

**APPLICATION OF NATURAL DYES EXTRACTED
FROM PLANTS ON COTTON FABRICS USING THE
SCREEN PRINTING TECHNIQUE**

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DECLARATION

I, MUWAYA Shafick, hereby declare that this is my original work and it has never been submitted to any institution for the award of a Master's degree.


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APPROVAL

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DEDICATION

I dedicate this book to my beloved friends; MUWAYA Family and NALUBEGA family and the entire MULINDWA family. Thank for the hand of love and support!

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I want to thank the almighty God my creator for having put me right in all difficult times through the period of this study.

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ABSTRACT

In this study experimented with the usage of natural dyes extracted from plants to decorate sample fabrics using Screen printing technique. This research were guided by the following objectives:

1. To analyze various plants in Uganda for extraction of dyes to decorate fabrics using screen printing technique.
2. To extract natural dyes that can be applied on to cotton fabric using screen printing technique
3. To experiment with natural dyes to decorate fabrics using screen printing technique.
4. To produce screen printed sample fabrics using natural dyes.

The study focused on seven plants namely, sweet potatoes, yam (*balugu*), turmeric (*kinzali*), Momordica foetida (*boobo*), bidens pilosa (*ssele*), Madder (Manjistha) and vernonia amygdalina (*mululuza*). The researcher extracted colorants using the local methods of extraction. In chapter two of the study showed that they were many methods of extraction. The different methods for extraction of coloring materials were Aqueous extraction, Alkali or acid extraction, Microwave and ultrasonic assisted extraction, Fermentation, Enzymatic extraction, Solvent extraction, Super critical fluid extraction however, the researcher used local ways of extracting dyes from plants like pounding, squeezing, soaking and boiling the different parts of the plant because it had an advantage over the acid extraction which is harmful to the human health.

The study experimented with different three recipes as shown in table one and also used four thickening agents which were sodium alginate, gum Arabic, textile thickener and book binding gum. All the three yielded the same results on the colour fastness to washing. However, book binding glue was not good on the print sharpness when using vernonia amygdalina.

The study used the recipes in table one the researcher formed printing paste which was used to print sample fabrics. The study also used a direct photographic method of screen

printing. This means the researcher had to produce the screens which were used following the steps of producing a photosensitized screen. The printing process was a success but they were changes in the fabrics after washing. Which showed that natural dyes can be used in screen printing and they have unique colours.

Further research on the experimentation with the usage of natural dyes extracted from plants to decorate fabrics using Screen printing technique, will improve on colour imparting attribute through the introduction of mordant into the dye extracted paste. There is also a need to investigate the potential of the dye extracts in detecting presence of a variety of colour ranges.

CHAPTER ONE INTRODUCTION

1.0 Overview

Fabric decoration spans the history of mankind from the caves. This was not the beginning of art as we know it rather it was the downing of visual communication because the early fabrications were made for survival and were created for utilitarian and ritualistic purposes as said by Edwin Wathum a Senior Lecturer at Kyambogo University of art historyⁱ.

According to Thesaurus.com a textile is any cloth or goods produced by weaving, knitting, or felting. Or a material, as a fiber or yarn, used in or suitable for weaving. Textiles are defined as the yarns that are woven or knitted to make fabrics. The use of textiles links the myriad cultures of the world and defines the way they clothe themselves, around their surroundings and go about their lives. Textile have been an integral part of human daily life for thousands of years, with the first use of textile, most likely felt dates back to the late stone Age, through 100,000 years agoⁱⁱ.

However, the earliest instances of cotton, silk and linen being to appear around 5000 BC in India, Egypt and china. The ancient methods of manufacturing textiles, namely plain weave, satin weave and twirl, have changed very little over the centuries. Modern manufacturing speed and capacity, however, have increased the rate of production to levels unthinkable even 200 years ago.

Human's have been printing on fabrics for thousands of years, basically since people started twisting and weaving fibers together to make the first fabric. Techniques that were used to decorate the body began to be applied to the earliest fabrics that were developed. Two basic methods emerged; coloring (directly applying an image with color to the fabric) and patterning (painting with resists in patterns and then coloring the fabric).

The continent of Asia has a long history of decorating fabrics. Printing blocks have been discovered that date back to around 3000BC by 327BC when alexander the great invaded India, colorful printing fabrics were commonly found. As trade routes began to develop, these beautifully patterned fabrics were commonly found.as trade routes began to develop, these beautifully patterned India fabrics were traded throughout Asia, Egypt and Greece. In

the second century AD they made their way to Europe and Africa. At the same time in china, beautiful block printing on fabric was taking place. The Chinese introduced resist and stencil techniques to japan. The Japanese developed this art in to beautiful forms of patterning on fabric. In Peru there have also been found same very early examples (around 200BC) of resist techniques, Similar techniques were developing in to unique forms in these different parts of the world and have evolved in to that we know today as batik, tie-dye and Shibori.ⁱⁱⁱ

1.1 Background

Natural dyes are pigments derived from mineral, animal or plant sources. They are known since prehistoric times for their use in colouring of food substrate, leather as well as natural fibers like wool, silk and cotton. The plants provide a vast source of natural dyes which can be obtained from many parts of the plant e.g., leaves, fruits, seeds, flowers, barks and roots. Most of the natural dyes have no affinity to textile fibers so need to use mordanting agents. The metallic salts as mordanting agent create the bridging link between the dye molecules and the fiber by forming coordinating complexes^{vi}.

In this study were used sweetpotatoes, turmeric, bidens pilosa, boobo, vernonia, amygdalina, akalamata murder, dioscora polystachya (*balugu*) as natural plants during screen printing of cotton fabrics. Screen printing is not only the oldest but also the easiest printing method as far as simplicity of application is concerned. Screen printing is one of the techniques used in pigment printing, it gives good effects and simple to use. Pigment printing is the most economical printing process and can be applied to all substrates addition to them it is a simple technical process, results in good light fastness, however, wash fastness is limited and the handle of the printed goods is often unduly hard^v.

For many years, improving the quality of pigment prints was the main goal in product development. Lately, economic, environmental and toxicological considerations have become more important^{vi}. Using printing paste from natural dyes is now one of the key concerns in the decorating fabrics in the education sector of Uganda. Most universities in Uganda are embarking on using natural materials for production of art artifacts. For example Kyambogo University is focusing on the use of natural materials in all disciplines of art by

putting course units to teach research in the extraction of natural dyes. However, the extraction of dyes is only for dyeing purposes for getting printing of fabrics yet this is an area where much of synthetic pigments are being used. Since the research focused on experimenting with the usage of natural dyes extracted from plants to decorate fabrics using Screen printing technique we need to look at the history of dyeing.

The history of dyeing is an ancient art which predates written records ^{vii}. It was practiced during the Bronze Age in Europe. Primitive dyeing techniques included sticking plants to fabric or rubbing crushed pigments into cloth. The methods became more sophisticated with time and techniques using natural dyes from crushed fruits, berries and other plants, which were boiled into the fabric and gave light and water fastness (resistance), were developed. Some of the well-known ancient dyes include madder, a red dye made from the roots of the *Rubia tinctorum*, blue indigo from the leaves of *Indigofera tinctoria*, yellow from the stigmas of the saffron plant, and dogwood, an extract of pulp of the dogwood tree. The first use of the blue dye, woad, beloved by the Ancient Britons, may have originated in Palestine where it was found growing wild.

Furthermore, the most famous and highly prized colour through the age was Tyrian purple, noted in the Bible, a dye obtained from the spiny dye-murex shell fish. The Phoenicians prepared it until the seventh century, when Arab conquerors destroyed their dyeing installations in the Levant. A bright red called cochineal was obtained from an insect native to Mexico. All these produced high-quality dark colours. Until the mid-19th century all dyestuffs were made from natural materials, mainly vegetable and animal matter.

Today, dyeing is a complex, specialized science. Nearly all dyestuffs are now produced from synthetic compounds. This means that costs have been greatly reduced and certain application and wear characteristics have been greatly enhanced. But many practitioners of the craft of natural dyeing (i.e. using naturally occurring sources of dye) maintain that natural dyes have a far superior aesthetic quality which is much more pleasing to the eye.

Not all fabric can be easily dyed with natural materials. The best ones to use are those made from natural materials themselves. Cotton, silk, wool and linen will take the dye the best.

Synthetic blends will take some dye, but will usually be lighter in color. Not all natural materials will produce a dye, and some produce colors that are nothing like the original plant it came from. Some of the colors and the plant material that give shades in that colour, Orange: carrots, gold lichen, onion skins, Brown: dandelion roots, oak bark, walnut hulls, tea, coffee, acorns, Pink: berries, cherries, red and pink roses, avocado skins and seeds, Blue: indigo, woad, red cabbage, elderberries, red mulberries, blueberries, purple grapes, dogwood bark, Red-brown: pomegranates, beets, bamboo, hibiscus (reddish color flowers), bloodroot, Grey-black: Blackberries, walnut hulls, iris root, Red-purple: red sumac berries, basil leaves, day lilies, pokeweed berries, huckleberries, Green: artichokes, sorrel roots, spinach, peppermint leaves, snapdragons, lilacs, grass, nettles, plantain, peach leaves, Yellow: bay leaves, marigolds, sunflower petals, St John's Wort, dandelion flowers, paprika, turmeric, celery leaves, lilac twigs, Queen Anne's Lace roots, mahonia roots, barberry roots, yellow root roots, yellow dock roots. This shows that we can get rich colours from plants for not only dying but also for printing.

Application of natural dyes in today's scenario makes use of modern science and technology not only to revive the traditional technique but also to improve its rate of production, cost effectivity and consistency in shades. It therefore, requires some special measures to ensure evenness in dyeing.

1.2 Statement of the Problem

Research on natural dyes has been carried out by many scholars like Liz, Plummer, (Siva, 2007),

(Kunio and Patricia, 2009) and so many others in the world. In Uganda some scholars like Wanyama (2010), Kiremire, Ogwok, Murumu (2010), Rubona and Kiryantamu craft women, Rubona weavers association have used natural dyes to decorate mats and baskets for export to outside market. However, the knowledge and applicability of these studies still lack in their implementation capabilities. Research shows that natural dyes have been experimented on cotton cloth sisal and raffia using tie and dye approach living out screen printing technique in decorating. This has also been done the same way in institutions of higher learning like Makerere University and Kyambogo University where the School of

Art and Design Department respectively have created a gap in the way that they have not done enough to experiment with natural dyes using screen printing technique when decorating fabrics still students go for synthetic dyes for decoration which are scarce and expensive. The researcher decided to add knowledge to the existing one to show the students how natural dyes can be applied on fabrics using screen printing technique hence limiting the use of synthetic dyes.

1.3 Purpose of the Study

To experiment with the usage of natural dyes extracted from plants to decorate fabrics using Screen printing technique.

1.4 Objectives of the Study

The study was guided by the following objectives.

- I. To analyze various plants in Uganda for extraction of dyes to decorate fabrics using screen printing technique.
- II. To extract natural dyes that can be applied on to cotton fabric using screen printing technique.
- III. To experiment with natural dyes to decorate fabrics using screen printing technique
- IV. To produce screen printed sample fabrics using natural dyes.

1.5 Research Questions

- I. What plants can be used to decorate fabrics using screen printing?
- II. What are the different methods used to extract natural dyes?
- III. How can natural dyes be used to decorate fabrics using screen printing technique?
- IV. What type of screen printing technique is best used with natural dyes to decorate fabrics?

1.6 Justification

As long as there is nature, natural dyes will exist. Indigenous natural dyes, by virtue of possessing an endless variety of fascinating hues/shades, have been and will continue to be used for decades all over the world. Cotton, raffia, sisal and other fibers grow abundantly in

a number of areas in Uganda. And various items are locally produced using those fibers in their natural and or dyed forms. Developing a compendium of natural dyes will provide a wide option of natural colors to be used instead of or along with the chemical dyes. at the same time, Uganda is endowed with a wide range of both natural vegetation types with a variety of plant species, such as trees, shrubs, grasses, vines, mosses, and different soils types such as ferrallitic, lateritic and others with varied mineralogical properties, which can be transformed in to sources of natural dyes.

Information about such dyes, their sources, application and so forth have neither been systematically recorded nor adequately disseminated. Yet craftspeople, industrialists and scholars need this knowledge, which they would be able to apply exhaustively in their areas of specialization. in addition supporting the use of natural dyes^{ix}.

Today, with the growing awareness of the pitfalls of using certain chemical dyes, there is a resurgence of interest in natural dyes. Also, when conscious consumers choose naturally dyed products over those with cheaper, stronger chemical dyes, they ensure the survival of natural dyes which represent centuries of wisdom, art and craftsmanship.

There for there was a need for the researcher to carry out research on natural dyes and how they can be used in screen printing.

1.7 Significance of the Study

The textile industry will borrow ideas used in the research to produce fabrics.

The artists in the community of Kyambogo University will benefit in the values of using natural dyes in screen printing to produce pieces of works.

The research will help people generate income through growing different plants to produce natural dyes for fabric decoration.

1.8 Scope of the study

1.8.1 Geographical scope

The study was based at Kyambogo University however; it will cover areas of Wakiso, Rubona, and Kampala district because it is the most known area to the researcher.

1.8.2 Content scope

The content scope of this study is based on the objective one, To identify various plants for extraction of dyes to be used in the decoration of fabrics, to extract natural dyes that can be applied on to cotton fabric using screen printing technique, to experiment with natural dyes to decorate fabrics using screen printing technique and to produce screen printed sample fabrics using natural dyes

In objective one, the study focused on identifying various plants for extraction of dyes to decorate cotton fabrics, in this message plants that produce natural dye were analyzed.

In objective two and three the study focused on the extraction of natural dyes that can be applied on to cotton fabric using screen printing technique, the constituencies that would aid studio experimentation with natural dye as a medium in decorating fabrics. In this the researcher explored possibilities of producing decorations focusing on material and technique as well as content, composition and inspirational objects from people taking local beer and women fetching water from the well.

In objective four the study focused on the production of finished screen printed sample fabrics using natural dye as a medium under investigation.

1.8.3 Material scope

In the material scope natural dyes from plants, cotton fabric, bazaar, and salt was used in the decorating of fabrics.

1.8.4 Time scope

The time scope tends to cover all the period that was spent when compiling the research from chapter one to five.

1.9 limitations

The study was limited by time consumed to extract dye from the plants.

The study also faced a problem because plants are dependent on the growing seasons which were mostly sunny.

1.10 Definition of operating terms/of key terms

Pace: The rate at which the product takes to be produced

Research is a scientific approach to decision making which seeks to determine how best to design and operate a system usually under conditions requiring the allocation of scarce resources.

Natural dyes refer to colors from plant life of Uganda that stains materials.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The use of dyes cannot be underestimated in the production of fabric decoration and worldwide some improvisation has been achieved some for centuries. This chapter will identify some of the gaps that may be useful in promoting the use of natural dyes in Uganda and the wider east and central African region.

2.1 Natural dyes from Plants

Dyeing is an old art which can be traced in times of civilization. Dyed textile remnants found during archaeological excavations at different places all over the world provide evidence to the practice of dyeing in ancient civilizations^x. Natural dyes are got from natural resources which may be plants, minerals or animals. It's also important to note that the colours from these natural sources depends on many aspects which may include weather, soils etc. meaning that different regions of the world have got different natural dyeing traditions and the way they utilize the natural resources available in that region. Coloring materials obtained from natural resources of plant, animal, mineral, and microbial origins were used for coloration of various textile materials^{xi}. This is evident that Natural dyes have been in use for a very long time but started to decline after the invention of synthetic dyes.

However, natural vegetable dyes have gained reputation all over the world after a lapse of more than one century due to their eco-friendly nature and hence, their prominent long time usage as histopathological stains^{xii}. Uganda is endowed with a wide range of natural vegetation with many plant species and different soil types with varied mineralogical properties, which can be transformed into sources of natural dyes^{xiii}. This shows that we have a range of plants that we can extract colours from. Akinloye, A.J (2010) states that plants yield many colours for dyeing a variety of articles; some trees and many herbs produce dyestuffs, and hitherto the bulk of world's dyes were produced from plant sources. And he continues to say that Plant dyes are found in the root, root bark, leaves, flowers, stem, stem bark, fruit skins and nutshells. Some plants may have more than one colour or

sources of colour among the various parts and/ or at various stages of their growth or development.

Plants contain natural colors ranging from yellow to black (Siva 2007). The colour of dyed fabrics depends on the nature of the chromophores well as the substituent functional groups, the auxochromes, of the dye molecular species (Padma, 2000; Siva, 2007). Chromophores and auxochromes are considered the most important chemical constituents of dyes responsible for textile coloration (Trotman, 1993; Foulds, 1995).

Dye-yielding plants unlike synthetic dyes, may contain more than one chemical constituent, each exhibiting a different color and properties, operating singly or in combination with the different groups, depending on their chemical structure and composition (Siva, 2007; Bechtoldital, 2007; Samanta and Agarwal. 2009).

The fading of dyestuffs by light radiation is a major factor influencing the useful life span of dyed clothing (Kunio and Patricia, 2003). A high quality colored fabric possess an acceptable amount of color fastness rating of at least 3.0 on a five point grey scale (Kadolph, 2005; Papits and Siddhartha, 2003). Depth of color on a fabric depends on absorption levels of dyes by the fibers and its distribution coefficient between the dye baths, solution and fibers (Kadolph, 2005). The amount of dye present on the substrate is therefore very critical in determining the fastness property (Guinot et al; 2006; Samanta et al 2006).

Traditionally, plants were used for coloring silk, woodland cotton fibers but gradually were replaced by cheaper synthetic dyes (Anna and Christian, 2003). However since the ginning of 1990s there has been a growing interest in the re-introduction of natural dyes and dye yielding plant for textile application (Anna and Christian, 2003). The reason for this new scientific interest in natural dyes are based on the growing awareness to find sustainable and non-alternatives to synthetic dyes, a growing market for naturally dyed and the search for additional, economically viable, alternative crops for farmers (Anna and Christian, 2003; Bhuyan and Saikia, 2005). Recently, 40 plants with potential of yielding dyes of good characteristics for application in the textile industry were identified in Uganda (Wanyama et al. 2010).

Results on characterization of the color produced from nine selected dye-yielding plants for textile coloration are also reported (Wanyama, et al. 2010) These dyes are capable of improving the contrast of plant sections, so that distinction can be made between one cell and the other or between cell and its constituents. All these confirms that we can get dyes from plants in many ranges of colour depending on which part of the plant is used. However, nature dyes are mainly being used for dyeing fabrics and little attention given in using them for screen printing on fabrics in Uganda and this study is focusing on the available dyes from nature to be applied in screen printing on cotton.

2.2 Extraction of natural dyes

Plants cannot be directly used for dyeing textiles. But many plant materials such as flowers and fruits are seasonal and contain a large amount of water and hence cannot be stored as such ^{xiv}. Therefore, in order to make them suitable for textile dyeing purposes and to make them available throughout the year, these are subjected to some processing operations. Meaning they are step by step procedures to be followed when extracting dyes from plants. S. Saxena (2010) states that collected plant materials are first dried: either in shade or in a hot air drier at a low temperature of about 40–50 °c to reduce their water content to about 10–15 % or less. Many materials can also be sun dried. Dried material is then powdered in a pulverizer to reduce particle size and to facilitate better dye extraction.

However, the researcher disagrees with Saxena because not all plant materials require drying to extract dyes, some plants like sweet potatoes, turmeric bidens pilosa and vernonia amygdalina. To extraction of natural dyes on a large scale different techniques maybe applied by manufacturers since the plants nature and solubility characteristics of the coloring materials need to be ascertained before employing an extraction process. The different methods for extraction of coloring materials are Aqueous extraction, Alkali or acid extraction, Microwave and ultrasonic assisted extraction, Fermentation, Enzymatic extraction, Solvent extraction, Super critical fluid extraction ^{xv} however, they are local ways of extracting dyes from plants like pounding, squeezing, soaking and boiling the different

parts of the plant which has an advantage over the acid extraction which harmful to the human health.

The study found it necessary to revisit some literature of the large and old manufacturing companies citing their shortcomings and achievements. Dye manufacturing in the United States was hampered by a lack of industrial chemists, limited availability of intermediates derived from coal-tar, and tariff regulations that favored imports. The first efforts are attributed to European chemists who set up rudimentary facilities in the Green Point area of Brooklyn along the Newtown Creek.

In the early 1860s, Dr. August F. W. Partz, a German chemist, attempted to manufacture magenta in a small wood building on the banks of Newtown Creek. The venture failed but in 1864 Thomas and Charles Holliday, sons of Read Holliday, who began making dyes in Huddersfield, England in 1860, came to the US and successfully made magenta at a plant in the same area. The Holl plant produced the first aniline in the country, in addition to nitrobenzene, picric acid a range of dyes.

Three larger scale companies soon followed, The Albany Aniline and Chemical Company were founded in 1868 by A. Bott, a cardboard manufacturer. Bayer became financially involved with this company in order to manufacture magenta in the U.S. The Schoellkopf Aniline and Chemical Company was set up in Buffalo in 1879. The Hudson River Aniline Color Works was established in 1882 in Rensselaer; this site was acquired by Bayer in 1903, seized by the U.S. government in 1917 as enemy property, and eventually become a leading dye producer under General Aniline and Film Corporation and later BASF. By the time World War I erupted in 1914, there were still only a handful of U.S. companies making dyes; the market was totally dominated by imports from Germany. But the German dye factories now had to switch to making explosives and Britain blockaded German shipping, cutting off imports. This resulted in a dye famine that quickly drove prices up. Dye manufacture suddenly became an attractive investment.

U.S. companies, large and small, built plants to capitalize on the opportunity. In 1912, Dr. William G. Beckers, a German chemist had started a small dye works in the Flatbush section of Brooklyn. This plant was wrecked by an explosion in 1914 that killed two chemists. The strong demand for dyes, along with financial aid from capitalist Eugene Meyer, Jr., convinced Becker to build a much larger plant in the Canarsie section of Brooklyn. The company was known as the Beckers Aniline and Chemical Works and employed 1200 men. The Beckers firm merged into the National Aniline & Chemical Company in 1917. Dr. Beckers became one of the wealthiest industrialists of the era and retired in 1920 to a palatial estate in Lake George, New York. But pollution from the Brooklyn plant contributed to the end of oyster harvesting in Jamaica Bay. This was an early warning sign of the environmental problems that would taint the dye industry and erode public support.

The synthetic organic chemical industry began in 1856 when an English chemist William Henry Perkin prepared the dye mauve from coal tar chemicals. Perkin built a factory near London to supply the world's first synthetic dye. Synthetic versions of alizarin and indigo, dyes previously derived from plants, followed. Although England had the early lead, Germany soon became the leading global supplier of a rainbow of brilliant colors.

The Calco Chemical Company was founded in 1915 at a site near Bound Brook and the Raritan River in New Jersey. Initially Calco manufactured coal-tar intermediates. After 1918 the company also produced synthetic dyes. Calco was acquired by American Cyanamid in 1929 and the Bound Brook site became a leading manufacturer of dyestuffs, sulfa drugs and resins ^{xvi}.

The General Aniline Works plant in Grasselli (Linden), New Jersey traces its origins to 1915 when Caesar A. Grasselli, head of the Grasselli Chemical Company, built a dye plant there. The initial product line consists of sulfur dyes, alizarin dyes and intermediates. During World War I, U. S. government seized control of the company from owner I. G. Farben of Germany. The plant became the largest producer of vat dyes in the U.S. ClorantsHistory.Org discusses many other dye and pigment companies that were established around the time of World War I. These companies include Pharmacy Chemical of Bayonne, New Jersey,

Verona Chemical of Newark, New Jersey, Harmon Colors of Haledon, New Jersey, Beaver Chemical of Damascus, Virginia, Federal Dyestuff and Chemical of Kingsport, Tennessee and Standard Ultramarine of Huntington, West Virginia. Some large, well-capitalized companies failed in just a few years, while some smaller companies starting with limited resources prospered for many years. Other companies were absorbed by large domestic or international firms.

The emerging dye industry had significant impact on the development of the chemical industry in the U.S. Dye chemistry was the foundation for pharmaceuticals, fibers, plastics and many other products. But after peaking around 1970, the U.S. dye industry declined in importance and relevance. By the early 1980s, the four largest companies, Du Pont, Allied Chemical, American Cyanamid and GAF, dropped dyes. All of the plants discussed here, except Standard Ultramarine, now known as BPS Printing Systems, has been closed and demolished. The European dye industry lasted longer but is now almost gone. Clayton Aniline, a Manchester dye maker since 1876, was shut down in 2007.

Most dyers that use dye stuffs, whether grown in their own garden know that a plant such as nettle is capable of producing various depths of color depending on the type of picking, the weather and much other environmental condition. Therefore it is through time, season and weather condition that a dyer can know when a plant can yield color.

The essential function of art is to change and intensify ones perception of reality. In other words through perceiving and admiring of nature one can be able to create something new that can positively contribute to his or her state ^{xvii}.

Crews (1987) constructed the fading rate curves of selected natural dyes from color difference Measurements by using a tristimulus colorimeter. Examination of the curves showed that most natural dyes fade rapidly initially followed by a slower rate of fading. Only the most lightfast natural dyes fade at a constant rate over time. The implications of these findings for museum textiles are discussed. Similarly, Crews (1987) evaluated two ultraviolet filters of polyester film, one colorless and one with a strong yellow color for their effectiveness in reducing fading of wool dyed with selected natural dyes and one synthetic

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dye. Results showed that clear filters offer no protection against fading for some natural dyes.

Therefore, clear filters should not be regarded as a slightly less effective alternative to yellow filters for the protection from fading of museum artifacts colored with natural dyes because, in some instances, they are totally ineffective. When the use of yellow filters is unacceptable because of their distortion of color in exhibition areas, controlling level of luminance to 50 lux is more beneficial than the use of clear filters in protecting some natural dyes from fading. Wouters and Verhecken (1991)^{xviii} separated four major components of blue and purple natural dyes of indigoid class and also spectrally characterized by high-performance liquid chromatography: Indigotic, indirubin, 6-monobromoindigotin and 6, 6'-dibromoindigotin. It has been shown for the first time that a dyeing with a hypobranchial glandular secretion of *Murex trunculus* contains indigotic and both its mono and disubstituted brominated derivative. The analytical features presented may be used to study the composition of old dyes on yarns.

Frigerio (1992) compared characteristics of natural dyes with synthetic dyes to minimize environmental pollution. Logwood, tropical legume dyes, yellow woad of Cuba, dyes extracted from insects, indigo, mollusks extraction and extraction from Sandalwood, saffron, curcuma, nuts, henna and lichens are described.

Korean (1994) applied linear gradient elution methods to the HPLC analysis of plant and scale insects red for anthraquinonoid mordant dyes and molluscan blue and red purple indigoid vat dyes. The method enables the use of same elution program for the detection of different chemical classes of dyes. In addition, it significantly shortens the retention times of natural anthraquinonoid dyes over those previously published. For the first time a new dye, probably dibromoindirubin has been detected in *Murex trunculus* sea snail. The dye families investigated include the ones most often found on ancient textiles and shards.

Kusaka et al. (1994) prepared quinine polymethine dye I (a red dye) by culturing safflower Flower buds. The dye I has λ_{max} 554 nm. The dye is highly stable and has a characteristic

color hue, and is insoluble in water but soluble in Me₂CO. The dye is expected to be useful in various fields of coating materials, textile dyeing, cosmetics, and food additive.

Teli et al. (1994) successfully applied the natural dye extracted from turmeric on the cotton material. They described that if fabric is treated with tannic acid and/or metal salts and then dyed, the dyeing show improvement in depth and performance properties such as fastness to light, washing, rubbing (dry as well as wet) etc. They used CuSO₄ and FeSO₄ and got variation in tones, improvement in light fastness and properties otherwise inferior. The influence of concentrations of tannic acid and metal salts on cotton dyeing was also studied. Gallotti (1995) discussed the feasibility of using plant-based dyes for textile application with reference to the use of set-aside land for non-food crops. Then the processes used to extract dyestuffs from the plant materials are described: traditional methods; ultra-filtration and inverse osmosis; extraction with fluids in a supercritical state. Finally, the analysis of natural dyes is discussed with reference to analyzing the dye and its precursor, checking the purity of the extract and identifying the dyestuffs on textile materials.

Rao et al. (1995) worked to replace chrome mordanting in anticipation of a total ban on chromium in industrial effluents and a viable alternative method of mordanting. In the decentralized sector of the Indian textile industry, covering the area of carpets and other floor coverings, natural dyeing has scope for exploitation as there is a growing interest in the renewal of the art of extraction and application of natural colourants on textiles in view of worldwide awareness on the potential of possible toxicity and carcinogenic effects associated with some of the present day synthetic dyes and their intermediates.

Tsatsaroni and Kyriakides (1995) studied the dyeing of cotton and wool fabrics with the natural dyes, chlorophyll and carmine after treatment with the enzymes cellulase, α -amylase and trypsin. Wash and light fastness of the dyed samples were studied. Enzymatic pretreatment resulted in an increase in pigment uptake in all cases compared with the corresponding untreated samples, and did not affect fastness properties. Pretreatment with metallic salts and dyeing of pretreated samples was also carried out and the fastness

properties of the dyed materials were studied. The effect of conventional mordanting with metallic salts was compared with that of enzymatic treatment on the dyeing properties of the dyes used.

Zou (1999) described the preparation process comprised of soaking 100 parts of madder or sappan wood dust with water for 3-5 hours, adding 5-7 parts of 3% wood alcohol, filtering, removing the supernatant from the filtrate, heating to 18-22°C, sealing, fermenting for 65-79 hours, concentrating into 50-75% bright red pigment liquid for dyeing fibers. The fiber dyeing process comprised of mixing the pigment liquid 1, water 25-30 and 5% tannic acid 0.03-0.05 parts, dipping 5 parts of animal fiber or 6 parts of natural silk in the solution, boiling for 20-30 minutes, holding at 70-90°C for 60-75 minutes and drying. The bright red pigment liquid can be used together with other plant pigments.

ZQU (1999) produced a pure yellow natural dye for dyeing animal fiber or natural silk for producing carpets in a process comprises mixing crushed Gardenia fruit 100, 3% acetic acid 3-5 and water

2000-2200 parts, heating to 50°C, holding for 100-140 minutes, filtering, removing the supernatant of the filtrate and concentrating into 50-75% pure yellow pigment liquid. The fiber dyeing process comprises mixing the pigment liquid 1, 3% KAl(SO₄)₂ solution 0.03-0.04 and water (30°C) 30-35 parts, dipping 7 parts of animal fiber or 9 parts of natural silk in the solution, holding for 60-80 minutes, boiling for 30-40 minutes, cooling to 90°C, washing with cold water, and drying. The pigment liquid may also be used to prepare fiber-dyeing liquors by mixing with other plant pigments. Unlike ZQU who extracted dyes from mixing crushed gardenia, Ansari and Thakur (2000) extracted the natural dye from pomegranate and optimized the conditions of extraction. Optimization of conditions for extraction of C.I. Natural Yellow 7 dye from pomegranate rind has been carried out by studying the effect of pH of extraction media, time and temperature of soaking/extraction and mass to liquor ratio on quality and yield of the dye. The extracted dye has been characterized by its physico-chemical properties, viz. solubility, micro-chemical analysis, thin layer chromatography and UV Visible spectrophotometry.

Dyeing experiments and analysis of red listed chemicals have also been carried out to see the efficiency and eco-friendliness of the dye and to explore the possibility of its commercial use as a substitute for synthetic dyes based on forbidden aryl amines. Bhattacharya (2000) dyed wool fabric with Catechu by two different process sequences using various metal sulphates as mordant. The dyeing behavior has been assessed by measuring k/S values and different fastness properties. The effect of different metal ions has been studied with respect to their influence on colour and fastness properties. The mechanism of mordant interaction with the fiber has been briefly considered.

Vankar et al. (2007) diverted from Bhattacharya who dyed wool fabric and instead studied two step ultrasonic dyeing of cotton and silk fabrics with natural dyes, Terminalia arjuna, Punica granatum, and Rheum emodi have been developed in which an enzyme is complexed with tannic acid first as a pretreatment. This was found to be comparable with one step simultaneous dyeing. The effectiveness of three enzymes protease-amylase, diastase and lipase was determined. The enzymatic treatment gave cotton and silk fabrics rapid dye adsorption kinetics and total higher adsorption than untreated samples for all the three dyes. The cie Lab values also showed improvement by enzymatic treatment. The tannic acid-enzyme dye combination method offers an environmentally benign alternative, 'soft chemistry' to the metal mordanted natural dyeing.

Vankar et al. (2007) studied the production of anthraquinone reddish orange dyes in roots stem and leaves, which has been used for dyeing textiles since ancient times from Rubia cordifolia (Tamin, local name). Commercial sonicator dyeing with Rubia showed that pretreatment with biomordant, Eurya acuminata DC var euprista Karth. (Theaceae family) [Local name, Nausankhee (Apatani tribe), Turku (Nyishi'tribe) in 2%] showed very good fastness properties for dyed cotton using dry powder as 10% of the weight of the fabric is optimum. Use of biomordant replaces metal mordants making natural dyeing ecofriendly. Indigotin and indirubin was eliminated. For acidic extraction of dyes from fibers, ethanol was used. Due to its higher boiling point than methanol it evaporates slower from the

extraction solution enabling a more efficient extraction of dyes. This greatly informed the researcher as he went ahead to extract dyes from sweet potatoes, turmeric, bidens pilosa, boobo, vernonia amygdalina, akalamata murder, dioscora polystachya, balugu, charcoal which the study employed in screen printing sample fabrics^{xix}.

2.3 Use of Natural Dyes on Textiles

Natural dyes are used in many traditional systems like indigenous knowledge systems and indigenous technology, traditional medicine and indigenous health systems, built forms and architecture, indigenous food systems, performing arts, socio-cultural systems, arts, crafts and materials^{xx}.

This shows that natural dyes have many uses in the society for example Turmeric when used as a food additive is used to protect food products from sunlight. The oleoresin is used for oil-containing products. A curcumin and polylobate solution or curcumin powder dissolved in alcohol is used for water-containing products. Over-coloring, such as in pickles, relishes, and mustard, is sometimes used to compensate for fading.

In combination with annatto turmeric has been used to color cheeses, yogurt, dry mixes, salad dressings, winter butter and margarine. Turmeric is also used to give a yellow color to some prepared mustards, canned chicken broths, and other foods (often as a much cheaper replacement for saffron). Natural dyes are mostly employed for dyeing of natural fiber textiles to enhance their eco-friendly characteristics. They are usually applied to textiles by dyeing. Apart from indigo, other natural dyes are usually not used for printing directly. For producing printed fabrics, the printing is usually done with mordant and the whole material is dyed whereby only the area printed with mordants picks up the color.

Natural dyes, like synthetic dyes, can also be used to dye textiles at all stages such as fiber, yarn, or fabric. Fiber dyeing has the advantage that any shade variation can be easily adjusted by blending and therefore has been practiced at industrial scale also but is costly due to problems in spinning and loss of dyed fibers. Wool is generally dyed in yarn form and traditional dyers prefer yarn dyeing for all materials as it offers versatility in designing

during weaving. Dyeing in hank form is preferred by traditional dyers operating at the cottage level due to its simplicity and low investment and also its compatibility with their usage of crude dye-bearing natural resources for reasons of authenticity as well as cost effectiveness.

2.3.1 Fastness

Fastness is the resistance of a textile material to specific chemical agencies ^{xxi}. And it's also defined by dictionary .com as the state of being fixed or firm ^{xxii}. Therefore when experimenting with natural dyes for screen printing on the fabrics is very essential to explore the different types of fastness of natural dyes on fabrics. The fastness among all types of color fastness, light fastness, wash fastness and rub fastness are considered specifically for apparels only.

Colour fastness is the resistance of a material to change any of its color characteristics or extent of transfer of its colorants to adjacent white materials in touch. The color fastness is usually rated either by loss of depth of color in original sample or it is also expressed by discoloration scale, i.e., the accompanying, white material gets tinted or stained by the colour of the original fabric ^{xxiii}. However colour fastness of natural fibers and dyes is not that good and this confirmed by TSC group inc in their report of 2010 – 2013 which states that colorfastness is typically more of a problem with dyed natural fibres such as cotton and silk ^{xxiv}.

Below is an image extracted from that report showing the results of colour fastness on different fabrics

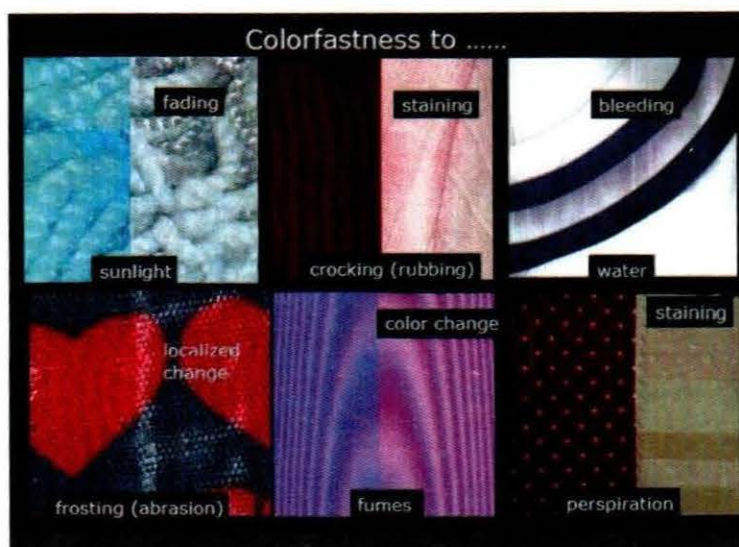


Plate 1 showing the results of colour fastness on different fabrics by TSC group inc.

Source: TSC group inc

Natural dyes have poor light fastness unless subject to further treatments of mordant as explained by Tassew A, Zenebesh T (Vol.2(Iss.2):November2014) that light fastness of many natural dyes particularly which are extracted from flower petals are found to be poor to medium. So an extensive work has been carried out to improve the light fastness properties of different natural dyed textiles. The study includes tannin- related after treatment for improving the wash fastness and light fastness of mordant able dyes on cotton. Some of these treatments might be applicable to specific natural dyes

A large proportion of natural dyes are course, mordant dyes. There is strong influence nature, type, concentration of mordents on wash and light fastness grades. The influences of different mordents were found to play important role in fading of 18 yellow natural dyes. Wool dyed with different natural dyes specimens was exposed to a xenon arc lamp for assessing its light fastness. The corresponding color change after exposure to xenon arc lamp was also assessed in each case. Turmeric, fustic and Marie gold dyes faded significantly more than any of the other yellow dyes. However the use of tin and alum mordents causes significantly more fading than that with the use of chrome, iron, or copper mordant. Thus

the types of mordant are found to be more important than the dye itself in determining the light fastness of natural colored textile

The light fastness and wash fastness under standard condition (50°C) and also at 20°C with a washing formulation used in conservation work for restoration old textiles. Some dyes undergo marked changes in color on washing due to the presence of even small amounts of alkali in washing mixtures, highlighting the necessity to know the pH of alkaline solutions used for the cleaning of textiles dyed with natural dyes. As a general rule natural dyes show moderate wash fastness on wool

In general, shine fastness of most of the natural dyes is found to be moderate go good and does not require any after treatment. The dye color strength related parameters and compatibility for dyeing cotton fabrics with binary mixture of jack fruit wood and other nature of dyes. However it must be remembered that the color fastness of natural dyes not only depends on chemical nature and type of natural colorants, But also on chemical nature and types of mordant's being used. So a dye must know. The use of proper combinations of fiber mordant is to achieve best color fastness. The use of natural after treatment agents is to improve both wash and light fastness of natural dyes.

This literature about fastness was a grate input to this research as it helped the researcher in the aspects of experimenting with natural dyes in the screen printing of sample fabrics. It provided the loopholes in using natural dyes on different fabrics after they have been dyed. Therefore the study tried to employ the knowledge from the literature to achieve objective three of the study.

2.4 Screen printing with Natural Dyes

Sudha Babel in his article entitled Screen Printing on Silk Fabric using Natural Dye and Natural Thickening Agent expounds on the printing with natural dyes and states that Printing is a form of dyeing in which the color is applied to specified area. The resulting multicolored patterns have attractive and artistic effects which enhance the value of fabric. To resist the coloring matter to the design area, it is pasted with thickening agent which may be natural or synthetic polymer. Plant products are attractive alternatives to synthetic

products because of biocompatibility, low toxicity, environmental “friendliness” and low price compared to synthetic products. Natural products are also generally non-polluting renewable sources for the sustainable supply.

Cassia seed gum and Mango kernel gum has been taped to explore as a source of natural thickening agent for sustainable development. The present paper deals with preparation of thickening agent from Cassia seed gum and mango kernel gum and investigating their suitability as thickening agent in screen printing on silk fabric using *Butea monosperma* flower dye extract with two different mordants and testing its CIE Color coordinates and color fastness towards light, washing, rubbing and perspiration. The principal goal of the project was to experiment with the usage of natural dyes extracted from plants to decorate fabrics using Screen printing technique. The research of traditional dyeing led to the inspirational concepts and brought the textile screen prints to achievement.

Understanding the dyeing practices informed the design process and directly influenced the composition and images of the designs. Research was conducted on the use of natural plant-based dyes sweet potatoes leaves, yam roots, turmeric roots, *Momordica foetida* leaves, *bidens pilosa* leaves, Madder (*Manjistha*) roots and *vernonia amygdalina* leaves for screen-printing by determining the most effective natural thickener used in making pastes. The study established thickening agents of sodium alginate and gum Arabic were used in the screen printing of sample fabrics.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This Chapter outlines the manner in which the study was carried out. The chapter shows studio experimentation methods which were used in the study describing a step by step process of extracting natural dyes from plants and screen printing of sample fabrics. It covers the research design, area of study, population sample, sampling strategy, sampling techniques and procedures of data collection, tools and materials for studio work and research procedure of the study.

3.1 Research Design

The study used experimental survey structure. Experimental approach in this study was used to experiment with the usage of natural dyes extracted from plants to decorate fabrics using Screen printing technique.

3.2 Population

The researcher selected a sample of thirty (30) respondents to participate in the study. The selection of respondents was based on one's skills and knowledge in the field of fabric decoration. The respondents were selected from textile designers, local groups dealing textiles and textile students within Kampala District in Uganda. The respondents participated in the unstructured interview through which the study was informed. The study used population because population was used when working with units and this was confirmed by Parahoo (1997:218) who defines population as "the total number of units from which data can be collected", such as individuals, artifacts, events or organizations.

3.3 Sample Size and Sampling Technique

This study used (20) respondents, simple random sampling and purposive sampling techniques. Simple random sampling was used in order to avoid bias and to ensure that each respondent has an equal chance of being selected. Purposive sampling was used in selecting

respondents because the researcher wanted to study the usage of natural dyes in the screen printing of fabrics. And this supported by Bryman (2008), who states that “Purposive sampling is a method that entails selecting respondents in a strategic way, so that those sampled are relevant to the research questions that are being posed”. Patton (1990) affirms Bryman’s definition of purposive sampling when he maintains that, “The logic and power of purposive sampling lies in selecting information-rich cases for study in depth^{xxv}”.

3.4 Data collection Methods

The researcher used the following methods to collect data:

- Interviews
- Direct observation
- Library and archival survey
- Studio experimentation

3.4.1 Interview

Kakooza (2002; 20) defines interview as “a conversation in which a researcher tries to get information from the interviewee and records it by him or herself”. In this study, the researcher made appointments with various people to be interviewed, made preparations and utilised unstructured relevant questions for the study. The data from respondents was recorded and utilised during studio practice

3.4.2 Direct observation

Observation is way of gathering data by watching behavior, events, or noting physical characteristics in their natural setting. The researcher used direct observations and watched the use of natural dye in the screen printing of fabrics. The researcher states that this observation started a way back when he was doing his undergraduate study in the department of Art and Industrial Design where he noticed that natural dyes were only being used for dyeing purposes. The data collected through direct observation was recorded and used for reference purposes during studio experimentation.

3.4.3 Library

The researcher read through a number of books and newspapers and journals especially before the actual collection of data. The information got from these sessions enabled the researcher to find the proper direction and the informed perspective in the study.

3.5 Studio Experimentation

3.5.1 Plants used

The study focused on seven plants namely, sweet potatoes, yam, turmeric, *Momordica foetida*, *bidens pilosa*, Madder (*Manjistha*) and *vernonia amygdalina*

3.5.1.1 Sweet potatoes

Sweet potatoes are an excellent source of vitamin A (in the form of beta-carotene). They are also a very good source of vitamin C, manganese, copper, pantothenic acid and vitamin B6. Additionally, they are a good source of potassium, dietary fiber, niacin, vitamin B1, vitamin B2 and phosphorus. Sweet potato [*Ipomoea batatas* (L.) Lam] is the sixth most important food crop in the world, and new uses for this crop have been identified. Sweet potato is one of the crops selected by the U.S. National Aeronautics and Space Administration (NASA) to be grown in a controlled ecological life support system as a primary food source^{xxvi}. However the study used Sweet potato leaves in the experimentation of extracting colour for screen printing and the leaves of the plant used were collected from wakiso district Uganda



Plate 2 showing Sweet potato grown in Wakiso district Uganda

Source: Researcher

3.5.1.2 Turmeric

Turmeric is a member of the *Curcuma* botanical group, which is part of the ginger family of herbs, the *Zingiberaceae*. Its botanical name is *Curcuma longa*. Turmeric is widely grown both as a kitchen spice and for its medicinal uses. Two closely related plants, *Curcuma petolata* and *Curcuma roscoeana*, are natives of Cambodia and are grown for their decorative foliage and blossoms. All curcumas are perennial plants native to southern Asia^{xxvii}. For this research turmeric used in this study was collected from wakiso district and employed for colour extraction.



Plate 3 showing Turmeric grown in Wakiso district Uganda

Source: Researcher

3.5.1.3 Madder (Manjistha)

Madder is branched climber with bristles. The stem is slender and four angled. The leaves are rough, and arranged in whorl of four per node and oval to heart shaped with long leaf stalk. The leaves have 5-7 main nerves. The stipules are short living (leafy structures found at the nodal region). The flowers are very small, greenish white and arranged in branched cluster called dichasial cyme (forked flowering stalk, which bears specific number of flowers in each branch). The fruit is round fleshy drupe^{xxviii}. The madder plant used in this study was collected from Mukono District.



Plate 4 showing Madder grown in Mukono district Uganda

Source: Researcher

3.5.1.4 *Momordica foetida*

Momordica foetida is a perennial vine native tropical Africa, closely related to the bitter melon (*M. charantia*) and balsam apple (*M. balsamina*). Its species name ("bad-smelling") refers to its unpleasant smell. It was previously named *M. morkorra* (A. Rich) and *M. cordata* (Cogn.)

It's also known by many local names which include *concombre sauvage* (French for "wild cucumber"), *nyanya-nua*, $\sigma\pi\rho\sigma\pi\sigma$, *kakle*, *awoduan* ("snake food"), *aoasongo*, *gaayama*, *nanã*, *ngessannia*, *boobo*, *bobonowron*, *vovolé*, *vovoné vono*, *hepa*, *isúgū*, *alu-osi*, *akb'an`udene*, *ejinrin*, *tsekiri*, and *a-bos-a-wir*. *Momordica foetida* leaves were executed to produce dye which was used in the studio experimentation of screen printing with natural dyes on cotton fabric.



Plate 5 showing *Momordica foetida*

Source: Researcher

3.5.1.5 *Bidens pilosa*

Bidens pilosa is a species of flowering plant in the aster family. It is native to the Americas but it is known widely as an introduced species of other regions, including Eurasia, Africa, Australia, and the Pacific Islands. It is a tall branched weed with thin yellow flowers that develop into a cluster of barbed seeds. Its many common names include black-jack, beggar-ticks, cobbler's pegs, and Spanish needle.

Bidens pilosa is a wild plant which is found a lot ever way in Uganda and the one which was used in this collected from the Kyambogo University farm.

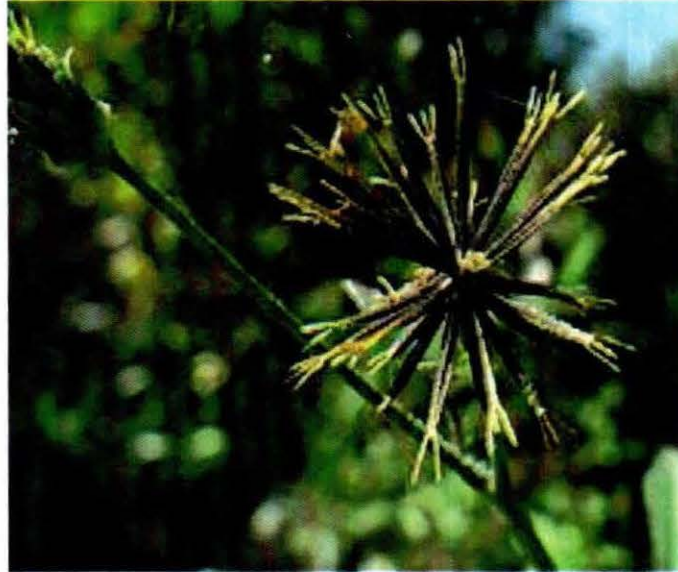


Plate 6 Showing *Bidens pilosa*

Source: Researcher

3.5.1.5 *Vernonia amygdalina*

Vernonia amygdalina, a member of the Asteraceae family, is a small shrub that grows in tropical Africa. *V. amygdalina* typically grows to a height of 2–5 m (6.6–16.4 ft). The leaves are elliptical and up to 20 cm (7.9 in) long. Its bark is rough. *V. amygdalina* is commonly called bitter leaf in English because of its bitter taste. The cooked leaves are a staple vegetable in soups and stews of various cultures throughout equatorial Africa. African common names include grawa (Amharic), ewuro (Yoruba), etidot (Ibibio), onugbu (Igbo), ityuna (Tiv), oriwo (Edo), chusar-doki (Hausa), mululuza (Luganda), labwori (Acholi), olusia (Luo), and ndoleh (Cameroon).

Vernonia amygdalina used in this study was collected from wakiso district



Plate 7 Showing *Vernonia amygdalina*

Source: Researcher

3.5.1.5 Yam roots

Chinese yam roots (*Dioscorea polystachya*), also called cinnamon-vine or yam roots (balugu), is a species of flowering plant in the yam roots family. This perennial bine native to China now grows throughout East Asia (Japan, Korea, Kuril Islands, Vietnam). It is believed to have been introduced to Japan in the 17th century or earlier. Introduced to the United States as early as the 19th century for culinary and cultural uses, it is now considered an invasive plant species.

Yam roots were collected from wakiso district and used for extraction of dyes which were used for screen printing on cotton fabrics.



Plate 8 Showing yam plant (*balugu*)

Source: Researcher

3.5.2 Materials used

The study focused several materials namely cotton fabrics, sodium alginate, gum Arabic, salt, sodium bicarbonate, ash water, textile thickener, Book binding glue, squeegee, screen mesh, rags, nails and masking tape.

3.5.2.1 Cotton Fabric

A plain-weave cotton fabric was used. It was washed, thoroughly rinsed and air dried at room temperature. This was used as surface for printing.

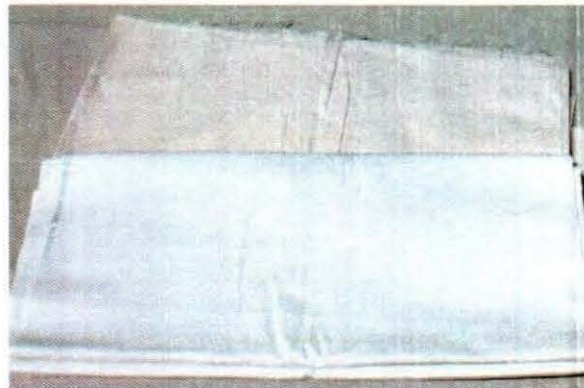


Plate 9 Showing Cotton fabric

Source: Researcher

3.5.2.2 Thickening agents

The study experimented with four different thickening agents which were sodium alginate, gum Arabic, wood glue and textile thickener (tubvis)



Plate 10 Showing sodium alginate

Source: Researcher



Plate 11 Showing gum Arabic

Source: Researcher

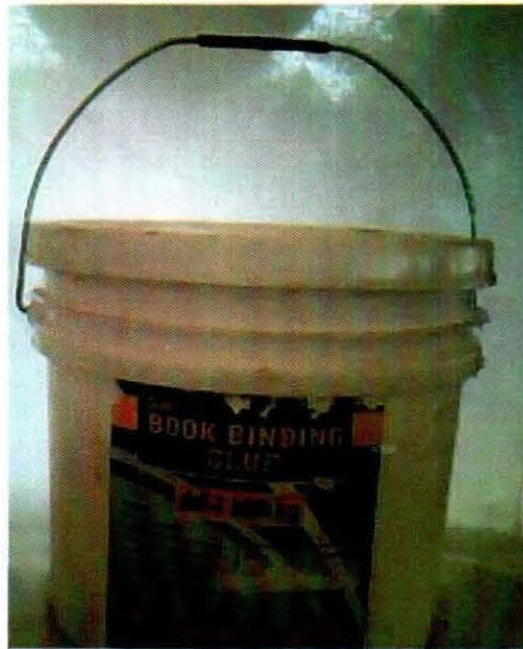


Plate 12 Showing Book binding glue

Source: Researcher



Plate 13 showing a tin of textile thickener

Source: Researcher

3.5.2.2 Chemicals used

The study used sodium bicarbonate, salt, ash water and vinegar sodium carbonating in the studio experimentation.



Plate 14 showing a tin of Vinegar

Source: Researcher



Plate 15 showing salt and sodium bicarbonate

Source: Researcher



Plate 16 showing ash water

Source: Researcher

3.5.3 Process of Extraction of the colour from the plants

There are many methods used to extract dyes from plants and use them to dye or print fabrics. The research used the mordant method to screen print on cotton fabrics.

The amount of pigment in each of plant is dependent not only on the genetics of each plant, but also the stage of development, and growing conditions^{xxix}. After collecting all plants

that were selected, the researcher begun by cleaning the plants with water to remove soil and dust in order to make it ready for extraction through using a pestle and mortar.



Plate 17 showing the washed sweet potato leaves

Source: Researcher



Plate 18 showing the research putting the leaves in the mortar for pounding

Source: Researcher

After the process of pounding the different plant leaves and roots all the pounded staffs were put in tins waiting to be made into a paste. Below are the images showing the pounded staff.



Plate 19 showing the pounded turmeric
Source: Researcher



Plate 20 showing the pounded Madder (Manjistha)
Source: Researcher



Plate 21 showing the pounded Sweet potato leaves

Source: Researcher



Plate 22 showing the pounded yam roots (*balugu*)

Source: Researcher



Plate 23 showing the pounded *Vernonia amygdalina*

Source: Researcher



Plate 24 showing the pounded *Momordica foetida*

Source: Researcher

The process was followed by forming a paste to be used for printing. The each pounded plant staff was mixed with the four thickening agents. The printing pastes for the selected plants used in screen printing on cotton were prepared as follows:

Table 1: The recipe of printing paste

Sn	Printing paste	Recipe 1	Recipe 2	Recipe 3
1	Sweet potato leaves (g)	30	30	30
2	Momordica foetida (g)	30	30	30
3	Vernonia amygdalina (g)	30	30	30
4	yam roots (<i>balugu</i>) (g)	30	30	30
5	Madder (<i>Manjistha</i>) (g)	30	30	30
6	Turmeric (g)	30	30	30
7	Salt (g)	5	10	15
8	Sodium bicarbonate (g)	5	5	10
9	Ash water (spoons)	1	2	3
10	Vinegar (spoons)	1	2	3
11	Sodium Alginate (g)	10	10	10
12	Book binding glue (g)	10	10	10
13	Gum Arabic (g)	20	40	50
14	Textile thickener (tubvis) (spoons)	2	3	5

3.5.4 Source of inspirations

Although the study did not focus on design development it was necessary come with an original design for the study. Therefore the researcher selected two sources of inspiration from people taking local beer and women fetching water which were used in the studio experimentation of screen printing with natural dyes on to cotton fabrics.

The study had a variety of ideas selected from the society to be studied in the design process, such as people taking local beer and women fetching water from the well.

The researcher developed photographic impressions and sketches from live specimens for extended references and reflections during studio practice.

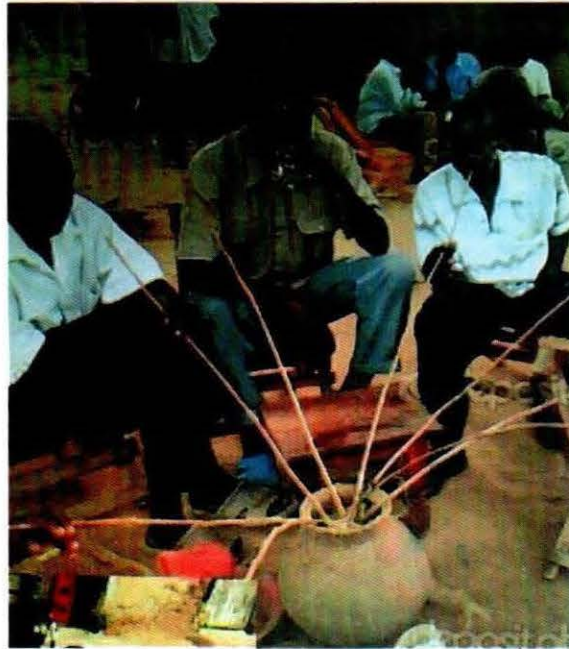


Plate 25 Showing people taking local beer

Source:<http://depositphotos.com/12477299/stock-photo-drinking-local-brewsoroti-ug>

In plate25 above the researcher presents a number of people sited taking local beer from one pot. This is mostly found in local places in Uganda, which also shows a sign of togetherness among the people in the society.

From plate 25 the researcher used computer aided design in manipulating of the image and then developing the design.



Plate 26 showing the image in plate 25 converted into vector graphics.

Source: Researcher

The researcher employed vector graphic above to further manipulate it to produce different repeats of patterns which were used in the study

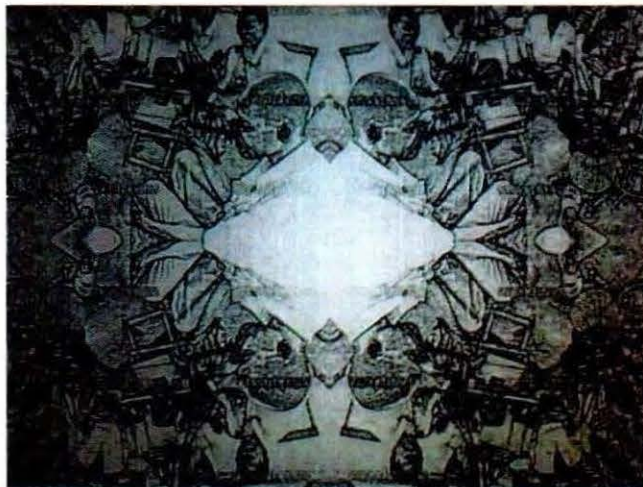


Plate 27 showing one of the repeat patterns formed using computer aided design.

Source: Researcher

From this stage the researcher went ahead to make more repeat patterns in colour with the aid of computer application of Adobe Illustrator to give an impression of the final design. Below is an example of one of the repeats in colour.

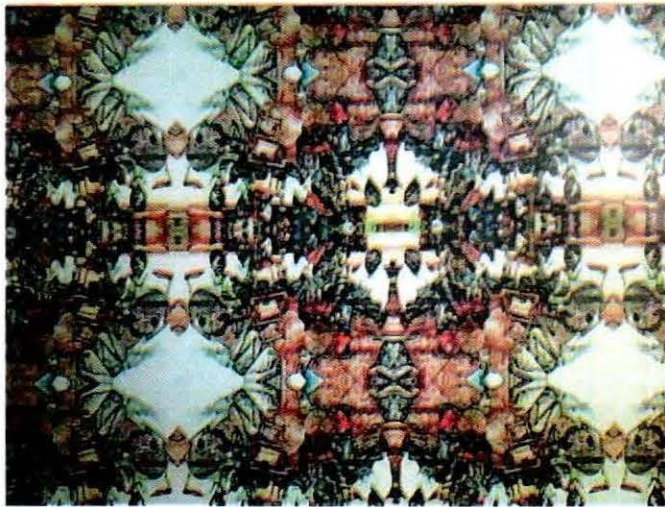


Plate 28 showing the final repeat in colour

Source: Researcher

In the plate 28 above the researcher presents a final design developed from people taking local beer. In the all process of coming up with the design the researcher used a computer aided design programmes of Photoshop and Illustrator to develop the pattern from the raster images of people taking local beer to the vector repeats in colors forming the final design, which was screen printed with natural colours extracted from plants on to cotton fabrics.

The study used three designs with different approaches the first one I have presented was developed from a secondary source of inspiration with the aid of computer aided design softwares while the second one involved hand drawn studies in pencils, pen and brushes then later perfected it using Adobe Illustrator one of the best 2D vectors programmes for designers.

In second one the researcher started by making drawings on paper of people drawing water from a well. The drawings were of an imaginative composition of two women drawing water from a well from which one study was selected.

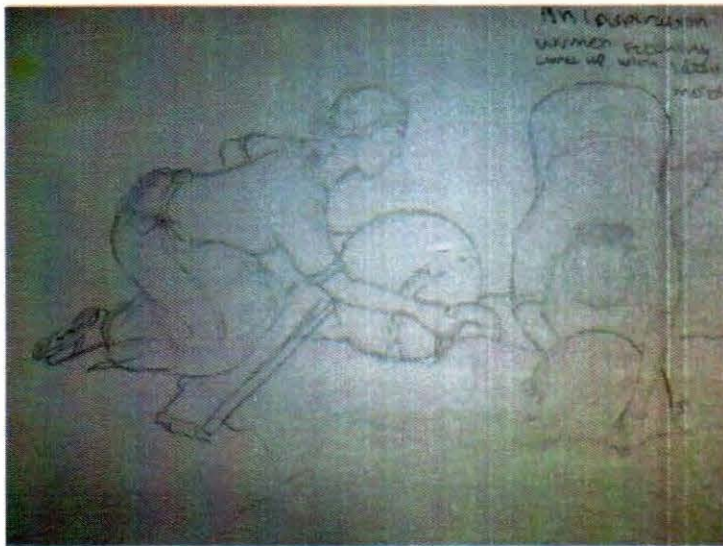


Plate 29 showing an outline imaginative composition of two women drawing water from the well.

From the line drawing above the researcher went head to develop different stages including putting the design in colour using poster colours. The researcher used his textile: fabric decoration knowledge acquired from textile classes to make repeats and patterns to come up with the second design. Below are the stages which the researcher took in developing the design.

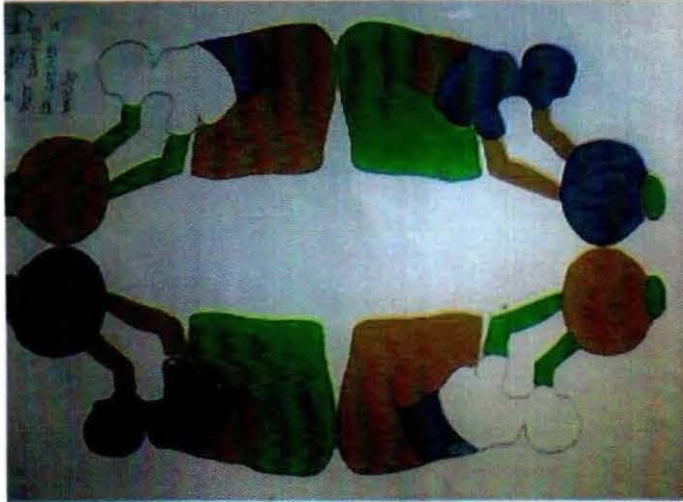


Plate 30 showing the first repeat pattern in colour

Source: Researcher



Plate 31 showing the first repeat pattern in colour

Source: Researcher

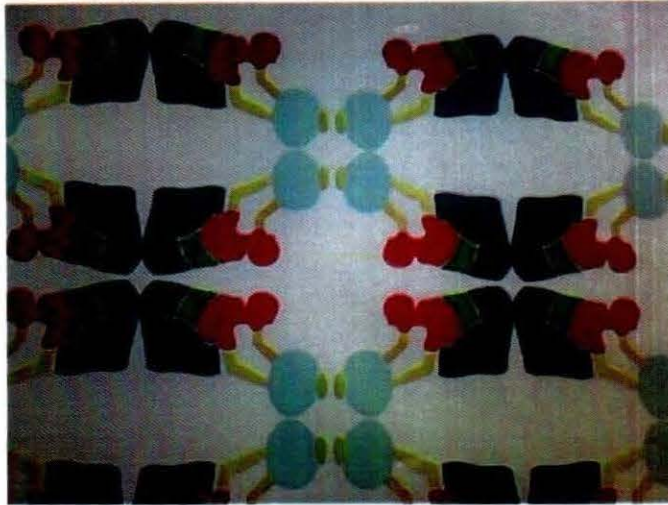


Plate 32 showing the third repeat in colour

Source: Researcher

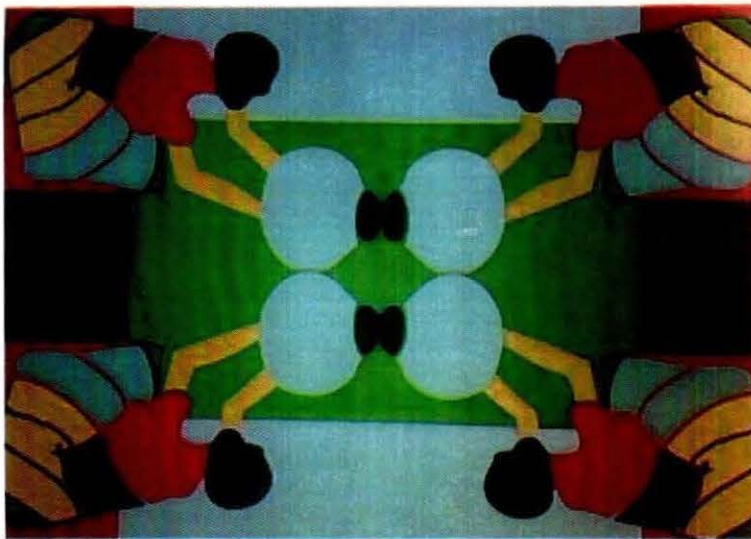


Plate 33 shows the design with an added outline to give other feel

Source: Researcher

In plate 29 the researcher started by making drawings on paper of fetching. The drawings were also of an imaginative composition of two women carrying pots of water from which one study was selected.

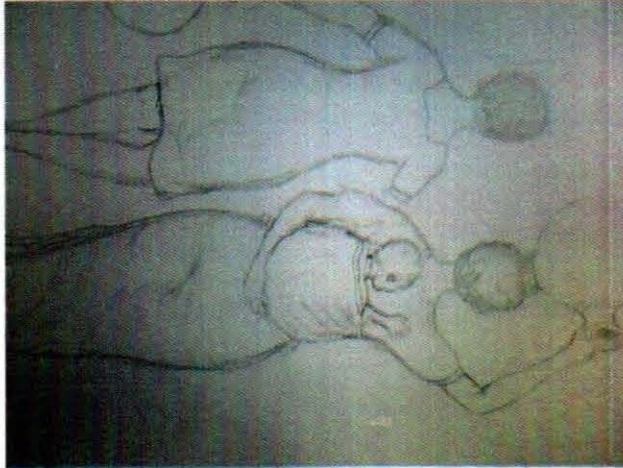


Plate 34 showing women going to the well to fetch water

Source: Researcher

From plate 34 above the researcher developed stages from which the third final design was made. The researcher followed the same design process as those used in the second design.

Below are some of the design steps taken in developing the third design

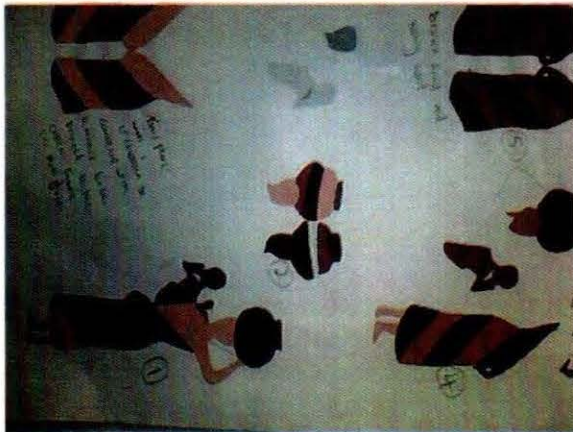


Plate 35 showing the different manipulations of the in colour

Source: Researcher



Plate 36 showing suggested color patterns of design three

Source: Researcher

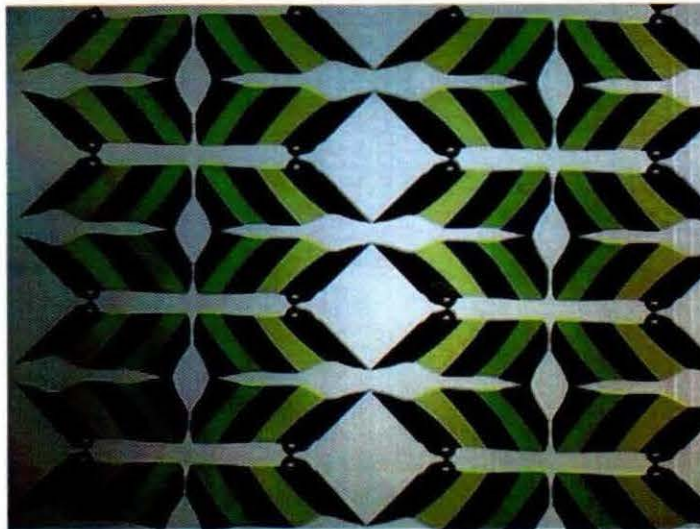


Plate 37 showing the final selected repeat

Source: Researcher

The research improved the final repeat by using computer aided design applications. Since the developing of designs were not the focus of the study the researcher therefore concentrated on the printing of natural dyes.

3.5.5 Printing Procedure

Printing was carried out using the flat screen technique. Printed samples were then dried in the sun for one hour and fixed by use of two different methods. The fixing methods included ironing and putting the fabrics in an electric oven. Ironing method took 15 minutes while that of the oven took 20 minutes. Printed samples were rinsed with cold water until the excess dyes were removed from the fabrics.

The printing process started by developing photosensitized screens from the designs made by the researcher which has been discussed already in 3.6.4 sections.

Then the fabrics were stretched on a printing a table and here the researcher used the Art and Industrial Design Departmental textile studio. Then proceeded by printing the natural dyes using the recipes shown in table one.



Plate 38 showing one of the screens developed

Source: Researcher



Plate 39 showing the screen printing using natural dye in the textile studio

Source: Researcher

After the printing process the fabrics were dried in the sun, fixed and rinsed to remove excess dyes.

3.6 Validity and readability

Reliability and validity are important issues in assessing quality of research (Bryman, 2008) as they indicate the extent to which study findings reflect the world that they are seeking to explore (Kabanze, B. M. (2012)^{xxx}. To ensure the validity and reliability of the study, pilot testing of the instruments were carried out. Studio guiding questions and interview guide were distributed to willing participants and friends. The research supervisors' also read through and made necessary changes regarding the instruments before administering.

3.7 Procedure

The researcher using a letter from the head of the department of Art and Industrial Design of Kyambogo University, obtained authority from different heads of various institutions. The researcher explained to respondents the purpose of study in order to get their formal consent before involving them in the interviewing process or photographing their

collections. Documentation of data did not include the names of institutions and respondents in order to keep responses confidential.

CHAPTER FOUR:

PRESENTATION AND INTERPRETATION OF STUDIO FINDINGS

4.0 Introduction

This chapter presents and interprets the studio findings of the study. Findings are based on study outcomes of natural dye possibilities with the purpose of using it to decorate fabrics.

4.1 Effect of printing on colour value

A study on the selected plants of sweet potatoes, yam roots, turmeric, *Momordica foetida*, Madder (Manjistha) and *vernonia amygdalina* using the different thickeners of sodium alginate, gum Arabic, book binding glue and textile thickener were applied in screen printing using natural dye. The colour value results obtained are presented in Table 2, 3, 4, 5, 6 and 7. It can be observed that the colour strength (CS) value of recipe 3 was the best printed result, and the next good result was obtained in the order of recipe 2 and recipe 1.

The study used ISO test no. 1 (ISO1) formerly known as hand washing to test colour fastness to wash where 5 = excellent, 4 = very good, 3 = good, 2 = moderate, and 1 = poor

Cotton fabric screen printed with *Momordica foetida* showed very good handling and sharpness, as shown in table 2.

Table 2 showing the colour fastness to wash for *Momordica foetida*

Sn	Thickening agents	Handling	Sharpness	Colour fastness to wash	
				Before Washing	After Washing
1	Sodium Alginate	5	5	5	3
2	Gum Arabic	5	5	5	3
3	Book binding glue	5	5	5	3

According to table 2 above all thickening agents produced excellent results in handling and sharpness that were rated 5 according ISO test no.1. However, color fastness to wash before washing was rated 5 against 3 after washing.



Plate 40 showing a Printed fabric using *Momordica foetida* with sodium alginate as thickener before washing

Source: Researcher

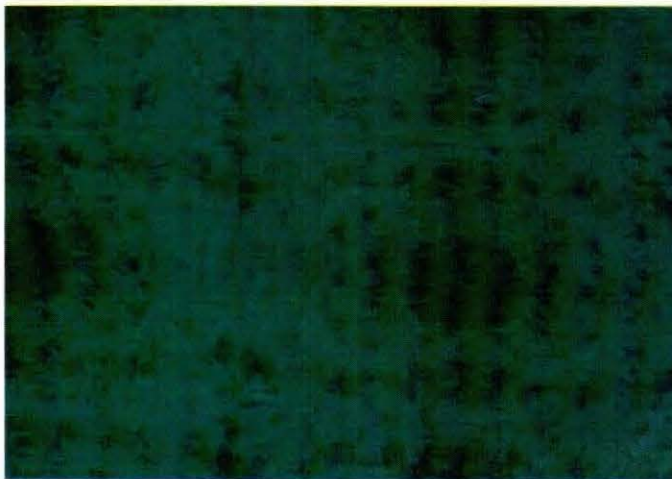


Plate 41 showing a Printed fabric using *Momordica foetida* with sodium alginate as thickener after washing

Source: Researcher

Momordica foetida showed a very good colour strength before washing with all the different thickening agents but was good after washing. Momordica foetida gave a green colour when printed.

Cotton fabric screen printed with sweet potatoes leaves showed very good handling and sharpness, as shown in table 3.

Table 3 showing the colour fastness to wash for sweet potatoes leaves

Sn	Thickening agents	Handling	Sharpness	Colour fastness to wash	
				Before Washing	After Washing
1	Sodium Alginate	4	4	5	2
2	Gum Arabic	4	4	5	2
3	Book binding glue	4	4	5	2

According to table 3 above all thickening agents produced very good results in handling and sharpness that were rated 4 according ISO test no.1. However, color fastness to wash before washing was rated 5 against 2 after washing.



Plate 42 showing a Printed fabric using sweet potato leaves with gum Arabic as thickener before washing

Source: Researcher



Plate 43 showing a Printed fabric using sweet potato leaves with gum Arabic as thickener after washing

Source: Researcher

Sweet potato leaves showed a very good colour strength before washing with all the different thickening agents but was fair after washing. Sweet potato leaves gave a green colour when printed.

Cotton fabric screen printed with Madder (Manjistha) showed very good handling and sharpness, as shown in table 4.

Table 4 showing the colour fastness to wash for Madder (Manjistha)

Sn	Thickening agents	Handling	Sharpness	Colour fastness to wash	
				Before Washing	After Washing
1	Sodium Alginate	4	4	5	3
2	Gum Arabic	4	4	5	3
3	Book binding glue	4	4	5	3

According to table 4 above all thickening agents produced very good results in handling and sharpness that were rated 4 according ISO test no.1. However, color fastness to wash before washing was rated 5 against 3 after washing.

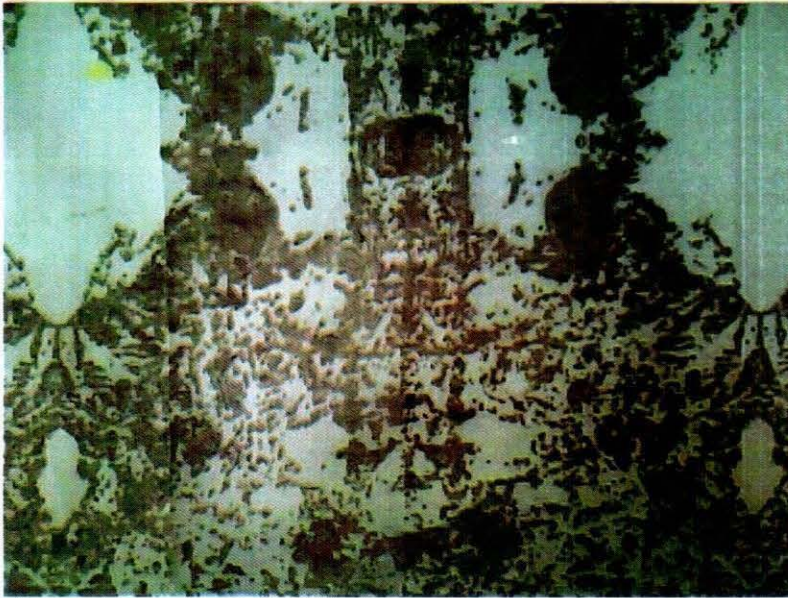


Plate 44 showing a Printed fabric using madder roots with gum Arabic as thickener before washing

Source: Researcher

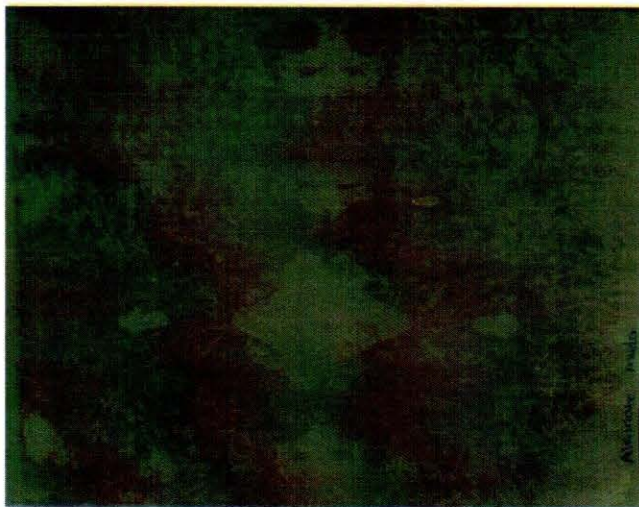


Plate 45 showing a Printed fabric using madder roots with gum Arabic as thickener after washing

Source: Researcher

Madder roots showed a very good colour strength before washing with all the different thickening agents but was good after washing. Madder roots leaves gave a maroon colour when printed.

Cotton fabric screen printed with vernonia amygdalina showed very good handling and sharpness with all the thickeners a part from book binding glue, as shown in table 5.

Table 5 showing the colour fastness to wash for vernonia amygdalina

Sn	Thickening agents	Handling	Sharpness	Colour fastness to wash	
				Before Washing	After Washing
1	Sodium Alginate	4	4	5	3
2	Gum Arabic	4	4	5	3
3	Book binding glue	4	4	5	1

According to table 5 above all thickening agents produced very good results in handling and sharpness that were rated 4 according ISO test no.1. However, use of book binding glue as a thickener had low fastness of 1 against sodium, alginate and gum Arabic which had 3 after washing.

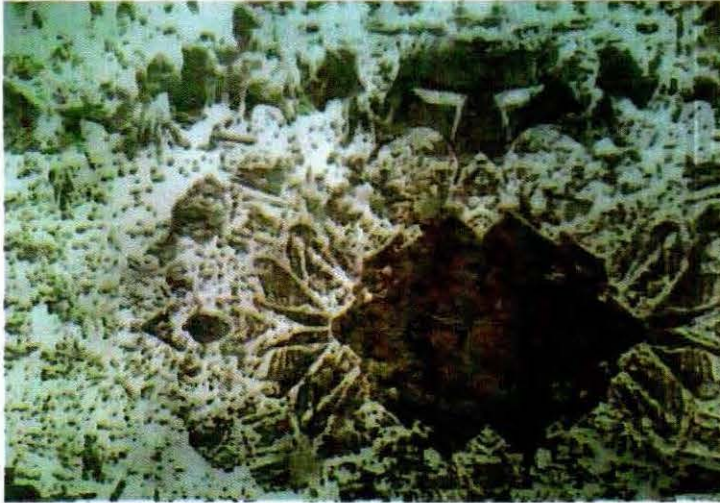


Plate 46 showing a Printed fabric using vernonia amygdalina with sodium alginate as thickener before washing

Source: Researcher



Plate 47 showing a Printed fabric using vernonia amygdalina leaves with book binding glue as thickener after washing

Source: Researcher

Vernonia amygdalina leaves showed a very good colour strength before washing with all the different thickening agents but was good after washing. Vernonia amygdalina leaves gave a green colour when printed however, did not give a good sharpness of a print when using book binding glue.

Cotton fabric screen printed with turmeric showed very good handling and sharpness with all the thickeners, as shown in table 6.

Table 6 showing the colour fastness to wash for turmeric roots

Sn	Thickening agents	Handling	Sharpness	Colour fastness to wash	
				Before Washing	After Washing
1	Sodium Alginate	4	4	5	4
2	Gum Arabic	4	4	5	4
3	Book binding glue	4	4	5	4

According to table 6 above all thickening agents produced very good results in handling and sharpness that were rated 4 according ISO test no.1. However, color fastness to wash before washing was rated 5 against 4 after washing.

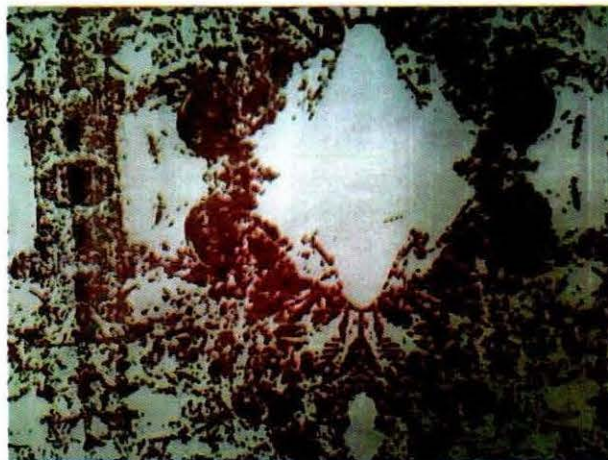


Plate 48 showing a Printed fabric using turmeric roots with sodium alginate as thickener before washing

Source: Researcher



Plate 49 showing a Printed fabric using turmeric roots with sodium alginate as thickener after washing

Source: Researcher

Turmeric roots showed a very good colour strength before washing with all the different thickening agents but was very good after washing. Turmeric roots gave a brick red colour when printed.

Cotton fabric screen printed with yam roots showed very good handling and sharpness with all the thickeners, as shown in table 7.

Table 7 showing the colour fastness to wash for yam roots

Sn	Thickening agents	Handling	Sharpness	Colour fastness to wash	
				Before Washing	After Washing
1	Sodium Alginate	4	4	5	2
2	Gum Arabic	4	4	5	2
3	Book binding glue	4	4	5	2

According to table 7 above all thickening agents produced very good results in handling and sharpness that were rated 4 according ISO test no.1. However, color fastness to wash before washing was rated 5 against a low fastness of 2 after washing.



Plate 50 showing a Printed fabric using yam roots with sodium alginate as thickener before washing

Source: Researcher



Plate 51 showing a Printed fabric using yam roots with sodium alginate as thickener after washing

Source: Researcher

Yam roots showed a very good colour fastness to wash before washing with all the different thickening agents but was very good after washing. Yam roots gave a brown colour when printed.

The researcher also experimented with the natural dye by mixing different plants in equal proportions and without using any thickening agent and the results are shown below.



Plate 52 shows a Printed fabric using Black jack and hibiscus leaves before washing

Source: Researcher

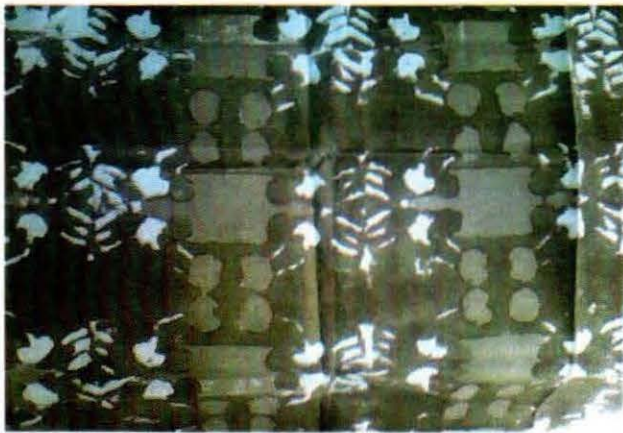


Plate 53 showing a Printed fabric using black jack dye and Vernonia amygdalina leaves before washing

Source: Researcher



Plate 54 showing a Printed fabric using turmeric roots before washing

Source: Researcher



Plate 55 showing a Printed fabric using madder roots before washing

Source: Researcher

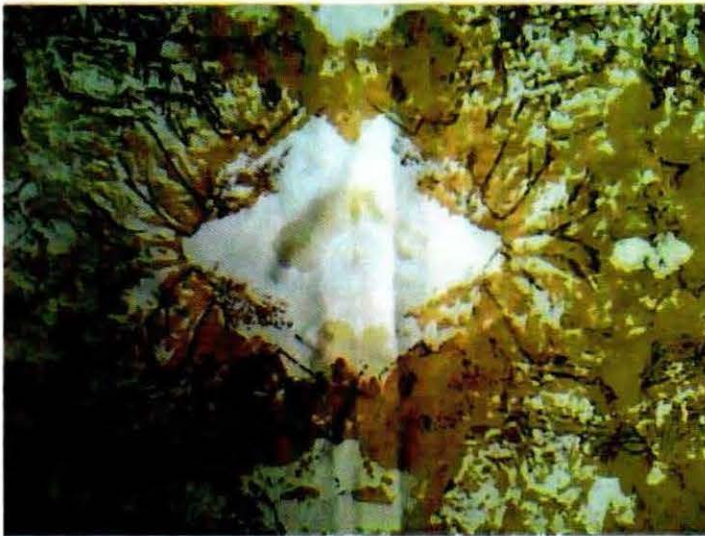


Plate 56 showing a Printed fabric using madder and turmeric roots before washing

Source: Researcher



Plate 57 showing a Printed fabric using madder and turmeric roots before washing

Source: Researcher

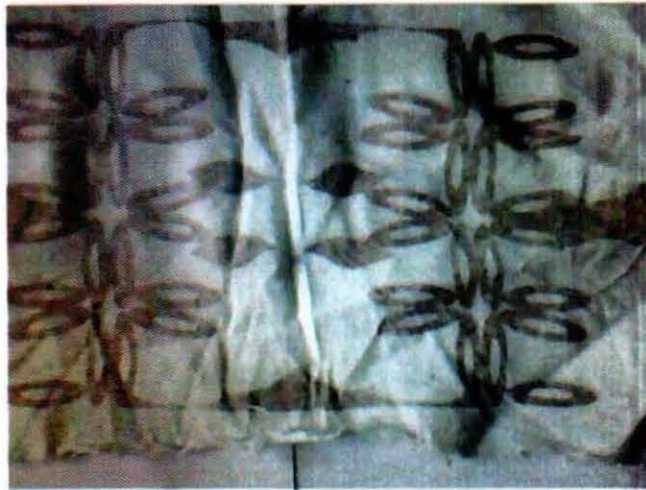


Plate 58 showing a Printed fabric using yam roots (balugu) roots with textile binder after washing

Source: Researcher



Plate 59 showing a Printed fabric using turmeric roots with textile binder after washing

Source: Researcher

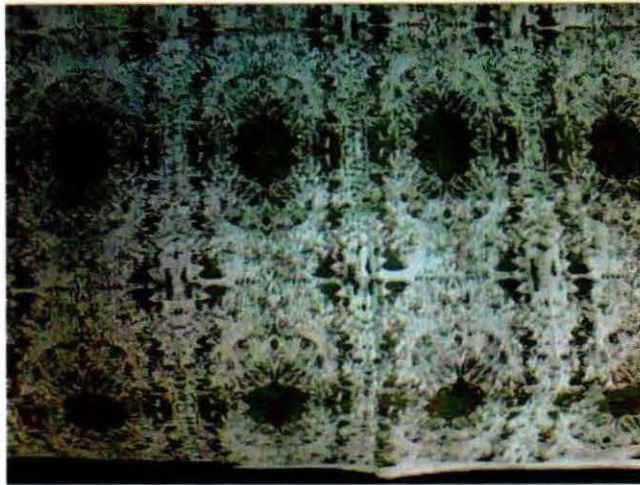


Plate 60 showing a Printed fabric using mululuza and bombo with textile binder before washing

Source: Researcher

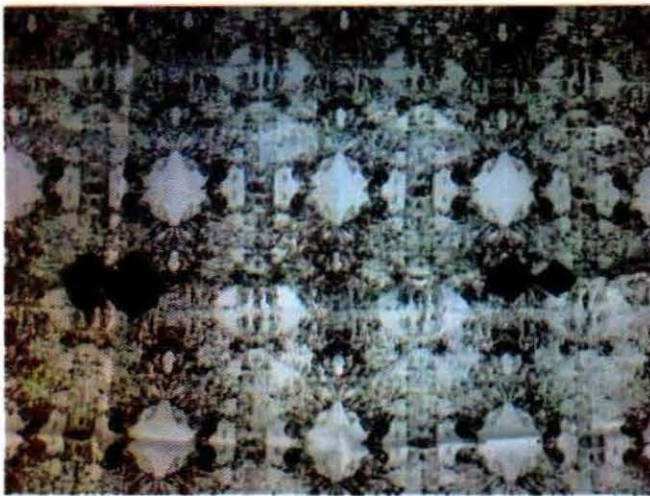


Plate 61 showing a Printed fabric using all the plants in the study with textile binder before washing

Source: Researcher



Plate 62 showing a Printed fabric using yam roots with textile binder before washing

Source: Researcher

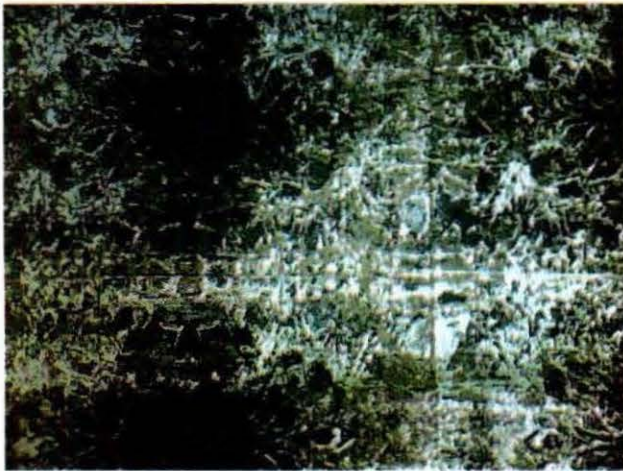






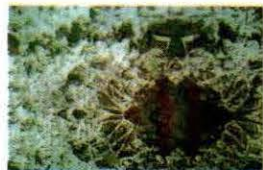







Plate 63: showing a Printed fabric using yam roots with textile binder before washing

Source: Researcher

Table 8 showing a summary of samples and their performance in colour fastness

	Samples	Original Shade	Change in shade after washing
1	Momordica foetida Leaves		
2	Sweet potatoes leaves		
3	Madder Roots		
4	Vernonia amygdalina Leaves		
5	Turmeric roots		
6	Yam roots		

CHAPTER FIVE: DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

In this chapter, the researcher presents the discussion, conclusion and recommendations drawn on the study. The purpose of this study was to experiment with the usage of natural dyes extracted from plants to decorate sample fabrics using Screen printing technique. The discussions were guided by the following objectives:

1. To analyze various plants in Uganda for extraction of dyes to decorate fabrics using screen printing technique.
2. To extract natural dyes that can be applied on to cotton fabric using screen printing technique.
3. To experiment with natural dyes to decorate fabrics using screen printing technique
4. To produce screen printed sample fabrics using natural dyes.

5.1 In Relation to Research Objective One

Research objective one which stated; to identify various plants in Uganda for extraction of dyes to decorate fabrics using screen printing technique.

According to the findings of the study showed that Uganda had got many plants that can produce colour and this can be related to the literature review where: Wanyama found out 40 plants with potential of yielding dyes of good characteristics for application in the textile industry were identified in Uganda (Wanyama et al. 2010). How colorants from Uganda are mainly used for dyeing purposes only.

The study focused on seven plants namely, sweet potatoes, yam roots, turmeric, *Momordica foetida*, *bidens pilosa*, Madder (*Manjistha*) and *vernonia amygdalina*

5.2 In Relation to Research Objective Two

Research objective two which stated: to extract natural dyes that can be applied on to cotton fabric using screen printing technique.

From the plants selected in objective one the researcher extracted colorants using the local methods of extraction. In chapter two of the study showed that they were many methods of extraction. The different methods for extraction of coloring materials were Aqueous extraction, Alkali or acid extraction, Microwave and ultrasonic assisted extraction, Fermentation, Enzymatic extraction, Solvent extraction, Super critical fluid extraction^{xxxix} however, the researcher used local ways of extracting dyes from plants like pounding, squeezing, soaking and boiling the different parts of the plant because it had an advantage over the acid extraction which is harmful to the human health.

5.3 In Relation to Research Objective Three

Research objective three which stated: to experiment with natural dyes to decorate fabrics using screen printing technique.

The study experimented with different three recipes as shown in table one and also used four thickening agents which were sodium alginate, gum Arabic, textile thickener and book binding gum. All the three yielded the same results on the colour fastness to washing. However, book binding glue was not good on the print sharpness when using vernonia amygdalina.

5.4 In Relation to Research Objective four

Research objective four which stated: to produce screen printed sample fabrics using natural dyes. Using the recipes in table one the researcher formed printing paste which was used to print sample fabrics. The study also used a direct photographic method of screen printing. This means the researcher had to produce the screens which were used following the steps of producing a photosensitized screen. The printing process was a success but they were changes in the fabrics after washing. This showed that natural dyes can be used in screen printing and they have unique colours.

5.5 Conclusions

The study based on the objectives were the researcher sought to carry out a studio exploration into possibilities of using natural dye to produce fabric decorations using screen

printing techniques. Following the findings in this study, shows natural dyes can be used to screen print cotton fabrics however, there is need to make more investigations on the different plants to get more colours.

This study has established the fact that dyes from sweet potatoes leaves gives a green colour, yam roots give a brown colour, turmeric roots give yellow without thickening agent and brick red with thickening agent, *Momordica foetida* leaves give light green colour, *bidens pilosa* leaves give brownish colour, Madder (*Manjistha*) roots give red orange colour and *vernonia amygdalina* leaves gives green colour which were successfully utilized for screen printing. The results also revealed further that they give a high performance of these dye extracts on sharpness of the print using sodium alginate, gum Arabic, textile thickener and book binding glue.

5.6 RECOMMENDATIONS

This study discovery will go a long way in reducing over-dependence on toxic, expensive and non-available exotic print pastes for printing on cotton fabrics. This study recommends that when you need to print a green colour you can use sweet potatoes leaves and *vernonia amygdalina* leaves, *Momordica foetida* leaves for light green, yam roots for a brown colour, turmeric roots for yellow without thickening agent and brick red with thickening agent, *bidens pilosa* leaves for brownish colour and Madder (*Manjistha*) roots for red orange colour. Further research on the experimentation with the usage of natural dyes extracted from plants to decorate fabrics using Screen printing technique, will improve on colour imparting attribute through the introduction of mordant into the dye extracted paste. There is also a need to investigate the potential of the dye extracts in detecting presence of a variety of colour ranges.

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