents who partook in the interview agreed that palm kernel expeller reacted positively with resin and give it an interesting color and a good finishing. Also, more than half of the class said that the white glue reacted positively with the material and they enjoy its toughness after drying. *Konkonte* that was new to them received good feedback. It reacted nicely with the material and became strong after drying within three days. Fante kenkey reacted positively to the material and they said they like the texture it gives. The six students could cast all the selected binders with the material.

5. Conclusion

The study has revealed that the palm kernel expeller reacts positively with synthetic resin, white glue, *Konkonte*, and kenkey. It was used for casting various casts from bust to relief figures. The palm kernel expeller was used to help the students at the Sculpture Section to produce works of their own using the palm kernel expeller. Using the palm kernel expeller as an alternative sculpture material to a large extent, will reduce environmental pollution, stress on art students in the quest for materials, and improve palm kernel cultivation in Ghana. It is recommended that Senior High Schools and Tertiary institutions should introduce waste raw materials into materials in sculpture to be researched and make use of the material for art production. Also, raw waste material such as Palm Kernel Expeller should be introduced as an alternative sculpture material in Curriculum Research and Development Division in Ghana Education Services as a Sculpture teaching syllabus for Ghanaian Art schools in all sectors. Future researchers could investigate the feasibility of using other binders with the palm kernel aside from those used in this study. The palm tree presents several opportunities for artists in exploring the possibilities of using other aspects of the plant for artistic creation. For instance, future researchers must explore how to process, finish and use the stem of the palm tree as a substitute for wood for carving purposes.

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References

1. Abdeltawab, A. M., & Khattab, M. S. A. (2018). Utilization of Palm Kernel Cake as a Ruminant Feed for Animal; A Review. *Asian Journal of Biological Sciences*, 11(1): 157-164.
2. Akinyeye, R. O., Emmanuel, I. A., Olayinka, F., & Adedunke, A. (2011). Physico-chemical properties and anti-nutritional factors of palm fruit products (Elaeisguineensis Jacq.) fromEkiti State Nigeria. *Electronic Journal of Environmental, Agricultural and Food Security*, 10(5): 2190-2198
3. Alimon, A. (2004). The nutritive value of palm kernel cake for animal feed. *Palm Oil Development*, 40: 12-14.

4. Atil, O. (2009). Enhancing the MPOB-Q-Palm kernel cake in poultry diet, animal feedstuffs in Malaysia-issues, strategies and Opportunities. In: M. A. o. Science, ed. *Enhancing the MPOB-Q-Palm kernel cake in poultry diet, animal feedstuffs in Malaysia-issues, strategies and Opportunities.* Malaysian: Malaysian Academy of Science, pp. 57-67.
5. Chitedze J., Monjerezi, M., Saka, J. D. K., & Steenekamp, J. (2012). Binding Effect of Cassava Starches on the Compression and Mechanical Properties of Ibuprofen Tablet. *Journal of Applied Pharmaceutical Science*, 2(4): 4-10.
6. Kemp, R., & Foxon, T. (2007). *Typology of Eco-Innovation*. Deliverable 2 of MEI Project (D1), Maastricht.
7. Hartley, S. C. (1988). The Oil Palm. In: *Tropical Agriculture Series*. Singapore: Longman, pp. 724-729.
8. Jayalekshmy, A., & Mathew, A. G. (1991). Effect of roasting on the Lipids, sugars and amino acids of oil palm kernel. *Oleagineux*, 46(2): 163-168.
9. Sakoalia, K. D., Adu-Agyem, J., & Amenuke, D. A. (2019). Groundnut Shell Powder as an Alternative Sculpture Material for Modelling, Casing and Carving: The Case of Salaga Senior High School, Ghana. *Journal of Arts and Humanities,* 8(4): 30-43. http://dx.doi.org/10.18533/journal.v8i4.1575
10. Makafui, T. (2015). *Exploring Natural Latex for Mould Making in Teaching Sculpture.* Master of Philosophy thesis, Department of General Art Studies, Kwame Nkrumah University of Science and Technology, Kumasi. Retrieved from https://ir.knust.edu.gh/bitstream/123456789/8791/1/Final%20Thesis.pdf
11. Okpala, B. (2015). Some Important Facts about Palm Kernels. Retrieved from https://globalfoodbook.com/some-important-facts-about-palm-kernels#google_vignette
12. Pizzi, A., & Mittal, K. L. (2003). *Handbook of adhesive technology.* Taylor & Francis. 1036p.
13. Spurgeon, H. (2016). Reactive and non-reactive binders. Retrieved from www.researchgate.net