EXTRACTION AND UTILIZATION OF BANANA PLANT RESiN FOR POSSIBLE USE AS PIGMENT BINDER ON COTTON FABRIC

BY

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AHMADU BELLO UNIVERSITY, ZARIA NIGERIA

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BY

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DECLARATION

I declare that the work in this thesis entitled Extraction and Utilization of Banana Plant Resin for Possible Use as Pigment Binder on Cotton Fabric has been written and performed by me in the Department of Industrial Design, Ahmadu BeHo University, Zaria; under the supervision of Dr. Maiwada S., Dr. Ada P.O and Prof. Yakubu M.K. the information derived from the literature has been duly acknowledged in the text and in the list of references provided. No part of this thesis was previously presented for another degree at any university.

Lubasa, Siku Fololo _____ _____

Name of Student **Signature** **Date**

CERT1FICATION

This thesis entitled EXTRA TIONAND UTILIZATION OF BANANA PLANT RESIN FOR POSSIBLE USE AS PIGMENT BINDER ON COTTON FABRIC by Luhasa Siku Fololo meets the regulations governing the award of the degree of Masters of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to God Almighty, and to my late Mother Siku Landu Catherine may her gentle soul rest in perfect peace of our Lord Jesus Christ, Amen.

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ABSTRACT

The study focuses on, possible methods of extracting and processing resins obtained from Musaceae (banana plant), precisely: Musa Cavendish Dwarf and Musa Paradisiaca to be used as pigment binder and its fastness properties when printed on cotton fabrics. Additional purpose of the study was to determine the quantity and quality of resins extracted from different species of the banana plant. To achieve these purposes some additives such as alum, potash and salt were used and also some fixative processes such as oxidization, steaming and ironing, were explored. All samples were printed on cotton fabric and subjected to standard washing, rubbing as well as light fastness tests. The tests were done through some manual and laboratory approaches with pigment paste on cotton fabric. The resins from banana plant species were extracted by tapping and pounding then squeezed out. They were used fresh into the paste, whereby different thickeners were introduced namely: sodium alginate, gum tragacanth, in separate beakers, and all were mixed with three different mordants namely: alum, potash and salt. It was then printed on the cotton fabric, oxidized, steamed and ironed. The printed fabrics were tested for wash, rubbing, and light fastness tests: It is also inferred that the amount of resins mixed was 2.5mls of resin with half pellet of pigment, 2 tea spoons of thickener 2/3 spoon of mordants well mixed for 3-4mins. I.S.O. (International Standard Organization) 3 for the wash fastness test, the results of wash and rubbing fastness tests were interpreted using the grey scale (I.S.O. 150), while the light fastness test was interpreted using the blue standard. All results were reported in photoraphs, samples, specimens, plates and tables. It can be concluded that locally produced binder from both species of Musaceae namely Musa cavendish dwarf and Musa paradisiaca produced acceptable results, especially wash fastness test, followed by the rub fastness test and then light fastness test.

Based on the selection, collection, analysis and uses of data obtained in the cause of this study, conclusions are as follow:

1. Two species of Musaceae were selected namely:

- Musa Cavendish Dwarf

- Musa Paradisiaca

2. The quantity extractable from the pseudostem of each species was as follow:

- 74gm mass weight of raw material used produced—45mls of resin from Alusa Cavendish Dwarf

- 200gm mass weight of raw material used produced—*l4Omls of resin from Alusa Paradisiaca. The quantity extractable from Musa Paradisiaca was more than the one of Musa Cavendish Dwarf

3. The method of extraction employed was direct method, which has to do with pounding and then squeeze out the resin. The method adopted was profitable.

4. The mordants used in the study were: Alum, Potash, Sodium chloride, and Ammonium chloride

5. The Wash, Rub, and Light fastness property was of acceptable quality.

Therefore, the results of this study have proven its relevance to the economic need of this Nation.

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DEFINITION OF OPERATIONAL TERMS

Definition of Operational Terms

Adhesive: a substance used to bind two or more surfaces together.

Aquatint: intaglio method of printing, similar to etching that produces tonal areas rather than lines.

Characterization: are set of qualities that make something distinctive.

Extraction: in chemistry, method used both commercially and in the laboratory to separate a substance from a mixture or solution. This is usually done by using a solvent in which the substance being extracted is very soluble but the materials from which it is being extracted are not..

Mordant: the simplest method of indirect dyeing which involves pre-treating the fibre with mordants, or fixing solutions, before applying the dye solution.

Oxidation dyes: these are like azoic dyes, oxidation dyes are water soluble colourants (pigment) formed on the fibre during dyeing from water-soluble starting materials. They are applied to the fibre as an oxidation base in the form of water-soluble salt and thereafter oxidized to a pigment.

Pseudostem: common name for a plant family with about 50 genera and 1300 species.

Resins: a group of sticky, liquid, organic substances that usually harden, upon exposure to air, into brittle, amorphous, solid substances. Natural resins are secreted by many plants, appearing on the external surface of a plant after a wound.

Soxhlet extractor: is a piece of laboratory apparatus invented in 1879 by Franz von Soxhiet. It was originally designed for the extraction of natural oils from a solid material.

Sulphur dye: are two part "developed" dyes used to dye cotton with dark colours. The initial bath imparts a yellow or pale chartreuse colour; this is aftertreated with a sulfur compound in place to produce the dark black we are familiar with in socks for instance.

Varnish: liquids that solidify when exposed to air, and are used to cover surfaces for decorative and protective purposes. Paints are formed by mixing a pigment.

ABBREVIATION OF TERMS

...1-74...: Sample Numbers with different treatments.

WF. . .A: Wash Fastness Test with Alum

WF. . .P: Wash Fastness Test with Potash

WF.. . S: Wash Fastness Test with Salt (Sodium Chloride)

RF. . .D: Dry Rubbing Fastness Test

RF. . .W: Wet Fastness Test

LF...: Light Fastness Test

I.S.O.: International Standard Organization

°C: Degree Celsius

Mins: Minutes

Gr: grammes

Exci: Excellent

U.V.: Ultra Violent

M.C,D.: Musa Cavendish Dwarf

M.P.: Musa paradiciaca.

S. Ag → Sodium Alginate

Trag. → Tragacanth

G.A → Gum Arabic

NaCI → Sodium Chloride

NH4C1 → Ammonium Chloride

Pot. →Potash

Ptha. → Pthalocynine

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Textile is a tradition that goes back through time and may in fact be one of the earliest collected art form. According to archaeologists and anthropologists, the earliest clothing probably consisted of fur, leather, leaves or grass draped, wrapped or tied about the body. The textile industry, with its extremely long and rich history, has had a massive impact on the world's economy and the very evolution of modern society. The desire to protect the entire body from harsh weather as well as from bites of insects has led to many exploits, even that of textile raw materials, (Maiwada, 2001).

Every nation, be it developed, developing or underdeveloped is moving with time through one research or the other with the aim of protecting and developing further action on variables needed for new findings. This in turn serves as achievement in the bid to attain self reliance, self-sufficiency or supremacy in the world. Nigeria, not left out in this race is gradually getting industrialized with various projects proposed. The country over the years has suffered from insufficient and shortage of textile raw materials such as chemicals, colourants, binders, pigments, dyes, fibres, to mention but a few. This problem increased as a result of the ban on importation of textile materials by the federal government of Nigeria since 1977. This has been compounded by a gradual and steadily increasing population. (Bako, 1989)

Due to inadequate supply of imported textile raw materials, the rate of production of fabric in most textile industries in Nigeria has dropped below average, Mohammed (1984) in Mosaku (1987). Many manufacturers of textile raw materials have been attempting to produce chemicals including dyes, adhesives and colourants; however, these are rather low in quality and ineffective to meet people's needs.

Heaton (1984) explored a variety of textile raw materials in Nigeria, and stated that if Nigeria's textile local resources are thoroughly exploited and processed, the importation of textile raw materials will be put to an end within a relatively short period of time. Bako (1989) recommended that efforts should be made towards working with locally available sources of textile raw materials rather than depending on imported ones.

Researches have been conducted in Nigerian Universities and those outside Nigeria on textile colours, extracted from plants to supplement the synthetic dyes, introduction of local techniques of dyeing, printing and weaving into contemporary ones as a new development in textiles. Some researches were also made on raw material that could fix or bind colourant. Kogi (1997) affirms that researches have been conducted on colours extracted from plants that will substitute synthetic dyes. Siva (2007) also reviewed an article on status of natural dyes and dye-yielding plants in India. Murray (1960) and Clarke (1974) in Bako (1989) confirmed the use of resins as binder and photo-screen blockage when coating designs on the screen so as not to allow pigment paste penetrate through those areas not needed.

Encarta student dictionary (2007) and Halsey (1968) in Alau (1986) defined dye as a substance used to colour materials permanently in such a way and manner that the imparted colour seems to be part of the fabric and not merely applied to the surface as in painting.

Storey (1978) in Alau (1986), defines natural dyes as those obtained from plants, animals and minerals. Dyeing improves the market value and enhances the aesthetic of clothes. From a simple experiment it was observed that when Banana resins - be it from leaves or its stem, gets in contact with cotton fabric, a permanent stain is fixed. This background provides the motivating factor for this research.

1.2 Statement of the Problem

Nigerian industrial manufacturing activities are import-oriented in terms of the necessary inputs namely: - machinery, raw materials and in some cases man power. The insufficiency of textile raw materials such as binders, adhesives, fibres, inks, pigments and dyes, for the production of textile fabrics, has caused increase of the cost price on their sale. It sought to find an alternative solution to the problem of scarcity of dyestuff, binders, inks, and fibers in schools and industries. There is need for research on locally available raw materials; this will help to put an end on importation of textile materials.

The problem of this study therefore focuses on possible methods of extracting and processing resins obtained from musaceae (banana plant), to be used as pigment binder and its fastness properties when printed on cotton fabrics. The study will also determine the quantity and quality of resins extracted from different species of the banana plant.

1.3 Aims and Objectives of the Study

1. Aims

The aims of this study is to make the hypotheses of this study valid and to select identify, collect, extract, and process resins that can be collected in Sabon Gari, Zaria in Kaduna State for the production of binder. The locally produced resins will be tested to see to which extent the raw material could be used as binder in textile printing and to determine the type of alkali based, agencies and additives that will be suitable for binding pigment on cotton fabric. The study will also determine the wash, rub and light fastness property of the pigment binder on cotton fabric

2. Objectives

The objectives of this study are to:

1) select and collect the different species of the study plant which are musaceae (banana) plant.

2) determine its quantity and quality.

3) determine the suitable methods of extracting resin from musaceae.

4) select suitable mordants that will be introduced to help fix the produced ink on cotton fabric.

5) test the wash, light, and rub fastness property of the pigment binder on cotton fabric.

1.4 Research Questions

The following research questions which are based on the objectives of the study were designed to guide this research:

1) what are the possible methods to select species of musaceae and what is the quantity extractabe?

2) what are the suitable methods of extracting musaceae plants resin?

3) to what degree will the gum resin be mixed with pigment paste and to what possible state can the resin be used to bind pigment on cotton fabric?

4) is mordant needed to serve as fixative for pigment on the fabric?

5) will the efficacy level of wash, rub and light fastness tests be of acceptable quality?

1.5 Significance of the Study

Man's desire to appear beautiful through the ages has been expressed in the use of clothing for personal adornment, (Mac, 1963). The fabrics used for this purpose essentially require paint in their production. Paints are formed by mixing a pigment and resins binders such as: gum Arabic, egg white, gelatin and beeswax were the first vehicles used in these pigments, (Nguyen, 2008).

In every society, nature provides certain raw materials, that, societies have freedom to select from and to reshape for the benefit of its people. Some make use of them while others do not. Enamali (1987) in Bako (1989) states that through contact with appropriate societies coupled with readiness and willingness to exploit natural resources and to yield fruitful result, yet in some, this merely serves to preserve status quo and promote further dependency. In Nigeria, certain plants are yet to be explored for textile colouration and plants for extraction of pigment binders or adhesives. The Federal Government directive that industries should strive to source their raw materials locally is seen as a step forward in realisation of this noble objective. The Raw Materials Research and Development Council (RMRDC) have a vital role to play until date, (Bako, 1989).

Taking a critical look at Nigeria's state of industrial and technological advancement since independence, it will not be far from the truth if one says that progress is rather slow, Maiwada (2001). He further states that, there is need to work much hard towards achieving more meaningful development.

Banana plant cultivators observed that a touch of banana plant resin on cloth can stain it permanently; this implies that Banana sap is extremely sticky and can be used as a practical adhesive. Sap can be obtained from the pseudostem, from the peelings, or from the flesh. Therefore, there is need to exploit this plant, as to study the type of binder that can be obtained from it, both in terms of the quantity and quality. It is also to get suitable methods of extraction, to determine the biological properties and components of the binder obtained. Today in Nigeria, there is demand for supply of dyes, binders, inks because of the scarce commodity. According to Peterson (1974) in Alau (1986), prices are determined by the forces of demand, and supply.

In the present economic position of this country, in the case of pigment binder the importation supply is low while the demand is high which makes the purchase price very high. This fact is a product of dependency on importation of dye stuffs and binding agents. To solve this problem, researchers and federal government should make serious effort in exploiting the local resources, this can reduce the problem of depending on imported synthetic binders and dyes, and this is an attempt in attaining equilibrium between demand and supply and conversely, the cost of binders and dye in this area. If locally extracted dyes, inks and binders (adhesives) are found to be significantly suitable (as it is in the case of indigo dye, gum Arabic, and gum karaya), this will provide an alternative and save the home dyers (small scale industries) from buying synthetic adhesives and dyes on a high rate.

Schools will not only find it cheaper to use, but also will contribute to how and the method or steps to use in extracting adhesives for their pigments, this will be a challenge and will contribute to the knowledge of students especially if the extracted binder is suitable. This study will contribute into the existing literature on the subject, and it will be deliberately addressed to Nigerian local plants. The findings of this study will also help institutions offering textiles as a course to be able to prepare little dye for teaching.

Colour sometimes speak louder than words, its appeal is universal and repeatedly serves as a mode of expression as it relates to cultural and social values. The aesthetics value of this study will be found in the fastness quality of the coloured the cloth. The findings of this study will be documented, thus it will contribute to the literature of textile education in particular and the body of knowledge in general. Educational institutions as well as cottage textiles industries will certainly benefit from the results.

1.6 Scope and Delimitation of the Study

Mbah (1983), in a comparative study of bananas (Musa ABB groups) and plantains (Musa AAB groups), reveals that there are different species of banana plants which include: the Cavendish, Burro, Nino, Dwarf and Plantain. Also Omotoso and Ogunsile (2009) discussed that Four Musa species, namely; Musa cavendish, Musa paradisiaca, Musa nana and Musa sapientum are widely distributed and cultivated in south-western part of Nigeria, were obtained from the Department of Agronomy of the University of Ibadan. The study was conducted in 2004. Therefore this study has covered some species found in Sabon Gari local government area and Zaria in Zaria local government and its environs in Kaduna state, Nigeria. Especially those capable to be used as pigment binder (adhesive) for textile printing.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0 Introduction

The review of related literature in this study is based on: 1. Review of local raw materials, 2. Natural and synthetic gum-resins, and their uses, 3. some plants used as binders, 4. methods of extraction: manual and laboratory, description of Musaceae plant and its chemical composition, pretreatment of the fabric, experimental procedures: mordanting, mixing the binder with pigment, thickening and varnish, printing processes, fixing techniques, colour fastness test.

2.1 Review of natural raw materials

Textile is a tradition that goes back through time and may in fact be one of the earliest collected art form. According to archeologists and anthropologists, the earliest clothing probably consisted of fur, leather, leaves or grass; draped, wrapped, or tied about the body. The desire to protect the entire body from harsh weather as well as from bites of insects led to many exploits, even that of textile raw materials, (Maiwada, 2001).

Humans have been painting on fabrics for thousands of years, basically since people started twisting and weaving fibres together to make the early fabrics. According to anonymous (2010) the techniques that were used to decorate the body began to be applied to the earliest fabrics that were developed. Two basic methods emerged: colouring, (directly applying an image with colour to fabric) and patterning printing with resists in pattern and then colouring the fabric. The paint used was essentially composed of a binder, pigment and solvent, fabrics, (Michael, 1983). Asia has a long history of decorating fabrics printing blocks have been discovered that dated to around

3000 B.C by 327 B.C when Alexander the great invaded India, colourfully printed and painted fabric were commonly found. As the trade routes developed, beautiful Indian patterns were traded throughout Asia, Egypt and Greece. In the second century AD they made their way to Europe and Africa.

2.1.1 Primitive Pigments

According to Michael (1983) paint was made more than 35 000 years ago by prehistoric man as they mixed clays and chalks with animal fats and used these paints to depict their hunts on cave walls. By 2500BC the Egyptians had improved this technology considerably. They had developed a clear blue pigment by grinding azurite, and instead of animal fats they used gums, wax and maybe also albumen (egg white) as binders and solvents for their paints.

Early man used pigments from his natural environment in painting, thus the pigment found in different areas of the world tend to vary. It is thought that pigments were applied by two methods; the first was to mix pigment withs animal fat and apply it as paint with fingers or a reed, the second method was to blow pigment onto the painting surface using a hollow tube, (Anon., 2004).

2.1.2 Adhesive: an adhesive is a material capable of holding together solid materials by means of surface attachment. An adherend is a solid material to which the adhesive adheres and the adhesive bond or adhesive joint is the assembly made by joining adherends together by means of an adhesive bond. It primarily depends on the forces of adhesion, but its magnitude is determined by the physical properties of the adhesive and the adherend, as well as the engineering of the bond. The interphase is the volume of material in which the properties of one substance gradually change into the properties of another. The interphase is useful for describing the properties of an adhesive bond, (Pocius, 1991).

He further gives record of one of the earliest used adhesive bonding is a mural discovered in a sepulcher in ancient Thebes which depicts veneering of furniture by means of a hot-melt adhesive. The oldest forms of adhesives were those of natural origin. Glues that are made from collagen-containing parts of animals or from animal blood are examples of oldest forms of adhesives. Casein or milk, glues have been known since the 9^{th} century and exist to this date in a form not substantially different from that discussed by Theophilus. Some of the more ancient resins used to form adhesives are materials such as Bitumen, Shellac, and Pitch.

2.1.3 Guidelines for good adhesion

The following are guidelines for good adhesion according to Procius (1991) in Smith (1991):

1. An adhesive should posses a liquid surface tension that is less than the critical wetting tension of the adherends' surface.

2. The adherend should be mechanically rough enough so that asperities on the surface are on the order of, or less than, one micrometer in size.

3. The adhesive's viscosity and application conditions should be such that the asperities on the adherends' surface are completely wetted.

4. If an adverse environment is expected, covalent bonding capabilities at the interface should be provided.

For good adhesion the adhesive and the adherend should, if possible, display mutual solubility to the extend that both diffuse into one another, providing an interphasal zone, (Pocius, 1991)

According to Cottrell and Baird (1991) in Smith (2010), over the years the term gums was used to denote a wide rage of compounds including polysaccharides, terpenes, proteins and synthetic polymers. Today, the term, more specifically denotes a group of industrially useful polysaccharides or their derivatives that hydrate in hot or cold water to form viscous solution or dispersions. Gums are classified as natural and modified gums. Natural gums include seaweed extracts, plants exudates, gums from seed or root and gums obtained by microbial fermentation. Modified or semi-synthetic gums include cellulose and starch derivative and certain synthetic gums such as low – methoxyl pectin, propylene glycol alginate, triethanolamine alginate, carboxymethyl locust bean gum, and carboxymethyl guar gum. They are used in industry because their aqueous solutions or dispersion possess suspending and stabilizing properties. In addition, gums may produce gels; act as emulsifiers, adhesives, flocculants, binders, film formers, lubricants or friction reducers, depending on the shape and chemical nature of the particular gum.

2.2 Natural and synthetic gum-resins and their uses

2.2.1 Natural resins

According to Smith (2010), natural resin is a resin product which comes from a plant, in contrast with synthetic resin, which is made through chemical synthesis. Natural resins have been used in various human cultures for thousands of years; one notable examples of an ancient use of resin can be seen in Egypt, where resin was used in the preparation of mummified bodies. Such as the Cashew tree gum represented non-conventional alternatives; the art began in china centuries ago, reaching its climax of development during the period of 1368 - 1644 AD. The resin is synthesized in the epithelia cells having canals and then secreted into these internal cavities. Synthesis

generally occurs in all organs of the plant with different qualitative composition, appearing to be genetically controlled and influenced by environmental condition, (Azeez, 2002).

Natural resins continue to be used today for a wide range of applications which stretch from perfume to the treatment of bows for instruments such as violins and cellos.

The quality of individual gums resins and few distinguishing features define a natural resin. The first is the fact that it starts out in a sticky, slightly gummy state and hardens over time. The second is that it is soluble in alcohol and related compounds but not in water. This is what makes resins so useful; they can be heated or processed in alcohol to soften them, applied to something and allowed to dry. Once dry, the resin will not admit water intrusion. And thirdly the quality of individual resins is mainly determined by colour and odor. Many are colourless when secreted but darken on aging, (Smith, 2010). Resins is produced naturally by many plants and have a hydrocarbon base, they can contain other compounds as well. When fresh they are gummy, sticky, and soft over time they harden up. This hardening is what makes it useful to humans, as resin is hard enough to be used in varnishes, paints, sealants, lacquers, and adhesives, among other things. (Rigdon, 2003)

- Hydrocarbon resins: According to Holohan, et al (1991) in Smith (2010) the product usually referred to as hydrocarbon resins are low molecular weight, thermoplastic polymers derived from cracked petroleum distillated turpentine fractions, coal tar, and a variety of pure olefinic monomers. They are used extensively in adhesives, rubbers, hot-melt coatings, printing inks, paints, flooring, and other applications. They generally modify other materials and are rarely used alone; the average molecular weight is usually below 2000. Hydrocarbon resins range from viscous liquids to hard, brittle

solids. The colours range from water white in the case of resin from pure aromatic vinyl monomers polymerized with boron trifluoride, to pale yellow and amber, and to very dark brown in the case of certain inexpensive petroleum by-product resins.

- Gums from Botanical sources

When we think of plants we think of wood, medicinal herbs, vegetables, and maybe we even think of essential oils, fibres, and dyes. but rarely will think of gums and resins – the sticky stuff that many plants usually exude when their protective membrane or bark has been injured, though some do not, but freely excrete resin without prior injury, (Morgenstern, 2006)

According to Cottrell and Baird (1991) in Smith (2010), the botanical gums represent a family of polysaccharides obtained from a wide variety of plant sources. They are subdivided into exudates gums, seed gums and gums obtained by extraction of plant tissue. The properties of a botanical gum are determined by its source, the climate, season of harvest, and extraction and purification procedures. The considerable viscosity variation observed among gums from different sources determines in part, their uses.

- Plant exudates: They further state that most families include species that exude gums, and those that produce copious quantities represent a ready supply of gums. These exudates were the first gums to be used commercially and still represent a significant but diminishing segment of the natural gum market. The plants are usually shrubs or low-growing trees, whereby collection is by hand and labor costs represent a large proportion of the cost of these gums. Raw gums prices have remained low and steady because of the low labor costs in the producing countries of the Middle East and North Africa.

2.2.2 Synthetic resins

Rigdon (2003) explains that synthetic resins are typically manufactured using a chemical polymerization process. This process then results in the creation of polymers that are more stable and homogeneous than naturally occurring resin. Since they are more stable and are cheaper, various forms of synthetic resin are used in a variety of product, such as plastics, paints, varnishes, and textiles. Generally, synthetic resins are broadly categorized into two areas: thermoplastic synthetic resins and thermosetting synthetic resins. Thermoplastic resins are those that can be softened and reformed through application of heat and pressure, even after being set in a particular shape.

The most common type of product in this class of synthetic resins is polyester. Polyester is widely used in the textile industry for its highly strength fiber based properties. Another common application for this type of resin is epoxy resin, which is used in industrial materials and construction for its high-strength properties, (Rigdon, 2003).

2.3 Some plants used as binding agent

Natural gums are exuded in variety of shapes, characteristic of the species of origin. These shapes include the globular shape of gum Arabic and the flakes or thread like ribbons of gum *tragacanth*. The quanlity of individual gums is mainly determined by colour and taste or odor. Many gums are colourless when secreted but darken on aging, . According to Morgenstern (2006), numerous plants produce some kind of resin, latex or gum but only a few are commercially important today, even though their uses and applications are truly manifold. They have been used as adhesives, emulsifiers, thickening agents; they are added to varnishes, paints and inks. Although many plants' resins and gum exudates are known, only gum Arabic, Ghalti, Karaya, sodium alginate and Tragacanth have wide industrial use.

1. Gum Arabic: gum Arabic is a dried exudate from species of the acacia tree found in various tropical and semi-tropical areas of the world. Most of the commercial gum comes from a single species, *Acacia Senegal*. The largest producers are the republic of Sudan and several other West African countries, with over 75% of the world's production coming from the Sudan. The best grade comes from Acacia Senegal and about 90% of the Sudan's production is from this source; the remainder comes from *Acacia Seyal*. (Smith, 2010)

The origin of gum Arabic and other natural gum exudates has been the subject of much speculation. Some authorities believe that gum Arabic is produced by bacteria on wounded surfaces of the acacia trees. The wounds are generally produced deliberately in cultivated trees by stripping bark during the dry season. The gum is collected by hand over a period of several weeks with average of yields of 250g per tree per year. Crude exudates are hand sorted and exported before processing and milling to various specification. Gum Arabic is a complex mixture of calcium, magnesium, and potassium salts of Arabic acid, a complex branched polysaccharide that contains galactose, rhamnose, glucuronic acid and arabinose residues. Although the constituent sugars are the same, composition and molecular weight of the gum vary from species to species. Reported molecular weights are in the range of 260,000 to 1,160,000, suggesting a broad molecular weight of distribution. The gum is highly soluble in water and solution of up to 50% gum concentration can be prepared, (Smith, 2010).

Gum Arabic has wide and varied industrial uses, but is mainly as a stabilizer and thickener in foods. But the main non-food uses are in the formulations of inks and adhesives and in the textile industries. It is used in traditional water soluble adhesive paste for paper and for its protective colloid properties in all kind of inks. In textiles, gum Arabic is used in combination with starch as a sizing agent.

2. Gum Karaya: or Sterculia gum is the dried exudates of the Sterculia Urens tree, which is now cultivated in India, the primary producing area. The best quantity gum is collected by tapping the tree during the period of April to June with the second collection of lower quantity product later in the year. Gum Karaya is a partially acetylated high molecular weight ($9.5x10^9$) polysaccharide which contains L-Rhamnose, D-galacturonic acid. It is the least soluble gum exudates and does not dissolve completely in water to give true solution but swells in cold water to give viscosity of a 1% solution is ca 3 Pa·s (30 P), the gum concentration is up to 4% can be prepared in cold water and up to approximately 25% by heating.

This gum is used in the paper industry, it is used as a binder in the preparation of long fibered light weight papers, gum Karaya solution containing 15-18% gum solids, prepared by cooking a water suspension under pressure, are used as thickening agents for printing dyes as well as textile sizes.

3. Gum Tragacanth: is an exudate from several species of tree of the genus *Astranlagus*, found in dry, mountainous regions of Iran, Syria, and turkey. Iran is the best source and produces the highest quality gum. It consists of a complex mixture of acidic polysaccharide containing galacturonic acid, galactose, fucose, xylose, and arabinose. A soluble fraction, tragaacanthin, dissolves when added to water whereas an insoluble fraction (60-70%), bassorin, swells to gel like state. Solutions of gum Tragacanth have extremely high viscosity, possibly the highest of the natural hydrocolloids. Gum Tragacanth is used in the textile industry as a sizing agent and print paste thickener and as an emulsifier in furniture, floor, and auto polishes.

2.4 Methods of Extraction

There are several extraction methods for resins and extracts or latex from plants. But generally there are two methods of extraction, they are manual and laboratory.

Most commonly found types of plants exudates are chemically different to gums. Resins are terpene-based compound. Terpenes constitute one of the largest groups of plant chemicals, and they can be very complex. They are not water soluble, but can be either oil soluble or spirit soluble, depending on their specific chemical composition. Anvar and Burkhon (2009) states two methods of extraction: blender method and flow method. The results of the two methods were compared, and it indicates that optimum latex extraction can be achieved with flow method. The purity of latex by blender method (75%) was significantly lower than that extracted by flow method (99.5%). When the latex particles were stabilized with casein, the latex was concentrated significantly.

1. Most resins and latexes are obtained from the tree trunk by making incisions, and bleeding the tree. This method is known as 'incision'.

2. Oleoresins are chemically terpene compounds with high volatile oil content. Because of the rich oil content they are softer and more pliable than the resins. The volatile oil content is often extracted by solvent extraction to create various essential oil that are used in perfumery or as scenting agents for numerous household products, (Morgenstern, ibid).

According to Garner (1966) in Kogi (1997) a true gum is miscible in all proportions with water to form a paste or mucilage but insoluble in benzene or alcohol, is carbohydrate in character. She classified the gum into three types:

- Insoluble gums: these are insoluble in water, but if steeped in water, it swells into a stiff-jelly, which can be diluted into a thick paste. One of the best examples of these gums is gum Tragacanth is similar to gums extracted from Kharya tree.

- Soluble gums: these dissolve to a clear, and very viscous, highly refractive solutions that give good adhesives. Typical example of these gum are gum Arabic and Senegal gum.

- Semi – soluble gums: this intermediate type includes such gum as Indian hog gum, gum Karaya and Kathira. They may be regarded as mixtures in varying proportions of soluble gums, insoluble gums and a product which does not swell in water alone, but may be converted into the insoluble gums type of body by steam or alkali. Another method of extraction is pounding and squeezing, the plant will be cut into small pieces then pounded with the aid of a mortar and pestle, when it is soft the extract squeezed out is the resin. The pounding method is employed when the extract is not out when using the incision method or when the extract is not coming out in large quantity.

2.5 Description of Musaceae (Banana and plantain) Plant and its chemical composition

2.5.1. Description

Banana is the common name for any of the genus of tropical, treelike herbs and also for their fruits. Species of the genus are native to Southeast Asia but are now grown extensively in all tropical countries for their fruits, fibre, and foliage. The banana is a large, herbaceous plant with a perennial root, or rhizome, from which the plant is perpetuated by sprouts or suckers. In the tropics the stems are annual, that is, they die after perfecting the fruit, and new stems are developed from buds in the rootstock. These stems, or buds, are the common means of propagating and making new

plantations, and the growth is so rapid that the fruit is usually ripe within ten months after the offsets are planted. When fully grown the stem attains a height of 3 to 12 m (10 to 40 ft) and is surmounted by a crown of large oval leaves up to 3 m (10 ft) long, with a strong fleshy footstalk and midrib. The flowers spring in great spikes from the center of the crown of leaves and are arranged in whorl-like clusters along the spike; the female flowers occupy the base of the spike, and the male the apex. The fruits vary in length from about 10 to 30 cm (about 4 to 12 inches). The average weight of a bunch is about 11 kg (about 25 lb), but individual bunches often exceed 18 kg (40 lb). A stalk bears only once, and then dies down.

The fruit, of the family Musaceae (Banana) are known all over the world and seem to have been one of the earliest known tropical crops as they are said to have been under cultivation for over 4000 years Allen, (1967) in Mbah (1983). Apart from the fruits, the banana plant also provides man with fibre.

The following details are about the genus Musa L. – Banana as recorded by Anonymous (2007):

Kingdom	Plantae – Plants
Subkingdom	Tracheobionta - Vascular plants
Super-division	Spermatophyta - Seed plants
Division	Magnoliophyta - Flowering plants
Class	Liliopsida – Monocotyledons
Subclass	Zingiberidae
Order	Zingiberales

Family	Musaceae - Banana family
Genus	Musa L. – banana
Species	Musa acuminata Colla – banana fruit, plantain-plantaginaceae,

Manila hemp is a fibre from a wild species, Musa Textilis, L. and from it comes the world's famous ropes and cords. The fibre is used in weaving cloths and they are also used in the manufacture of matting and durable cordage.

Banana plant cultivators observed that a touch of banana plant resin on cloth can stain it permanently, therefore assumed that gum and adhesive can be gotten from the banana plant. Therefore, there is need to exploit this plant, as to study the classes and the quantity that can be extracted from it.

2.5.2 Scientific classification of the plantain

Kingdom:	Plantae
(unranked):	Angiosperms
(unranked):	Monocots
(unranked):	Commelinids
Order:	Zingiberales
Family:	Musaceae
Genus:	Musa
Species:	M. Paradisiaca (plantain)

2.5.3. Chemical composition of Musaceae: According to Oliveira et al (2007), the composition and structure of component from different morphological parts of 'dwarf cavendish', banana plant (petioles/midrib, leaf blades, floral stalk, leaf sheaths and

rachis) have been carried out aiming to evaluate their potential as eventual raw materials for the chemical processing. Macromolecular components were analysed using solid- state NMR, ATR – FTIR and wet chemistry methods.

Cellulose (37.3% leaf sheaths and only 15.7% in floral stalk). They further state that, all morphologic parts of banana plant contained considerable amounts of ashes (from 11.6 to 26.8%) composed mainly by potassium, calcium and silicium salts. The hemicelluloses in banana plant are proposed to be mainly glucuronoxylan and xyloglucan (from 5.5% in floral stalk to 21.5% in petioles/midrib). Rather significant amount of proteins was found in leaf blades (8.3%).

2.6 Pretreatment of Fabric (Desizing)

Pretreatment of fabric has to do with removal of natural and non-fibrous impurities. These could be done in different operations. Removal of glycerides is known as scouring treatment and they are often followed by bleaching. Oguntona (1986), states that for high quality cotton materials-voil, poplin etc, desizing is very necessary so as to remove starches which had previously been applied to help the process of manufacture. But this size must be removed in separate operation if the subsequent processes of bleaching, dyeing and printing are not to be impaired. Clarke (1977) shared the same view, that fabric to be printed must be pretreated it should either be scoured, desized or mercerized and causticized to remove impurities. Nkeonye (1993) support Oguntona (1986)'s view, that the objective of desizing is to remove the size applied to the warp yarn before weaving into cloth. Sizing of the warp yarns is achieved by passing them through a box containing a size mix. This process helps in strengthening the warp yarn to reduce breakage during weaving. He further states, that if size is not removed, the absorbency of the fabric towards water, dyeing, and printing reagent will be seriously

impaired. Oguntona (1986) further states that there are three ways or methods of removing size ingredient from fabric:

1. Rot Steeping: is an old method of steeping which takes place in warm water for 24 hours at a temperature of 35^oC - 40^oC or overnight at 60^oC. the prolonged soaking increases the absorbency and removes the starch as well as 2-3% natural impurities.

2. Acid Steeping occurs after singeing when the cloth is impregnated with 0.5-1% sulphuric acid (H_2SO_4) at constant temperature of 40^oC.

3. Enzyme Steeping: is a thorough and rapid method of desizing under suitable conditions of temperature and pH. Activity of enzymes is affected by concentration, time pH and temperature. The enzyme decomposes starch in three stages: - liquification, - dextrinisation, -conversion to maltose.

Kparevzua (1983) believes that when the fabric is immersed in lukewarm solution of sodium chloride (NaCl), then dried and used for printing, the concentration and penetration of pigment will be enhanced. According to Kaufman and Johnson (1967) in Alau (1986) any fabric to be decorated with any dye, must be starch free and must be washed in warm and mild soaped water in order to achieve a successful dyeing result. Clarke (1974) in Kogi (1997) says that if the cotton fabric is light, the pretreatment should be, by boiling the fabric for a period of 30 – 45 minutes in a solution containing a part of lissapol' ND and 5 parts (g) of soda ash per 1000 parts of liquor and later rinsed thoroughly in water dried and ironed, ready for printing.

However, cotton was chosen for this study because, it is in abundance in Nigeria and it has therefore been considered a related variable to this study, whose motive is to utilize local resources. Thus the cotton to be used is plain weaved and bleached fabric produced in Funtua Textile Industry in Katsina state, purchased from Zaria markets.

2.7 Mordants and Mordanting of Fabric

The name mordant according to Noah (1995), is derived from the French word "mordre" (to corrode or to bite) because the early French dyers believed on the utility of the metallic salts, they employed consisted in their corrosive nature; it was believed that these substances opened the pores of textile fibres and thus rendered them more capable of absorbing dyes. At a later period, it was recognized into a chemical combination with the so-called mordants entered into a chemical combination with the natural dyes and formed insoluble compounds, or 'colour-lakes'; hence the substances were considered principally as fixing agents for the dyestuffs. He further states that mordants can be considered as substances which, partly or wholly combine with the natural dyes to form definite compounds in the fibre, thus distinguishing them from those compounds which take part in the dyeing process without entering into the composition of the ultimate colour. Salam (2009) added that, the repulsive charge between dye and jute fiber can be overcome by adding a salt such as sodium chloride, which has the effect of screening the surface charge on the charge.

Mairet (1952) in Bako (1989) believes that some dyes give colour directly to the substrate of the fabric without the use of any additives but a greater number of dyes and pigment, require the use of mordants to bring out the colour. Different mordants give different colours with same dyestuff. Bliss (1980) in Bako (1989) supports Mairet's opinion; that there are two classes of dyes. These are:

1. The non-mordants also called substantive dyes, whereby colours are being imparted directly to the fibres without a preliminary preparation. Lichen dyes are the most important in this group.

2. Mordant dyes also known as the adjective dyes in which the fabric to be dyed has to receive special preparation before it can absorb the colour. This process of preparation is called mordanting.

According to Nkeonye (1993) there are probably several methods for mordanting, but the three successful ones are:

1. To mordant before the fabric is dyed or printed

2. To mordant while the fabric is being dyed or printed

3. To mordant before and after the fabric is dyed or printed (Bako, 1989).

There are advantages to each method; - when the fabric is mordanted before they are dyed, the colours are clearer and there is more control over the mordanting results. However, it is quicker to mordant while the fabric is being dyed, and this eliminates one handling process. And, if the fabric is mordanted before, and after, they are dyed, it can make the colours fast, make brighter and stronger colours, and change the colour, (Lesch, 1970).

Mordanting is a technique considered as fixing agent for dyestuffs in printing which partly or wholly forms definite compounds in the fibre, Nkeonye, (1993). He further states that very few natural dyes are substantive (that yield a colour which is fast) without the addition of a mordant because of the chemical affinity between the fibre and the dye, and so enables the dye to be retained on the fabric. Therefore mordanting of fabric is encouraged in order to fix the dye on the fabric or yarn. Alau (1986) states that different mordants give different colours with the same dye stuff. Thus the following mordants can be applied:

- Table salt (sodium chloride)

- Alum
- Potash
- Wood Ashes
- Hydrosulphite
- Caustic soda

2.8 Paint preparation

According to Clarke (1974), the class of dyestuff and fabric to be printed must first be chosen to be compatible. Water soluble dyestuffs are often required in a concentrated solution for addition to the thickening agent. Solvents or solution assistants are sometimes necessary to ensure complete solution. He further states that any chemicals that may be necessary to assist the fixation of the dyestuff are incorporated in the dyestuff solution or added to the thickening later. The dyestuff solution or dispersion must be thickened to form a print paste. A useful general rule in the preparation of the printing paste is added thin to thick, i.e. solutions or dispersions should be added to the thickening agent and not vice versa. According to Zakari (1984), and Onyia (1983) in Kogi (1997) pigments are colourants that are relatively insoluble in the medium (usually water) in which they are used. They exhibit no affinity for the materials upon which they are applied. They maintained that pigments can also be defined as small discrete solid particles used for covering, decorative or protective purpose and which are insoluble in the medium in which they are employed and have sizes in range of 0.1 – 1 micron. Some of its properties include opacity, light fastness, heat stability, and ease of dispersion in fluid media. They further states that the pigment can be classified into two main groups of organic and inorganic pigments. Both groups are manufactured, so that purity, specific shade, fastness properties and finesses are ensured.

For this study the use of pigment involves incorporating it in a medium and spreading or printing it over a surface in a thin film which is subsequently exposed to the destructive action of light, moisture, and in many cases corrosive gases, for a prolonged period. The chemical composition of the pigment therefore, should be perfectly stable, that is, able to stand exposure to the air without decomposition and should not be liable to react with any material with which it is likely to come in contact either in the solution or on the surface. Kparevzua (2003) explains that raw pigment that has not been mixed with binder should be obtained and used for experimenting with natural gum-resins in order to examine the fastness properties of the gum-resins which serves as binder in printing.

According to Kopeliovich (2009), paint is formulated as a mixture of four ingredients:

1. <u>Binder</u>: The binder, commonly referred to as the vehicle, is the actual film forming component of paint. It is the only component that must be present; other components listed below are included optionally, depending on the desired properties of the cured film. The binder imparts adhesion, binds the pigments together, and strongly influences such properties as gloss, exterior durability, flexibility, and toughness. It is the main ingredient of paints. Binders are polymers (resins) forming continuous film on the substrate surface. The binder holds the pigment particles distributed throughout coating. The binder is dispersed in a carrier, (water or organic solvent) either in molecular form or as colloidal dispersions.

<u>The following are common binders:</u>

Alkyd resins, Acrylic resins, Latex (PVA), Phenolic resins, Urethanes resins, Expoxy resins, Chlorinated rubber

2. Solvent: is a medium where the binder, pigment and additives are dispersed in molecular form or as colloidal dispersions. They are also used for modification of paint viscosity required for the application methods. The evaporation rate is one of the important properties of solvents. Other properties are the ability to dissolve the paint ingredients and toxicity.

The following are solvents used as carrier in paints: Water, white spirits (mineral turpentine spirits), xylene, toluene, alcohols (n-butanol, isopropanol), ketones.

3. Pigment: is a solid substance dispersed throughout the coating to impart it a colour, opacity (hide the substrate surface). Pigment may protect substrate from UV light. Pigment changes the paint appearance and properties: increase hardness and decrease ductility. They may be natural and synthetic, inorganic or organic. Fillers and extenders are also referred to as pigments, they are non-expensive commonly natural inorganic materials added to the paint in order to increase its volume, to increase the paint film thickness, to impart toughness or abrasion resistance to the coating.

Pigments commonly used in paints are:

Titanium dioxide, zinc oxide (ZnO), zinc yellow (yellow 36), yellow dyes, benzidine yellows, chrome oxide green, phthalocynine Green, phtalocynine blues, ultramarine blue, vermilion, pigment brown 6, red 170, dioxazine violet, carbon black, iron(II) oxide (FeO).

Examples of fillers and extenders:

Quartz sand (sio_2), talc, barite ($BaSO_4$), kaolin clay, limestone.

4. Additives: are small amounts of substances modifying the paint properties.

Examples of additives:

Driers, plasticizers, fungicides, flow control agents, defoamers, emulsifiers, UV stabilizers, anti skinning agents, adhesion promoters, corrosion inhibitors, texturizers.

Nkeonye (1993), lists the constituents of a pigment printing paste are: pigment, binder, thickener, acid catalyst, solvent and antifoam agent

2.9 Printing Processes

A Number of fabric decorating techniques have long been used in central Africa. The first decorated fabrics were probably painted directly with fingers or a simple brush. The motifs fall into three categories; there are those that tell a story, those that have symbolic significance of that serve as identification, and those that are simple ornamentation with a pattern, (Kaufman, 1967 in Alau, 1986). According to Nkeonye (1993) the art of textile printing dates back to at least two thousand years. Fragments of printed fabrics have been found in the tombs and pyramids in Egypt, and various records show that printed fabric did exist as early as 2500 BC. Printed textiles have now become a household requisite, combining colour and design to enhance the appearance of the living environment. In printing coloured patterns or designs are introduced on the fabric, and the patterns may be of the same or different colours. This is made possible by the use of a highly concentrated solution of dye suitably thickened with materials such as starch or gum to give a thick paste, so that the colour applied in a given pattern does not spread beyond the patterned area.

He further, discourses four common methods of fabric printing which include:

i) Block Rock printing – manual.

ii) Roller printing – manual, mechanical.

iii) Screen printing – manual, mechanical.

iv) Transfer printing – manual, mechanical.

i) Block printing: is the oldest method of printing design on fabric. The design is carved on wooden or metal block, and the printing paste is applied to the face of the block and the block is pressed down firmly by hand on the fabric surface.

ii) Roller printing: this technique was developed at the latter part of the 18th century. The design to be printed is engraved onto a set of copper-coated rollers, depending on the number of colours in the design, the engraving is done by pentagraph transfer whereby the design is engraved by hand with an awl, then the craftsman will on his turn duplicate the artist's design on copper roller.

iii) Screen printing: is carried out by the use of either flat or cylindrical screens. Flat screens are used in hand and automatic flat screen printing, while cylindrical screens are used in the more recent rotary screen printing. This is also an old method of printing especially the screen printing by hand. The artist's design was copied onto a series of very fine flat screens, one for each colour in the design to be printed, and then a coating of lacquer or an impermeable substance applied to all parts of the screen except the area carrying the design which are left porous. The fabric to be printed is laid on a long metal table with a resilient surface of felt foam, then the screen is positioned on the fabric, the print paste is poured on the screen and with the help of a squeegee the paste is forced through the unblocked areas of the screen thereby transferring the pattern onto the fabric. But later on a new method emerged that was faster than the table technique; this was called the rotary screen printing because of the use of cylindrical screens.

iv) Transfer printing: this process also called 'Sublistatic' was developed in France in the mid 1960s, the process consist of the first printing a coloured design on paper and

then transferring the design from paper to fabric by heat and pressure. The process is now termed heat transfer printing or transfer printing.

2.10 Fixing Techniques

According to Clarke (1974), there are various methods of fixation depending on the class of dyestuff and substrates applied they are: 1. Baking (dry heat), 2. Wet development, 3. Pad-batch development, 4. Flash ageing, 5. Pressure steaming, 6. High temperature steaming, 7. Normal steaming. Kparevzua (2004), states that decorated fabric are designed to remain durable, attractive, valuable, for satisfaction of consumers, most of the dyestuffs used in producing them are usually held on the surface of the fabric and not much of it penetrate the fibre before fixation process takes place. Potter and Corbman (1967) in Kparevzua (2004) reported that a beautifully decorated fabric is of little value to the customer and consumer unless the colours are fast enough for the fabric to be used. They believe that colours meant for decorating fabric must meet such tests as washing, ironing, steaming, perspiration, sun, light, and heat etc. they further report that the United States Government has enforced the process of testing fabric for colour fastness, to maintain and enforce trade standards according to the International Standard Organization, (ISO), by the society of dyers and colourists, fourth edition, (1981). Nkeonye (1993) highlights that the beauty of a decorated fabric rest on the fastness of the dyes or pigment used. Kparevzua (2004) point out that the processes of fabric decorations are so complex, so elaborate and pains-taking that, decorated fabrics require good treatment, in order to attain satisfactory result so that the fabric remain durable, attractive and valuable to consumers. Most of the media used in fabric decoration are not permanent and therefore require fixation. Trotman (1970) in Kparevzua (2004) believes that the most outstanding and important property of a

decorated fabric or material is the fastness of the shade, which must be as high as possible.

As observed since most of fixation is based on treatment with heat, craftsmen tend to use the regular household pressing iron for treating their productions, in absence of industrial or special steaming equipment. Baking (dry heat) for 1/2 - 2 hours on 140^{o}C, ironing 4-5mins using the reverse side of the printed fabric on 60^{o}C- 90^{o}C of temperature, and the steaming procedure suggested in Kparevzua (2004), in her article on 'cooking pot steamer method…' was applied for fixation of printed fabric of this work..

2.11 Colour Fastness Tests

The Etherington and Roberts dictionary (2009) states that colour fastness is "that property of pigment or dye, or the leather, cloth, paper, ink, containing the colouring matter, to retain its original hue, especially without fading, running, or changing when wetted, washed, cleaned or stored under normal conditions when exposed to light, heat or other influences. According to Clarke (1974) colour fastness is the resistance of dyed or printed textiles to various agencies to which they may be exposed during use or manufacture. He further states that ideally the dyestuffs on a printed fabric or on a dyeing should last as long as the fabric itself. In addition the dyes should not give rise to staining on the unprinted parts of the fabric or on other fabrics coming into close contact during wear or washing.

One aspect of fabric which is always of interest to the consumers is how fast the colour is, Nkeonye (1993). He further said that, this is because the beauty of fabric is of no value unless the dye is 'fast' under the condition in which the fabric is used. No dye is however, absolutely fast under all conditions of use, and the most suitable dyes for a

particular end-use are those which will provide the required fastness at minimum cost. Clarke (1974), states that exposure to light and washing are often major factors. Cotton articles are usually required to stand up to much more severe washing than wool, so the washing fastness of dyes printed or dyed on cotton is usually more important than in the case of wool. Nkeonye (1993) observed that some dyes may be fast to washing and dry-cleaning but not to daylight. Others may be fast to perspiration and rubbing when wet, but not to hot pressing or bleaching. He notes that the varying fastness of dyes to different agencies originates from several factors. These include the chemical structure of dye, the type of fibre onto which it is applied, the method of application, the depth of the dyeing and, for light –fastness, the condition of the atmosphere (especially its relative humidity and ultraviolet light content).

According to Lesch (1970), there are tests for colour fastness, and these may be made in a number of ways. Nkeonye (1993) supports Lesch (1970) by listing the common agencies, scales and principle of test, which are of particular interest to the user of coloured textiles. These are fastness to: - washing, - light, - chlorinate water, - dry-cleaning, - perspiration, - dry-heat pleating, - pressing, - rubbing, - water or steam and sea water. Kogi (1997) and Nkeonye (1993) shared the same opinion that, in each case, the fastness rating of the tested specimen is the number of the Grey scale whose contrast approximates to the contrast between the untested (original) and the tested specimen. The scale is as follows: 5 – Excellent, 4 – very good, 3 – good, 2 – fair, 1 – poor. They also stated that colour fastness test could be obtained excellently when these factors are put into consideration, time, temperature, and weight of substance solutions used for any study.

Bako (1989) opines that the most important test for vegetable dyes are of light and washing, he suggested that test for light fastness is carried out by cutting a piece of

fabric into equal halves and then putting one half of the dyed piece in direct sunlight and after a week, it is then compared with the other half, which has been kept away from the sun entirely. Then test for washing is done by washing a small piece of dyed fabric in hot water and soap. If the dyed piece of cloth does not wash off, then one will know how fast the dye obtained is.

2.11.1 Light Fastness

The criterion of light fastness is a major concern amongst the dyers. The stringent requirement of light fastness is getting more and more importance in the European as well as in the American market. It is very much essential to understand the different test methods, grading and factors affecting light fastness. Generally it is difficult to achieve good grade of light fastness in light, medium, tricky shades viz, khaki, olive grey, browns etc. A proper combination always helps to arrive at the customer requirement. Generally two methods of testing are widely accepted by most customers. They are:

- American tests method (AATCC 16 E).
- British Test Method (ISO 105/B02), (Anonymous, 1996)

Clarke (1974) explains that the I.S.O. daylight fastness test which has been adopted by 21 countries uses eight dyed wool standards. The test samples are exposed alongside the standards. When a change of colour can just be perceived in the test sample a note is made of the standard showing a similar change. A mask is used to cover part of the preliminary fade, and exposure is continued for as long as required to evaluate fully the light fastness. The results are usually expressed in terms of the number of standard fading hours necessary to produce a Grey Scale for contrast. Much has been said about the inferiority of vegetable colourants with regard to light fastness, and some colours are highly fugitive, Beetroot and Red Cabbage suffer from this drawback. The fact is that quite a number of traditional pigments are far from permanent. (Phil Shaw, N.d.)

2.11.2 Wash Fastness Test

Clarke (1974), further states that there are five I.S.O. wash test increasing in severity from 1-5 as follows:

Wash test	Treatment time	Treatment temperature	Composition of test solution
ISO No. 1	30min.	40^{o}C (105^{o}F)	5partssoap/1000parts
ISO No. 2	45min	50^{o}C (122^{o}F)	5 parts soap/1000parts
ISO No. 3	30min	60^{o}C (140^{o}F)	5 parts soap, 2parts, soda ash/1000parts
ISO No. 4	30min	95^{o}C (203^{o}F)	5 parts soap, 2parts, soda ash/1000parts
ISO No. 5	4h	95^{o}C (203^{o}F)	5 parts soap, 2parts, soda ash/1000parts

2.11.3 Rubbing Fastness Test

Some dyes, especially the insoluble dyes such as vat dyes or azoic dyes, may have good fastness to light and washing, but are sensitive to abrasion in that the dyestuff may be removed from the fibre surface by the physical action of wet or dry rubbing, (Nkeonye, 1993). A simple test is to rub the dyed fabric with a piece of white fabric wrapped round the finger, first with the white fabric dry and then wet. If the dye is not fast it will stain the white fabric. The colour fastness of the dyed fabric against rubbing is assessed as a means of evaluating the aesthetic qualities of the coloured materials services life. It is determined by the extent of staining of a white sample used for rubbing and it is expressed by the appropriate grades of a Grey scale.

How to Perform Test for Colour Fastness to Rubbing

Technical Specifications:

Select a sample that is a representative of the lot.

Apparatus: For determining the colour fastness to rubbing a suitable device (crock meter) with a rubbing finger, comprising a cylinder of 1.6 cm diameter moving to and from in a straight line along a 10.0 cm track on the specimen with a downward force of 9N should be used.

Rubbing Cotton Cloth: Desized, bleached and the fabric to be used is cut into 5cm x 5cm squares.

Grey Scale- is used to evaluate the stain on the cotton cloth, (Priyank, 2011).

He further gives detail on how to preparation of the Specimen

1. If the textile to be tested is a fabric, two pieces, each not less than 14 cm x 5 cm for dry rubbing and two pieces for wet rubbing should be drawn from the sample.
2. One specimen of each pair should have the direction parallel to the yarn yarns and other parallel to the weft or filling yarn.
3. If the textile to be tested is yarn or thread, same should be knitted or woven into fabric to provide 4 specimens each of minimum size of 14 cm x 5 cm, two for dry rubbing and two for wet rubbing. Alternatively 4 specimens should be prepared by forming a layer of parallel strand by wrapping it lengthwise on a rectangular card board of suitable dimension.
4. The test specimen should be fixed on the rubbing device by means of clamps such that the long direction of the specimen follows track of the device.
5. In case of multicoloured textiles, care should be taken to position the specimen in such a way that all colors of the design are rubbed in the test. If the areas of colors are sufficiently large, more test specimens should be taken and individual colours should be assessed separately.

- Dry Rubbing

With the dry rubbing cloth flat in place over the end of the finger of the crock meter,

same should be rubbed 10 times to and fro in a straight line along a track 10 cm long on the dry specimen in 10 seconds and with a downward force of 9 N.

- Wet Rubbing

The above described procedure should be repeated with a fresh dry specimen and with wet rubbing cloth. The wet rubbing cloth should be prepared by soaking a fresh rubbing cloth in distilled water and squeezing the same to contain its own weight of water.

The staining of the rubbing cotton cloth is assessed with the help of the grey scale.

It is necessary to eliminate dyed fibres pulled out during rubbing and retained on the surface of rubbing cotton cloth, the colouration due to staining by dye stuff only should be considered.

Assessment of the test

In case of doubt on the assessment of colour fastness rating by a single observer, the assessment should be done by at least three observers and overall average rating should be reported. The numerical rating for dry staining and for wet staining of the rubbing cotton cloth for each direction of manufacture should be reported.

Colour Fastness To Rubbing and Textile Sample's Colour Measurement

In previous post we talked about colour fastness to wash. Besides measuring the colour fastness to wash it is mandatory to measure the colour fastness to rubbing. Here, just know about the whole process of color fastness to rubbing phenomenon.

Principle:

This test is designed to determine the degree of colour which may be transferred from the surface of a coloured fabric to a specify test cloth for rubbing (which could be dry and Wet).

Equipment that needed for measurement:

1.Crock Meter.

2. Cotton Rubbing Cotton.

3. Grey Scale

4. Stop Watch

5. Colour Matching Cabinet.

Size of Fabric:

You will need to have 14 Cm * 5 Cm pieces of textile fabric sample (one warp direction/wale direction and other weft/course direction).

Test Procedure of Colour Fastness To Rubbing:

a) Lock the test specimen (textile sample) onto the base of the crock meter.

b) Using the spinal clip, set 5 Cm * 5Cm of the white cotton fabric to the finger of the crock meter.

c) Lower the covered finger on the test sample.

d) Turn hand crank at the rate of the one turn per second.

e) Remove the white rubbing test cloth and evaluate with grey scale.

Evaluation

In this stage samples are been compared to see the contrast between the treated and untreated white rubbing cloth using the grey scale and then is rated 1 to 5.

CHAPTER THREE

MATERIALS AND METHODS

3.0 Introduction

This chapter focuses on the materials and methods applied in selecting, collecting and treatment of data, in order to achieve the objectives of this study. The chapter comprises:

Methods, materials, research instruments, identification, collection, preparation of raw materials, method of extraction, pre-treatment of fabric, mixing and printing, fixing, colour fastness tests and classification of raw materials.

3.1 Materials

The following materials and equipment were used: ammonium chloride, thickeners (gum arabic, gum tragacanth, sodium alginate), Alum, Potash, Sodium chloride (salt) were used as additives, resins (Binder) from two species of Musaceae, laboratory tools and equipment, machines such as: Spoon, pigment, fabric (cotton), iron, weighing balance, spatula, hot plate, oven, beakers, syringe, stirring rod, metal and glass beakers for collecting samples, hot plates, crockmeter and oven for baking or drying samples were used as tools in this study as recommended by (Jen (2004)) as supported by (Olaofe, 2010), in order to help the researcher to be sure in identification, data collection, and experimental processes.

3.1.1 Research Instruments

The following were the instruments used, they are: Participant observation, observation, unstructured interview, camera, documentations.

3.2 METHODS

3.2.1 Identification of Banana Plant Species

To be able to identify the different species of banana plants, research assistants in the field from the Botanical science section of Biological Sciences Department and the Department of Agronomy, Ahmadu Bello University, Zaria together with the researcher went to different locations of the study area specifically; Fadama farms and gardens in residential compounds in Samaru, in Sabon Gari and Zaria Local Government Area, for the identification. The research assistants used scientific methods for the identification, by knowing how the leaf shape, stem shape and the height of the plant look like.

3.2.2 Collection of Banana plant Species

The method of collection that has been employed in this study is gotten from the suggestions and emphasis made by Kogi (1997), that one of the processes of obtaining information on natural raw materials requires going into the fields to find the appropriate plants and to obtain the desired quantity of the raw materials. Collection of two selected species of *Musaceae* plants found in Zaria Local Government namely: *Musa Cavendish Dwarf* and *Musa Paradisiaca* were around Fadama farms and gardens in residential compounds of Samaru, in Sabon Gari Local Government Area and Zaria in Zaria local Government Area. The study plants were cut-off from the primary source, and then transported to the laboratory for the extraction process and the printing experimental procedures.

3.2.3 Experiment 1

3.2.3.1 Preparation and Extraction of raw material

1. Processing of raw materials

Raw materials from plants Musa Species were extracted in liquid form and were used fresh just the way they were extracted right from the plant for the next experiment. The reason why the resin was used fresh was in order not to temper with the chemical composition not only that, also to try a different method from previous methods that were employed from other researchers, one of them is to boil the resin until it coagulated.



Plate I: A piece of the raw material, to be processed.

2. Extraction of raw material

Concerning the methods of extraction, review of literature reveals that there are different methods of extraction depending on the quality and quantity desired According to Kogi (1997). The following are the various methods of extraction, which include:

i. coagulated form after exuding naturally.

ii. after incision (gel or semi dried form).

iii. after incision (liquid form) also known as direct extraction.

iv. soxhelet (machine for extraction).

The following selected method of extraction is employed in this study;

i. after incision (liquid form) also known as 'tapping' or direct extraction by pounding.

3.2.3.2 Direct extraction of the Resin

The extraction method that was employed in this research was the direct extraction also called tapping. The plant pseudo-stem was cut into pieces, transported to the secondary source, and then washed. After washing, the plant was weighed;

Mass weight of the raw material (Musaceae) used in the study

- Mass weight of Musa Cavendish Dwarf in grammes: 74grammes - which produced 45mls of resin.
- Mass weight of Musa paradisiaca in grammes : 200grammes - which produced 140mls of resin.

The plant was cut into smaller pieces, poured into the mortar and pounded until it became soft in order to facilitate squeezing. The pounded plant was later squeezed to extract the resin into a clean bowl, sieved and filtered using a mesh. This was just to get rid of particles and impurities so as to obtain a clean resin extract that was used into the paste solution.



Plate II: Extraction Technique Adopted (pounding)

The resin was preserved in a refrigerator to prevent it from fermenting. It was used fresh into the pigment and was applied as paint onto cotton fabrics, immediately after extraction.



Plate III: Already Processed Resin from Musaceae

3.2.4. Experiment 2: Pretreatments of Fabric (Desizing)

Rot steeping as earlier discussed is an old method of steeping which takes place in warm water for 24 hours at a temperature of 35^{o}C - 40^{o}C, or overnight at 60^{o}C. The prolonged soaking increases the absorbency and removes the starch as well as 2-3% of natural impurities. The fabric was soaked for a day, scrubbed and then rinsed with fresh water to remove starch from it. Finally the fabric was ironed, and then cut into pieces.

3.2.5. Experiment 3: Mixing and Printing

1. Mixing of Paste

The paste solution was made of: 2 spoon full of Sodium alginate (prepared into jelly form), 1/3 spatula of pigment (powdered form), 2.5mls of resin from *musa cavendish dwarf* and *musa paradisiaca* drawn from a syringe into the solution, 1 cafe spoon of ammonium chloride was used, this is to help the fabric maintain its strength and one tea spoon of mordant was added into the solution in a liquid form. All these were added subsequently into the solution and stirred for 3-5mins to mix up the solution.



Plate IV: Prepared ink with Musaceae Plant Resi

2. Printing on Cotton Fabric

Printing has different descriptions and definition according to authors, designers and artists. In the designers world printing is an impression, mark or pattern produced on a flat surface with a number of coloured medium like pencil, dye, ink, pigment, and paint, which might have meaningful or meaningless signs.

For the purpose of this study raw cellulose based pigment that has not been processed or mixed with synthetic binder, was used. The prepared coating was used on the fabric as follows; - Desized fabric was cut into pieces of weight between 3.30 – 3.50 grams, it was spread on a printing table, masking tape was used to hold it firm onto the table for printing. Dubbing technique was used to print on the fabric using a piece of foam.

The printed fabric was well dried; the drying process helps in removing the water that comes with the colour paste to retain good print. Drying some times helps in fastening colour on the fabric, thereafter, it was kept for the next treatment which is the fixing processes, (Kogi, 1997).

3.2.6 Fixing techniques adopted

1. Steaming

The printed fabric samples were mounted on folded newsprint then wrapped in a small blanket and later laid on arranged cross wires. The cross wires were placed on a well covered cooking pot that contained little water almost at the base, which was placed on fire to be boiled for about 30min. to 45min. The boiling water ($100^{o}C$) produced heat with moisture which retains the moisture on the blanket, and allows the dry steam heat to concentrate at the upper part of the pot where the sample was placed. Each sample was treated separately.

2. Fixing by Ironing

The printed sample was placed upside down on a folded news paper and ironed on a table for a period of 2 to 5mins. The iron was regulated using the thermostat at temperature $60^{o}C$ - $90^{o}C$. This procedure was effective on each of the samples, from sample No1 – sample No74.

3.3 Colour Fastness Tests

To achieve the objective of this study on colour fastness test, the following tests were carried out;

1. Wash fastness test

2. Fastness to rubbing test

3. Light fastness test (sun fastness)

3.3.1 Determination of wash fastness

Methods: Two (2) tests were carried out, wash fastness and stain level, it consisted of 74 samples. Each sample had 4 specimens of 10cm x 4cm. The printed specimen was placed in between two plain fabrics the three pieces were attached together and washed, after washing each specimen was rinsed using fresh tap water and then dried in a shade in order to drain out excess water. Glass beakers and glass stirring rods were the instruments for this test, the test was done manually.

Materials: solution for wash fastness test was block soap (B29) of 5g + 2g of sodium carbonate (Na_2CO_3) was mixed in a 1000ml of distilled water, using the I.S.O. No3 (Clarke, 1973).

1 = no mordanted, 1 = alum, 1 = potash, 1 = sodium chloride.

Test Standard: all tests were carried out after a minimum period of 336 hours (2 weeks) conditioning time in a standard atmosphere of $30^oC \pm 1^o$ and washed at liquor ratio of 50:1 in a 60^oC solution for a period of 30mins for each specimen.

Test results: visual judgment of the colour change using the grey scale of I.S.O. 150 standard expressed by sample code. e.g: WF1A (wash fastness of sample 1 with alum): discussing the effect of the fastness test results.



Plate V: Soap Solution for Wash Fastness Test

3.3.2 Determination of fastness to rubbing (wet and dry)

Method: Two tests were carried out for each sample each test consist of wet and dry test.

► **Dry test:** Printed fabric was cut into square of 5cm x 5cm then clamped on the device, while fresh 5cm x 5cm piece of fabric was clamped on the top (finger) of the

crock meter; this was rubbed 10 times with a to and fro of a straight line movement in 10 seconds.

► **Wet test:** Printed fabric was cut into square of 5cm x 5cm then clamped on the device, while fresh 5cm x 5cm piece of fabric was dipped in clean water brought out and then clamped on the top (finger) of the crock meter; this was rubbed 10 times with a to and fro of a straight line movement in 10 seconds.

Materials: both dry and wet tests were done on a crock meter apparatus with a to and fro movement, using the I.S.O. for test.

Test standard: all tests were carried out after a minimum period of 14 hours, 20 minutes sample conditioning time. Fresh specimens for wet test were cut into pieces of 5cm x 5cm, dipped into water and then tied on the finger of the crock meter.

Test results: visual judgment of the colour change using the grey scale of I.S.O. 150 standard for stains, expressed by sample code. e.g.: RF1D (rub fastness of sample 1 dry): discussion of the effect of fastness test results.

3.3.3 Determination of Colour Fastness to Light

Methods: The printed samples were placed on a wooden board whereby the positive side was facing the top together with the blue standard, and then a transparent glass was placed on it. This was placed directly facing the solar radiation, from 9am to 4pm for the duration of six days. When a change of colour can just be perceived in the test pattern a note is made of the standard showing a similar change.

Materials: The 74 printed samples were exposed along side with the blue standard, manually, using the I.S.O. daylight fastness test.

Test Standard: The test was carried out for the period of 12 days for all the 74 samples. The samples were placed on a wooden board, whereby a transparent glass was placed on it facing the solar radiation for a period of 7 hours a day.

Test Results: Visual judgment of the colour change using the eight blue standard daylight fastness tests which has been adopted by 21 countries, (Clarke, 1974). Standard 1 is very fugitive and the fastness increases stepwise to standard 8 which is very fast.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter discusses the research findings and the data analysis, the chapter has answered the research questions and has also seen if the objectives of the study have been achieved. This view agrees with Adetoro's (1986) assertion that the adoption of data analysis is subject to the intents and purposes of the study. In a related opinion Ndagi (1984) in Nyam (1985) stated that experimental research focuses attention on data analysis with intention of discussing and interpreting the results, approach and techniques. According to Adetoro (1986), the purpose of data analysis is to simplify the data so as to clarify the relationships between and among variables and objects. Some of the ways to analyse are: in groups, use of tables, interpretation of the analysis, drawing inferences and generalization.

The study was based on the use of resins extracted from two species of Musaceae namely; *Musa Cavendish dwarf* and *Musa Paradisiaca* as binder. Pigment was used on fabric. However, this research is essentially experimental; therefore the data analysis was substantially based on discussion and interpretation. This is to help know if the resin can bind pigment to the substrate. The results of the methods used in chapter three, are reproduced in this chapter and then data were analysed emparately to facilitate better understanding of their interpretation.

Pretreatments of Fabric (Desizing)

Procedures

Cotton was the selected type of fabric used for this work, and rot steeping was the technique adopted for the pre-treatment of the fabric. The following is the procedure;

One yard of cotton fabric was weighed and desized. It was soaked in water for a period of 24 hours, and then it was sun dried for a period of 1hour 30mins. After which it was ironed for 4-6 minutes with temperature between $80^{o}C$ – $100^{o}C$.

Observation

Weight of cotton fabric before desizing (1 yard) =121.20 grammes.

Weight of cotton fabric after desizing (1 yard) = 115.90 grammes.

The fabric lost a weight of 5.70 grammes. The percentage lost in weight = $\frac{5.70}{121.2} \times 100 = 4.7\%$

Total weight of cotton fabric used for the experimental was between 244 – 249grammes

Then the desized fabric was cut into 74 pieces that weighed between 3.30 - 3.50grammes each, these pieces were later used for the printing.

Resin Extracted and Quantity Extractable

Species	Mass Weight of plants per gramme	Quantity of extracted resin in liquid form	Quantity of resin Extract after evaporation	Resins Yield per %
Musa cavendish dwarf	49.0g	30ml	0.54g	$\frac{0.54}{49} \times 100 = 1.1\%$
Musa paradisiaca	46.0g	33ml	0.58g	$\frac{0.58}{46} \times 100 = 1.26\%$

Table 4.1.0: Percentage yield of the resin from *Musa Cavendish Dwarf* and *Musa Paradisiaca*

4.1 Wash Fastness Test Results

		Grades				
Resin	Mordants	1	2	3	4	5
Resin from Musa Cavendish Dwarf	**No Mordant**	WF11, WF12	WF1,WF3,WF4, WF5,WF6,WF7, WF8,WF9,WF10, WF13,WF14,WF15, WF16,WF17,WF18	WF2	-	-
	Alum	-	WF5A,WF6A, WF8A,WF11A, WF12A,WF14A, WF17A,WF18A	WF7A,WF9A, WF15A	WF1A,WF2A, WF3A,WF4A, WF9A,WF10A, WF16A	WF13A
	Potash	WF11P, WF12P	WF1P,WF3P, WF4P,WF5P, WF7P,WF8P, WF13P,WF14P, WF15P,WF16P, WF17P,WF18P	WF2P,WF6P, WF9P,WF10P	-	-
	Salt	WF7S, WF8S, WF13S, WF14S, WF15S, WF16S	WF3S,WF5S, WF11S,WF12S, WF17S,WF18S	WF1S,WF2S, WF4S,WF6S, WF9S,WF10S	-	-

Table 4.1.1: Wash fastness of the samples printed with *Musa Cavendish Dwarf* resins.

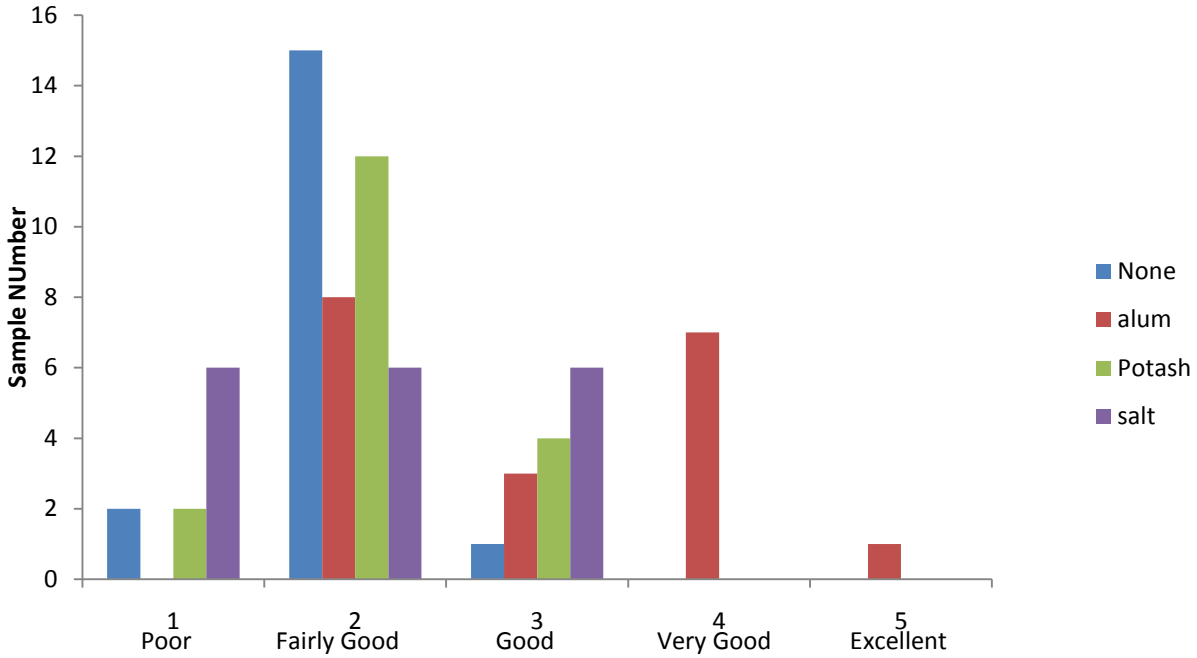


Figure 4:1.1 Wash fastness summary of the samples printed with *Musa Cavendish Dwarf*

Discussion of Table 4.1.1

Wash Fastness Test of Samples 1-18 without Mordants (WF1 - WF18)

Specimens WF1, WF3, WF4, WF5, WF6, WF7, WF8, WF9, and WF10 were fairly good; all were at the same grade, both the mordanted and the control specimen. Specimens WF11 and WF12 were both poor, specimen WF13, WF14, WF15, WF16, WF17 and WF18 were all fairly good and specimen WF2 was good. The result of Table one was not impressive.

Wash Fastness Test of Samples 1-18 treated with Alum Mordant (WF1A - WF18A)

Specimens WF5A, WF6A, WF8A, WF11A, WF12A, WF14A, WF17 and WF18 were fairly good, specimens WF7A, and WF15 were good, specimen, specimens WF1A, WF2A, WF3A, WF4A, WF9A, WF10A and WF16A were very good, specimen

WF13A was excellent, it gave the best result of this test. Treatment of banana resin with sodium alginate thickener with ammonium chloride and sodium chloride mordants was the one that gave the best result in this table.

Wash Fastness Test of Samples 1-18 treated with Potash Mordant (WF1P - WF18P)

Specimen WF11P and WF12 were poor, specimens WF1P, WF3P, WF4P, WF5P, WF7P, WF8P, WF13P, WF14P, WF15P, WF16P, WF17P and WF18P were all fairly good, specimens WF2P, WF6P, WF9P, and WF10P were good.

The results of wash fastness test treated with potash were not good.

Wash Fastness Test of Samples 1-18 treated with Sodium Chloride (Salt) Mordant (WF1S - WF18S)

Specimens WF7S, WF8S, WF13S, WF14S, WF15S, and WF16S were poor, specimens WF3S, WF5S, WF11S, WF12S, WF17S, WF18S were fairly good; Specimen WF1S, WF2S, WF4S, WF6S, WF9S and WF10S were good.

		Determination of Wash Fastness		
Treatment	Samples No & scales	Resin with mordants	No resin with mordants	Wash and stain level of samples 1&2
No mordant	Original samples			
	Washed samples			
	Scale	2	3	
	Staining level			
	Scale	3/4	3/4	
Alum	Not washed			Wash and stain level of samples 1&2
	Washed samples			
	Scale	4	4	
	Staining level			
	Scale	4/5	4/5	
Potash	Not washed			Wash and stain level of samples 1&2
	Washed samples			
	Scale	2	3	
	Staining level			
	Scale	2/3	3/4	
Salt	Not washed			Wash and stain level of samples 1&2
	Washed samples			
	Scale	3	3	
	Staining level			
	Scale	3/4	3	

Table 4.1.2: Resin from Musa Cavendish Dwarf stem, mordanted with Ammonium Chloride and Alum. Direct dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: No resin with mordants	Wash and stain level of samples 3&4
No mordant	Original samples			
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	2/3	2/3	
Alum	Not washed			Wash and stain level of samples 3&4
	Washed samples			
	Scale	4	4	
	Staining level			
	Scale	4/5	4/5	
Potash	Not washed			Wash and stain level of samples 3&4
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	2/3	2/3	
Salt	Not washed			Wash and stain level of samples 3&4
	Washed samples			
	Scale	2	3	
	Staining level			
	Scale	2/4	3	

Table 4.1.3: Resin from Musa Cavendish Dwarf stem, using Sodium tragacanth as thickener, mordanted with Ammonium Chloride and Alum. Direct dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants.	Determination of Wash Fastness: No resin with mordants.	
No mordant	Original samples	5 	6 	Wash and stain level of samples 5&6
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	4	4/5	
Alum	Not washed			Wash and stain level of samples 5&6
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	2	2	
Potash	Not washed			Wash and stain level of samples 5&6
	Washed samples			
	Scale	2	3	
	Staining level			
	Scale	3	3	
Salt	Not washed			Wash and stain level of samples 5&6
	Scale			
	Washed samples			
	Scale	2	3	
	Staining level			
	Scale	4	4	

Table 4.1.4: Resin from Musa Cavendish Dwarf stem, using gum Arabic as thickener, mordanted with Ammonium Chloride and Alum. Basic dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: No resin with mordants	
No mordant	Original samples			Wash and stain level of samples 7&8
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	2/3	2/3	
Alum	Not washed			Wash and stain level of samples 7&8
	Washed samples			
	Scale	2	3	
	Staining level			
	Scale	3	3	
Potash	Not washed			Wash and stain level of samples 7&8
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	2/3	2/3	
Salt	Not washed			Wash and stain level of samples 7&8
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	2/3	2/3	

Table 4.1.5: Resin from Musa Cavendish Dwarf stem, using Sodium Alginate as thickener mordanted with Ammonium Chloride and potach. Direct dye was the pigment used.

	Grades							
Mordants	1	½	2	2/3	3	¾	4	4/5	5
No mordant				SR3,SR4, SR7,SR8, SR16	SR9,SR10, SR13,SR14, SR15	SR1,SR2	SR5, SR11	SR6, SR12, SR17,SR18	
Alum					SR5A,SR6A, SR7A,SR8A, SR11A,SR12A, SR14A,SR17A, SR18A		SR9A, SR10A	SR1A, SR2A, SR3A, SR4A, SR13A, SR15A, SR16A	
Potash				SR1P,SR3P, SR4P,SR7P, SR8P,SR13P, SR14P	SR9P,SR10P, SR15P,SR16P	SR2P	SR5P, SR6P	SR11P, SR12P, SR18P	SR17P
Salt				SR3S, SR7S, SR8S, SR13S, SR14S	SR2S, SR4S, SR9S, SR10S	SR1S, SR15S, SR16S	SR5S, SR6S, SR17S, SR18S	SR11S, SR12S	

Table 4.1.6: Staining test of samples printed with *Musa Cavendish Dwarf* resins

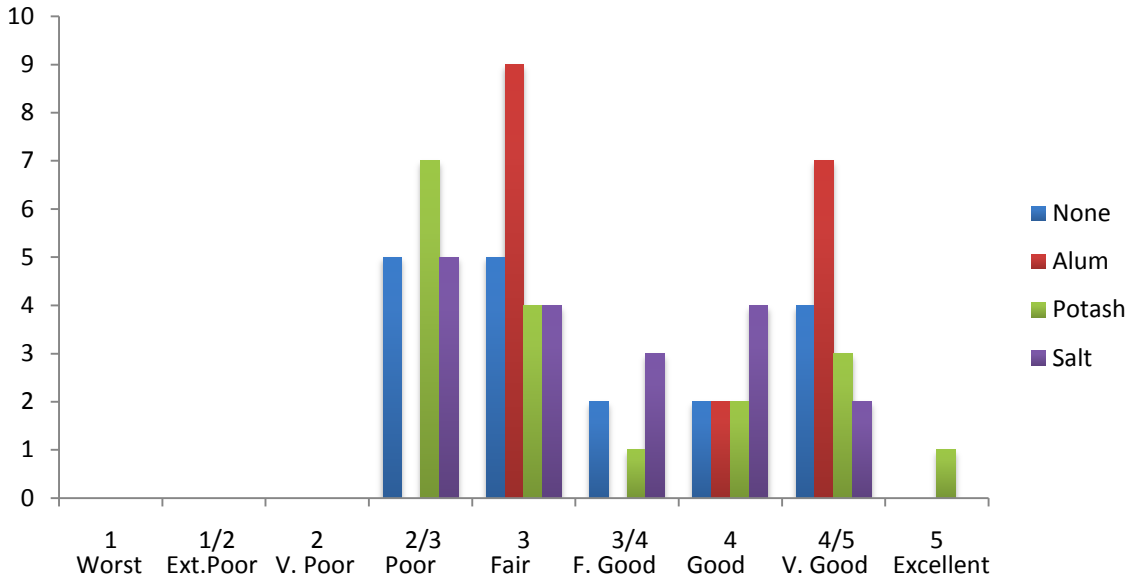


Figure 4:1.2 Total results for staining samples wash fastness test specimen samples for *Musa Cavendish Dwarf.*

Discussion of Table 4.1.6

Staining Specimens Result of Washing Fastness Test

Stain Results of samples 1-18 Treated without Mordants (SR1 – SR18)

Specimens SR3, SR4, SR7, SR8 and SR16 were poor, specimens SR9, SR10, SR13, SR14 and SR15 fair, specimen SR1and SR2 were fairly good, specimen SR5 and SR11 good, specimens SR6, SR12, SR17, and SR18 were very good.

Stain Results of samples 1-18 Treated with Alum Mordants (SR1A – SR18A)

Specimens SR5A, SR6A, SR7A, SR8A, SR11A, SR12A, SR14A, SR17A and SR18A were all fair, specimens SR9A, specimens SR9A and SR10A were good, specimens SR1A, SR2A, SR3A, SR4A, SR13A, SR15A and SR16A were all graded very good. Here all experiment samples were of the same results with their control, only sample SR13A was better than the control, therefore was the best.

Stain Results of samples 1-18 Treated with Potash Mordants (SR1P – SR18P)

Specimens SR1P, SR3P, SR4P, SR7P, SR8P, SR13P and SR14P were poor, specimens SR9P, SR10P, SR15P and SR16P were fair, specimen SR2P was fairly good, specimens SR5P and SR6P were good, specimens SR11P, SR12P and SR18P were very good, specimen SR17P was graded excellent.

Note: Although the difference was not much with SR18P but specimen SR17P was the best which means it was not stained, while the remaining specimens were scaled and graded same with the control specimen, except of the specimen SR1P that was not as good as its control specimen SR2P.

Stain Results of samples 1-18 Treated with Sodium Chloride (salt) Mordants (SR1S – SR18S)

Specimens SR3S, SR7S, SR8S, SR13 and SR14 were fairly poor, while specimens SR2S, SR4S, SR9S and SR10S were good, specimen SR1S, SR15S and SR16S were of grade (3/4) fairly good, specimens SR5S, SR6S, SR17S and SR18S were good, specimens SR11S and SR12S very good.

Note: Specimen SR7S was much better than its control specimen SR8S, also specimen SR1S was better than the control specimen SR2S, while all the remaining specimens were at the same level with their control specimens, except specimen SR3S that was lower graded to its control SR4S.

Treatment	Samples No & scales	Determination of Wash Fastness		
		Resin with mordants	No resin with mordants	Wash and stain level of samples 9&10
No mordant	Original samples			
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	3	3	
Alum	Not washed			Wash and stain level of samples 9&10
	Washed samples			
	Scale	4	4	
	Staining level			
	Scale	4	4	
Potash	Not washed			Wash and stain level of samples 9&10
	Washed samples			
	Scale	3	3	
	Staining level			
	Scale	3	3	
Salt	Not washed			Wash and stain level of samples 9&10
	Washed samples			
	Scale	3	3	
	Staining level			
	Scale	3	3	

Table 4.1.7: Resin from Musa Cavendish Dwarf stem, using tragacath as thickener, mordanted with Ammonium Chloride and potach. Direct dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: No resin with mordants	Wash and stain level of samples 11&12
No mordant	Original samples			
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	4	4/5	
Alum	Not washed			Wash and stain level of samples 11&12
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	3	3	
Potash	Not washed			Wash and stain level of samples 11&12
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	4/5	4/5	
Salt	Not washed			Wash and stain level of samples 11&12
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	4/5	4/5	

Table 4.1.8: Resin from Musa Cavendish Dwarf stem, using gum Arabic as thickener, mordanted with Ammonium Chloride and potash. Basic dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness		
		Resin with mordants	No resin with mordants	
No mordant	Original samples			Wash and stain level of samples 13&14
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	3	3	
Alum	Not washed			Wash and stain level of samples 13&14
	Scale			
	Washed samples			
	Scale	5	2	
	Staining level			
	Scale	4/5	3	
Potash	Not washed			Wash and stain level of samples 13&14
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	2/3	2/3	
Salt	Not washed			Wash and stain level of samples 13&14
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	1	1	

Table 4.1.9: Resin from Musa Cavendish Dwarf stem, using Sodium Alginate as thickener, mordanted with Ammonium Chloride and NaCl. Direct dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: No resin with mordants	
No mordant	Original samples			Wash and stain level of samples 15&16
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	3	2/3	
Alum	Not washed			Wash and stain level of samples15&16
	Washed samples			
	Scale	3	4	
	Staining level			
	Scale	4/5	4/5	
Potash	Not washed			Wash and stain level of samples 15&16
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	3	3	
Salt	Not washed			Wash and stain level of samples 15&16
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	3/4	3/4	

Table 4.1.10: Resin from Musa Cavendish Dwarf stem, using tragancath as thickener, mordanted with Ammonium Chloride and NaCl. Direct dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: No resin with mordants	Wash and stain level of samples 17&18
No mordant	Original samples			
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	4/5	4/5	
Alum	Not washed			Wash and stain level of samples 17&18
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	3	3	
Potash	Not washed			Wash and stain level of samples 17&18
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	5	4/5	
Salt	Not washed			Wash and stain level of samples 17&18
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	4	4	

Table 4.1.11: Resin from Musa Cavendish Dwarf stem, using gum Arabic as thickening agent mordanted with Ammonium Chloride and NaCl. Basic dye was the pigment used.

		Grades				
Resin	Mordants	1	2	3	4	5
Resin from *Musa paradisiaca* (plantain)	**No Mordant**	WF19,WF20, WF21,WF22, WF23,WF24, WF28,WF29, WF30,WF33, WF34,WF35, WF36,WF65, WF66,WF71	WF25,WF26, WF27,WF32, WF39,WF40, WF41,WF48, WF49,WF50, WF52,WF53, WF54,WF55, WF56,WF69, WF70,WF72, WF74	WF31,WF38, WF45,WF51, WF58,WF60, WF62,WF64, WF68,WF73	WF42,WF43, WF47,WF57, WF59,WF61, WF63,WF67,	WF37, WF44, WF46
	Alum	WF19A,WF20A,WF21A,WF22A, WF23A,WF33A, WF34A,WF35A, WF36A	WF24A,WF28A, WF29A,WF30A, WF31A,WF32A, WF48A,WF49A, WF69A,WF70A, WF71A,WF72A	WF25A,WF26A, WF27A,WF50A, WF51A,WF52A, WF53A,WF54A, WF56A,WF60A, WF74A	WF38A,WF39A, WF42A,WF43A, WF45A,WF47A, WF55A,WF57A, WF58A,WF59A, WF62A,WF63A, WF64A	WF37A, WF40A, WF41A, WF44A, WF46A, WF61A, WF65A, WF66A, WF67A, WF68A
	Potash	WF19P,WF20P, WF21P,WF22P, WF23P,WF24P, WF33P,WF34P, WF35P,WF36P, WF48P,WF55P, WF69P,WF71P	WF25P,WF26P, WF27P,WF28P, WF31P,WF32P, WF39P,WF41P, WF49P,WF50P, WF52P,WF53P, WF54P,WF56P, WF65P,WF66P, WF68P,WF70P	WF29P,WF30P, WF38P,WF40P, WF45P,WF51P, WF58P,WF59P, WF60P,WF62P, WF72P,WF73P, WF74P	WF42P,WF43P, WF46P,WF47P, WF57P,WF61P, WF63P,WF64P, WF67P	WF37P, WF44P
	Sodium Chloride	WF19S,WF20S, WF23S,WF24S, WF33S,WF34S, WF35S,WF36S, WF74S	WF21S,WF22S, WF25S,WF26S, WF27S,WF28S, WF31S,WF32S, WF39S,WF48S, WF49S,WF52S, WF53S,WF55S, WF65S,WF66S, WF67S,WF70S, WF71S,WF73S	WF29S,WF30S, WF38S,WF40S, WF41S,WF45S, WF47S,WF50S, WF51S,WF54S, WF56S,WF58S, WF60S,WF69S, WF72S	WF42S,WF43S, WF46S,WF57S, WF59S,WF61S, WF62S,WF63S, WF64S,WF68S,	WF37S, WF44S

Table 4.1.12: Detailed results interpretation of wash fastness tests samples printed with *Musa Paradisiaca* (plantain resins)

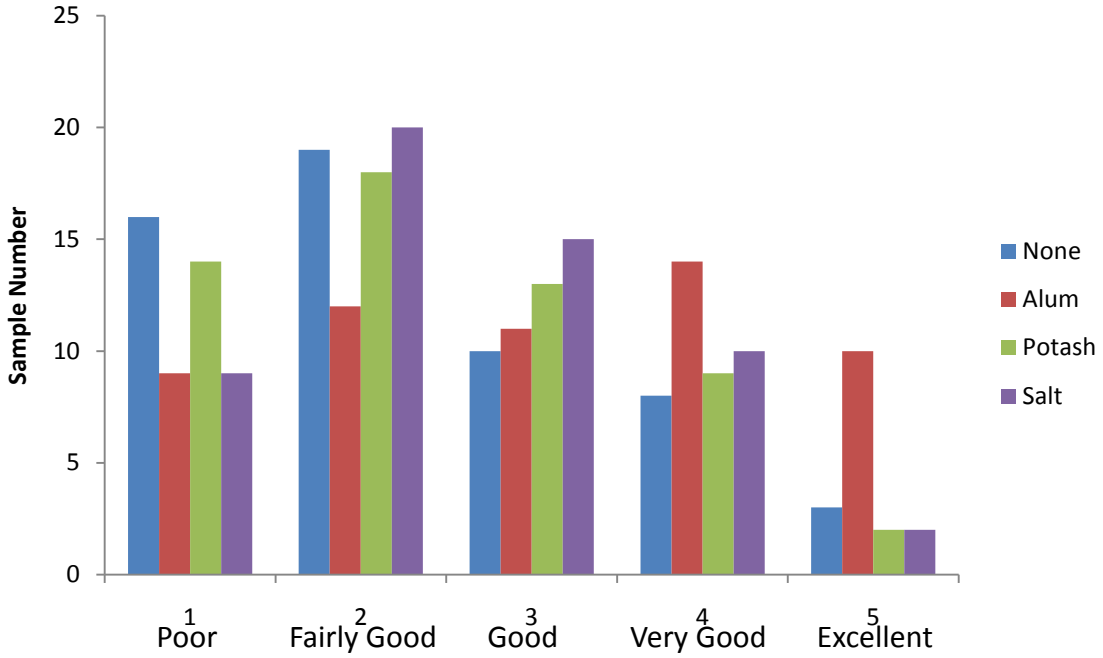


Figure 4:1.3 Total results of wash fastness test resin from *Musa Paradisiaca*, for colour change

Discussion of Results for Table 4.1.12

Wash Fastness Test of Samples 19-74 without Mordants (WF19 – WF74)

Specimens WF19, WF20, WF21, WF22, WF23, WF24, WF28, WF29, WF30, WF33, WF34, WF35, WF36, WF65, WF66 and WF71 graded poor, specimens WF25, WF26, WF27, WF32, WF37, WF39, WF40, WF41, WF48, WF50, WF52, WF53, WF54, WF55, WF56, WF69, WF70, WF72 and WF74 were fairly good, specimens WF31, WF38, WF45, WF51, WF58, WF60, WF62, WF64,WF68 and WF73 were all good, specimens WF42,WF43, WF47, WF57, WF59, WF61, WF63 and WF67 were very good, while specimens WF37, WF44 and WF46 graded excellent.

Note: After conducting the fastness test without mordant the result shows that three specimens were best with grade 5 (excellent) and these specimens were samples whose

printing paste was mixed with resin from *Musa Paradisiaca* (plantain) they were of samples WF37, WF44 and WF46. For the result that reads very good only 2 specimens that the paste was not mixed with the resin, namely specimen WF43 and WF47. The other six specimens were printed with paste that was mixed with *Musa Paradisiaca* resin, therefore, indicating that the resin in the paste had positive binding effect on the fabric.

Wash Fastness Test of Samples 19-74 treated with Alum Mordant (WF19A – WF74A)

Specimens WF19A, WF20A, WF21A, WF22A, WF23A, WF33A, WF34A, WF35A and WF36A were graded poor, specimens WF24A, WF28A, WF29A, WF30A, WF31A,WF32A,WF48A, WF49A, WF69A,WF70A, WF71A and WF72 were assessed fairly good, while specimens WF25A , WF26A, WF27A, WF50A, WF51A, WF52A, WF53A, WF54A, WF56A, WF6OA and WF74A were good, specimens WF38A, WF39A, WF42A, WF43A, WF45A, WF47A, WF55A, WF57A, WF58A, WF59A, WF62A, WF63A, WF64A and WF73A were very good, specimens WF37A, WF40A, WF41A, WF44A, WF46A, WF61A, WF65A, WF66A, WF67A and WF68A were excellent.

Note: Out of ten specimens in this treatment with alum seven specimens were graded excellent and these specimens printing that had plantain resin in it.

Wash Fastness Test of Samples 19-74 treated with Potash Mordant (WF19P – WF74P)

Specimens WF19P, WF20P, WF21P, WF22P, WF23P, WF24P, WF33P, WF34P, WF5P, WF36P, WF48P, WF55P, WF69P and WF71P were graded poor, specimens WF25P, WF26P, WF27P, WF28P, WF31P, WF32P, WF39P, WF41P, WF49P, WF50P,

WF52P, WF53P, WF54P, WF56P, WF65P, WF66P, WF68P and WF70P were all fairly good, specimens WF29P, WF30P, WF38P, WF40P, WF45P, WF51P, WF58P, WF59P, WF60P, WF62P, WF72P, WF73P and WF74P also were on the same scale (3) good, specimens WF42P, WF43P, WF46P, WF47P, WF57P, WF61P, WF63P, WF64P and WF67P were very good, and specimens WF37P, and WF44P were excellent.

Note: Two specimens, WF37P and WF44P whereby the ink paste produced was mixed with plantain resin were graded excellent. This shows positive results.

Wash Fastness Test of Samples 19-74 treated with Sodium Chloride (salt) Mordant (WF19S – WF74S)

Specimen WF19S, WF20S,WF23S, WF24S, WF33S, WF34S, WF35S, WF36S and WF74S were poor, specimens WF21S, WF22S, WF25S, WF26S, WF27S, WF28S, WF31S, WF32S, WF39S, WF48S, WF49S, WF52S, WF53S, WF55S, WF65S, WF66S, WF67S, WF70S, WF71S and WF73 were fairly good, specimens WF29S, WF30S,WF38S, WF40S, WF41S, WF45S, WF47S, WF50S, WF51S, WF54S, WF56S, WF58S, WF60S, WF69S and WF72S were good, specimens WF42S, WF43S, WF46S, WF57S, WF59S, WF61S, WF62S, WF63S, WF64S and WF68S were very good, specimens WF37S and WF44S were excellent.

Note: In the treatment of printed fabric with sodium chloride two specimen were assessed Excellent, they were sample printed with, paste that was mixed with plantain resin.

Observation: Specimens WF37S and WF44S also brought out a good result when treated with all the three mordants and even when treated without mordants.

Treatment	Samples No & scales	Determination of Wash Fastness		
		Resin with mordants	No resin with mordants	Wash and stain level of samples 19&20
No mordant	Original samples			
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	5	4/5	
Alum	Not washed			Wash and stain level of samples 19&20
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	4	2/3	
Potash	Not washed			Wash and stain level of samples 19&20
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	5	4/5	
Salt	Not washed			Wash and stain level of samples 19&20
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	5	4/5	

Table 4.1.13: Resin from Musa Paradisiaca stem, using Sodium Alginate as thickening agent mordanted with Ammonium Chloride and Alum. Basic dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: No resin with mordants	
No mordant	Original samples			Wash and stain level of samples 21&22
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	4/5	4/5	
Alum	Not washed			Wash and stain level of samples 21&22
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	4/5	4	
Potash	Not washed			Wash and stain level of samples 21&22
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	4/5	4/5	
Salt	Not washed			Wash and stain level of samples 21&22
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	4	4	

Table 4.1.14: Resin from Musa Paradisiaca stem, using gum Tragacanth as thickening agent mordanted with Ammonium Chloride and Potash. Basic dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: No resin with mordants	
No mordant	Original samples			Wash and stain level of samples 23&24
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	4/5	5	
Alum	Not washed			Wash and stain level of samples 23&24
	Washed samples			
	Scale	1	2	
	Staining level			
	Scale	4	4	
Potash	Not washed			Wash and stain level of samples 23&24
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	4/5	4/5	
Salt	Not washed			Wash and stain level of samples 23&24
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	4/5	4/5	

Table 4.1.15: Resin from Musa Musa Paradisiaca stem, using Gum Arabic as thickening agent mordanted with Ammonium Chloride and Nacl. Basic dye was the pigment used.

		Determination of Wash Fastness		
Treatment	Samples No & scales	Resin with mordants	No resin with mordants	Wash and stain level of samples 25&26
No mordant	Original samples			
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	4/5	4/5	
Alum	Not washed			Wash and stain level of samples 25&26
	Washed samples			
	Scale	3	3	
	Staining level			
	Scale	2/3	2/3	
Potash	Not washed			Wash and stain level of samples 25&26
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	4/5	4/5	
Salt	Not washed			Wash and stain level of samples 25&26
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	5	4/5	

Table 4.1.16: Resin from Musa Musa Paradisiaca stem, using Tragacanth as thickening agent mordanted with Ammonium Chloride and Alum. Direct dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: No resin with mordants	
No mordant	Original samples			Wash and stain level of samples 27&28
	Washed samples			
	Scale	2	1	
	Staining level			
	Scale	5	4/5	
Alum	Not washed			Wash and stain level of samples 27&28
	Washed samples			
	Scale	3	2	
	Staining level			
	Scale	3	3	
Potash	Not washed			Wash and stain level of samples 27&28
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	4/5	4/5	
Salt	Not washed			Wash and stain level of samples 27&28
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	5	5	

Table 4.1.17: Resin from Musa Musa Paradisiaca stem, using Gum Arabic as thickening agent mordanted with Ammonium Chloride and Potash. Direct dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: No resin with mordants	Wash and stain level of samples 29&30
No mordant	Original samples			
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	5	4/5	
Alum	Not washed			Wash and stain level of samples 29&30
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	3	3	
Potash	Not washed			Wash and stain level of samples 29&30
	Washed samples			
	Scale	3	3	
	Staining level			
	Scale	4/5	4/5	
Salt	Not washed			Wash and stain level of samples 29&30
	Washed samples			
	Scale	3	3	
	Staining level			
	Scale	4/5	4/5	

Table 4.1.18: Resin from Musa Paradisiaca stem, using Sodium Alginate as thickening agent mordanted with Ammonium Chloride and Sodium chloride. Direct dye was the pigment used.

Grades	1	1/2	2	2/3	3	¾	4	4/5	5
No mordant	-	-	-	-	-	-	SR32, SR35, SR36	SR20,SR21,SR22,SR23,SR25, SR26,SR28,SR30,SR31,SR33, SR34,SR39,SR40,SR41,SR45, SR47,SR48,SR49,SR50,SR52, SR55,SR56,SR57,SR58,SR63, SR64,SR68,SR74	SR19,SR24,SR27,SR29,SR37,SR38,SR42,SR43,SR44,SR46,SR51,SR53,SR54,SR59,SR60,SR61,SR62,SR65,SR66, SR67,SR69,SR70,SR71,SR72,SR73
Alum	-	-	-	SR20A, SR25A, SR26A	SR27A, SR28A, SR29A,SR30A, SR36A	SR31A,SR33A, SR35A,SR55A	SR19A, SR22A, SR23A,SR24A,SR32A, SR34A	SR21A,SR37A,SR42A,SR45A, SR47A,SR48A,SR49A,SR52A, SR53A,SR56A,SR59A,SR60A, SR66A,SR74A	SR38A,SR39A,SR40A,SR41A,SR43A, SR44A,SR46A,SR50A,SR51A,SR54A, SR57A,SR58A,SR61A,SR62A,SR63A, SR64A,SR65A,SR67A,SR68A,SR69A, SR70A,SR71A,SR72A,SR73A
Potash	-	-	-	-	-	-	SR52P	SR20P,SR21P,SR22P,SR23P, SR24P,SR25P,SR26P,SR27P, SR28P,SR29P,SR30P,SR31P, SR32P,SR33P,SR34P,SR35P, SR36P,SR37P,SR38P,SR39P, SR40P,SR41P,SR44P,SR45P, SR47P,SR49P,SR50P,SR55P, SR56P,SR57P,SR58P,SR62P, SR69P	SR19P,SR42P,SR43P,SR46P, SR48P,SR51P,SR53P,SR54P, SR59P,SR60P,SR61P,SR63P, SR64P,SR65P,SR66P,SR67P, SR68P,SR70P,SR71P,SR72P, SR73P,SR74P
Salt	-	-	-	-	-	SR36S	SR2S1,SR22S, SR31S,SR32S, SR33S,SR34S, SR35S,SR39S, SR41S	SR20S,SR23S,SR24S,SR26S, SR29S,SR30S,SR37S,SR38S, SR40S,SR42S,SR43S,SR44S, SR45S,SR46S,SR47S,SR48S, SR52S,SR55S,SR56S,SR59S, SR62S	SR19S,SR25S,SR27S,SR28S, SR49S,SR50S,SR51S,SR53S, SR54S,SR57S,SR58S,SR60S, SR61S,SR63S,SR64S,SR65S, SR66S,SR67S,SR68S,SR69S, SR70S,SR71S,SR72S,SR73S, SR74S

Table 4.1.19: Results interpretation of staining samples printed with *Musa Paradisiaca* (plantain) for wash fastness test.

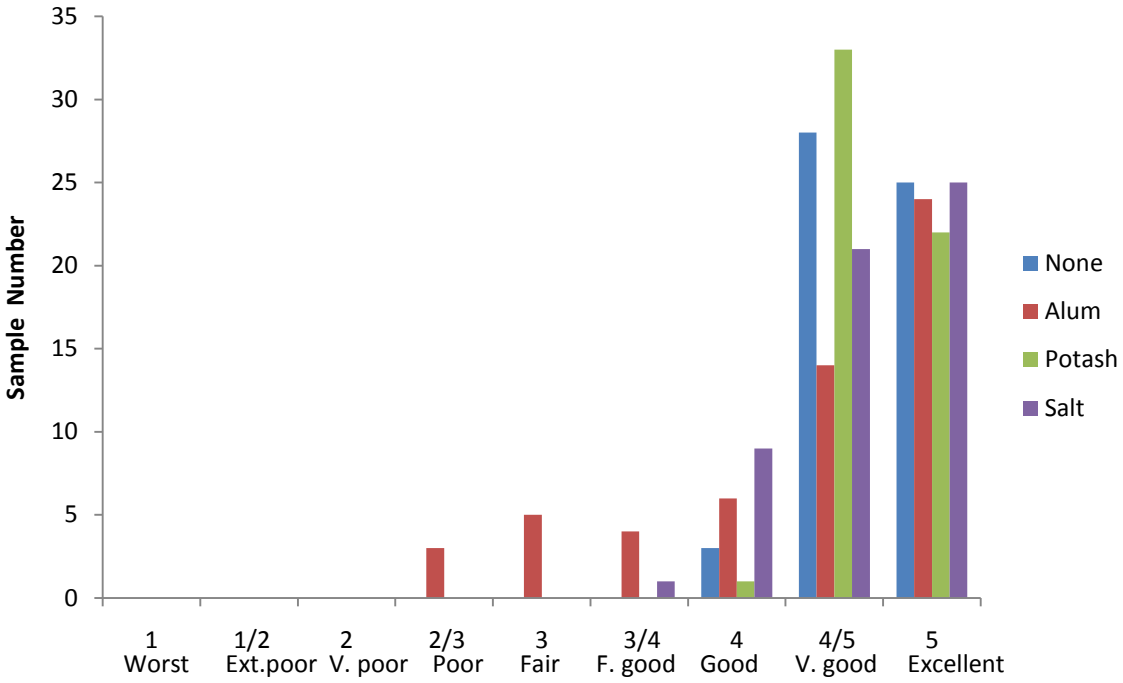


Figure 4.1.4: Wash fastness summary of samples printed with *Musa Paradisiaca*

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: No resin with mordants	Wash and stain level of samples 31&32
No mordant	Original samples			
	Washed samples			
	Scale	3	2	
	Staining level			
	Scale	4/5	4	
Alum	Not washed			Wash and stain level of samples 31&32
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	3/4	4	
Potash	Not washed			Wash and stain level of samples 31&32
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	4/5	4/5	
Salt	Not washed			Wash and stain level of samples31&32
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	4	4	

Table 4.1.20: Resin from Musa Paradisiaca stem, using Gum Arabic as thickening agent mordanted with Ammonium Chloride and Alum. Direct dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: No resin with mordants	Wash and stain level of samples 33&34
No mordant	Original samples			
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	4/5	4/5	
Alum	Not washed			Wash and stain level of samples 33&34
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	3/4	4	
Potash	Not washed			Wash and stain level of samples 33&34
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	4/5	4/5	
Salt	Not washed			Wash and stain level of samples 33&34
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	4	4	

Table 4.1.21: Resin from Musa Paradisiaca stem, using Sodium Alginate as thickening agent mordanted with Ammonium Chloride and Potash. Direct dye was the pigment used.

		Determination of Wash Fastness		
Treatment	Samples No & scales	Resin with mordants	No resin with mordants	Wash and stain level of samples 35&36
No mordant	Original samples			
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	4	4	
Alum	Not washed			Wash and stain level of samples 35&36
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	3/4	3	
Potash	Not washed			Wash and stain level of samples 35&36
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	4/5	4/5	
Salt	Not washed			Wash and stain level of samples 35&36
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	4	3/4	

Table 4.1.22: Resin from Musa Paradisiaca stem, using Tragacanth as thickening agent mordanted with Ammonium Chloride and Sodium Chloride. Direct dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: Resin with mordants	
No mordant	Original samples			Wash and stain level of samples 37&38
	Washed samples			
	Scale	5	3	
	Staining level			
	Scale	5	5	
Alum	Not washed			Wash and stain level of samples 37&38
	Washed samples			
	Scale	5	4	
	Staining level			
	Scale	4/5	5	
Potash	Not washed			Wash and stain level of samples 37&38
	Washed samples			
	Scale	5	3	
	Staining level			
	Scale	4/5	4/5	
Salt	Not washed			Wash and stain level of samples 37&38
	Washed samples			
	Scale	5	3	
	Staining level			
	Scale	4/5	4/5	

Table 4.1.23: Resin from Musa Paradisiaca stem, using Sodium Alginate as thickening agent mordanted with Ammonium Chloride and Potash. Azo was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness		
		No resin with mordants	Resin with mordants	
No mordant	Original samples			Wash and stain level of samples 39&40
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	4/5	4/5	
Alum	Not washed			Wash and stain level of samples 39&40
	Washed samples			
	Scale	4	5	
	Staining level			
	Scale	5	5	
Potash	Not washed			Wash and stain level of samples 39&40
	Washed samples			
	Scale	2	3	
	Staining level			
	Scale	4/5	4/5	
Salt	Not washed			Wash and stain level of samples39 &40
	Washed samples			
	Scale	2	3	
	Staining level			
	Scale	4	4/5	

Table 4.1.24: Resin from Musa Paradisiaca stem, using Sodium Alginate as thickening agent mordanted with Ammonium Chloride and Alum. Direct dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness		
		No resin with mordants	Resin with mordants	
No mordant	Original samples			Wash and stain level of samples 41&42
	Washed samples			
	Scale	2	4	
	Staining level			
	Scale	4/5	5	
Alum	Not washed			Wash and stain level of samples 41&42
	Washed samples			
	Scale	5	4	
	Staining level			
	Scale	5	4/5	
Potash	Not washed			Wash and stain level of samples 41&42
	Washed samples			
	Scale	2	4	
	Staining level			
	Scale	4/5	5	
Salt	Not washed			Wash and stain level of samples 41&42
	Washed samples			
	Scale	3	4	
	Staining level			
	Scale	4	4/5	

Table 4.1.25: Resin from Musa Paradisiaca stem, using Sodium Alginate as thickening agent mordanted with Ammonium Chloride and Alum. Direct dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness		
		No resin with mordants	Resin with mordants	
No mordant	Original samples			Wash and stain level of samples 43&44
	Washed samples			
	Scale	4	5	
	Staining level			
	Scale	5	5	
Alum	Not washed			Wash and stain level of samples 43&44
	Washed samples			
	Scale	5	4	
	Staining level			
	Scale	5	5	
Potash	Not washed			Wash and stain level of samples 43&44
	Washed samples			
	Scale	4	5	
	Staining level			
	Scale	5	4/5	
Salt	Not washed			Wash and stain level of samples 43&44
	Washed samples			
	Scale	4	5	
	Staining level			
	Scale	4/5	4/5	

Table 4.1.26 Resin from Musa Paradisiaca stem, using Sodium Alginate as thickening agent mordanted with Ammonium Chloride and Alum. Direct dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: No resin with mordants	Determination of Wash Fastness: Resin with mordants	
No mordant	Original samples			Wash and stain level of samples 45&46
	Washed samples			
	Scale	5	3	
	Staining level			
	Scale	4/5	5	
Alum	Not washed			Wash and stain level of samples 45&46
	Washed samples			
	Scale	4	5	
	Staining level			
	Scale	4/5	5	
Potash	Not washed			Wash and stain level of samples 4 &46
	Washed samples			
	Scale	3	4	
	Staining level			
	Scale	4/5	5	
Salt	Not washed			Wash and stain level of samples 45&46
	Washed samples			
	Scale	3	4	
	Staining level			
	Scale	4/5	4/5	

Table 4.1.27: Resin from Musa Paradisiaca stem, using Sodium Alginate as thickening agent mordanted with Ammonium Chloride and Alum. Direct dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: No resin with mordants.	Determination of Wash Fastness: Resin with mordants.	Wash and stain level of samples 47&48
No mordant	Original samples			
	Washed samples			
	Scale	4	2	
	Staining level			
	Scale	4/5	4/5	
Alum	Not washed			Wash and stain level of samples 47&48
	Washed samples			
	Scale	4	2	
	Staining level			
	Scale	4/5	4/5	
Potash	Not washed			Wash and stain level of samples 47&48
	Washed samples			
	Scale	4	1	
	Staining level			
	Scale	4/5	5	
Salt	Not washed			Wash and stain level of samples 47&48
	Washed samples			
	Scale	3	2	
	Staining level			
	Scale	4/5	4/5	

Table 4.1.28: Resin from Musa Paradisiaca stem, using Sodium Alginate as thickening agent mordanted with Ammonium Chloride and Alum. Direct dye was the pigment used.

Discussion of Table 4.1.19

Stain Results of samples 19-74 Treated without Mordants (SR19 – SR74)

The result shows that all specimens were between scale 4, 4/5 and 5 which mean the staining results were good, they were not really stained.

Specimens SR32, SR35 and SR36 were good. while specimen SR20, SR21, SR22, SR23, SR25, SR26, SR28, SR30, SR31, SR33, SR34, SR39, SR40, SR41, SR45, SR47, SR48, SR49, SR50, SR52, SR55, SR56, SR57, SR58, SR63,SR64, SR68 and SR74 were very good, specimens SR19, SR24, SR27, SR29, SR37, SR38, SR42, SR43, SR44, SR46, SR51, SR53, SR54, SR59, SR60, SR61, SR65, SR66, SR67, SR69, SR70, SR71and SR73 excellent.

Note: Some stained results of experimental specimens were assessed better than the control specimens as presented on the table.

Stain Results of samples 18-74 Treated with Alum Mordants (SR19A – SR74A)

Specimens SR20A, SR25A and SR26A were poor, while specimens SR27A, SR28A and SR29A were fair, specimens SR31A, SR33A, SR35A and SR55A were all fairly good, specimens SR19A, SR22A, SR23A, SR24A, SR3SA and SR34A were good, specimens SR38A, SR39A, SR40A, SR41A, SR43A, SR44A, SR46A, SR50A, SR51A, SR54A, SR57A, SR58A, SR61A, SR62A, SR63A, SR64A, SR65A, SR67A, SR68A, SR69A, SR70A, SR71A, SR72A and SR73 were all graded excellent.

Stain Results of samples 19-74 Treated with Potash Mordants (SR19P – SR74P)

Results of staining samples treated with potash was positive or very good, because most of the results were between 4/5 and 5 grades of the grey scale 150, only one (1) specimen read good.

Specimen SR52P was poor, specimens SR20P, SR21P, SR22P, SR23P, SR24P, SR25P, SR26P, SR27P, SR28P, SR29P, SR30P, SR31P, SR32P, SR33P, SR34P, SR35P, SR36P, SR37P, SR38P, SR39P, SR40P, SR41P, SR44P, SR45P, SR47P, SR49P, SR50P, SR55P, SR56P, SR57P, SR58P, SR62P and SR69P both experiment and control graded very good. Specimens SR19P, SR42P, SR43P, SR46P, SR48P, SR51P, SR53P,SR54P, SR59P, SR60P, SR61P, SR63P, SR64P, SR65P, SR66, SR67P, SR68P, SR70P, SR71P, SR72P, SR73P and SR74P were excellent.

Stain Results of samples 19-74 Treated with Sodium Chloride (Salt) Mordants (SR19S – SR74S)

Specimen SR36S was fairly good, while specimens SR21S, SR22S, SR31S, SR32S, SR33S, SR34S, SR35S, SR39S and SR41S were all good, results specimens SR20S, SR23S, SR24S, SR26S, SR29S, SR30S, SR37S, SR38S, SR40S, SR42S, SR43S, SR44S, SR45S, SR46S, SR47S, SR48S, SR52S, SR55S, SR56S, SR59S and SR62S were very good, specimens SR19S, SR25S, SR27S, SR28S, SR49S, SR50S, SR51S, SR53S, SR54S, SR57S, SR58S, SR60S, SR61S, SR63S, SR64S, SR65S, SR67S, SR68S, SR69S, SR70S, SR71S, SR71S, SR72S, SR73S and SR74S were excellent.

Most of the stained specimens treated with sodium chloride results, were between good, very good and excellent.

		Determination of Wash Fastness		
Treatment	Samples No & scales	No resin with mordants	Resin with mordants	Wash and stain level of samples 49&50
No mordant	Original			
	Scale			
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	4/5	4/5	
Alum	Not washed			Wash and stain level of samples 49&50
	Washed samples			
	Scale	2	3	
	Staining level			
	Scale	4/5	5	
Potash	Not washed			Wash and stain level of samples 49&50
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	4/5	4/5	
Salt	Not washed			Wash and stain level of samples 49&50
	Washed samples			
	Scale	2	3	
	Staining level			
	Scale	5	5	

Table 4.1.29: Resin from Musa Paradisiaca stem, using Sodium Alginate as thickening agent mordanted with Ammonium Chloride and Alum. Direct dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness		
		No resin with mordants	Resin with mordants	
No mordant	Original samples			Wash and stain level of samples 51&52
	Scale			
	Washed samples			
	Scale	3	2	
	Staining level			
	Scale	5	4/5	
Alum	Not washed			Wash and stain level of samples 51&52
	Scale			
	Washed samples			
	Scale	3	3	
	Staining level			
	Scale	5	4/5	
Potash	Not washed			Wash and stain level of samples 51&52
	Scale			
	Washed samples			
	Scale	3	2	
	Staining level			
	Scale	5	4	
Salt	Not washed			Wash and stain level of samples 51&52
	Scale			
	Washed samples			
	Scale	3	2	
	Staining level			
	Scale	5	4/5	

Table 4.1.30: Resin from Musa Paradisiaca stem, using Sodium Alginate as thickening agent mordanted with Ammonium Chloride and Alum. Direct dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: No resin with mordants	Determination of Wash Fastness: Resin with mordants	Wash and stain level of samples 53&54
No mordant	Original samples			
	Scale			
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	5	5	
Alum	Not washed			Wash and stain level of samples 53&54
	Scale			
	Washed samples			
	Scale	3	3	
	Staining level			
	Scale	4/5	5	
Potash	Not washed			Wash and stain level of samples53&54
	Scale			
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	5	5	
Salt	Not washed			Wash and stain level of samples 53&54
	Scale			
	Washed samples			
	Scale	2	3	
	Staining level			
	Scale	5	5	

Table 4.1.31: Resin from Musa Paradisiaca stem, using Sodium Alginate as thickening agent mordanted with Ammonium Chloride and Alum. Direct dye was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness		
		No resin with mordants	Resin with mordants	
No mordant	Original samples			Wash and stain level of samples 55&56
	Scale			
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	4/5	4/5	
Alum	Not washed			Wash and stain level of samples 55&56
	Scale			
	Washed samples			
	Scale	4	3	
	Staining level			
	Scale	3/4	4/5	
Potash	Not washed			Wash and stain level of samples 55&56
	Scale			
	Washed samples			
	Scale	1	2	
	Staining level			
	Scale	4/5	4/5	
Salt	Not washed			Wash and stain level of samples 55&56
	Scale			
	Washed samples			
	Scale	2	3	
	Staining level			
	Scale	4/5	4/5	

Table 4.1.32: Resin from Musa Paradisiaca stem, using Sodium Alginate as thickening agent mordanted with Ammonium Chloride and Alum. Azo was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: Resin with mordants	Wash and stain level of samples 57&58
No mordant	Original samples			
	Washed samples			
	Scale	4	3	
	Staining level			
	Scale	4/5	4/5	
Alum	Not washed			Wash and stain level of samples 57&58
	Washed samples			
	Scale	4	4	
	Staining level			
	Scale	5	5	
Potash	Not washed			Wash and stain level of samples 57&58
	Washed samples			
	Scale	4	3	
	Staining level			
	Scale	4/5	4/5	
Salt	Not washed			Wash and stain level of samples 57&58
	Washed samples			
	Scale	4	3	
	Staining level			
	Scale	5	5	

Table 4.1.33: Resin from Musa Paradisiaca stem, using Sodium Alginate as thickening agent mordanted with Ammonium Chloride and Alum. Azo was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: No resin with mordants	
No mordant	Original samples			Wash and stain level of samples 59&60
	Washed samples			
	Scale	4	3	
	Staining level			
	Scale	5	5	
Alum	Not washed			Wash and stain level of samples 59&60
	Washed samples			
	Scale	4	3	
	Staining level			
	Scale	4/5	4/5	
Potash	Not washed			Wash and stain level of samples 59&60
	Washed samples			
	Scale	3	3	
	Staining level			
	Scale	5	5	
Salt	Not washed			Wash and stain level of samples 59&60
	Washed samples			
	Scale	4	3	
	Staining level			
	Scale	4/5	5	

Table 4.1.34: Resin from Musa Paradisiaca stem, using Gum Tragacanth as thickening agent mordanted with Ammonium Chloride and Alum. Pthalocinine was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness		
		Resin with mordants	No resin with mordants	Wash and stain level of samples 61&62
No mordant	Original samples			
	Washed samples			
	Scale	4	3	
	Staining level			
	Scale	5	5	
Alum	Not washed			Wash and stain level of samples 61&62
	Washed samples			
	Scale	5	4	
	Staining level			
	Scale	5	5	
Potash	Not washed			Wash and stain level of samples 61&62
	Washed samples			
	Scale	4	3	
	Staining level			
	Scale	5	4/5	
Salt	Not washed			Wash and stain level of samples 61&62
	Washed samples			
	Scale	4	4	
	Staining level			
	Scale	5	4/5	

Table 4.1.35: Resin from Musa Paradisiaca stem, using Gum Tragacanth as thickening agent mordanted with Ammonium Chloride and Sodium chloride. Pthalocinine was the pigment used.

		Determination of Wash Fastness		
Treatment	Samples No & scales	Resin with mordants	No resin with mordants	Wash and stain level of samples 63&64
No mordant	Original samples			
	Washed samples			
	Scale	4	3	
	Staining level			
	Scale	4/5	4/5	
Alum	Not washed			Wash and stain level of samples 63&64
	Washed samples			
	Scale	4	4	
	Staining level			
	Scale	5	5	
Potash	Not washed			Wash and stain level of samples 63&64
	Washed samples			
	Scale	4	4	
	Staining level			
	Scale	5	5	
Salt	Not washed			Wash and stain level of samples 63&64
	Washed samples			
	Scale	4	4	
	Staining level			
	Scale	5	5	

Table 4.1.36: Resin from Musa Paradisiaca stem, using Gum Tragacath as thickening agent mordanted with Ammonium Chloride and Potash. Pthalocinine was the pigment used.

		Determination of Wash Fastness		
Treatment	Samples No & scales	Resin with mordants	No resin with mordants	Wash and stain level of samples 65&66
No mordant	Original samples			
	Washed samples			
	Scale	1	1	
	Staining level			
	Scale	5	5	
Alum	Not washed			Wash and stain level of samples 65&66
	Washed samples			
	Scale	5	5	
	Staining level			
	Scale	5	4/5	
Potash	Not washed			Wash and stain level of samples 65&66
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	5	5	
Salt	Not washed			Wash and stain level of samples 65&66
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	5	5	

Table 4.1.37: Resin from Musa Paradisiaca stem, using Sodium Alginate as thickening agent mordanted with Ammonium Chloride and Sodium Chloride. Phalocynine was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: No resin with mordants	
No mordant	Original samples			Wash and stain level of samples 67&68
	Washed samples			
	Scale	4	3	
	Staining level			
	Scale	5	4/5	
Alum	Not washed			Wash and stain level of samples 67&68
	Washed samples			
	Scale	5	5	
	Staining level			
	Scale	5	5	
Potash	Not washed			Wash and stain level of samples 67&68
	Washed samples			
	Scale	4	2	
	Staining level			
	Scale	5	5	
Salt	Not washed			Wash and stain level of samples 67&68
	Washed samples			
	Scale	2	4	
	Staining level			
	Scale	5	5	

Table 4.1.38: Resin from Musa Paradisiaca stem, using Sodium Alginate as thickening agent mordanted with Ammonium Chloride and Sodium Chloride. Pthalocinine was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: No resin with mordants	Wash and stain level of samples 69&70
No mordant	Original samples			
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	5	5	
Alum	Not washed			Wash and stain level of samples 69&70
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	5	5	
Potash	Not washed			Wash and stain level of samples 69&70
	Washed samples			
	Scale	1	2	
	Staining level			
	Scale	4/5	5	
Salt	Not washed			Wash and stain level of samples 69&70
	Washed samples			
	Scale	3	2	
	Staining level			
	Scale	5	5	

Table 4.1.39: Resin from Musa Cavendish Dwarf stem, using Gum Arabic as thickening agent mordanted with Ammonium Chloride and Alum. Pthalocinine was the pigment used.

		Determination of Wash Fastness		
Treatment	Samples No & scales	Resin with mordants	No resin with mordants	Wash and stain level of samples 71&72
No mordant	Original samples			
	Washed samples			
	Scale	1	2	
	Staining level			
	Scale	5	5	
Alum	Not washed			Wash and stain level of samples 71&72
	Washed samples			
	Scale	2	2	
	Staining level			
	Scale	5	5	
Potash	Not washed			Wash and stain level of samples 71&72
	Washed samples			
	Scale	1	3	
	Staining level			
	Scale	5	5	
Salt	Not washed			Wash and stain level of samples 71&72
	Washed samples			
	Scale	2	3	
	Staining level			
	Scale	5	5	

Table 4.1.40: Resin from Musa Cavendish Dwarf stem, using Gum Arabic as thickening agent mordanted with Ammonium Chloride and Sodium Chloride. Pthalocinine was the pigment used.

Treatment	Samples No & scales	Determination of Wash Fastness: Resin with mordants	Determination of Wash Fastness: No resin with mordants	Wash and stain level of samples 73&74
No mordant	Original samples			
	Washed samples			
	Scale	3	2	
	Staining level			
	Scale	5	4/5	
Alum	Not washed			Wash and stain level of samples 73&74
	Washed samples			
	Scale	4	3	
	Staining level			
	Scale	5	4/5	
Potash	Not washed			Wash and stain level of samples 73&74
	Washed samples			
	Scale	3	3	
	Staining level			
	Scale	5	5	
Salt	Not washed			Wash and stain level of samples 73&74
	Washed samples			
	Scale	2	1	
	Staining level			
	Scale	5	5	

Table 4.1.41: Resin from Musa Cavendish Dwarf stem, using Gum Arabic as thickening agent mordanted with Ammonium Chloride and Potash. Pthalocinine was the pigment used.

4.2 RUBBING FASTNESS TEST RESULTS

Grades	1	½	2	2/3	3	¾	4	4/5	5
Dry Test	-	-	-	-	RF1D,RF11D, RF17D	RF2D,RF5D, RF6D,RF12D	RF3D,RF4D, RF8D,RF10D, RF15D	RF7D, RF9D, RF13D, RF14D, RF16D, RF18D	
Wet Test	-	RF11W, RF12W, RF17W, RF18W	RF5W, RF6W	RF2W, RF3W, RF4W	RF1W,RF8W, RF9W,RF10W, RF13W,RF14W, RF15W,RF16W,	RF7W	-	-	-

Table 4.2.1: Detailed results of staining samples of rubbing fastness test arranged according to their grey scales *Musa Cavendish Dwarf* (dessert banana).

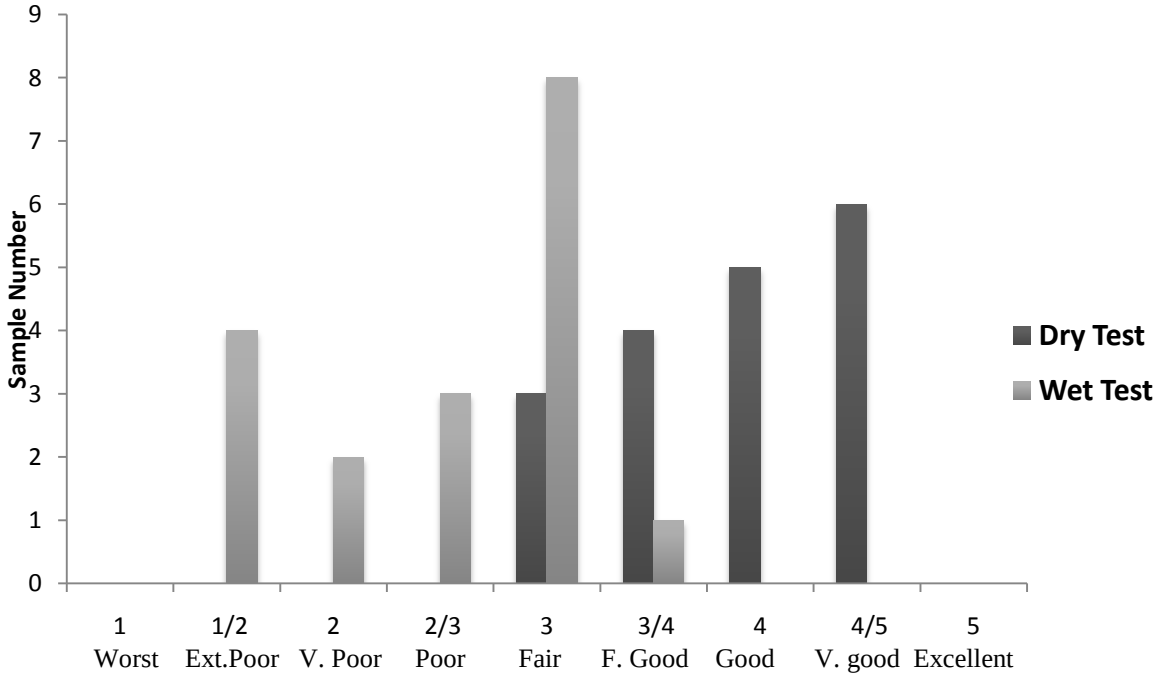


Figure 4:2.1 Staining samples of rubbing fastness test arranged according to their grey scales *Musa Cavendish Dwarf*

Discussion of Table 4.2.1

Stain Samples Results of Fastness to Rubbing Test

Stain Samples of Rubbing Fastness, Dry Test (RF1D – RF18D)

Specimens RF1D, RF11D and RF17D were fair, specimens RF2D, RF5D, RF6D and RF12D were fairly good, specimens RF3D, RF4D, RF8D, RF10D and RF15D were all good, while specimens RF7D, RF9D, RF13D, RF14D, RF16D and RF18D were graded very good.

Staining Samples of Rubbing Fastness, Wet Test (RF1W – RF18W)

For the wet rub fastness test the results were weak all the results were between 1/2 and 3/4 and these were for both experiment samples or specimen and the control samples.

Specimens RF11W, RF12W, RF17W and RF18W were extremely poor, specimens RF5W and RF6W were both very poor. Specimens RF2W, RF3W and RF4W were poor, specimens RF1W, RF8W, RF9W, RF10W, RF13W, RF14W, RF15W and RF16W were fair, specimen RF7W was graded fairly good.

		Determination of Fastness to Rubbing		
Treatment	Samples No & scales	Resin with mordants	No resin with mordants	Stain test samples 1&2
Stain test samples of dry and wet fastness	Control Sample	1	2	
	Dry			
	Scale	3	3/4	
	Wet			
	Scale	3	2/3	
	Control Sample	3	4	Stain test samples 3&4
	Dry			
	Scale	4	4	
	Wet			
	Scale	2/3	2/3	
	Control Sample	5	6	Stain test samples 5&6
	Dry			
	Scale	3/4	3/4	
	Wet			
	Scale	2	2	

Table 4.2.2 Dry and Wet staining samples of rubbing fastness test, samples using the Grey Scale (ISO 150)

		Determination of Fastness to Rubbing		
Treatment	Samples No & scales	Resin with mordants	No resin with mordants	Stain test samples 7&8
Stain test samples of dry and wet fastness	Control Sample	7 	8 	
	Dry			
	Scale	4/5	4	
	Wet			
	Scale	3/4	3	
	Control Sample	9 	10 	Stain test samples 9&10
	Dry			
	Scale	4/5	4	
	Wet			
	Scale	3	3	
	Control Sample	11 	12 	Stain test samples 11&12
	Dry			
	Scale	3	3/4	
	Wet			
	Scale	1/2	1/2	

Table 4.2.3 Dry and Wet staining samples of rubbing fastness test, samples using the Grey Scale (ISO 150)

		Determination of Fastness to Rubbing		
Treatment	Samples No & scales	Resin with mordants	No resin with mordants	Stain test samples 13&14
Stain test samples of dry and wet fastness	Control Sample	13 	14 	
	Dry			
	Scale	4/5	4/5	
	Wet			
	Scale	3	3	
	Control Sample	15 	16 	Stain test samples 15&16
	Dry			
	Scale	4	4/6	
	Wet			
	Scale	3	3	
	Control Sample	17 	18 	Stain test samples 17&18
	Dry			
	Scale	3	4/5	
	Wet			
	Scale	1/2	1/2	

Table 4.2.4 Dry and Wet staining samples of rubbing fastness test, samples using the Grey Scale (ISO 150)

Grades	1	½	2	2/3	3	¾	4	4/5	5
Dry Test	-	-	-	RF63D, RF64D	RF37D, RF40D, RF72D	RF19D,RF24D, RF25D,RF26D, RF29D,RF30D, RF38D,RF41D, RF44D,RF47D, RF51D,RF52D, RF53D,RF54D, RF55D,RF56D, RF59D,RF62D, RF65D,RF66D, RF67D,RF68D, RF69D,RF71D, RF73D	RF20D,RF21D, RF22D,RF23D, RF27D,RF28D, RF32D,RF36D, RF39D,RF42D, RF43D,RF45D, RF46D,RF48D, RF49D,RF50D, RF57D,RF58D, RF60D,RF61D RF70D,RF74D	RF31D,RF33D, RF34D,RF35D	-

Table 4.2.5: Results interpretation of staining samples printed with *Musa Paradisiaca* (plantain) resins for dry rubbing fastness test.

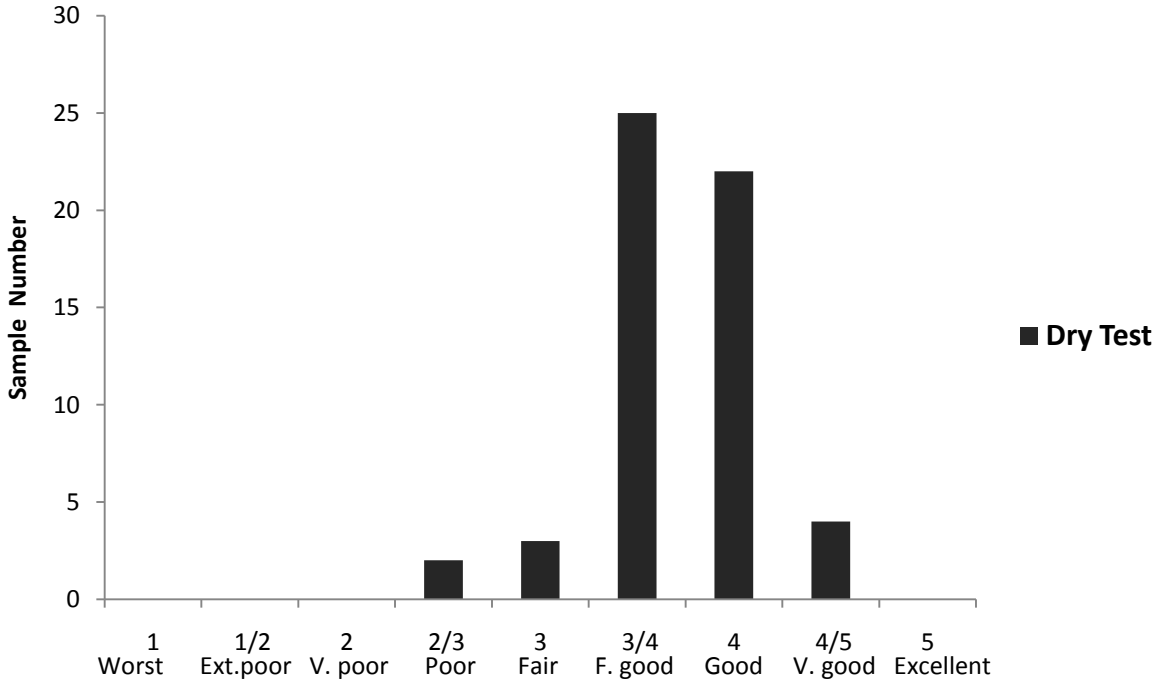


Figure 4:2.2 Summary of dry rubbing fastness test of samples printed with *Musa Paradisiaca*

Treatment	Samples No & scales	Determination of Fastness to Rubbing: No resin with mordants	Determination of Fastness to Rubbing: Resin with mordants	
Stain test samples of dry and wet fastness	Control Sample	19 	20 	Stain test samples 19&20
	Dry			
	Scale	3/4	4	
	Wet			
	Scale	2/3	3	
	Control Sample	21 	22 	Stain test samples 21&22
	Dry			
	Scale	4	4	
	Wet			
	Scale	3/4	3/4	
	Control Sample	23 	24 	Stain test samples 23&24
	Dry			
	Scale	4	3/4	
	Wet			
	Scale	2/3	3	

Table 4.2.6 Dry and Wet staining samples of rubbing fastness test, samples using the Grey Scale (ISO 150)

		Determination of Fastness to Rubbing		
Treatment	Samples No & scales	No resin with mordants	Resin with mordants	Stain test samples 25&26
Stain test samples of dry and wet fastness	Control Sample	25 	26 	
	Dry			
	Scale	3/4	3/4	
	Wet			
	Scale	1/2	1/2	
	Control Sample	27 	28 	Stain test samples 27&28
	Dry			
	Scale	4	4	
	Wet			
	Scale	2/3	2	
	Control Sample	29 	30 	Stain test samples 29&30
	Dry			
	Scale	3/4	3/4	
	Wet			
	Scale	2	2	

Table 4.2.7 Dry and Wet staining samples of rubbing fastness test, samples using the Grey Scale (ISO 150)

		Determination of Fastness to Rubbing		
Treatment	Samples No & scales	No resin with mordants	Resin with mordants	Stain test samples 31&32
Stain test samples of dry and wet fastness	Control Sample	31 	32 	
	Dry			
	Scale	4/5	4	
	Wet			
	Scale	2/3	2	
	Control Sample	33 	34 	Stain test samples 33&34
	Dry			
	Scale	4/5	4/5	
	Wet			
	Scale	2/3	2/3	
	Control Sample	35 	36 	Stain test samples 35&36
	Dry			
	Scale	4/5	4	
	Wet			
	Scale	2/3	3	

Table 4.2.8 Dry and Wet staining samples of rubbing fastness test, samples using the Grey Scale (ISO 150)

Discussion of Table 4.2.5

Staining Specimens of Fastness to Rubbing Test

Staining Samples of Rubbing Fastness, Dry Test Specimens (RF19D – RF74D)

A reasonable number of samples and specimens in this table for dry rubbing test were of good results.

Specimens RF63D and RF64D were poor, specimens RF37D, RF40D and RF72D were fair, specimens RF19D, RF24D, RF25D, RF26D, RF29D, RF30D, RF38D, RF41D, RF44D, RF47D, RF51D, RF52D, RF53D, RF54D, RF55D, RF56D, RF59D, RF62D, RF65D, RF66, RF67D, RF68D, RF69D, RF71D and RF73D were all graded fairly good while specimens RF20D, RF21D, RF22D, RF23D, RF27D, RF28D, RF32D, RF36D, RF39D, RF42D RF43D, RF45D, RF46, RF48D, RF49D, RF50D, RF57D, RF58D, RF60D, RF61D, RF70D and RF74D were assessed good, and lastly specimens RF31D, RF33D, RF34 and RF35 were very good.

Treatment	Samples No & scales	Determination of Fastness to Rubbing No resin with mordants Resin with mordants		Stain test samples
Stain test samples of dry and wet fastness	Control Sample	37 	38 	Stain test samples 37&38
	Dry			
	Scale	3	3/4	
	Wet			
	Scale	3	3	
	Control Sample	39 	40 	Stain test samples 39&40
	Dry			
	Scale	4	3	
	Wet			
	Scale	3	3	
	Control Sample	41 	42 	Stain test samples 41&42
	Dry			
	Scale	3/4	4	
	Wet			
	Scale	3	3	

Table 4.2.9 Dry and Wet staining samples of rubbing fastness test, samples using the Grey Scale (ISO 150)

		Determination of Fastness to Rubbing		
Treatment	Samples No & scales	No resin with mordants	Resin with mordants	Stain test samples 43&44
Stain test samples of dry and wet fastness	Control Sample	43 	44 	
	Dry			
	Scale	4	3/4	
	Wet			
	Scale	3	3	
	Control Sample	45 	46 	Stain test samples 45&46
	Dry			
	Scale	4	4	
	Wet			
	Scale	3	3	
	Control Sample	47 	48 	Stain test samples 47&48
	Dry			
	Scale	3/4	4	
	Wet			
	Scale	3	3/4	

Table 4.2.10 Dry and Wet staining samples of rubbing fastness test, samples using the Grey Scale (ISO 150)

		Determination of Fastness to Rubbing		
Treatment	Samples No & scales	No resin with mordants	Resin with mordants	Stain test samples 49&50
Stain test samples of dry and wet fastness	Control Sample	49 	50 	
	Dry			
	Scale	4	4	
	Wet			
	Scale	3	3	
	Control Sample	51 	52 	Stain test samples 51&52
	Dry			
	Scale	3/4	3/4	
	Wet			
	Scale	3	3	
	Control Sample	53 	54 	Stain test samples 53&54
	Dry			
	Scale	3/4	3/4	
	Wet			
	Scale	3	3	

Table 4.2.11 Dry and Wet staining samples of rubbing fastness test, samples using the Grey Scale (ISO 150)

Grades	1	½	2	2/3	3	¾	4	4/5	5
Wet Test	-	RF25W, RF26W	RF28W, RF29W, RF30W, RF32W	RF19W, RF23W, RF27W, RF31W, RF33W, RF34W, RF35W, RF59W, RF67W,	RF20W,RF24W,RF36W, RF37W,RF38W,RF39W, RF40W,RF41W,RF42W, RF43W,RF44W,RF45W, RF46W,RF47W,RF49W, RF50W,RF51W,RF52W, RF53W,RF54W,RF55W, RF56W,RF57W,RF58W, RF61W,RF62W,RF63W, RF64W,RF65W,RF66W, RF68W,RF69W,RF70W, RF71W,RF72W,RF73W	RF21W,RF22W, RF48W,RF60W, RF74W	-	-	-

Table 4.2.12: Wet rubbing fastness test of samples printed with *Musa Paradisiaca*

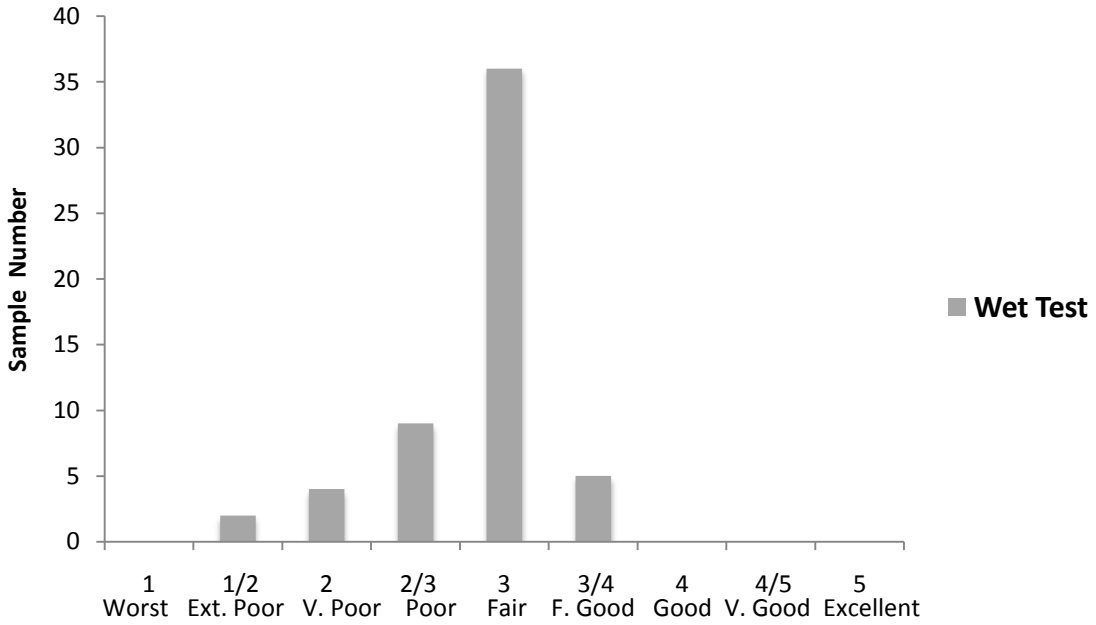


Figure 4:2.3 Summary of wet rubbing fastness test samples *Musa Paradisiaca*

Discussion of Table 4.2.12

Staining Specimens of Fastness to Rubbing Test

Staining Result of Rubbing Fastness, Wet Test (RF19W – RF74W)

Specimen RF25W and RF26W were both extremely poor, specimens RF28W, RF29W, RF30W and RF32W were graded very poor, specimens RF19W, RF23W, RF27W, RF31W, RF33W, RF34W, RF35W, RF39W, RF59W and RF67W were poor, specimens RF20W, RF24W, RF36W, RF37W, RF38W, RF39W, RF40W, RF41W, RF42W, RF43W, RF44W, RF45W, RF46W, RF47W, RF49W, RF50W, RF51W, RF52W, RF53W, RF54W, RF55W, RF56W, RF57W, RF58W, RF61W, RF62W, RF63W, RF64W, RF65W, RF66W, RF68W, RF69W, RF70W, RF71W, RF72W and RF73W were all fair, specimens RF21W, RF22W, RF48W, RF60W and RF74W were scaled fairly good.

Treatment	Samples No & scales	Determination of Fastness to Rubbing No resin with mordants Resin with mordants		Stain test samples 55&56
Stain test samples of dry and wet fastness	Control Sample	55 	56 	
	Dry			
	Scale	3/4	3/4	
	Wet			
	Scale	3	3	
	Control Sample	57 	58 	Stain test samples 57&58
	Dry			
	Scale	4	4	
	Wet			
	Scale	3	3	
	Control Sample	59 	60 	Stain test samples 59&60
	Dry			
	Scale	3/4	4	
	Wet			
	Scale	2/3	3/4	

Table 4.2.13 Dry and Wet staining samples of rubbing fastness test, samples using the Grey Scale (ISO 150)

		Determination of Fastness to Rubbing		
Treatment	Samples No & scales	Resin with mordants	No resin with mordants	Stain test samples 61&62
Stain test samples of dry and wet fastness	Control Sample	61 	62 	
	Dry			
	Scale	4	3/4	
	Wet			
	Scale	3	3	
	Control Sample	63 	64 	Stain test samples 63&64
	Dry			
	Scale	2/3	2/3	
	Wet			
	Scale	3	3	
	Control Sample	65 	66 	Stain test samples 65&66
	Dry			
	Scale	3/4	3/4	
	Wet			
	Scale	3	3	

Table 4.2.14 Dry and Wet staining samples of rubbing fastness test, samples using the Grey Scale (ISO 150)

		Determination of Fastness to Rubbing		
Treatment	Samples No & scales	Resin with mordants	No resin with mordants	Stain test samples 67&68
Stain test samples of dry and wet fastness	Control Sample	67 	68 	
	Dry			
	Scale	3/4	3/4	
	Wet			
	Scale	2/3	3	
	Control Sample	69 	70 	Stain test samples 69&70
	Dry			
	Scale	3/4	4	
	Wet			
	Scale	3	3	
	Control Sample	71 	72 	Stain test samples 71&72
	Dry			
	Scale	3/4	3	
	Wet			
	Scale	3	3	

Table 4.2.15 Dry and Wet staining samples of rubbing fastness test, samples using the Grey Scale (ISO 150)

		Determination of Fastness to Rubbing	
Treatment	Samples No & scales	Resin with mordants	No resin with mordants
Stain test samples of dry and wet fastness	Control Sample	73 	74 
	Dry		
	Scale	3/4	4
	Wet		
	Scale	3	3/4

Table 4.2.16 Dry and Wet staining samples of rubbing fastness test, samples using the Grey Scale (ISO 150)

4.3 LIGHT FASTNESS TESTS

Grades	1-2	2-3	3-4	4-5	5-6	6-7	7-8
Musa Cavendish Dwarf	-	-	LF1,LF8	LF2,LF9,LF10, LF11,LF12,LF13, LF14	LF3,LF4, LF5,LF6, LF7,LF15, LF16,LF18	LF17	-

Table 4.3.1: Details for light fastness test using the blue standard of *Musa Cavendish Dwarf*

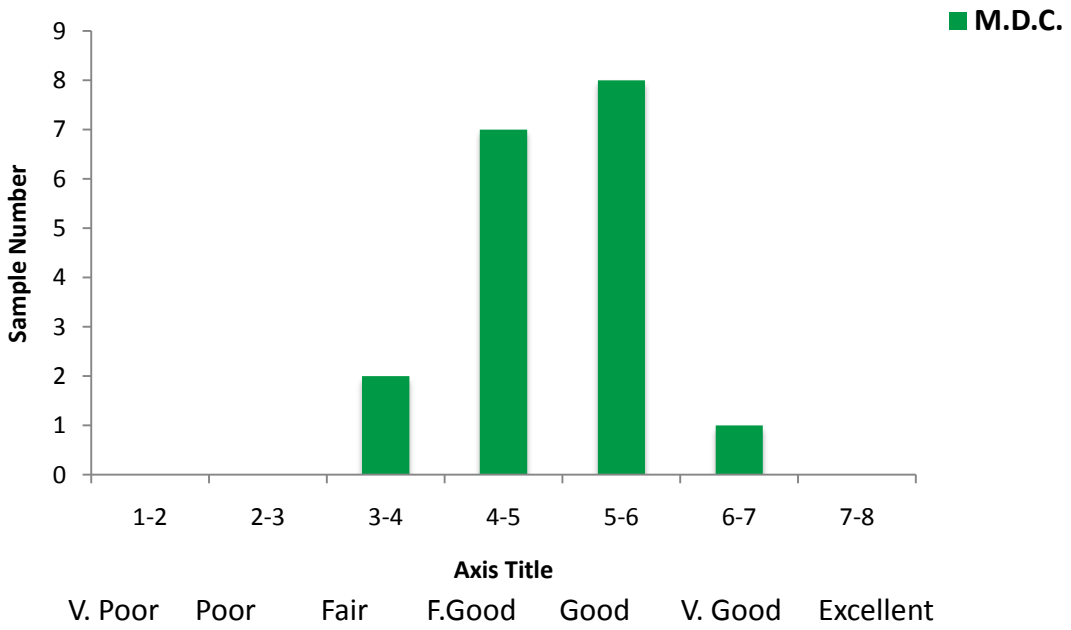


Figure 4:3.1 Summary of light fastness test samples printed with *Musa Cavendish Dwarf*

Discussion of Table 4.3.1

Light Fastness Test results of Samples (LF1-LF18)

Specimens LF1 and LF8 were at the standard (3-4), specimens LF2, LF9, LF10, LF11, LF12, LF13, and LF14 were at standard (4-5), LF3, LF4, LF5, LF6 LF7 LF15, LF16 and LF18 were graded (5-6) , specimen LF17 was at scale (6-7).

Treatment	Samples type & scales	Determination of Colour Fastness to Light	
		Resin with mordants	No resin with mordants
Determination of Colour Fastness to Light	Sample	1 	2 
	Scale	3-4	4-5
	Sample	3 	4 
	Scale	5-6	5-6
	Sample	5 	6 
	Scale	5-6	5-6
	Sample	7 	8 
	Scale	5-6	3-4
	Sample	9 	10 
	Scale	4-5	4-5
	Sample	11 	12 
	Scale	4-5	4-5
	Sample	13 	14 
	Scale	4-5	4-5
	Sample	15 	16 
	Scale	5-6	5-6
	Sample	17 	18 
	Scale	6-7	5-6
	Sample	19 	20 
	Scale	3-4	3-4
	Sample	21 	22 
	Scale	2-3	3-4

Table 4.3.2 Day light fastness test of samples 1-22 using the blue standard for scaling and as reference.

Grades	1-2	2-3	3-4	4-5	5-6	6-7	7-8
Musa paradiciaca	-	LF21	LF19,LF20, LF22,LF24, LF38,LF48, LF54,LF55, LF65	LF23,LF35, LF37,LF39, LF49,LF50, LF51,LF52, LF53,LF56, LF57,LF58 LF59,LF60, LF63,LF67, LF68,LF71	LF27,LF28, LF30,LF31, LF33,LF36, LF40,LF41, LF42,LF43, LF44,LF46, LF61,LF62, LF66,LF69, LF72,LF73 LF74	LF25,LF26, LF29,LF32, LF34,LF45, LF47,LF64, LF70	-

Table 4.3.3: Light fastness test of *Musa Paradisiaca*

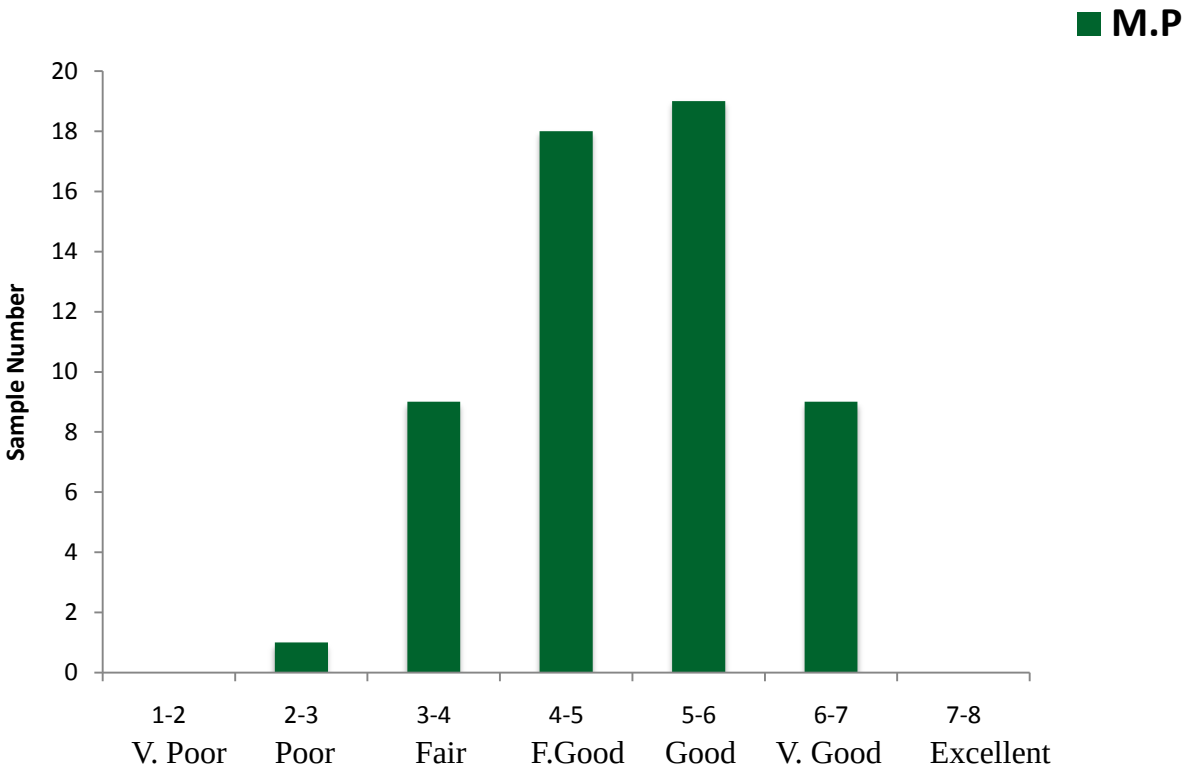


Figure 4:3.2 Summary of light fastness test of samples printed with *Musa Paradisiaca*

Treatment	Samples type & scales	Determination of Colour Fastness to Light No resin + mordants Resin + mordants	
Determination of Colour Fastness to Light			
	Sample	23 	24 
	Scale	4-5	3-4
	Sample	25 	26 
	Scale	6-7	6-7
	Sample	27 	28 
	Scale	5-6	5-6
	Sample	29 	30 
	Scale	6-7	5-6
	Sample	31 	32 
	Scale	5-6	6-7
	Sample	33 	34 
	Scale	5-6	6-7
	Sample	35 	36 
	Scale	4-5	5-6
	Sample	37 	38 
	Scale	4-5	3-4
	Sample	39 	40 
	Scale	4-5	5-6
	Sample	41 	42 
	Scale	5-6	5-6
	Sample	43 	44 
	Scale	5-6	5-6

Table 4.3.4 Day light fastness test of samples 23-44 using the blue standard for scaling and as reference.

Discussion of Table 4.3.3

Light Fastness Test Results of Samples (LF19 - LF74)

Specimen LF21 was graded (2-3), specimens LF19, LF20, LF22, LF24, LF38, LF48, LF54, LF55and LF56 were at standard (3-4), specimens LF23, LF35, LF37, LF39, LF49, LF50, LF51, LF52, LF53, LF56, LF57, LF58, LF59, LF60, LF63, LF67, LF68 and LF71 were all on grade (4-5), LF27, LF28, LF30, LF31, LF33, LF36, LF40, LF41, LF42, LF43, LF44, LF46, LF61, LF62, LF66, LF69, LF72, LF73 and LF74 they were at standard (5-6), while specimens LF25, LF26, LF29, LF32, LF34, LF45, LF47, LF64 and LF70 were at standard (6-7).

Treatment	Samples type & scales	Determination of Colour Fastness to Light No resin + mordants Resin + mordants	
Determination of Colour Fastness to Light			
	Sample	45	46
	Scale	6-7	5-6
	Sample	47	48
	Scale	6-7	3-4
	Sample	49	50
	Scale	4-5	4-5
	Sample	51	52
	Scale	4-5	4-5
	Sample	53	54
	Scale	4-5	3-4
	Sample	55	56
	Scale	3-4	4-5
	Sample	57	58
	Scale	4-5	4-5
	Sample	60	59
	Scale	4-5	4-5
	Sample 16&17	62	61
	Scale	5-6	5-6
	Sample	64	63
	Scale	6-7	4-5
	Sample	66	65
	Scale	5-6	3-4

Table 4.3.5 Day light fastness test of samples 45-66 using the blue standard for scaling and as reference.

Treatment	Samples type & scales	Determination of Colour Fastness to Light No resin + mordants Resin + mordants	
Determination of Colour Fastness to Light			
	Sample	68 	67 
	Scale	4-5	4-5
	Sample	70 	69 
	Scale	6-7	5-6
	Sample	72 	71 
	Scale	5-6	4-5
	Sample	74 	73 
	Scale	5-6	5-6

Table 4.3.6 Day light fastness test of samples 67-74 using the blue standard for scaling and as reference.

4.4 ANSWERS TO ALL RESEARCH QUESTIONS AND OBJECTIVES

4.4.1 Answers of Research Questions

1. Resins from both *Musa Cavendish Dwarf* and from *Musa Paradisiaca* were collected in liquid form. The plant was after brought to the laboratory cleaned and then cut into small pieces, then it was pounded until it was smooth with the use of a mortar and pestle after which it was squeezed and sieved using a nylon mesh, this is to get rid of impurities. 500mls of *Musa Cavendish Dwarf* was extracted for the first experiment; also 500mls of *Musa Paradisiaca* was extracted for the second experiment.

2. The extracted resin was used in a fresh state (liquid). The resin was mixed, with prepared thickener, pigment and mordant.

3. The prepared coatings were applied to the substances as demonstrated. Agencies such as oxidation, steaming and ironing were applied as fixing techniques. Additives such as alum, potash and sodium chloride were also used in order to enhance the binding effect; ammonium chloride was used in each solution in order to prevent the fabric from cracking or so that the paste solution does not affect the cotton fabric.

4. The three mordants were diluted in lukewarm water and were used in all the paste solution. After each printing samples, it was oxidized to dry for 3 to 4 hours, the printed samples were dried in shade, so that the sun does not affect the intensity of the hue. Each sample was also steamed using the steaming pot technique created by Kparevzua (2004). Each sample was steamed for 30 - 45 min and oxidized to dry up. Each sample was ironed using the electrical iron at 70^0C - 90^0C for 3-5 minutes each.

When the resin was introduced into the ink paste some had change of shades, the resin made it look darker than the one without resin. While in some, there were no changes.

5. The fastness tests were performed in order to determine the fastness properties of the ink paste on cotton fabric. Wash fastness test, fastness test to rubbing and light fastness test were the three tests that were performed, this was because, they are the day to day's common application properties of fabrics in our domestic use.

- Wash fastness test was done manually in different glass beakers using the International Standard Organization (I.S.O.) Test No.3. The composition of the test solution was made of 5 grammes of soap (block soap), 2 grammes of sodium carbonate in 1000mls of lukewarm distilled water, after which it was well agitated and left to settle for 2-3mins. 50mls of the solution was measured and poured into different beakers, they were set on the hot plate and when they were at temperature $65^{o}C$, they were brought off the fire. Three different mordants namely; Alum, Potash, Sodium Chloride were introduced into each beaker of the solution, the printed specimen were introduced into the solution when the solution was $60^{o}C$ for the duration of 30mins.
- Rubbing fastness test was performed using the rubbing fastness test machine which is called crockmeter, this crockmeter rubbed to and fro 10 times for a period of 10 seconds; this was done on each specimen. The tests for the rubbing fastness were: dry rubbing fastness test and wet rubbing fastness test. These tests were performed in the finishing section of the Angel Spinners and Dyers Textile Industry in Kano state.
- Light fastness test was done manually using the blue standard. The test was performed for a period of 6 days for each specimen; it was exposed under the day light from 9am – 4pm (7 hours) for 6 days.

All the results of the tests on the samples performed in this study have been examined and analyzed in this chapter.

4.4.2 Answers to Objectives of the Study

1. The selection and collection of the plant were performed by the aid of the staff of Biological Science Department of Ahmadu Bello University.

2. Resin from the study plant was of acceptable quality when mixed with pigment, because some samples that were mixed with the resin were better than those that were not mixed with the resin. And for the quantity, the percentage of the banana yield in term of mass production, it is of 20-23% yield in Zaria.

3. The test results of the binder in pigments on cotton fabric. The wash fastness test was performed and the result was 54% positive, while the rub fastness test was 51% positive and the light fastness test was 53% positive.

4. The results of this study have proven that this study is relevant to the economic need of Nigerians. Many textile practitioners especially the cottage industries and schools will have access to the locally made binders.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.0 Introduction

This chapter has to do with the summary, conclusion and recommendations of this research work. The summary of the study includes the purposes, problems, methodology and procedures of this study, followed by a summary of the findings. Conclusions based on the findings which are related to the research questions and recommendations for future research in line with the findings.

5.1 Summary

The insufficiency of raw materials was what led to this study titled "extraction and utilization of banana plant resin for possible use as pigment binder on cotton fabric" and its fastness properties when printed. Two species of musaceae plant namely: *Musa Cavendish dwarf and Musa Paradiciaca* were collected at fadama farms located in Sabon Gari and gardens of residential compounds in Samaru, also in Sabo Gari Local Government Area, which is the selected area of study.

The following were steps used in achieving the objectives of the study: pretreatment of fabric, identification of species of the research plant, collection, extraction of resins, mixing, printing procedures, colour fastness test and finally interpretation and discussion of results were carried out.

One yard of cotton fabric was weighed and desized. It was soaked in water for a period of 24 hours, and then it was sun dried for a period of 1hour 30mins. After which it was ironed for 4-6 minutes with temperature between $80^{o}C$ – $100^{o}C$. Research assistants from Botanical science section of Biological Sciences Department and the Department

of Agronomy, Ahmadu Bello University Zaria, used scientific methods for the identification of plant species. The raw materials were then taken to the laboratory for the extraction, direct extraction also called tapping was the technique employed in this work.

The specimens were used fresh in liquid condition into the paste, different thickeners were introduced namely: sodium alginate, gum tragacanth. Pigments were introduced into the solution in separate beakers, and all were mixed with three different mordants namely: alum, potash and salt. It is also inferred that the amount of resins mixed was 2.5mls, with half pellet of pigment, 2 tea spoon full of thickener, 2/3 tea spoon of mordants well mixed for 3-4mins, and then printed on the fabric. Some fixative processes such as oxidization, steaming and ironing, were done. All samples were printed on cotton fabric and were subjected to standard washing, rubbing or light fastness tests.

I.S.O. 3, was the standard used for the washing fastness test, the results of wash and rubbing fastness tests were interpreted using the grey scale (I.S.O. 150), while the light fastness test was interpreted using the blue standard, and at last all results were reported.

5.2 Conclusion

1) The method in which resin from Musaceae plant can be extracted is by pounding chopped pieces of the pseudostem until it became soft then squeezed into a bowl after which it was sieved and filtered using a nylon mesh to remove impurities. The resin was extracted in a liquid form. It can also be extracted by the tapping process, the tapping process has to do with incision of the plant or for the case of the Musaceae stem the plant stem has to be cut round and allow the resin to be dripping into a container.

2) Mordanting the prepared ink was the most appropriate way of helping in fixing the ink paste solution onto cotton fabric, the mordants that was used were: ammonium chloride, alum, potash (potassium of carbonate) and salt (sodium chloride). It can be deduced that additives and agencies helped in enhancing the binding of pigment paste when used with resin from *Musa cavendish dwarf* and *Musa paradisiaca* species of Musaceae. During the mordanting of the paste process, Alum mordant brought out the best results, followed by potash and then sodium chloride.

3) The resin extracted was used fresh in a liquid form into the pigment solution and was applied as paint onto cotton fabric, immediately after the period of extraction of resins (binder).

4) Some of the additives tended in changing the shades of pigment colour and also the resins when mixed gave some darker shade.

5) From the analysis of the experiments performed, both extracted resin from pseudostem of *Musa cavendish dwarf* and *Musa paradisiaca* helped in binding pigment on cotton fabric by mixing it with mordants which helped in fixing the prepared ink paste on cotton fabric. It can be concluded that locally produced binder from both species of Musaceae namely *Musa cavendish dwarf* and *Musa paradisiaca* produced acceptable results, especially wash fastness test, followed by the rub fastness test and then light fastness test.

5.3 Recommendations

- Further research should be made to find out other local plants that can be used as pigment binders such as: *Calotropis*, *sarostemma* and *Pedilanthus Tithymaloides*.

- Farmers of these localities should be encouraged by the Ministry of Agriculture to cultivate more Musaceae plants of different species and they should try and preserve the available ones and farmers should locate more banana plant species especially the wild grown species and preserve large quantity of it for the use in industries.

- The Ahmadu Bello University authority should assist the textile section of the Department of Industrial Design financially to purchase laboratory equipment for research activities such as: wash fastness machines, driers (oven), rubbing fastness machines (crockmeter), and light fastness machines. This will help in enhancing quick results of the tests.

- To reduce foreign dependency, Nigerian research institutes should explore effective ways to develop local raw materials in the textile production. The Federal and State Governments should include textile graduates in the graduates' loan scheme, this will create job opportunities for skilled and unskilled workers considering textile being a labour intensive industry.

- The Federal Government of Nigeria should release fund to revive the existing textile industries for the purpose of manufacturing and processing of raw material that has to do with the textile industries. They should try and sponsor researches to be handled by technologists and industrial chemists in order to locate more banana plant species especially the wild grown species and preserve large quantity of it for the use in industries.

- Since the research was based on resin from musaceae resins in a liquid form, research should be conducted on the appropriate chemicals that can preserve the resin for a long period of time, so that researchers will not have to go for fresh ones. In this study the resin was preserved in a refrigerator and it was still suitable for use.

- Alum ($KAl(SO_4)_2.12H_2O$), potassium carbonate (K_2CO_3), ammonium chloride (NH_4Cl) and sodium chloride (NaCl) were used to enhance and help fix the ink on cotton fabric. Different catalysts should be researched on.

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Appendix I

The resins used are from species of the Musaceae:

1. M.C.D.: *Musa Cavendish Dwarf.*

2. M.P.: *Musa paradiciaca.*

Thickeners: S. Ag → Sodium Alginate

Trag. → Tragacanth

G.A → Gum Arabic

Additives: NaCl → Sodium Chloride

NH4Cl → Ammonium Chloride

Alum → Alum

Pot. → Potash

Pigments: - Direct

- Basic

- Azo

- Ptha. → Pthalocynine

Appendix II

Tables representing Sample numbered 1 – 74 with their treatments.

Samples 1-17 Odd numbers

Ingredients									
M.C.D Resins	1	3	5	7	9	11	13	15	17
Thickener	-.	Trag.	G.A	S.Ag	Trag.	G.A.	S.Ag	Trag.	G.A.
Additives	Alum	Alum	Alum	Pot.	Pot.	Pot.	Nacl	Nacl	Nacl
Pigment	Direct	Direct	Basic	Direct	Direct	Basic	Direct	Direct	Basic

Samples 1-18 Even numbers

Ingredients									
No M.C.D.Resins	2	4	6	8	10	12	14	16	18
Thickener	-	Trag.	G.A	S.Ag	Trag.	G.A.	S.Ag	Trag.	G.A.
Additives	Alum	Alum	Alum	Pot.	Pot.	Pot.	NaCl	NaCl	NaCl
Pigment	Direct	Direct	Basic	Direct	Direct	Basic	Direct	Direct	Basic

Samples 19-35 Odd numbers

Ingredients									
M.P. Resins	19	21	23	25	27	29	31	33	35
Thickener	-	Trag.	G.A	Trag.	G.A.	S.A.	G.A.	S.A.	Trag.
Additives	Alum	Pot.	NaCl	Alum	Pot.	NaCl	Alum	Pot.	NaCl
Pigment	Basic	Basic	Basic	Basic	Basic	Basic	Basic	Basic	Basic

Samples 20-36 Even numbers

Ingredients									
No M.P. Resins	20	22	24	26	28	30	32	34	36
Thickener	-	Trag.	G.A	Trag.	G.A.	S.A.	G.A.	S.A.	Trag.
Additives	Alum	Pot.	NaCl	Alum	Pot.	NaCl	Alum	Pot.	NaCl
Pigment	Basic	Basic	Basic	Basic	Basic	Basic	Basic	Basic	Basic

Sample 37

Ingredients	
M.P. Resins	37
Thickener	-
Additives	Alum
Pigment	Azo

Samples 38-54 Even numbers

Ingredients									
M.P. Resins	38	40	42	44	46	48	50	52	54
Thickener	S.Ag.	S.Ag	Trag.	Trag.	Trag.	G.A.	G.A	G.A	G.A.
Additives	Pot.	NaCl	Alum	Pot.	NaCl	Alum	Pot.	Nacl	Alum
Pigment	Azo	Azo	Azo	Azo	Azo	Azo	Azo	Azo	Azo

Samples 39-55 Odd numbers

Ingredients									
No M.P. Resins	39	41	43	45	47	49	51	53	55
Thickener	S.Ag.	S.Ag	Trag.	Trag.	Trag.	G.A.	G.A	G.A	G.A.
Additives	Pot.	NaCl	Alum	Pot.	NaCl	Alum	Pot.	Nacl	Alum
Pigment	Azo	Azo	Azo	Azo	Azo	Azo	Azo	Azo	Azo

Samples 56, 57 and 58

Ingredients			
M.P. Resins	56	57	58
Thickener	G.A	Trag.	Trag.
Additives	NH4Cl,NaCl,Alum	NH4Cl,NaCl,Alum&Pot.	NH4Cl,Alum&Pot.
Pigment	Azo	Azo	Azo

Samples 59-73 Odd numbers

Ingredients								
M.P. Resins	59	61	63	65	67	69	71	73
Thickener	Trag.	Trag.	Trag.	S.Ag.	S.Ag	G.A.	G.A	G.A
Additives	Alum	NaCl	Pot.	NaCl	Pot.	Alum	Nacl.	Pot
Pigment	Pthal.	Pthal.	Pthal.	Pthal.	Pthal.	Pthal.	Pthal.	Pthal.

Samples 60-74 Even numbers

Ingredients								
No M.P. Resins	60	62	64	66	68	70	72	74
Thickener	Trag.	Trag.	Trag.	S.Ag.	S.Ag	G.A.	G.A	G.A
Additives	Alum	NaCl	Pot.	NaCl	Pot.	Alum	Nacl.	Pot
Pigment	Pthal.	Pthal.	Pthal.	Pthal.	Pthal.	Pthal.	Pthal.	Pthal.