EXTRACTION AND APPLICATION OF CYPERUS PAPYRUS FIBERS IN HAND WEAVING

BY

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RESEARCH DISSERTATION SUBMITTED TO THE DIRECTORATE OF RESEARCH AND GRADUATE TRAINING IN PARTIAL FULFILLMENT FOR THE REQUIREMENT OF THE AWARD OF MASTER DEGREE IN ART AND INDUSTRIAL DESIGN OF KYAMBOGO UNIVERSITY

AUGUST, 2023

DECLARATION

I Kemirembe Monica of registration number 18/U/GMID/19595/PD, declare that this thesis is my original work and it has not been submitted or presented for a degree in any other institution.

Signature: ……..

Date: …….....

APPROVAL

This is to certify that the thesis of Kemirembe Monica Reg No 18/U/GMID/19595/PD carried out under the title; **"Extraction and application of Cyprus papyrus fibers in hand weaving"** under our supervision is now ready for submission to the Directorate of Research and Training with our approval as University supervisors.

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DEDICATION

I dedicate this thesis to all Textile students especially those interested in using natural fibers.

ACKNOWLEDGEMENTS

I greatly acknowledge my supervisors Mr. Muturi Kimani and Madam Penelope Tusaasiirwe for their guidance throughout this study. Great appreciation to the Director of Texfad and his staff for allowing me use their machinery during this study.

I also thank all the Masters in Art and Industrial Design (MAID) lecturers who have supported me since I started this master's programme with motivation, pieces of advice, academic encouragement and a great deal of knowledge.

Great thanks to my parents Mr. and Mrs. Manirakiza Paul who kept encouraging me, my husband Mr. Ham Wilson Lukurwe who gave me full support, my daughter Murungi Faith and my family members Prisca, Assumpta, Pius, Paula, Augustine and Alex. May God bless you!

Great thanks to Senoga Maureen (PhD) ,Akampumuza Obed (PhD) and Tusiime Edwin Wyclif (PhD) who helped me to proof read my work. God bless you!

Finally, I thank the Master's class MAID 2018 for contributing ideas that have helped me come up with this work.

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LIST OF ACRONYMS

TEXFAD	Textile and Fashion Design
MAID	Master of Art and Industrial Design.
BVAD	Bachelor of Vocational Studies in Art and Design with Education.
TEXDA	Textile Development Agency
UN	United Nations
SDGs	Sustainable Development Goals.
KYU	Kyambogo University
DAID	Department of Art and Industrial Design

ABSTRACT

The study aimed at exploring the possibility of extracting natural fibers from Cyperus papyrus plants, examining the suitability of Cyperus papyrus fibers for textile use and producing Cyperus papyrus hand woven products for home applications. The study used qualitative data collection methods. Some quantitative interpretations like graphs were, however, used to present demographic data. Collection of data was through in-depth interviews, observation, and photography. The collected data was analyzed through studio and laboratory experimentation to affirm the suitability of Cyperus papyrus in craft textile production. Findings revealed that the extracted fibers were suitable for craft textiles. For further affirmation of the suitability of Cyperus papyrus as a material for craft textile production, various products such as wall hangings, table mats and door mats for decorative and educative purposes were woven. Based on the findings it was concluded that Cyperus papyrus could produce long resilient strong fibers efficient for weaving and highly recommended for all hand weavers especially in educational institutions and in the textile cottages as a viable hand weaving material.

CHAPTER ONE: INTRODUCTION

1.0 Overview

Chapter one presents the background of the study, statement of the problem, objectives of the study, studio guiding questions, purpose of the study, and scope of the study, its significance and the definition of operational terms.

1.1 Background of the study

The word fiber originates from a Latin word (fibra). The global Italian-English dictionary 2018 defines the word fibra as a fine thread or something like a thread. Fibers are natural or man-made substances that are significantly longer than their width. They are the smallest units yet the most basic component of textiles and significantly influence their structure, appearance, nature and properties during textile fabrication (Tabrej, Mohamed, & Ahmad, 2018).

Fibers are either man-made or natural basing on their origin. Man-made fibers (also known as synthetic) are manufactured and are in form of plastic or glass. These artificial fibers are made through chemical processes involving a combination of small units (monomers) to make longer strings (or polymers) of chemical substances. Some common examples of synthetic fibers are rayon, nylon, acrylic, and polyester.

Natural fibers on the other hand, can be defined as hair like materials directly obtained from vegetation, animals or minerals. Plant based natural fibers can be obtained from seeds, stem, leaf, and fruit. Animal fibers grow on skins like wool from the sheep, or are excreted, for example silk from the silkworms.

Weaving on the other hand is the art of entwining a set of vertical threads (the warp) with horizontal threads (the weft) to form a fabric. It is one of the oldest surviving practices in the world with a history that dates back to the Neolithic period. For centuries, weaving was carried out by hand in the home on a cottage industry basis where two process of spinning and weaving were carried out. There is evidence of cloth being woven that traces as far back as 7000 to 8000BC in Mesopotamia and Turkey but the exact date is difficult to pin point due to the perishable nature of textiles (Temesgen, Tursucular, & Yusuf, 2018). In Uganda weaving was done as a gender role where women and young girls made hand woven products like mats, in their homes. Men in the central region also wove fishing nets to help in catching fish on lake victoria. Prior to weaving warp yarns need to be strengthened temporarily so they can withstand the stresses of weaving, this process is called spinning.

Weaving looms can be characterized according to the type of mechanism used to insert the weft and the type of mechanism used to lift the warp ends in order to produce different patterns. As time went on weaving was slowly refined and perfected eventually leading to highly specialized cloth production. For plain woven fabrics, yarns at the right angles pass over and under each other and are the simplest and basic weaves. Weight of the products dictate the end use; light weights are used in apparel and curtains whereas heavy weight can be used in upholstery, draperies and industrial goods (Gokaarneshan, 2018).

Traditional weavers first used wool from the sheep, cotton and flax or linen for weaving though hemp could be made into serviceable canvas and heavy. Weavers got cotton crop each year until the invention of cotton ginning. Weaving looms that were being used were crafted with hands out of wood and a few metals and strings. Many communities and individuals around the

world have continued to weave by hand either as a hobby, for cultural identification or out of necessity to generate income.

Despite the fact that hand weavers have independent expertise in their skills, they are faced with various challenges among which are lack of knowledge on how to utilize the available raw resources, failure to know the modern techniques of extraction of fibers, lack of capital, high prices for weaving materials and competition from imported woven products (Gupta, 2019).

Manufacture of textiles is among the oldest and most important industries in the history of civilization (Monalisa, 2019). The study of textiles begins with the understanding of fibers. Fibers have a long history dating back to pre-historic times where they have served mankind for protective clothing. When humans first domesticated sheep and goats, they found that hides from these animals could keep them warm. However, as time went by, and with the onset of civilization, they began seeking elegance and comfort beyond that smelling hide. At some point in history, man found out that the long thin fibers produced by plants and animals could be twisted together to form a thread. Which threads could then be interlaced to provide a flexible, warm and supremely comfortable material: he had discovered cloth.

With continued civilization, consumers are now very keen on certain elements of the new textile products and top on the list is the utilization of the green and renewable resources (Akampumuza, Wambua, Azzam Ahmed, & Qin, 2017). Green marketing has pushed for the utilization of environmentally safe products and processes that minimize harm to or improve the physical environment. This coupled with the new directives on recycling, health threats from the use of synthetics, social influence, and change of cognitive values: have led the consumer towards environmentally friendly products.

To be used as woven or knitted textile materials, natural fibers are spun into yarn which are then woven or knitted to form fabric. As a sustainable resource, natural fibers can be used without depleting or damaging the environment. They are cheap, abundantly available, renewable, biodegradable, permeable, light weight, user friendly and carbon neutral (Shekar & Ramachandra, 2018).

Khan & Abdul, (2014) due to these sustainable benefits, there has been an urgency to use them for the majority of textile give indicates how the level of contamination from industries processing synthetic fibers is even higher despite the fact that the textile industry has long had a reputation of generating toxic effluents. Besides these benefits, natural fibers boast of good noise absorption properties and are beginning to replace man-made fibers in the automotive interiors (Thilagavathi, Pradeep, Kannanian, & Sasikala, 2010).

Natural fibers have also shown the capacity to block the UV radiation and can easily make flame retardant fabrics (Ranjan, 2010). Since they are absorbent, natural fibers can be properly dyed and their strength is highly recommended for textile production. Of these lesser utilized textile fibers, Cyperus papyrus is of the most interest in this research. It is a species of aquatic flowering plants that belongs to the sedge family Cyperaceae. there are other various species of papyrus like the spruce, master class papyrus, and the Egyptian papyrus among others.Table 1 below. It is a tender, herbaceous plant and features grass like clusters of triangular green stems arising from thick, woody rhizomes (Jones & Muthuri, 1985). It grows to a height between 4 and 5m and takes about 6–9 months to mature with a highly reliable natural regrowth and replenishment.

Class	Name
Common name	Papyrus .payprus sedge
Kingdom	Plantae(plants)
Family	Cyperaceae
Genus	Cyperus
Order	Cyperales
Species	Cyperus papyrus
Habitats	Often forms vast stands in swamps, shallow lakes and along stream lakes and along stream banks throughout Africa.it is considered a weed in the Sudan, Dahomy and Egypt.

Table 1: Classification of Cyperus papyrus

Source; The potential use of Cyperus papyrus Michael B Jones 2016

In addition to being a suitable weaving material, Cyperus has shown potential for use as a biofuel for cooking and heating on converting it to a suitably combustible form, such as compressed or carbonized briquettes (Jones & Muthuri, 1985).

This plant has tremendous uses not limited to; it can be browsed or cut for livestock feeding, paper made from dried, pressed and woven strips of Culm pith had been used since 3500 BCE to make paper by ancient civilizations in Egypt and the Mediterranean basin. The ancient Egyptians used the stem of the papyrus plant to make sails, cloth, mats cords, and above all, paper made from papyrus was the chief writing material in ancient Egypt, was adopted by the Greeks and was used extensively in the Roman Empire.

Worldwide, there were other natural fibers such as cotton, wool, silk and linen which were renewable and biodegradable resources. While they were more expensive than Cyperus Papyrus, the researcher chose to use Cyprus papyrus because it was more sustainable and have less impact on the environment which has not been utilized locally. The cyperus papyrus plant is commonly regarded as a useless shrub while other locals use it as a flower in their compounds

This research is aimed at affirming the feasibility of Cyprus papyrus as a viable raw material for the fabrication of woven textile products, and providing hand weavers with an extra option of low-cost materials for the production of hand-woven textile products. It will further improve on the study of weaving in institutions since it allows the students to interact with the environment hence becoming more creative.

1.2 Statement of the problem

Whereas the production of textiles uses two types of fibers which include natural and synthetic, most industries are currently producing synthetic despite their problems associated with environmental degradation. The production of synthetic fibers is associated with pollution of the environment since most of them are non-biodegradable. Most of the people who reside in the proximity of textile industries that fabricate synthetic fibers complain of health effects such as skin, eye and respiratory irritations. On the other hand, high costs of importation and manufacture of synthetic fibers have also led to stagnation of textile cottage industry and increased costs of the final products yet hand weavers can prepare and use natural fibers in production of textile products which are organic and based on the community narratives hence improving their livelihoods. More so using natural fibers would strengthen the aspirations of sustainable development goals (SDGs) such as creating jobs for all to improve living standards and providing sustainable economic growth (Goal 8). It would also generate employment and

income through innovation leading to achieving (Goal 9). The current study therefore identified Cyperus papyrus plant currently being used as an ornamental plant as a source of strong resilient natural fibers that have the potential of making excellent hand woven textile products.

1.3 Purpose of the study

The purpose of the study was to extract and apply Cyperus papyrus fibers in production of hand woven textile products for home use

1.4 Objectives of the study

The objectives of the study were to;

i. Explore the possibility of extracting natural fibers from Cyperus papyrus plants.

ii. Examine the suitability of Cyperus papyrus yarns for textile use.

iii. Produce Cyperus papyrus hand woven samples of various products for home applications.

1.5 Research questions

1. How can textile fibers be extracted from Cyperus papyrus plant?

2. What is the suitability of Cyperus papyrus fibers for textile use?

3. How can Cyperus papyrus fibers be used in the production of hand woven products for home use?

1.6 Scope of the study

This study consisted of the geographical scope, content scope and time scope: which were precisely translated as a description of where it's going to be carried out, what it was about and when it took place. All these aspects based on the three study objectives in order to achieve the purpose of the research.

16.1 Geographical Scope

The study was conducted from the department of Art and Industrial Design (DAID) in Kyambogo University and TEXFAD, a hand weavers' community-based organization in Sonde, Mukono district. These two choices were made based on their known concentration of hand weavers and the availability of the Cyperus papyrus plant. The DAID was relevant since it has students who offer the weaving course in various study programmes. On the other hand, TEXFAD in Sonde Mukono district is a fast-growing community organization that employs young hand weavers. It mostly specializes in weaving using banana fibers. These weavers were deemed the most resourceful for this study, since they taught and did business at the same time.

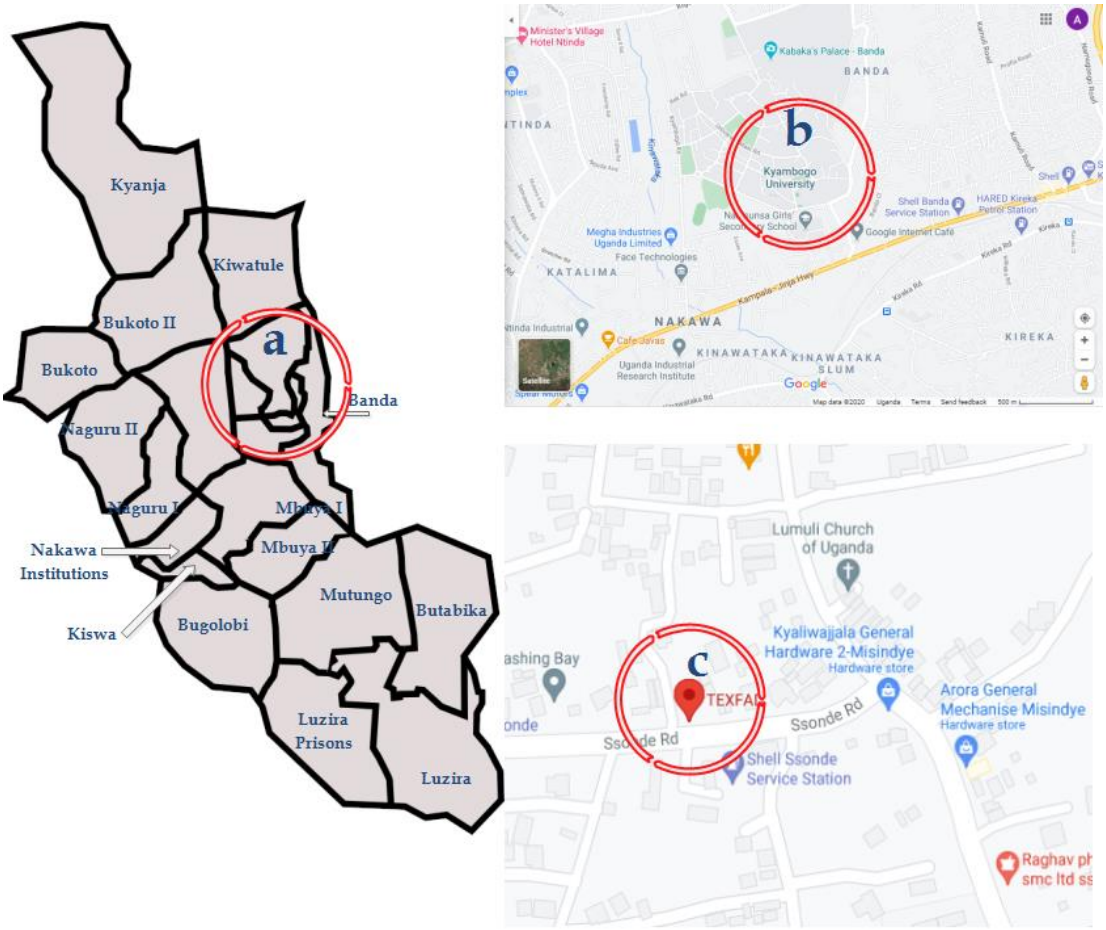


Figure 1: Geographical scope showing, (a) Map of Nakawa division, (b) Google maps of Kyambogo University and (c) Google maps of Sonde Mukono from where the samples were collected.

Source: Google maps

1.6.2 Content scope

The content of this research was on extracting natural fibers from the Cyperus papyrus plant which would be examined to verify their suitability for textile use. Content of weaving as a discipline with its detailed aspects such as materials, tools, and techniques was important in this study. The extraction methods of natural fibers which were both manual and automated were studied. Samples of hand-woven products were also produced using Cyperus papyrus fibers.

The research intended to test the suitability of the Cyperus papyrus fibers in various ways including spinning, dyeing weaving and fiber strength. The study findings were to enhance the textiles in weaving communities at cottage level. In addition, hand weavers would learn to make various woven products for home use from the Cyperus papyrus fibers.

1.6.3 Time scope

The study approximately took two years, from January 2019 to April 2021. This duration was considered sufficient to afford the researcher enough time to extract fibers from Cyperus papyrus, test their suitability through twisting, spinning, dyeing, and weaving them. It's also during this period that the research report was written.

Despite this prior planning, during the study, Uganda like all other countries in the world experienced the COVID-19 pandemic. As a result of this, most of the research activities were not done on time

1.7 Significance of the Study

This study will benefit various categories in and outside the textile industry in many ways as elaborated below;

The findings of this research are expected to be relevant for all hand weavers since the study will provide more fresh enlightenment on the benefits of natural fibers, like low cost, availability and renewability. Hand weavers will get to know that Cyperus papyrus plant in their localities which was looked at as a shrub actually had strong fibers that could be used in their weaving. This will also lead to achieving goal 8 of the SDGs which is generating employment and income through innovation.

This study will help students offering textiles in learning institutions where they would creatively interact with their environment and know that they can use fibers from their localities without actually buying synthetic fibers.

The project shall benefit the community since the use of Cyperus papyrus derived natural fibers will reduce on the environmental hazards that had been on the rise with the increasing use of synthetic fibers.

As far as policy makers are concerned, this research is of great importance since it helps the conservation of the environment in advocating for use of natural fibers which are biodegradable and environment friendly as compared to use of synthetic fibers.

Limitations

Various factors that hindered the research included:

For every research to be successful there needs to be enough funds which facilitate research activities like printing draft copies, transport, logistics for people involved in the research like hand weavers, tests of the fiber among others. The researcher being self-sponsored incurred a lot of expenditure all by herself.

Most of the activities in this study needed a lot of time for example fibers would be left to dry before being woven. This caused delays in other research activities.

Towards the end of the research, the world was hit by the Corona pandemic which led to the closure of all the educational institutions including Kyambogo University. The lock down of all people also affected the hand weavers from the community and this had a negative impact on the research activities.

DEFINITION OF OPERATIONAL TERMS

Cyperus papyrus: A species of aquatic flowering plant belonging to the sedge family. **Cyperaceae:** It is the main material of the study because the fibers were extracted from its plant stems.

Dyeing: dyeing is the application of colour pigments on textile surfaces. In this study colour pigments were extracted from fruits and locally obtained dyes.

Extraction: In reference to fiber processing, extraction is the process of getting fibers from the fiber bearing plants.

Fabric construction. This is art of arranging yarns to make a fabric. It may be by weaving as in this study or other forms like knitting or bonding.

Fibers: these are thread like small long thin strings that are used in formation of textiles. Fibers when combined together form yarn.

Filament: these are very thin strand that forms a fiber when joined together.

Spinning: This is the act of twisting fibers to form yarn. In this study fibers were twisted both by hands and by a spinning wheel.

Weaving: it's an art of interlacing two sets of yarns usually referred to as the warps and the wefts to form a fabric.

Textiles: refers to products of fiber fabrication, these can be woven or knitted fabric, non-woven fabric.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

Over view

This chapter presents a survey of literature and theoretical viewpoints underlining on the extraction and application of cyperus papyrus fibres in hand weaving. Literature reviewed was based on the three study objectives which were natural fiber extraction, fiber suitability for textile use and production of Cyperus papyrus hand woven products for home use. The study theory was also reviewed. “Related literature about the structure of natural fibers, processes of obtaining it like extraction, spinning, dyeing and weaving discussed in this chapter was from other fiber plants like banana, sisal, and pineapple”. It includes, among other things, academic research, dissertations, papers, journals, and websites, as detailed below.

2.1 Theoretical framework

The sustainable development theory by Rachel Emas, (2015) guided this study. It focuses on planning the actions necessary for promoting the interaction between man, nature and the environment. In the framework of sustainable. This theory help countries grow in ways that adapt to the challenges posed by climate change which will in turn help to protect important natural resources for ours and future generation. It posts that “development should be able to meet the present needs without compromising the ability of the future generations to meet their own needs.” The theory aims at maintaining economic advancement and progress while protecting the long term value of the environment.

This theory posts a desirable future state for human societies in which the living conditions and resources meet human needs without undermining the sustainability of natural systems and the

environment so that the future generations may also have their needs met. The sustainable development theory aims at maintaining economic advancement and progress while protecting the long-term value of the environment. It provides a framework for the integration of environment policies and development strategies (United Nations General Assembly, 1987).

Porter and Van der Linde theorized that pollution is a sign of inefficient resource use. Therefore, win to win opportunities for the environment could be captured through improvements and innovations which reduce pollution in production processes (Porter & Van der Linde, 1995).

The researcher finds this theory very relevant to the utilization of Cyperus papyrus fibers (a natural resource) for textile applications. Recently, the massive utilization of synthetic fibers in the textile cottage industry is a serious threat to the environment. Since they are produced through chemical processes, synthetic fibers are not safe for the producers and users; irritating the skin, and sometimes resulting in skin cancer. The fact that these fibers are not biodegradable means that on disposal, they can only harm the environment. However some fibres like cyperus papyrus was used by the researcher due to its texture of long lasting and was not harmful to the users and the environment.

The theory also looked into the agenda of the UN (2030) sustainable development summit which was to provide answers to issues of economic, social and environmental development. In the research study, hand weavers will start using these locally available natural resources that are much more sustainable without high costs since these fibers can be extracted using hand and manual extraction. The hand weavers through producing natural hand-woven products are going to locally grow the textile cottage hence environmental and economic development given the great advantages of natural fibers above synthetic fibers. Natural fibers

are classified in three categories depending on their sources. Plant fibers are obtained from different parts of various plants like the stems, leaves and seeds. There are also natural fibers obtained from animals such as wool from the sheep and silk from silk worm excretions. Geological processes also give natural fibers such as asbestos.

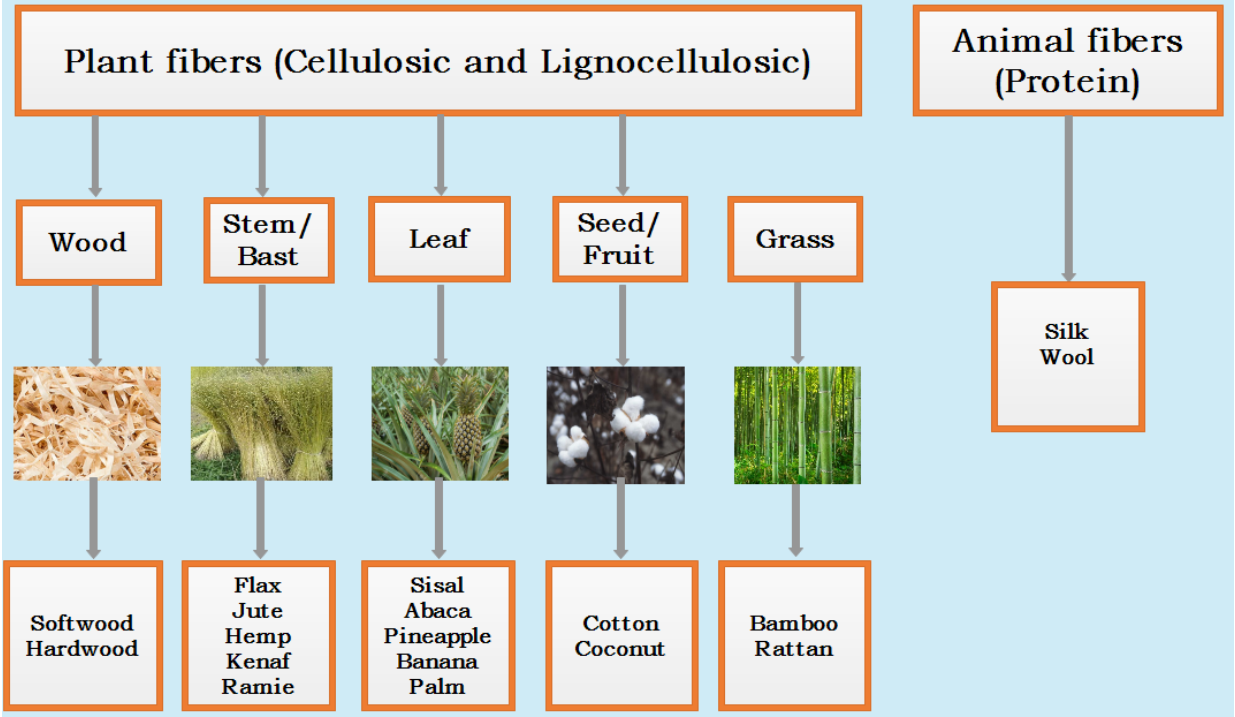


Figure 2: Natural fibers classified according to their sources

Source: Classification of natural fibers (Kozlowski & Mackiewicz-Talarczyk, 2020)

2.3 Fibers in textiles.

Fibers are the basic building blocks of fabrics (Zuhaib, M, Wiener, Fras, & Havalka). They further emphasize that fibers must be spun or twisted together to make yarn before they can be made into fabric.

A fiber is any product capable of being woven or otherwise made into a fabric. He further defines it as a pliable hair like strand that is very small in diameter in relation to its length (Mansoor, Javiad, & Moiz, 2019).

Mansoor agrees with Z. Ahmad that fibers are fundamental units or the building blocks used in the making of textile yarns and fabrics.

There are various types of fibers which include cellulose fibers like cotton and linen. Viscose fibers are made from cellulose from trees so they tend to have similar properties like cotton and linen. Fibers are the smallest yet most important units of textiles and should be given enough attention since they can affect the end product.

A fiber in detail is like a unit cell that is 1mm to 50mm in length and approximately 10 to 50um in diameter (Seemon, Uma, & Bhagawan, 2011). They have a microscopic tube look which consists of cell walls surrounding a central lumen. The central lumen controls the water uptake abilities of the fiber. Each cell wall of the natural fiber consists of oriented cellulose micro fibril reinforcement which is semi crystalline, incorporated into a matrix of hemicellulose and lignin.

Figure 3: Showing the inside structure of a natural fiber.

Source; Typical structure of natural fibers (Radoor, Karayil, Rangappa, Siengchin, & Parameswaranpillai, 2020).In figure 3 Radoor et al., (2020) illustrated the structure of a natural fiber under a microscope. The fibre structure exhibits, from a structural point of view, certain ability to transmit forces along its length thus reducing the amount of materials required.fibre structure in semi crystalline polymers has been explained based on the degree of molecular orientation, and differences in crystalline structure.

2.3 Extraction of natural fibers from plant materials

Plant fibers include sisal, bananas, cotton, pineapples, whereas animal fibers include wool, silk and hair. Extraction of natural fibers is done by various methods which include using hands, decorticator machine, blunt plates, and wooden pieces (Radoor, Karayil, Rangappa, Siengchin, & Parameswaranpillai, 2020).

During fiber extraction, fibers are separated from the cementing subtonics such as pectin, lignin, or waxes. Most natural fibers are composition of 54-68% cellulose and 32-24% lignin that help maintain their physical structure in real life. However, this assembly has to be disintegrated during extraction to expose fibers that are predominantly cellulosic. Accordingly, appropriate approaches that facilitate this stem break-down are used.

Shuhua (2020) also posts that a number of techniques have been found appropriate in enabling this process and these include, manual extraction [using elementary implements like ceramic plates, wooden boards or coconut shells], mechanical extraction using the decortication machine, chemical extraction using the likes of sodium hydroxide (NaOH), hydrogen peroxide (H2O2), sodium hypochlorite (NaClO), sodium chlorite (NaClO2), sodium perchlorate and benzoate, and bacterial extraction by retting. The selection of the most applicable process for the extraction of these vegetable fibers is of great importance as it determines the quality and yield of the extracted fibers. Extraction needs to be done methodically so that the production cost is not affected and the fiber quality is not compromised. Below are some of the common techniques of natural fiber extraction.

2.3.1 Manual Extraction

This is at times referred to as the hand extraction method. In this approach, traditional, simple and elementary methods are utilized to extract fibers from plants. Simple implements like ceramic plates, serrated and non-serrated knives, small wooden boards, and coconut shells are used in the process.

This method of extraction is most suitable for use by artisans in the cottage industry sector since it doesn't require use of electricity .Also, despite being labor intensive, it is cost effective (Jose, R, & Ammanyappan, 2016).

Taha et al., (2019) in a study to evaluate the technological and fungal infestation properties of swamp papyrus, manually extracted these fibers by peeling the stems to remove the green outer rind. Then, the exposed fibrous pith was cut lengthwise into thin strips of about 40 cm that were hammered to form fibers.

On the other hand Hoque, (2016) pineapple leaf fibers can be freed out of pineapple leaves by gently scraping the leaves with a ceramic plate whereas the manual extraction of banana fibers is commonly done by initially cutting the stripped leaf sheath to a size of 0.3–0.4 m long and 0.07 m wide, one by one laying them on a soft wooden plank and then scraping them by hand using 0.15 m long blunt blades.

Chand and Fahim, (2020) continuously gently removed the pith to give clean fibers, with the fresh pseudo stems yielding fibers which were 15 % of the pseudo stem weight.

Fibers can be extracted from fresh sisal leaves by squeezing them between two sticks to break the tissue after which they can be washed with water and dried for use in yarn formation.

Sisal extraction has a structure similar to that of the Cyperus papyrus stems which offers the possibility for technology transfer (Zimniewska, Frydrych, mankowski, & Trywianska, 2013).

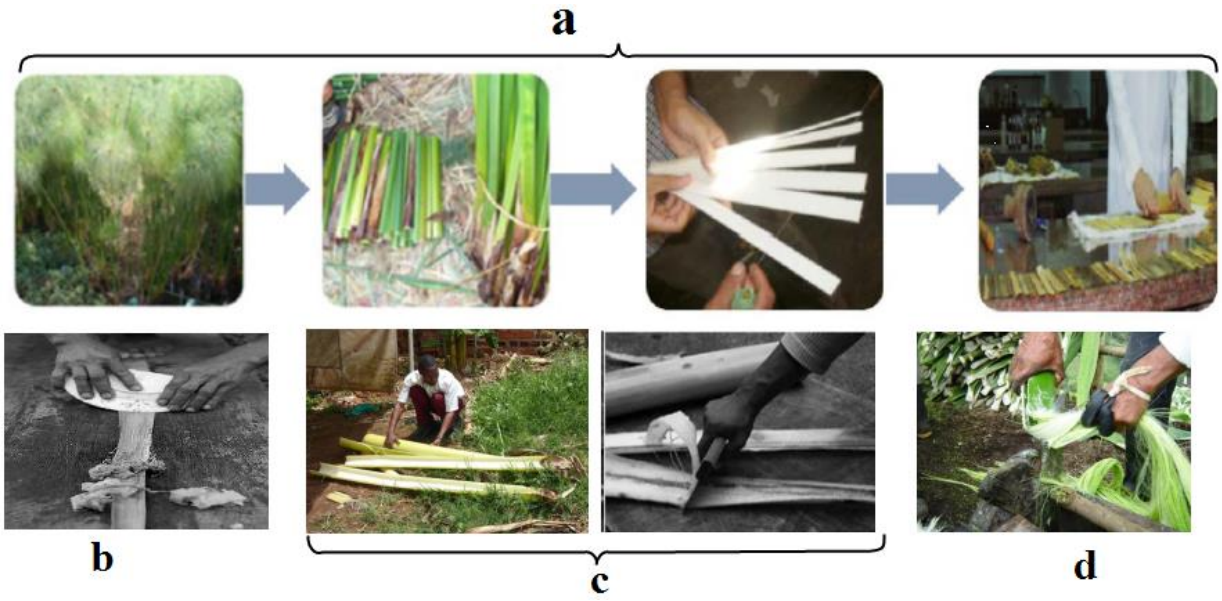


Figure 4: Manual extraction (a) of swamp papyrus fibers by hammering the pith (Taha et al., 2019), (b) pineapple leaf fibers using ceramic plates(Nasir Uddin et al., 2017), (c) banana fibers by stripping the leaf sheaths and using blunt blades Gebai et al., (2018)

Source; A review on extraction and application of pineapple lea f fiber in textiles and other fields, and properties of papyrus.

In figure 4, various fibers are be being extracted using different methods of hand extraction. In (a) papyrus is in its habitation, the stems are cut and collected, and fibers are separated using hands. (b) Shows extraction of fibers using an old ceramic plate whereas (c) and (d) show banana stems being prepared for extraction using a blunt knife.

2.3.2 Mechanical process

Whereas the hand extraction methods are economical, they are at the same time labor intensive, time consuming and often offer limited and poor-quality yields. For this reason,

cottage managers have had to utilize mechanical extraction approaches to separate fibers from the binding elements in the relevant plants stems.

A decortication machine that could be used in performing this process was fabricated by (Subagya & Chafidz, 2018). This was typically made up of feed rollers, leaf scratching rollers and serrated rollers.

Materials are fed through the feed roller and then passed through the scratching roller. The upper surface of the material undergoing extraction is first worked on by the scratching roller blades which remove the waxy layer and then passed through the serrated roller where the closely fitted roller blades macerate it. The machine has three rollers, the feed roller, stalk scratching roller and the serrated roller .The stalks were fed through the stalk feed and then crushed before the fibers could be obtained. A machine extractor extracting banana fibers is shown in fig 5.

Figure 5: Banana fiber extracting machine

Source; Banana pseudo stem fiber; preparation, characteristics and applications

Kumar and Suganya (2017) also post that bast fibers obtained by decortication are thick, too strong, non-divisible and long enough to sustain any textile application.

The softer part of the plant is peeled off and fibers remain. The fibers are then washed and dried. Proper drying is important as fiber quality depends largely on the moisture content.

(Subagyo & Chafidz, 2018) elaborates a detailed description of the decorticator by showing its inner parts and how they contribute towards fiber extraction. In fig 6 a plant material is shown being fed into the machine through its mouth piece and then the rollers and beater and finally split fibers are obtained.

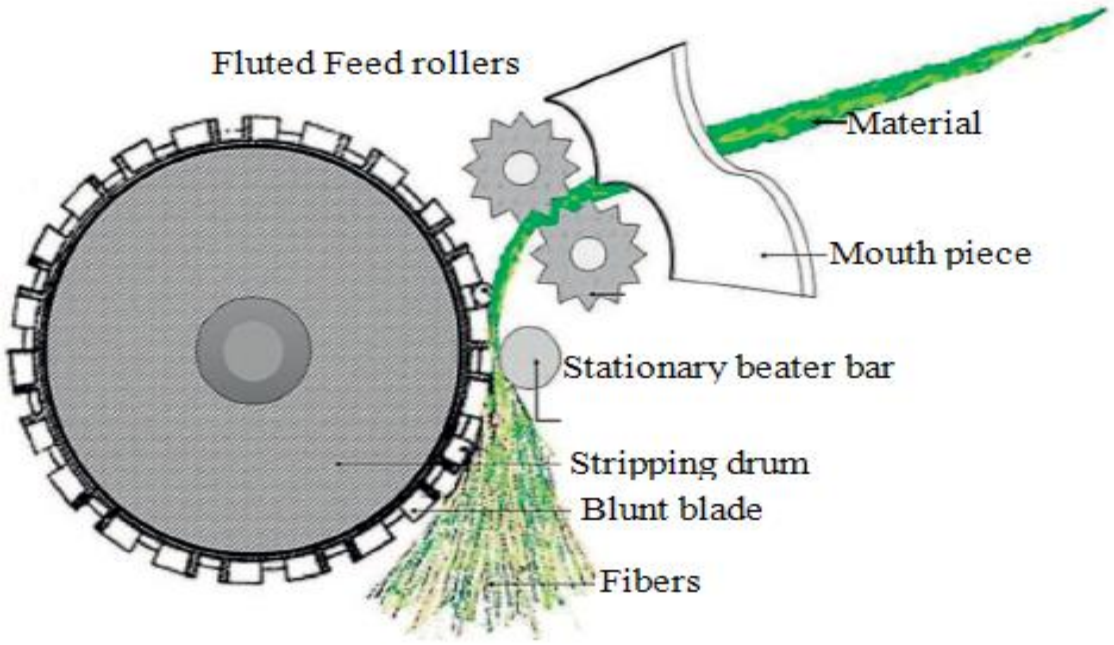


***Figure 6: Schematic diagram of a typical natural fiber decorticator* (Subagyo & Chafidz, 2018).**

Source: Banana pseudo stem fiber; preparation characteristics and application.

2.3.3 Retting (bacterial extraction)

Retting is the microbial freeing of plant fibers from the surrounding plant components which help to hold them together. When fibers extracted in this way, the non-fibrous elements acting as glue in Cyperus papyrus stems, banana leaves, sisal leaves, pineapple leaves, and bamboo stems are degraded without damaging the fiber cellulose (Hulle, Kadole, & Katkar, 2015). Retting microbes consume these non-fibrous cementing materials that are mainly pectin and hemicellulose. This microbial deterioration gradually softens the leaves by dissolving the less resistant intercellular adhesive substances. When fermentation has reached an appropriate stage, fibers are separated quite easily from the leaves. The process allows for the easy separation of individual fiber strands and the woody core. Since retting is a biological process, it requires both moisture and warm temperature for microbial action to occur. Some of the common retting methods are: water retting, dew retting, enzymatic retting and chemical retting. Lee et al., (2019). did a comprehensive exploration of the characteristics of these retting procedures and gave the summary in table below;

Retting Methods	**Description**	**Advantages**	**Disadvantages**	**Duration of Retting**
Water Retting	Plant stems are submerged in water and checked periodically	Produces retted fibre with good uniformity and high quality	Severe pollution issues arising from anaerobic bacterial fermentation, putrid odour, environmental problems and high cost. May requires intense treatment on wastewater.	7-14 days
Dew Retting	The Plant stems are spread evenly on fields to receive sufficient sunlight, atmospheric air and dew for fungal colonization which breaks down the cellular stem	Pectin materials are easily removed	Product is contaminated with soil, restricted to certain climatic conditions and produces inconsistent quality.	2-3 weeks

	tissues and adhesive substances to release single fibres			
Enzymatic Retting	Enzymes hydrolyse gum and pectin material in the stem.	Specific properties can be achieved for different application by varying retting period and type of enzymes used. The process is cleaner and faster.	Low fibre strength	12-24 hours
Chemical Retting	Hydrogen peroxide, sodium benzoate and sodium hydroxide are commonly used in chemical retting.	Smooth and clean surfaces are possible.	Fiber strength deteriorates when the concentration of NaOH is more 1%	60-75 minutes

Table 2: Retting methods

Source: A comprehensive review on Bast fiber retting process for optimal performance in fibers reinforced polymer composites by (Lee, Khalima, Lee, & Liu, 2020)**.**

2.3.4 Chemical extraction

In other instances, chemicals have been used to dissolve pectins, waxes and water-soluble substances, helping to extract fibers from fibrous materials. Fibers could be extracted from fresh lotus stems by either treating them with sodium hydroxide (NaOH) followed by microwave irradiation or treating them with hydrogen peroxide (H2O2) followed by microwave irradiation (Cheng, Guo, Lan, & Jiang, 2017).

A gradual change was observed in the chemical composition of stems with the increase in treatment time. It is evident that the content of cellulose kept going up with increasing treatment time as the other non-cellulosic components reduced. It has to be noted that cellulose is the most desirable component in spinnable fibres.

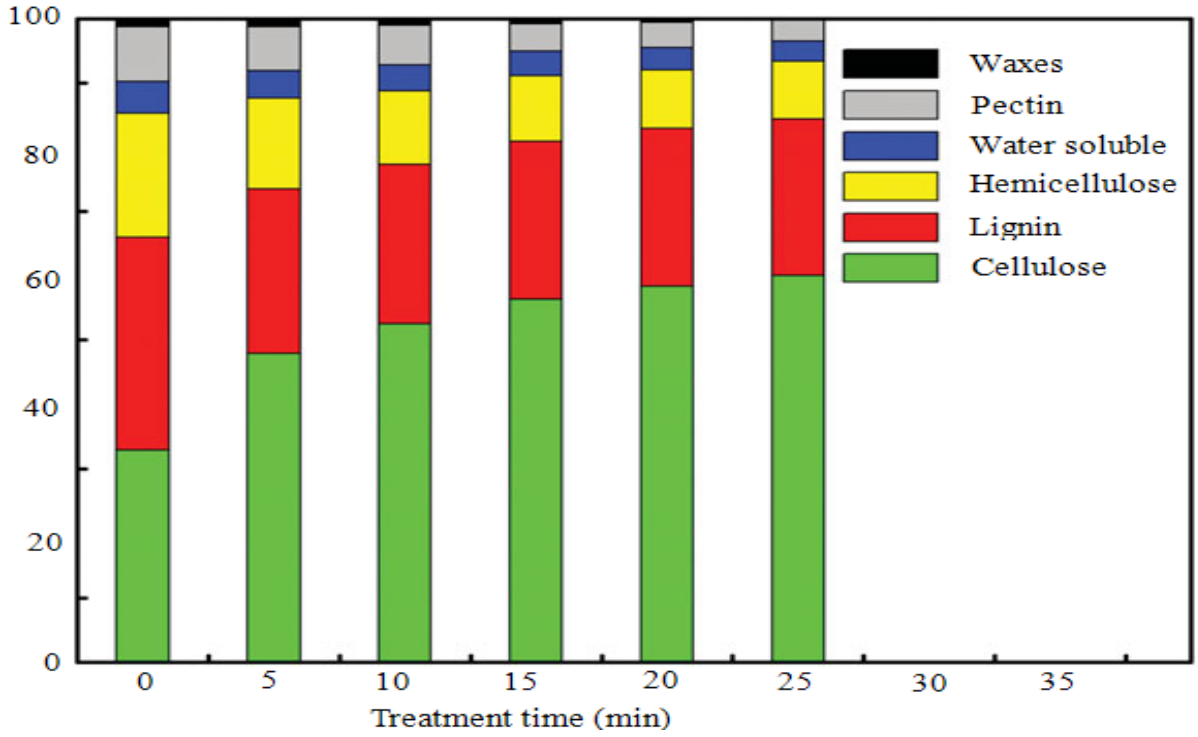


***Figure 7: Composition of lotus fibers as they are treated with hydrogen peroxide* (Cheng, Guo, Lan, & Jiang, 2017).**

Source; Extraction of lotus fibers from lotus stems.

Textiles/fabrics are made by directly bonding staple or filament fibers together by thermal, chemical or mechanical means. This method was however not tried out by the researcher because the study looked so much at using locally available resources that would be convenient for the hand weavers and students offering weaving in institutions.

Related literature on the possibilities of extraction of natural fibers gave various methods for extraction which included hand extraction and machine extraction of natural fibers. Natural fibers such as banana, sisal and pineapple were already being extracted using these methods. This positively contributed to the success of the first research objective since Cyperus papyrus fibers could easily be extracted from the Cyperus papyrus plant.

2.4 Exploring the Suitability of natural fibers for textile application.

Karimah (2014) submits that sustainability is a leading characteristic of textile products today. He further puts that natural fibers are suitable since they provide solutions regarding environment problems like air and water pollution which has become a big challenge in the textile industry. Natural fibers are very suitable for textile use since they easily absorb water they are naturally repellant to mold and dirty, the moisture wicking abilities allow ventilation through the fabric to pull dampness away from the skin.

Very many features that make natural fibers very suitable for textile use and these include the following (Kozlowski & Mackiewicz-Talarczyk, 2020). They argued that natural fibers easily absorb water due to the presence of hemicellulose that give hydrophilic properties that make them less compatible in the interaction with matrix with hydrophobicity properties. Their higher cellulose content and crystallinity tend to result better strength properties of the fibers. Fiber

anatomic characteristics vary between different and same species and this affects the density and mechanical properties.

Malgorzata Zimniewska et al. (2016) say that natural fibers can compete and co-exist within the 21st century with man-made fibers especially as far as quality, sustainability and economy of production is concerned. The essential requirements of fibers for textile use are ability to be spun into yarn, length of at least millimeters, flexibility, cohesiveness and sufficient strength. Other important features include fineness, uniformity, durability, dye ability and elasticity.

Suitability of fibers for textile application may imply their ability to be spun into yarns that can be feasibly processed into textile materials (Ghanhi, 2019). The ability of fibres to absorb and hold dye was also important.

2.4.1 Spinning

Spinning is simply the twisting of fibers together to make a strong usable cord. It is the primary fundamental process in the making of the cloth which involves a conversion of mass short fibers into long yarns suitable for weaving cloth. In hand spinning process the yarn is made by rolling fibers between the palms of the hands. Drop spindle method is a type of spinning where a straight spike made out of wood is used. It is often weighted at either the bottom, middle or top by a spherical object called a whorl. It usually has a hook, groove or notch at the top to guide the yarn. They derive their name from the fact that a spindle is allowed to drop while the thread is formed allowing a greater length of yarn to be spun before being wound on the bobbin, noted (Kennedy, 2012).

Ring spinning is another method that helps spinning of fibers. In this method a spinning wheel machine made out of wood is used. It is a fundamental device used to spin fibers into yarn commonly in the cotton textile industry before the industrial revolution. It laid the foundation for later machinery such as the spinning jenny. A spinning wheel was first invented in India. A spinning wheel incorporates a bobbin on which yarn is wound continuously. The distaff on which the raw fiber held became a stationary vertical rod and the wheel was actuated by a foot treadle thus fleeing both of the operator's hands.

Figure 8: Spinning fiber using a spinning wheel

Source: istockphoto/ David Mantel

2.4.2 Dyeing of natural fibers

Dyeing is the coloration of fibers, yarns, threads or textiles (Finlay, 2014). The dyeing process is as old as textiles and this is collaborated by the unearthing of records of the use of natural dyes dating as back as 2600BC and mummies that were found wrapped in dyed cloth. In

the normal dyeing process a specific chemical is used at the right temperature to dye the yarn. Natural dyes are got from plants, soil, fruits seeds are known to produce appealing colors on fabrics. Plant materials have been known to color objects since the prehistoric (Tabrej, Mohamed, & Ahmad, 2018).

Toxic and allergic reactions of synthetic dyes have compelled people to start looking for options which are natural dyes (Gupta, 2019). Natural dyes can be obtain from various plants, fruits, roots and seeds depending on the color pigment such as purple from purple cabbage, deep red from beet root, red from the hibiscus and brown from tea among others.

Figure 9: A picture showing various colors got from natural dyes

Source; Fundamentals of Natural Dyes and its Application on Textile Surfaces by (Gupta, 2019)***.***

Natural dyes are a renewable resource of coloring materials. They have no health hazards, are easy to extract and are highly sustainable. The intensity of a color shade varies from plant to

plant. For example, black berries give a deep blue, beet root gives a deep red while spinach leaves give green. Literature on the suitability of Cyperus papyrus fibers for Textile use was reviewed according to its spinnability and dyeability. Related natural fibers like sisal, pineapple, and banana were studied. All literature proved that it was very possible for natural fibers to be spun using various methods and also had the ability to withhold dye.

2.5 Exploring sample products of hand-woven products from natural fibers

Kozlowski and Mackiewics (2012) recorded that natural fibers have been used to make a wide range of products that have a long history of serving mankind. They note that for thousands of years, the usage of fiber set human needs ranging from clothing, storage, building materials and day to day use items such as ropes and fishing nets.

Natural fibres are famous for making various products for different functions. They can be processed for use in carpets, yarn, rope, geotextile (netting or matting), traditional carpets, hessian or burlap, paper, sacks, etc. Bast fibers are also used in the non-woven, molding, and composite technology industries for the manufacturing of non-woven mats and carpets, composite boards as furniture materials, automobile door panels and headliners, etc. Some of the cellulosic minor fibers have been given below.

TEXFAD, an organization focused on developing banana fibers as a resource for textile development, has taken an aggressive effort to ensure that banana fibers don’t go to waste. This way, they have demonstrated the feasibility of this natural fiber by weaving it into fabrics using frame looms.

Figure 10: Production of banana fiber yarn that is suitable for weaving into fabric at Texfad

Source: www. Texfad.co.ug

Through this approach, an assortment of textile products for home use, have been successfully produced and some of these include door mats, table mats, shoes and bags. In addition, one of the most utilized approaches to improving the utility of textile fibers is often via blending. By combining fibers of different origins, desirable characteristics from each of these are integrated to give a better product. This way, at Texfad, they have managed to blend cotton fibers with banana fibers in a 25% ratio, forming a fabric softer than what could be achieved with 100% banana fibers.

In the recent past there was a resurgence of interest in the use of natural fibers due to increasing ecological considerations availability and good textile properties (Sanjay, Arpitha, Laxmana, & Gopalakarikishna, 2016).

Thyavihalli (2019) mentions that Natural fibers are used to produce a variety of products such as particle board, medicine building materials, decorative pieces for interiors such as carpets and wall hangings, door panels, storage bags among many others. He further says most of these products are hand crafted by weavers on a small scale for purposes of earning income or to satisfy their daily home needs. In learning institutions like Kyambogo University most of the woven products were being done on wooden hand looms and frame looms. Thadikkaran (2012) urges that most of the natural products obtained from fibers depend on the nature of those fibers.

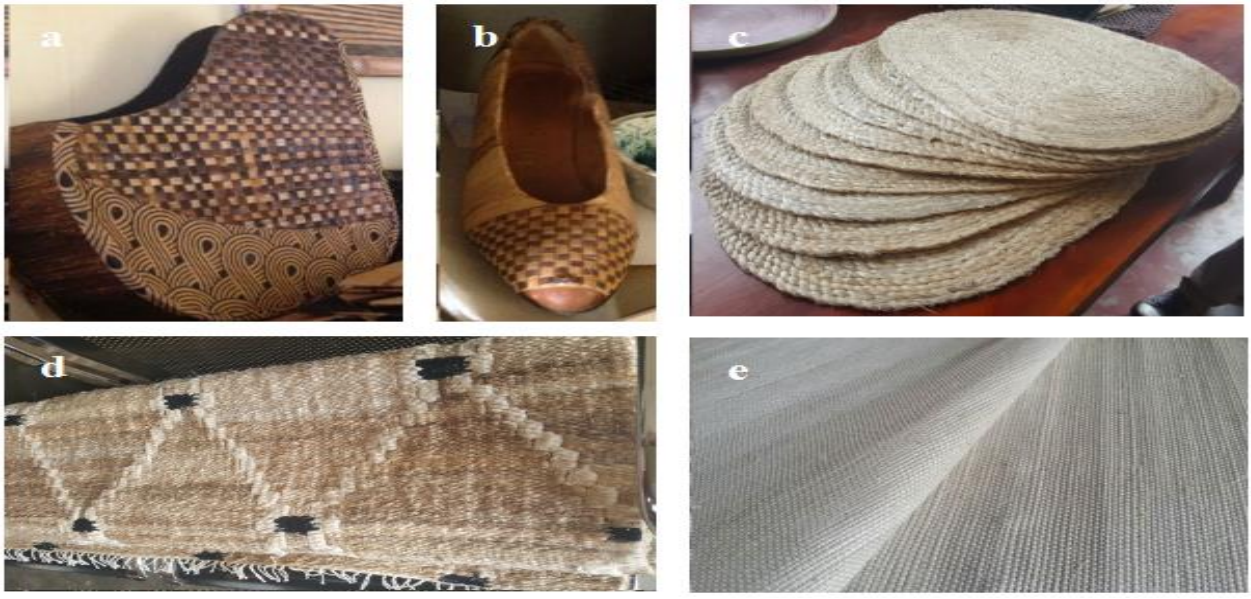


Figure 11: An assortment of products got from banana fibers (a) fashionable bag, (b) fashionable shoes, (c) a round rugs, (d) an ordinary rug and a woven fabric obtained by blending banana fibers and cotton in ratios of 75 and 25%:

Source; www.texfad.co.ug

Pineapple leaf fibers used in constructing underwear had high strength, small elongation, and large elastic modulus ((Gao, Zhuang, Li, Zhang, & Lian, 2015). In general, its spinnability and yarning quality were found to be superior to jute and inferior to flax. In addition, an

examination of water absorption and moisture permeability of pineapple leaf fiber underwear gave values that fulfilled the indicators of national textile standard.

Pineapple leaf fibers (PALF) were economically viable if they could be blended with silk waste (Hazarika, et al., 2018). Accordingly, a 90-tex blended yarn developed that was used in the production of a fabric on a traditional handloom using 2/40-s cotton as warp and blended yarn as weft. The quality parameters of this fabric that included tensile properties, crease recovery, fabric cover, stiffness, drape, and thickness were found to meet the essential apparel requirements. On the other hand, when a range of products that included a kurti, a jacket and a female dress, were produced from this fabric and subjected to comparative evaluation using a people from different age groups, educational, and occupational background,. It was concluded that the appearance was excellent whereas texture and luster were from medium to moderate. The only reported drawback was the crispness in the fabric.

Figure 12: Products of pineapple leaf fibers
Source; Development of apparels from silk waste and pineapple leaf fiber

All reviewed literature from various scholars showed that natural fibers had been used, were being used and would still be used for various applications all over the world. This positively contributes to the success of this research since Cyperus papyrus fibers would be used as a natural fiber for hand weaving a variety of home use products.

In summary, related literature confirmed that the study objectives of this research were achievable. The first objective which was to explore the possibilities of extracting natural fibers from the cyperus papyrus plant was very possible because plants with similar fibers like banana and pineapple had been extracted using the decorticator and knives. Various fibers had also been dyed and spun using a variety of natural dyes. Literature also confirmed that natural fibers like pineapple and banana could be woven to form various textile products.

CHAPTER THREE: METHODOLOGY

3.0 Overview

This chapter explains the procedures utilized in this research study to collect data obtained from shared narratives on extraction and application of cyperus papyrus fibres in hand weaving. It contains the research design, area of study, population sample, sampling strategy, methods and tools of data collection, sampling techniques, ethical considerations, validity, and reliability.

This chapter presents the Methodology which was used to collect data in this research to answer the studio guiding questions which were;

1. How can textile fibers be extracted from Cyperus papyrus plant?
2. What is the suitability of Cyperus papyrus fibers for textile use?
3. How can Cyperus papyrus fibers be used in the weaving of hand made products

3.1 Research Design

The study employed a qualitative research design. This design was selected because the study focused on descriptive data with minimal statistical data which was also presented in a descriptive form. The study also used experimental approach to a lower extent which involved testing of the Cyperus dyed fibers and woven fabrics to prove its ability to hold dye. The experiment to test the tensile strength of the Cyperus papyrus yarn was also done in the laboratory. Mitchell (2015) noted that in the experimental research design various trials or experiments are performed to reach the conclusion and they can be conducted basing on some findings from previous forms of research.

Qualitative research involves collecting of non-numerical data like texts, videos or audios to understand the concepts, opinions and experiences. The study took into consideration the

participants' responses and observed results of studio experimentation which could not be expressed statistically. The research design was suitable for this study since the researcher intended to know why students and hand weavers were not using the locally available natural fibers for making suitable textiles.

Studio experiments were effective in the study because many experiments were done especially in confirming the suitability of the Cyperus papyrus fibers which involved extraction, dyeing, wash fastness, and its strength properties. The researcher experimented with different dyes and the results were diverse. The experiments that presented best results were considered and recommended in this study.

3.2 Sample size

The sample size of this study involved six hand weavers. Three finalist students offering Bachelor of Vocational studies in Art and Design with Education (BVAD) majoring in the weaving discipline and three hand weavers from the community were selected to represent other hand weavers. The sample size was considered by the researcher to be efficient and effective since these finalists who had majored in weaving were few in number and they understood the challenges faced by hand weavers at University level and hand weavers at Textile and Fashion Design (TEXFAD) were community based and used natural fibers and already understood the market of these products. Data collected from the students included choice of material for weaving, challenges in accessing natural materials and the type of application done on the materials. The finalist students being teachers to be would also take this knowledge of extraction and application of Cyperus papyrus fibers for hand weaving and disseminate it to various schools hence helping in growth of the textile industry at cottage level. Three hand weavers from TEXFAD participated in the study. TEXFAD is a community based organization that deals in

extraction and weaving of banana fibers and was helpful since the data collected from the hand weavers included fiber extraction, dyeing, spinning and application of natural fiber.

Purposive sampling technique was employed by the researcher in selecting the sample size. The researcher found this technique adequate because it allows a strategic section of respondents who are conversant with extraction and usage of natural fibers and would therefore give relevant information to the study. Participants from BVAD and TEXFAD were selected because they had information on usage of natural fibers for weaving which was so relevant to the study in the table 3 below

Table 3: A table showing the sample size of the respondents and the technique that was used in the selection…

Source: Primary data

Category of respondents	**Sampling technique used**	**Number of respondents**
BVAD students in their final year offering weaving	Purposive sampling technique	03
Community hand weavers from Texfad; a community based organization which deals in weaving	Purposive sampling technique	03

3.3 Data collection techniques

Various data collection techniques were employed in the study and these included observations, photography, in-depth interviews, document review, and studio exploration. All these methods aimed at obtaining relevant information about extraction of natural fibers, their suitability and their application specifically in hand weaving. These techiques were thought to be the best in collecting data for this research because they gave the respondents a chance to express

their views in depth. Document review was also relevant because the information got was compared to the existing literature and this would later give reliable findings. These techniques were based on the three objectives of the study.

3.3.1 Observation

After the harvesting of Cyperus papyrus plants from the available mini plantations, the selection of the most viable to undergo the extraction process was done mostly by visual inspection (observation). After spinning some of the yarn was fit for use in the weaving process and the rest was, all this was also done by observation. In the dyeing processes, observation of the dyed fibers was key since some dyes did not wash out while others did. The research also critically observed the extraction processes of various natural fibers from plants such as bananas and pineapples. All these processes which gave a lot of targeted information on the study were largely attributed to the observation technique. The research partly being a visual art study deemed the observation method relevant. An observation guide was set with targets of answering the three research questions (Appendix 1).

3.3.2 Photography

In this study, several pictures were taken right from the description the Cyperus papyrus plant in its habitation, to the collection and extraction process and finally through all the studio experimentations and productions. The researcher found it a very relevant technique since it helped her keep track of what was already done and what was to be done in the study. Photography was also very important since it helped the researcher to document various sources of inspiration from sketches to real working drawing in the studio and this later helped in coming up with the final products. Use of a digital camera and phone cameras were employed.

3.3.3 In depth Interviews

In-depth Interviews with the hand weavers both from Kyambogo University and from TEXFAD were so instrumental in understanding the respondents' views, their interests, challenges and various approaches as far as hand weaving textiles were concerned. This method was chosen by the researcher so as to get detailed first-hand information from the hand weavers. It was guided by an in-depth interview guide which had a set of questions intending to answer the three research questions of the study (Appendix 11) Respondents gave information about the use of natural fibers and the outcomes and this greatly informed the study. Their views were so relevant in the study since she realized there was an urgent need for use of natural fibers in the hand weaving industry.

3.3.4 Document review

Literature of various scholars on natural fibers, extraction processes, dyeing, spinning, weaving and general hand craft textiles was reviewed. The researcher consulted various written documents, and information on internet to understand and appreciate the discoveries of related fibers such as banana, sisal and pineapple .All the information got paved way for the extraction and application of Cyperus papyrus fibers for hand weaving textiles.

3.3.5 Studio exploration

Studio exploration was a very important method in this research. It was in the studio that the researcher was able to develop sketches and working drawings that helped in the production of final woven products using Cyperus papyrus fibers. Most of the activities of the study like extraction, suitability tests like dyeing and spinning of fibers and weaving the end products were all conducted in the studio. Studio experimentation also involved various experiments which were carried out in the laboratory to test the suitability of Cyperus papyrus fibers. The tensile strength of the fibers to confirm whether the Cyperus papyrus fiber was strong enough for weaving was carried out using a tensometer. Various fibers like cotton and pineapple fibers were also tested in comparison with the Cyperus papyrus fibers. Fiber wash ability was also tested in the textile laboratory to test its capacity of withholding dye after washing. All these tests contributed a lot of relevant data especially to answer the second research question which was to test the suitability of Cyperus papyrus fibers for textile use.

Studio experiments included extraction processes, spinning, dyeing, weaving and finally the laboratory tests for its suitability.

The main material in this study was the Cyperus papyrus plant. The stem part of the plant which is where the fibers are found was of most interest. Other materials such as natural and local dyes were also used in the study. Natural dyes were obtained from fruits and seeds like the beetroot and turmeric.

Figure 13: shows the artistic impression of the Cyperus papyrus plant with its stems and foliation.

Source; drawing by the researcher 2020

Various tools were used in this study especially in studio exploration. The Cyperus papyrus stems were harvested using a sharp knife. The researcher used a sharp knife to cut the stems from its lower most part and to trim off the foliage. A fabricated fiber extractor machine was then used in extraction of the Cyperus papyrus fibers. A wooden mallet, a blunt knife and a ceramic plate were also important tools in hand extraction.

3.4 Instruments of data collection

Research tools such as the observation schedule, check list for photos to take using the digital camera and those which were hand drawn and library search were employed to help in data collection. In addition to the tools, interview guides and digital lab equipment were used to generate data through the tests according to the objectives n research questions

3.4.1 Observation schedule

In order to collect sufficient and credible data to satisfy the three objectives of the study through observation, a guide for observation was developed and this was to help in comparisons from data got from the respondents and what was actually on ground. The researcher participated in this critical observation process following the observation guide that she had formulated basing on the three objectives.

Study objective	**Data expected**	**Relevancy to the study**
1. Extraction of Cyperus papyrus fibers	• Types of fibers used by BVAD students and hand weavers at TEXFAD • Methods of extraction that were being used by the hand weavers in school and in the community	• To find out whether the hand weavers were already conversant with use of natural fibers for weaving.

2. Suitability of Cyperus papyrus fibers for textile use.	• Which dyes were preferred to be used by hand weavers • How the fibers used were being spun	• To find out which best dyes are used for dyeing natural fibers and introduce new knowledge of dying • To identify the most adequate spinning technique for natural fibers

Table 4: Showing the information expected from the observation guide

3.4.2 In depth interview guide

Study objective	Expected information	Relevancy to the study
Extraction of natural fibers	• Natural fibers being used by hand weavers • Methods of extraction being used by the hand weavers in extraction of fibers	• To identify which fibers the hand weavers were already familiar with and establish the gap of introducing Cyperus papyrus fibers • To find out the most

		favorable and convenient method of extraction of natural fibers
2. suitability of Cyperus papyrus fibers for textile use	Which dyes were being used to dye natural fibers by the hand weavers? How were the hand weavers spinning the natural fibers?	To identify which dyes are locally available and can dye fibers evenly. To know the most convenient method for spinning fibers and establish the gap for more methods.

Source: Primary data

3.5 Research Procedure

The researcher sought official permission from the University authorities. An introductory letter was issued by the Graduate School Dean and this was very important as it was presented to the TEXFAD community local chairman and the Director of TEXFAD before the researcher could start interacting with the community hand weavers. This introductory letter introduced the researcher as a student who only wanted information for academic purposes and this made all the respondents comfortable to offer any information. All the data collected from the in-depth interviews, observation, and photography was taken to the studio, analyzed and tested to come up with valid findings.

3.7 Validity and Reliability

In depth Interview guide questions were administered to stakeholders like lecturers, textile researchers and natural fiber hand weavers in business in the textile cottage industry to test the effectiveness of this research instrument and it was proved effective. When woven samples of Cyperus papyrus fiber and yarns were subjected to a textile laboratory, they were presented a huge potential for textile use hence considered reliable. Contradictory information that was found useless was removed. A set of questions that were to be asked in the in-depth interviews was discussed and amended with the university supervisors hence the data got would be reliable.

3.8 Ethical consideration

An introductory letter was acquired from the Director, Directorate of Graduate Research and Training to introduce the researcher to all the authorities that were relevant in the study. The researcher introduced herself to the LC1 chairman of Kyambogo University and Sonde communities and was later introduced to some of the people in these communities especially those that owned the land where Cyperus papyrus plant was in plenty. The researcher also first sought consent from the six respondents in this study before she could interview them. This was through and introduction of herself and request made before she could conduct the interviews. She promised them confidentiality and as indicated in the introduction, the information was used for this study purpose only (Appendix 11).

CHAPTER FOUR: PRESENTATION AND DISCUSSION OF RESULTS

4.0 Overview

This chapter presents the findings of the study in relation to the three research objectives which were exploration of possible ways for extracting Cyperus papyrus fiber, examining the fiber suitability and to produce Cyperus hand woven products for home use. Data was obtained from various methods which included observation, in-depth interviews, photography, and document review and studio experimentation.

4.1 Exploration of possible ways of extracting natural fibers from Cyperus papyrus plant

Cyperus papyrus plant was the main material used in this research and a careful study of how it grew, its features and people's perception about it were considered. The researcher obtained facts about this plant through observation, in-depth interviews, document review, and photography and studio experimentation.

The researcher took time to strategically observe the Cyperus papyrus plants in its habitation. It appeared a beautiful flower like plant which some people grew in their homes for beauty whereas others left it to grow by itself in the bushes as a shrub.

The researcher also visited Sonde where other respondents worked from and various fields of Cyperus papyrus plants were evident. The local people referred to the plant as Entobazi and most of them regarded it as only a shrub that grows in the bushes. By observation the Cyperus papyrus plant had long stems and it could grow up to 50cm tall. Cyperus had green long triangular leaves spread out to form an umbrella like structure. It grew both on land and in swamps. Through the researchers' observation Cyperus papyrus plant had evidently been ignored by hand weavers and other people in the community as any other shrub that is useless in the fields

Cyperus papyrus grew in a bunch of over 20 stems sprouting from one shoot. It could grow both on land and in swampy areas. When cut off, it took two to three weeks to sprout again. Its nature of growth was very favorable for hand weavers.

By observation, mature stems were identified and selected for harvesting since they were longer and had stronger fibers. The leaves were then trimmed off to make the stems ready for extraction.

More information about Cyperus papyrus plant was obtained through in-depth interviews were conducted amongst the hand weavers offering BVAD and from TEXFAD. An in-depth interview guide had a set of questions aimed at collecting data for the three study objective was followed.

Respondent 1 who was a student of Kyambogo University offering weaving told the researcher that she had always seen Cyperus papyrus plant in the compound of Art and Design department but did not know it had fibers which could be used for weaving the researcher.

Respondent 1 had this to say;

"I just see this plant growing in our department. I think it's just for beautifying our compound"

This hand weaver had no idea that for the three years she had been spending a lot of money to buy yarn yet she had abundance of Cyperus papyrus plant in her department which she could have used in her weaving discipline.

Photography is a method that was employed throughout the study. By use of a digital camera the researcher took photos of the Cyperus plant in its inhabitation and throughout all the research proceedings. Through photography the features of Cyperus papyrus like the long strong stems were evidently displayed and all this greatly influenced other research proceeding so helpful especially in the studio. Photography also helped in recording of data at this initial stage of the study.

Figure 14: Photos showing Cyperus Papyrus plant in its inhabitation.
Source; Primary data

Various documents were also reviewed to get more information about Cyperus papyrus as a plant in regards to being a fiber plant. Some scholars had written about it as a useful plant in creation of biomass fuel and exposed a gap of its fibers being tried out for textile use.

The researcher developed all sketches in the studio to clearly elaborate on the physical description of Cyperus papyrus plant to clearly bring out the long stems which were of interest in the study since they harbor the natural fibers.

Through studio experimentation the researcher discovered that the rind region of the Cyperus papyrus when split contained compact fibrous bundles and a discontinuous patch of fibrous sheath. The thick walls of the fibers indicated a high slenderness that was indicative of tear resistance. The tenacity and percentage elongation of the split culm was also high and this implied high strength of the strands.

Figure 15: An artistic drawing of the Cyperus papyrus plant showing the split stems to expose the fibers.

Source; Primary data

With the help of studio experimentation, the researcher still came up with more detailed drawings as in figure 15 showing the stems and the inside part which had the fibers. These drawings were done on paper using drawing crayons and a sketching pencil.

The researcher conducted in-depth interviews amongst BVAD respondents and TEXFAD hand weaver respondents to know which methods of natural fiber extraction they were using and the challenges or benefits they got by using those methods. The three respondents of BVAD all told the researcher that they were using a manual method of extracting the few natural fibers they

used in their weaving. They could arrange the fiber plant material like pineapple leaves and beat them up using pieces of wood and then use blunt knives to expose the fibers. The respondents told the researcher that they knew about fiber extraction using a decorticator but the Art and Design department did not have one so it was hard for them to first look for one before doing their weaving assignment so they opted for the manual extraction.

Respondents from TEXFAD on the hand told the researcher that they always preferred using the machine decorticator to extract banana fibers for weaving. She added that it was less labor intensive and it quickened their work. Respondent 6 added that machine fiber extraction had less wastage and since they didn't want to waste their fiber, it was the best option.

Various scholars had written about natural fiber extraction methods and this greatly informed the study especially on this objective. Historically hand weavers had always used manual methods to extract fibers. They used rudementally tools like broken ceramic plates, blunt knives, pieces of sharp wood to expose plant fibers. Some documents revealed that fiber plants could be left in the fields and soaked in water for about 14 days and after the plant matter rotting away, the fibers were exposed. Document review also gave detailed information on use of a decorticator machine for fiber extraction. This used blunt rollers to run over the plant several times leaving the fibers exposed.

The researcher went to the studio and explored more on the possibility of extracting Cyperus papyrus fibers using hands. Stems of mature Cyperus papyrus which were believed to have longer fibers were collected and prepared for extraction by cutting off the leaves.

Figure 16: Harvesting stems from the compound of industrial art at Kyambogo University, (b) appearance of the harvested stem and (c) the trimmed stems ready for extraction.
Source: Primary data

They were later bundled in groups of eight to ten stems and laid on a wooden table. The researcher then got a blunt knife and started scrapping the stems. This process removed the outer green sheath exposing the inside part that was rich of the natural fibers. With continued careful scrapping the Cyperus papyrus fibers are fully separated. The fibers were then washed and dried ready for hand weaving.

Figure 17: Photo showing hand extraction process of Cyperus papyrus fibers. Source; Primary data

Figure 18: Photo showing the hand extracted Cyperus papyrus fibers. Source; Primary data

Still in studio experimentation, extraction of Cyperus papyrus fibers using a decorticator which the weavers commonly knew as the extractor was explored. After harvesting the mature Cyperus papyrus stems, the leaves were cut off as was done in the hand extraction and bundled in groups of ten stems. The decorticator was then powered since it used a motor and the stems fed into the machine through the mouth piece. The rollers then ran over the bundle of stems as the researcher held the far end from outside the machine. The decorticator rollers are made blunt in a way they can only separate the fibers but cannot tear them apart. After a short time of approximately 3 to 7 minutes the researcher pulled out the part she held on the fibers had been successfully separated.

Figure 19: Photo showing the machine extraction process of Cyperus papyrus fibers.

Source; Primary data

Figure 20: Photo showing machine extracted Cyperus papyrus fibers

Source; Primary data

Data collected through the in-depth interviews, document review and studio experimentation all confirmed that it was possible to extract cyperus papyrus fibers using both manual and machine extraction methods hence achieving the first objective of the study.

4.2 Examining the suitability of Cyperus papyrus fibers for textile use.

Data to examine how suitable the cyperus papyrus fibers were for textile use was collected from in-depth interviews amongst the hand weavers, document review and studio experimentation. Suitability of these fibers was based on the dyeability and spinability or ability to form yarn from the fibers. Other properties like Cyperus Papyrus fiber strength and wash fastness were also considered.

Through the in-depth interview conducted amongst the BVAD students and hand weavers from TEXFAD, all the six respondents told the researcher that they were using local dyes to dye their natural fibers. They all confirmed that these dyes registered so well on natural fibers and they were not costly as compared to the synthetic dyes. The local dye was commonly being used by mat weavers and referred to as edagala rye nsasa.

Through the in-depth interview, the researcher got to know that BVAD students preferred to hand twist the fibers before weaving since they had only one spinning wheel machine that some did not know how to operate whereas the three TEXFAD hand weavers preferred to use a spinning wheel machine to ease and quicken their work.

The six hand weaver respondents were basically practicing only these two fiber suitability tests and did not know about testing fiber strength or the wash fastness.

Documents reviewed in this study showed that for a fiber to be suitable for textile use it had to possess various properties. Ghandi (2019) posted that suitability of fibers for textile application may depend on their ability to be spun into yarns that can feasibly be processed into textiles. Kozlowski and Mackiewisc (2020) also agree that for a fiber to be suitable for textile use it ought to have certain properties which they outlined as dye ability and spinnability. There

were many fibers in the world but not all of them could be used for textiles. Scholars went ahead to break down suitability in various ways. For a fiber to be considered suitable for textile use it had to be dye able. According to document review various textile scholars agreed that for fibers to be suitable for textile use they had to possess adequate length, fineness, strength and flexibility for yarn formation and fabric construction. Spinning of yarn in the old days was done by twisting fibers together using hands but as technology evolved, spinning wheel machines were innovated and used. The strength properties and ability to hold dye of a fiber were also essential.

The researcher went to studio to test if Cyperus papyrus fibers had properties that could make it suitable for textile use and various experiments were done as elaborated below. A lot of findings were achieved.

In hand spinning of fibers, the researcher twisted together by hand an average of eight (8) fibers to form a long strand. The first strand was tied on a piece of wood and the addition of fibers as they were being twisted formed a continuous strand known as yarn.

Figure 21: Photo showing hand twisting of Cyperus papyrus fibers to form yarn. Source; Primary data

The fibers created very long fine yarns but it was quite tiresome and time consuming. The study however confirmed that Cyperus papyrus fibers were suitable for textile use since they could form yarn. For small woven pieces, hand weavers could actually use this method of hand twisting to form yarn. By the spinning wheel method, a spinning wheel which is a device for spinning fibers into yarn was used. This method replaced hand spinning in the early textile industry. The spinning wheels function is to combine and twist the fibers together to form thread and then gather the twisted thread on the bobbin. The fiber was twisted as the flyer rotates as the spinner held the yarn. The spinner's foot pressed the treadle and its movement is connected to the footman which also rotates the drive wheel. the drive band that runs around the drive wheel and then to the flyer whorl is folded in half and runs around the drive wheel again and then over the pulley whorl. The rotation of the flyer and bobbin put a twist into fibers that are being spun. The spinner held the fibers in her hands until she felt enough twist had gone into it. The grip was then relaxed and the wheels draw pulls the material and wound it onto the bobbin.

Figure 22: Spinning on a spinning wheel and the fabricated yarns

Source; Primary data

This experiment concluded that Cyperus papyrus fibers were adequate for yarn formation. Their strength and length made spinning easy in the two methods that were used.

The researcher also experimented dyeing of Cyperus papyrus fibers and woven products with naturally obtained dyes and local dyes. The natural dyes were obtained from beet root and tea whereas the local dyes were bought from the local mat hand weavers. The results are presented below;

Figure 23: Preparation of the dyeing solutions, (a) beetroot, (b) dye solution from beetroot, (c) tablemat dyed with the beetroot dye, (d) dye locally used for dyeing handcrafts, (e) dye solution and (f) the table mat dyed with the locally obtained dye.
Source; Primary data

All the testes of dyeing the Cyperus papyrus fibers showed that natural dyes registered poorly with natural fibers. Locally obtained dyes which the locals were using to dye ensasa

commonly known as edagala rya nsasa gave a good registration on both the fibers and the woven products.

To prove more suitability a wash fastness test was done in a textile laboratory at Uganda Industrial Research Institute. A laundrometer which is used to determine the ability of a fabric to hold the applied dye was used. This method is mainly applicable to fabrics against washing, bleaching and dry cleaning. 500ml of water was poured in a beaker with 5g of a solvent soap. 10 metallic balls which help in the friction during the test were also added. The test was run at 95c for 30 minutes. By the end of the test the woven sample had not lost its color and according to the grey scale, Cyperus papyrus woven products were able to hold dyes.

Figure 24: (a) a laundrometer machine used to test the wash fastness of textiles and (b) a sample of Cyperus papyrus woven product.
Source; Primary data

Tensile strength of the Cyperus papyrus fiber was also tested in a textile laboratory. This was done using the tensile machine for yarn. The tensile strength and elongation of Cyperus Papyrus fiber tests were done from the Tensometer machine in the textile and polymer materials

laboratory of Uganda Industrial institute. Through this process, the maximum force at which these fibers could break is the breaking force and gives the strength of the fiber. Tensile test is used to measure the force required to break a material and the extent to which the specimen elongates to breaking point. Figure 25 shows the tests being done by the researcher and the results got are elaborated on the graphs

Figure 24: Testing for the tensile properties of the yarn
Source; Primary data

Cyperus papyrus tensile strength was tested in comparison to cotton and pineapple fibers which were also commonly used natural fibers by hand weavers. Results presented in the graphs below show the different fibers breaking after a certain time and different forces applied to them.

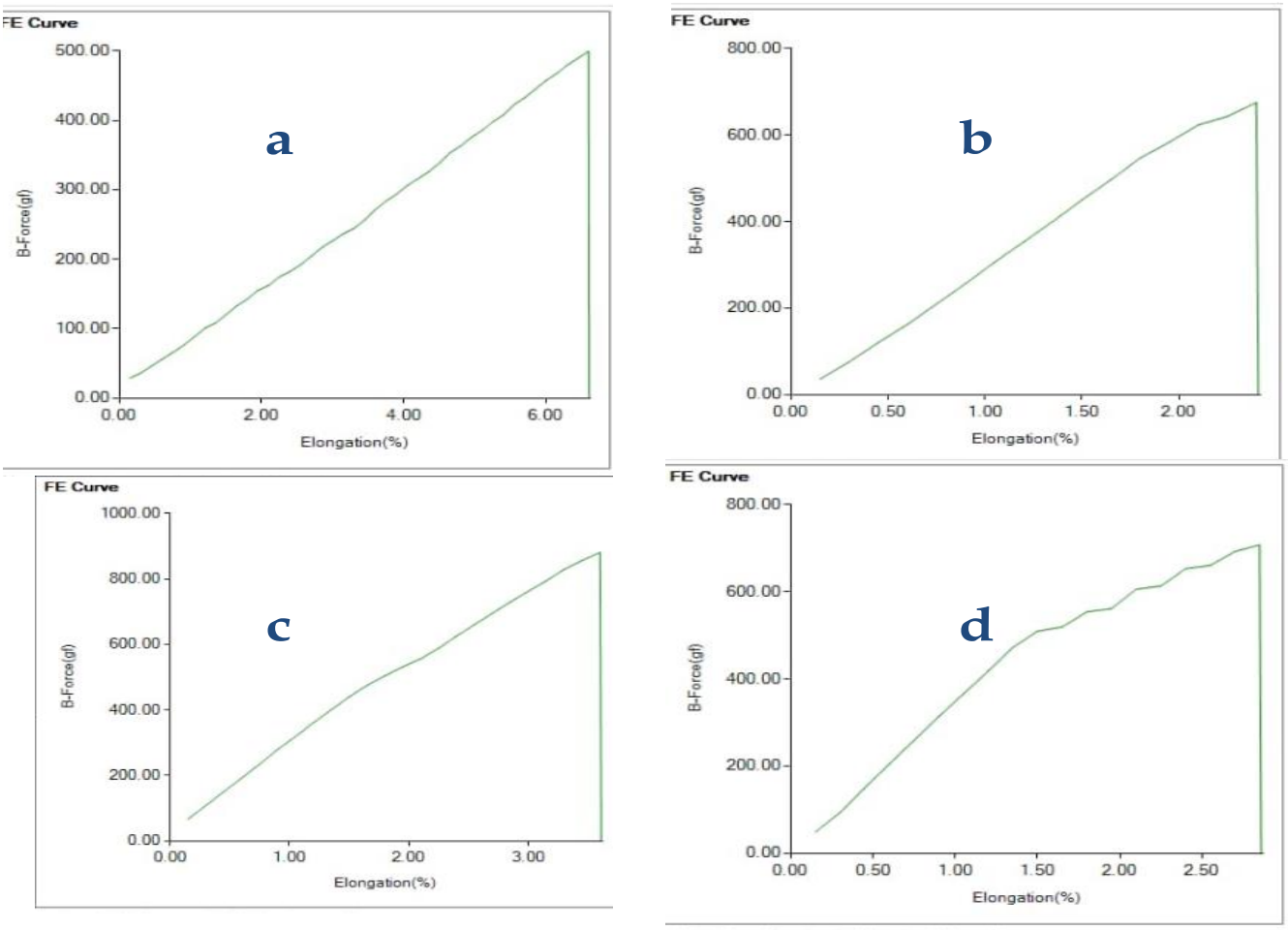


Figure 25: Graphs showing the breaking points of various fibers after ceratin forces were applied.

Source; graphs were obtained from the tensometer machine.

Cyperus papyrus fibers were easily spun, dyed and their strength was above average through the studio experiments. The fibers could also hold dye and they were not easily washed out. This proved that the cyperus papyrus fibers were suitable for textile use hence achieving the second objective of the study.

4.3 Producing Cyperus papyrus woven products for home use.

The third objective of the study determined to find out the products that could be woven from Cyperus papyrus fibers and the methods of weaving that were adequate and most convenient. Data collected from the in depth interview and document review was in comparison with other natural fiber products. The researcher also went to studio to experiment with Cyperus papyrus and the findings were presented.

Respondents offering BVAD and hand weavers from TEXFAD were interviewed. The three respondents offering BVAD told the researcher that they had used natural fibers before such as pineapple leaf fibers, banana fibers and sisal. They however admitted they were more familiar with using synthetic fibers in their weaving since these were ready to use and did not need any preparation processes.

The student respondents also gave a variety of products they hand wove from the natural fibers and these included rugs, table mats, table runners, wall hangings among others.

They said the department had various weaving looms but they preferred to use frame looms since they were handy and could be carried to their places of residence unlike the table looms and fly shuttle looms. Plain weave was the most used technique and students achieved designs by mixing other fibers like cotton or putting shapes and images.

The three respondents of TEXFAD told the researcher that they specialized in weaving banana fibers though other natural fibers were also woven but at a small scale. They said they were mostly weaving big rugs, door mats, table mats and decorative products like wall hangings among others. They had established market for their products both locally and internationally and this proved that these products were on demand.

The TEXFAD hand weavers were using very big frame looms that measured even up to 12 by 6 feet. They also majorly used the plain weave technique and achieved their designs by putting shapes or mixing banana fibers with other natural or colored fibers.

Various scholars urged that the world was more focused on natural products due to availability, ecological considerations and other good textile properties. Documents gave a wide range of products that were got from natural fibers in Uganda, Africa and over the whole world. In kozlowski's book handbook for natural fibers he gave examples of products that included ropes, fishing nets, carpets, rugs, table mats, decorative pieces among others. Various weaving looms were being used by weavers to come out with natural woven products and these included the table loom and the frame loom.

Figure 26; Pictures of a frame loom and a weaving table loom
Source; Woven textiles, Principles Technologies and Applications (2019)

In this study, weaving was mainly done on a frame loom. The researcher fabricated one in the studio by joining four pieces of wood with nails on the upper and lower pieces. These nails were spaced by a quarter inch and they are the ones were the cotton warp was tied before passing the Cyperus papyrus fiber weft. Warps were directly applied to the frame without use of a

warping board mill or peg. The warp was generally hand manipulated during the weaving process. The frame was prepared with warps of white cotton yarn with a length of 80cms and a width of 50cms. Cyperus papyrus fibers which were the weft were also prepared and weaving products such as table mats wall hangings, rugs, door mats, ropes for home use. The main weaving technique used was the plain weave which the hand weavers commonly referred to as one over one. The researcher was also inspired by the foliage of Cyperus papyrus plant which created a beautiful mat like structure. Fig. 27 shows drawings developing the source of inspiration into a plain weave pattern.

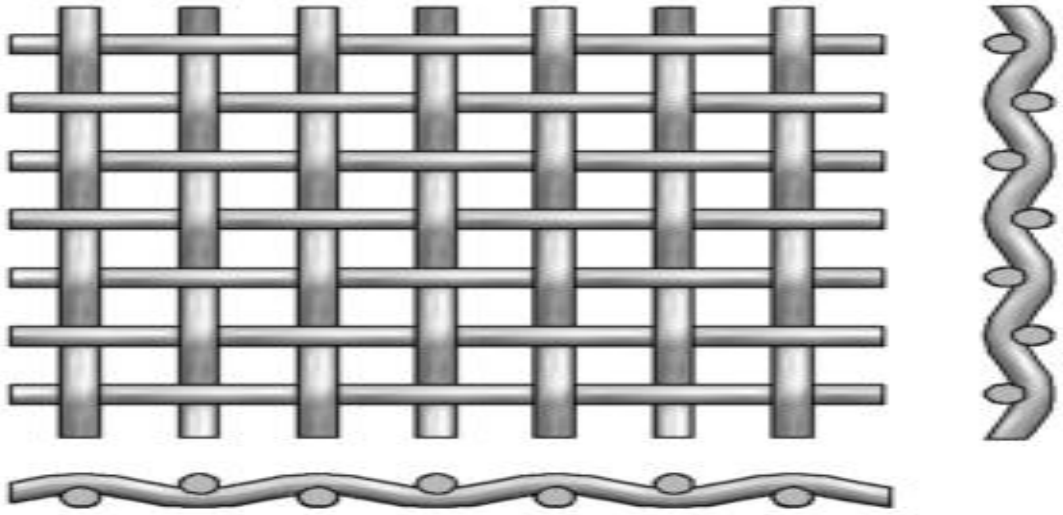


Figure 27: Showing wefts (the horizontal lines) crisscrossing the warps (vertical lines) in a plain weave.

Source; Weaving Technologies and Structures by E WOOD (2012).

The researcher also depicted the plain weave pattern from the historical products that were hand woven by our ancestors such as baskets.

Figure 28: Showing artistic pictures that inspired the plain weave technique

Source; Primary data

The extracted Cyperus fibers were woven as a frame loom using the plain weave techniques to come up with products for home use such as table mats, door mats and wall hangings Cotton warps were threaded on the loom and the Cyperus papyrus fibers which were the weft were manipulated to come up with designs. The study concluded that Cyperus papyrus fibers could easily be woven and various home use products could be made out of the fibre.

Cyperus papyrus table mats; The researcher through studio exploration wove table mats which were important items for home use. For uniqueness the researcher decided to weave circular table mats which are useful for decoration and beautifying a home. This was achieved by first twisting every rope using hands. The rope of cyperus papyrus fibers was then wound onto

each other and fastened by a hand stich. After the desired diameter was achieved, the table mats were given a finishing by strimming and candering which made them smooth flat to perform their purpose. Table mats on top of being decorative, pieces are placed on the table before putting cups or plates. They also prevent the table from dirt as evidenced in the figure below.

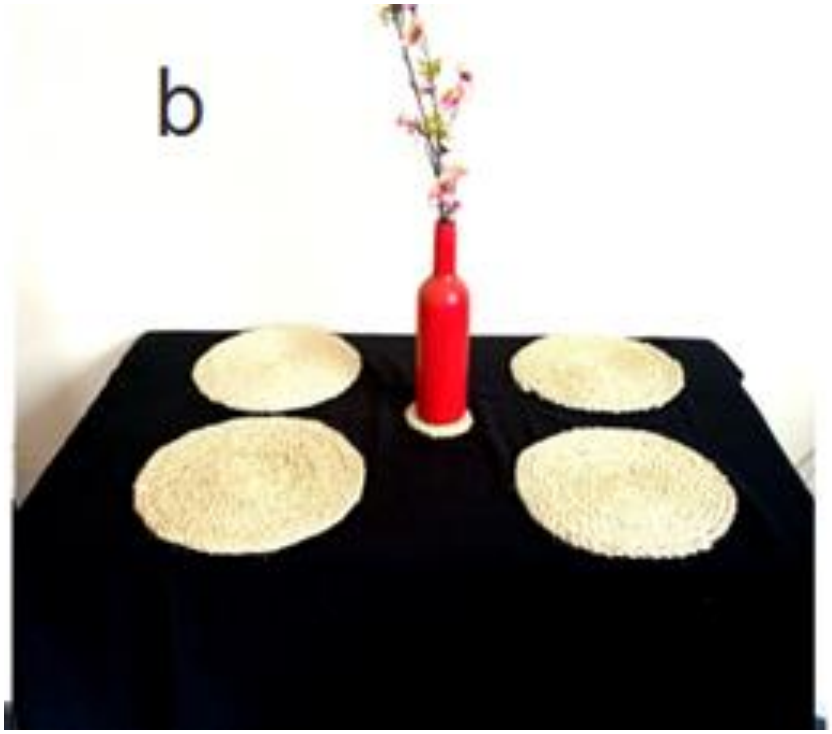


Figure 29: A photo showing a well laid table with the circular Cyperus papyrus woven table mats

Source; Primary data

Cyperus papyrus door carpets are another product that were woven out of Cyperus papyrus fibers. The dried washed fibers were well prepared and the frame loom which was the main device used was threaded. Threading of the warps which were cotton white threads was done with a distance of a quarter inch in-between. The weft which was the Cyperus papyrus fiber was also twisted to be long enough to avoid a lot of joining. Door carpets were then woven using a plain weave technique where one over one method was employed as illustrated below in figure 30..

Figure 30: Photo showing weaving of door carpet on a frame loom using Cyperus papyrus fibers

Source; Primary data

Door carpets were successfully woven and were suitable for their purpose of home use as they added interior beauty and could be used to clean the feet before entering houses. This was illustrated in figure 31.

Figure 31: A photo showing a door carpet woven out of Cyperus papyrus fibers on a frame loom.

Source; Primary data.

Cyperus papyrus wall hangings; these were basically for aesthetic purposes. Some wall hangings can also be used for demonstration and study purposes. In this study wall hangings made were mainly to demonstrate that Cyperus papyrus fibers could actually be woven to come out with these hand made products. In the first wall hanging the researcher combined cotton off cuts into the fiber to show that Cyperus fibers could well blend with the already existing materials. In the second wall hanging the researcher just used dry Cyperus fibers against the fresh fibers to create a contrast. The wall hangings were all woven using the frame loom as evidenced in figure 32 below.

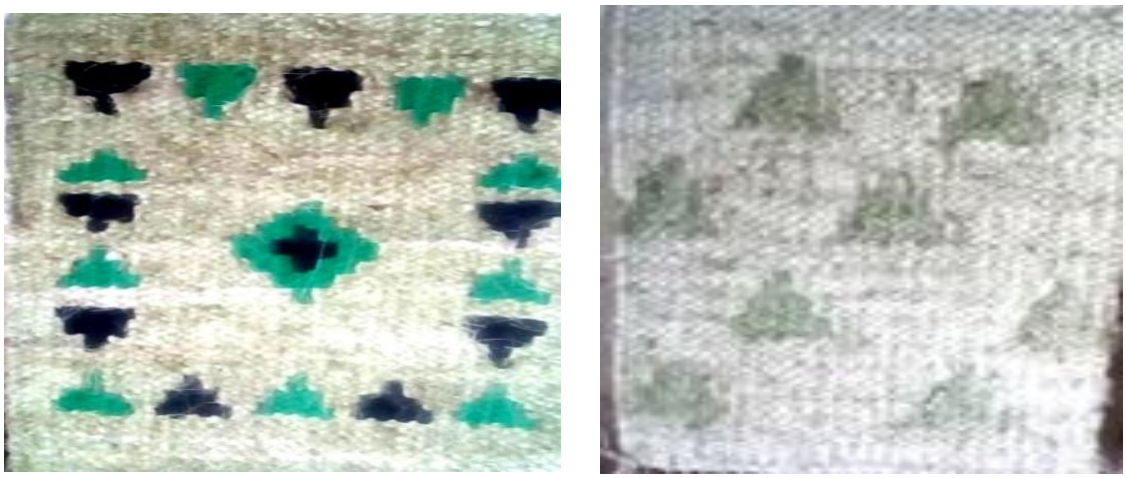


Figure 32: Photos showing wall hangings woven out of Cyperus papyrus fibers using the frame loom.

Source; Primary data

Ropes; however much this study did not intend to produce natural fiber ropes, there was wastage of fibers which couldn't be woven on the frame loom and the researcher decided and twist them to form ropes. Ropes are also important in home use since they can be used to tighten and hold together objects. The fibers were approximately divided into two groups and with use

of hands the researcher twisted one group over the other to produce a long strong Cyperus papyrus fiber rope.

Figure 33: Showing a photo of a one on one fiber twisted rope by the researcher
Source; Primary data

The extracted Cyperus papyrus fibers were used to weave samples of home use products such as table mats, door mats and wall hangings and ropes. Weaving was mainly done on a frame loom. Cotton warps were threaded on the loom and the Cyperus papyrus fibers which were the weft were manipulated to come up with designs. Cyperus papyrus fibers could easily be woven and they produced excellent products for home use hence successfully achieving the third objective of the study which was application of natural Cyperus papyrus fibers.

CHAPTER FIVE: DISCUSSION, SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

The purpose of the study was to extract and apply Cyperus papyrus fibers in production of hand woven textile products for home use Furthermore, this study was guided by the following objectives namely:

1. Explore the possibility of extracting natural fibers from Cyperus papyrus plants.
2. Examine the suitability of Cyperus papyrus yarns for textile use.
3. Produce Cyperus papyrus hand woven samples of various products for home

This chapter presented a summary discussion of the findings, conclusions and recommendations. The discussion is based on the results generated during the study that based on the three specific objectives of the study stated above.

5.1 Discussion

5.1.1 Exploring possible ways of extracting cyperus papyrus fibers

Just like various scholars such as Radoor et al. (2020), Jose et al. 2016 and Taha et al. (2019) wrote that natural fibers could be extracted using hand extraction or a machine decorticator; this study confirmed the literature as cyperus papyrus fibers were obtained through both methods of extraction. The decoration had been used by hand weavers in extraction of banana and pineapple fibers and through this study cyperus papyrus fiber was also extracted.

The fibers extracted from Cyperus papyrus plant were long and had a white tending to green color. They were strong and separated. Cyperus papyrus fibers could be extracted by both hand extraction and use of a decorticator. Fibers got by hand extraction were short and they did

not separate easily. There was also a lot of fiber wastage by this method. Extraction done using decorticator was on the other hand quicker and easy to use. This method saved a lot of time, fibers got were longer and could separate easily. There was minimum wastage of fibers in this method. The study showed that Cyperus papyrus fibers could be extracted from the plant.

5.1.2 Suitability of Cyperus papyrus fibers for textile use

There are many features that determine the suitability of fibers for textile use but for this particular study the researcher concentrated only on three which were the ability of the fiber to be spun or form yarn, its dyeability and tensile properties. Cyperus papyrus fibers and products were also subjected to a wash fastness test to confirm that they did not easily loose dye in case they were washed.

Kozlowski and M.Mackewics discussed various features that were considered for a fiber to be suitable for textile use and these included the following. The ability of a fiber to absorb dye, its flexibility to be spun and its strength to be woven. They argued that a natural fiber had to easily absorb liquids due to the presence of hemicellulose, the fibers were supposed to be flexible to be spun into longer yarn, and they had to be stronger to some extent so that they don't break during the weaving process.

Finlay (2014) posits that dyeing, the coloration of fibers, yarns and other textiles was important in creation of beauty and design. He added that dyeing of textiles had a long history that dated back to 2600BC. This implied that weavers had always dyed their textiles for beauty and design just like the respondents of BVAD and TEXFAD told the researcher in the in-depth interview that they had always dyed their products to add beauty and create various designs.

Cyperus papyrus fibers were dyed using both local dyes and natural dyes. Natural dyes included colour pigments that were got from fruits like the beet root. Salt was used as a mordant and the woven piece was dipped in boiling beet root. The cyperus papyrus woven piece did not register any colour of the beet root. It maintained its original colour. Another cyperus papyrus woven piece was dipped in a locally obtained dye called edagala rya nsasa it registered very well. The studio experiments confirmed that Cyprus papyrus fibers, yarn and woven products could be dyed. After extraction, Cyprus papyrus fibers were spun using both hand spinning and ring spinning.

Kennedy Norman? (2012) posits that a spinning wheel machine was so adequate for spinning various fibers into yarn. The three hand weaver respondents from TEXFAD also told the researcher that the spinning wheel machine made their weaving easy and quicker. The BVAD respondents, however, told the researcher that they were more familiar with hand spinning. The researcher went ahead to experiment yarn formation by both methods and these were the findings; hand spinning was quiet tiresome and it took a lot of time. The fiber spun by hands also had loose points which would cause the yarn to break. The ring spinning method was, however, quick and easy to use. The yarn spun was too long and had no breaking points. The spinning wheel was regarded the best method of spinning the cyperus papyrus fibers since hand spinning was time consuming and hectic. Cyperus papyrus fibers could be easily spun into yarn.

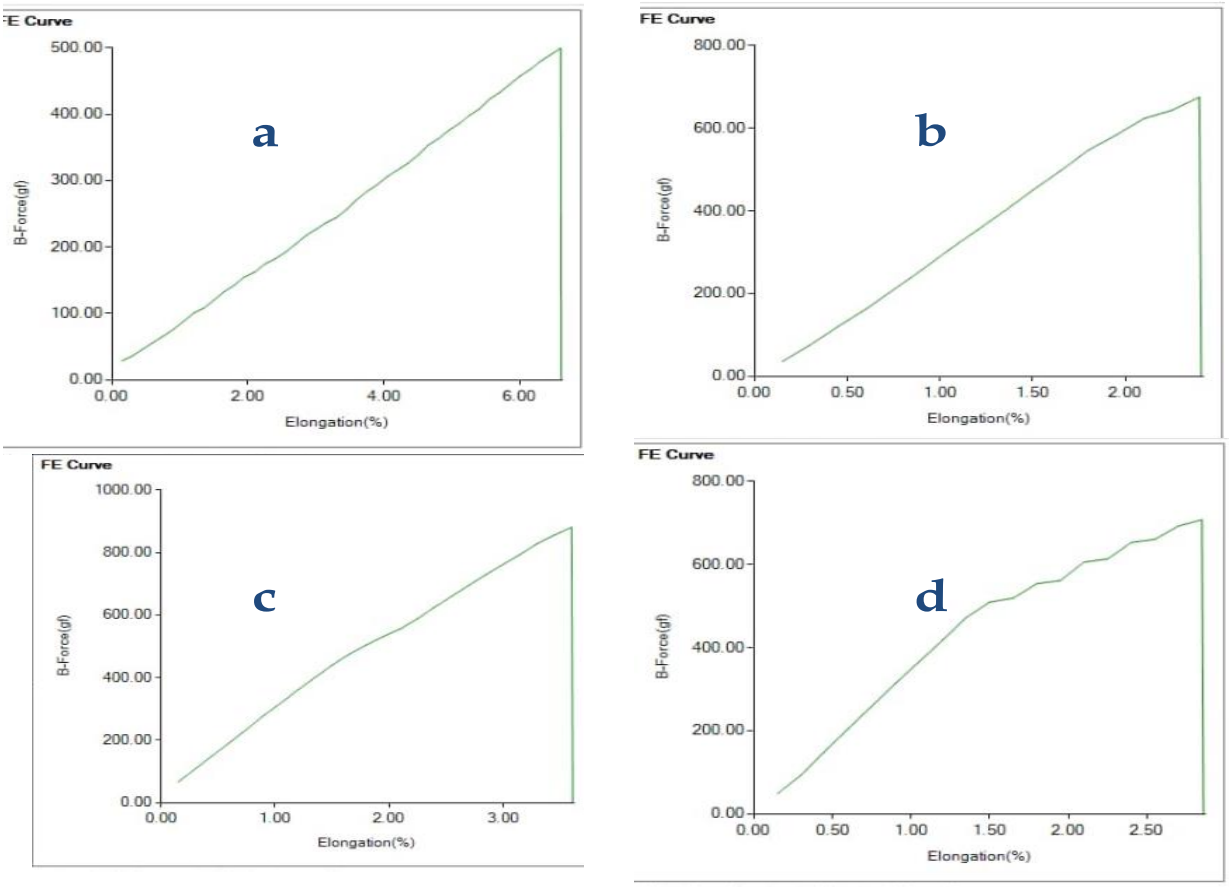
A wash fastness test was done on the Cyperus papyrus fibers and woven pieces. This was done using a laundrometer machine at Uganda Industrial Research Institute textile laboratory. The woven piece and fibers which had been dyed were washed for 30 minutes and they kept the dye. Grey scales used in the assessment of the color transfer to the fabric gave a reading of 2/3 which could be interpreted as a moderate wash fastness value. This indicated that the application

of dyes to the fabrics woven from the Cyperus Papyrus was feasible since the products and fibers had capacity to hold the dye.

Figure 34: Grey scales for assessing the change in color during the color fastness testing

Source; Primary data

By experimentation the tensile strength and elongation of Cyperus Papyrus fiber tests were done from the Tensometer machine in the textile and polymer materials laboratory of Uganda Industrial institute. Through this process, the maximum force at which these fibers could break is the breaking force and gives the strength of the fiber. Tensile test is used to measure the force required to break a material and the extent to which the specimen elongates to breaking point.



Graphs showing the breaking points of various fibers after ceratin forces were applied.

Graph a showed the breaking point of cotton fiber against Cyperus papyrus fiber in graph b. cotton fiber would break at elongation of 6 meters with a force of 500g applied on it whereas Cyperus papyrus fiber elongated to 2m with a weight of 800g applied to it. Graph c tested the strength of the pineapple against the Cyperus papyrus in graph d. the pineapple fiber broke at 3metres with a force of 1000g whereas Cyperus papyrus broke at 2.5 metres with 800g force applied. The data obtained in this experiment showed that Cyperus papyrus fibers were strong enough and suitable for textile use since they did not easily break even after various forces were applied.

5.1.3 Production of cyperus papyrus woven sample products

Many scholars argued that several products could be woven out of natural fibers and they were highly demanded because the world was more concerned on sustainable products with ecological considerations. Thyavihalli (2019) posted that products such as particle boards, wall hangings, carpets, paper, storage bags, ropes and many others could be produced from natural fibers.

Hand weavers at TEXFAD also confirmed that they had been weaving several products like carpets and wall hangings from banana fibers. Various weaving devices were used by the common ones were the frame loom and the weaving table loom.

This study confirmed that cyperus papyrus fibers could be used in hand weaving of products for home use which was the third objective of the study. The extracted Cyperus fibers were used to weave samples of home use products such as table mats, door mats and wall hangings. Weaving was mainly done on a frame loom. Cotton warps were threaded on the loom and the Cyperus papyrus fibers which were the weft were manipulated to come up with designs. The researcher however found challenges using the other weaving looms because the cyperus papyrus fibers were not long enough. Products woven out of cyperus papyrus fibers included wall hangings, table mats, door mats and ropes. Cyperus papyrus fibers could easily be woven and they produced excellent products for home use.

5.2 Conclusions

With data collected from observation, in-depth interviews, document review and various experiments that were done in the studio, the researcher came up with conclusions and these were based on the three specific objects;

5.2.1 To explore the possibilities of extracting Cyperus papyrus fibers.

The study concluded that Cyperus papyrus plant produced long resilient fibers of about 30 to 50cms in length. These could be extracted using both hand extraction and a decorticator. The decorticator was however preferable since it was quicker, had less wastage, and was not labor intensive. Fibers obtained from both methods of extraction were green like in color and strong enough for textile use. Extraction of Cyperus papyrus fibers was therefore confirmed to be very possible.

5.2.2 To examine the suitability of Cyperus papyrus fibers for textile use.

Various suitability tests were done on the Cyperus papyrus fibers and the study concluded that these fibers were very suitable for textile use. Cyperus papyrus fibers registered very well with local dyes and they did not easily wash out or loose the dye. Cyperus papyrus fibers were also hand twisted and spun using a spinning wheel machine and Cyperus papyrus yarn was formed. The strength properties of this yarn were tested in a textile laboratory using a tensometer and the experiments showed that Cyperus papyrus fibers only broke after a certain elongation when a certain force was applied. Cyperus papyrus fibers were suitable for textile use.

5.2.3 To produce Cyperus papyrus hand woven products for home use.

Several products for home use were hand woven from Cyperus papyrus fibers and these included wall hangings, table mats, door mats, and ropes. Weaving of these products was easily done using a frame loom. The woven items were all important for home use such as decorative purposes and addition of beauty in homes. The study therefore concluded that Cyperus papyrus fibers could be woven into products for home use.

5.3 Recommendations

The researcher highly recommends the use of Cyperus papyrus fibers as a weaving material for all hand weavers especially the textile students in the department of Art and Design at Kyambogo University. This is because the research has proved that not only are the Cyperus papyrus fibers long and resilient for weaving but also easy to extract and readily available in the environment.

For extraction of Cyperus papyrus fibers the researcher recommends use of the decorticator or machine extractor since it yielded results so fast and had less wastage as compared to hand extraction. These extractors can today be fabricated in metal workshops at a fair price and they are durable.

The local dyes commonly known as edagala rya nsasa are also recommended for dyeing Cyperus papyrus fibers and products since it registered very well as compared to the natural dyes. The researcher recommends that the government of Uganda supports further research that promotes the use of natural fibres because they have potential to propel the industry forward since they are renewable and sustainable this will aid achieving the UN 2030 sustainable development goal 12.

For weaving Cyperus papyrus fibers into home use products, a frame loom was used in the study. Frame looms are recommended because they are ease to carry and this implies that student hand weavers would carry them with flexibility. Frame looms also did not need a lot of fibers hence no wastage. The researcher however recommends for more research to be done on possibilities of weaving this natural fiber on bigger weaving looms like power looms in case of large scale production.

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APPENDICES

APPENDIX I: OBSERVATION GUIDE

A: Extraction of natural fibers

- Types of variuos fibers used by handweavers
- Methods used by hand weavers to extract natural fibers from there sources
- Challenges faced by handweavers.

B: Suiatabilty of cyperus papyrus fibers for textile use

- Types of dyes used to dye the natural fibers
- Spinning of fibers; which methods are used by hand weavers

C: Production of hand woven products from cyperus papyrus plant

- Tools used in weaving natural fiber products
- Techniques of weaving used b hand weavers
- Various products woven out of natural fibers

APPENDIX II

IN DEPTH INTERVIEW GUIDE FOR HAND WEAVERS FROM THE COMMUNITY

My name is Kemirembe Monica , a masters student in ART AND INDUSTRIAL DESIGN at kyambogo university. Am conducting a research on extraction and application of cyperus papyrus fibers in handweaving and considered it a good idea to interview you so as to get well informed on your use of fibers in handweaving so as to come up with other natural fibers like cyperus papyrus fibers suitable for hand weaving.

The information given will only be used for scholary purposes and the interview will take only 15 minutes.

A: Usage of natral fibers in school and community weaving

1. Have you used natural fibers in your processes of hand weaving?
2. How do you obtain these fibers?
3. Which extraction methods have you used before?
4. Which challenges have you faced while extracting and using natural fibers?

B: usage of natural and local dyes to dye natural fibers ,yarn foramation techniques and challenges faced

1. which dyes have you used to dye natural fibers?
2. what methods of spinninge do you use while spinning the natural fiber yarn?
3. which challenges have you encoutered while dying natural fibers?
4. Which challenges have you faced in the process of spinning yarn?

C: Nature of products woven in natural finbers and tools used.

1. Which tools have you used to weave products out of natural fibers?
2. Which products have you been able to weave out of th natural fibers?

3.Which challenges have you encountered while weaving with natural fibers?

APPENDIX III

INTERVIEW GUIDE FOR STUDENTS OF ART AND INDUSTRIAL DESIGN OFFERING WEAVING

My name is kemirembe monica , a masters student in ART AND INDUSTRIAL DESIGN at kyambogo university. Am conducting a research on extraction and application of cyperus papyrus fibers in handweaving and considered it a good idea to interview you so as to get well informed on your use of fibers in handweaving so as to come up with other natural fibers like cyperus papyrus fibers suitable for hand weaving.

The information given will only be used for scholary purposes and the interview will take only 15 minutes.

A: To explore the possibility of extracting natural fibers from cyperus papyrus plants.

1. Which type of fibers have you been using in your weaving classes.
2. Have you ever extracted fibers for your weaving? If yes, which method did you use?
3. If you were given an option between synthetic and natural fibers, which one would you preffer and why?

B: To examine the suitability of cyperus papyrus yarns for textile use

1. What are your considerations for a yarn to be suitable for textile use
2. What types of dyes do you use while dyeing your yarns in the weaving class
3. Which types of spinning fiber do you know and which one do you preffer? Give resoans
4. Which chalenges have you faced while dyeing and spinning your yarn?

C: To produce cyperus papyrus hand woven products for home application.

1. Which products have you woven using natural fibers
2. Which tools do you use for your weaving
3. Which challenges do you get while using natural fibers