KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF ART AND BUILT ENVIRONMENT

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EXPLORING MORDANTS FOR IMPROVED FASTNESS OF PLANT DYES FOR APPLICATION ON LOCAL VEGETABLE TANNED LEATHER

BY

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DECLARATION

I hereby declare that this submission is my own work towards the MPHIL Degree and that to the best of my knowledge does not contain materials previously published by another person nor materials which have been accepted for the award of any other Degree of the University, except where due reference has been made in the text.

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ABSTRACT

Natural dyes which were pushed for long in about six decades by synthetic dyes are gradually emerging to the interest of consumers. This as a result of the possible risk associated with the use of synthetic dyes on the environment. The manufacture of these dyes are energy intensive with adverse impact on environment adding to its greater pollution because of the petro-chemicals in its production. Against this background, that the researcher has delved into the exploration and use of different mordants on plant based dyes to test their affinity on natural leather. Different mordants in the group of metallic, tannins and oil were experimented for the purpose of the research. Plant based dyes namely, Sorghum bicolor leaves and Hibiscus sabdarifa flowers were tested together with identified mordants. The experimental processes were recorded critically and the results were observed and recorded as well. Interviews were also conducted with the sampled population as a means of ascertaining the experimental results obtained. According to the findings secured, it was noticed that plant dyes available locally require mordants to ensure fastness to light and washing, especially if applied on leather. However, not all mordants available on the local market work well with any plant dyes. Mordants used with plant dyes need to be applied in the right quantities to achieve the required efficacy. From all the mordants explored, three main ones worked very well in this study: salt, carbide, lime juice. It was recommended that locally available plant dyes when given the needed attention can serve as a breakthrough for obtaining variety of dye colours to enhance the aesthetics appeal of leathers tanned locally. Dye chemists and leather technicians therefore need to join forces to advance deeper research to harness the potentials of local plant dyes to expand socio-economic benefits.

P. B. N.

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CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter provides the basic structure of the research. It outlines the background to the study, statement of the problem, objectives, and research questions, significance of the study, delimitation of the study, definition of terms and organization of the study.

1.2 Background to the Study

The use and the development of natural dye dates back to the Bible era where people devised means to give different shades to their garments. Dyes obtained from animals, plants, and the earth which produced different shades were all used to give different colour to garments. They are considered eco-friendly and nontoxic, fitting nicely into similar trends of repurposing, up- cycling, and local food. It is so obvious of how people are becoming more aware of how they can affect their environment and the use, greatly posed no threat to the environment. Before British chemist William Perkins invented chemical dyes in the middle of the 19th century, textile dyeing was done with organic materials- plants, lichens, or insects.

Chemical dyes became common during the industrial revolution; as more clothes were being produced, more dyes were needed. The comfort of application and limitless palette made them very attractive to industry, and artisans soon followed. This was as a result of the heavy criticism natural dyes were facing because of it lacking the affinity to stick to garments and losing their strengths when it comes in contact with water and light. The piercing and very important argument made natural dyes loose their market share to synthetic, though it had very important reasons as to why it was an important choice than the accepted and adopted choice of dye in the textile industry.

Chemical dyes though have greater affinity for almost all kinds of fabrics, are highly carcinogenic and can cause serious health problem, as compared to the natural dyes which are environmental friendly. The drawback to advancement was labourer exposure to hurtful chemicals and the contamination of water and ground. This has been the reality for over a century despite the improvement of modern medicines to check contamination. On the other hand, natural dyes are experiencing a great resurgence of interest in the textile world, and this is due to the fact that people have now shifted their attention from just the brighter effects and the permanency of it staying in textile garments to the absolute facts of being highly chemical and diabolic to nature.

With the realization that there are several plant sources from which dyes can be extracted to dye leathers in Ghanaian local tanneries, tanners have also found it necessary to use plant dyes to render colour on the surface of leather for enhanced value. Since there are no well identified mordants to ensure permanent stay of the plant dyes on the surface of leather, it has become difficult for leather makers and users to boldly settle for plant dyes as dependable source of colourant. Research into mordants to guarantee permanent stay of plant dyes on leather has become a necessity.

1.3 Statement of the Problem

Natural dyes which exist in various forms have been tried on leather by tanners in the country, but observations made in various tanneries show that plant dyes available locally tend to fade after exposure to the environment, especially when washed or exposed to sunlight over a period. Meanwhile, the interest in the use of plant dyes by tanners to colour vegetable tanned leather has always been very high due to their natural and non-toxic nature. Unfortunately, leather works producers who buy leathers from these tanners have been complaining of lack of wash fastness and light fastness, tanners have ended up in a dilemma, since they do not have enough confidence in the use of local plant dyes.

According to Asmah et al. (2015), to make plant dyes permanent in fibre materials, one needs mordants to appropriately guarantee fastness. Mordants are known to be either natural or chemical substances that help dyes to fix permanently on a substrate (leather or fabric). This study sought to explore locally available mordants with plant dyes for improved fastness, and further test their affinity when applied on leather as a substrate.

1.4 Purpose of the Study

The intent of the study is to experiment selected mordants with plant based dyes for improved fastness on Ghanaian indigenous leather.

1.5 Objectives

1. To identify various mordants which can aid the wash and light fastness of natural dyes.
2. To experiments the various mordants with plant dyes on indigenous tanned leather.
3. To analyse the potential effects mordant(s) with plant dyes on the indigenous tanned leather over time.

1.6 Research Questions

1. What are the various mordants which can aid the wash and light fastness of natural dyes?
2. How can various mordants be experimented with natural dyes on indigenous tanned leather?
3. How can the effects of mordants with natural dyes be evaluated on indigenous tanned leather?

1.7 Delimitations

1. Mordant selection is limited to locally available ones such as sodium hydroxide, sodium hydrosulphite, salt, iodine solution and alum.
2. Plant selection for dye extraction is restricted to hibiscus sabdariffa flowers and Sorghum bicolor leaves.
3. Selection of leathers for the study is limited local vegetable tanned leather
4. The scope of the study is within Ashanti region, specifically, Ntonso, Gyinyase, Centre for National Cultural Kumasi and Asewase.

1.8 Significance of the Study

The significance of this study has been categorized under the following sub-headings.

1.8.1 To the Leather Industry

i. The study would help identify dye yielding plants (Sorghum bicolour and Hibiscus sabdariffa) as potential sources of tannins to the leather tanning industry.

ii. Usage of the identified mordants for plant dyes would confirm their suitability on leather.

iii. The study has the potential to serve as educative material for teachers, students, producers of leather craft, tanners, lecturers and researchers on the use of mordants with plant dyes which are readily available, eco-friendly, non-toxic and bio-degradable as compared to synthetic dyes which are harmful and hazardous to the environment.

iv. The research will serve as a reference material for tanners, dyers, teachers, students, lecturers and other researchers.

v. The study would enable tanners to produce leathers that can withstand the test of time.

1. 8. 2 Significance to Education

i. The result of the experimentation will serve as a material or pillar for other research to be conducted.

ii. The study seeks to bring about variation and innovativeness in the production of locally tanned leather.

iii. The study will introduce an additional way of improving the fastness property of locally tanned leather.

iv. The study will bring to light another dimension for research by exploring other mordants and plant dyes for improve fastness on Ghanaian indigenous leather.

1.8.3. Significance to Socio-Economic Development

i. People will start planting dye yielding plants which will create employment for people.
ii. People will also get income from the proceeds.
iii. It will offer alternatives to increase the preference of consumers.
iv. Through exhibition we can attract foreign investors into the leather industry.
v. The study will help Ghanaian tanned leathers to gain recognition in the world market.

1.9 Terminologies

1. **Mordant:** A substance used to set dyes on fabrics or tissue sections by forming a coordination complex with the dye which then attaches to the fabric or tissue.
2. **Plant Dyes:** They are dyes or colorants derived from plants.
3. **Soaking:** It is the act of putting the fat liquored leather in water.
4. **Pounding:** It is the act of putting the soaked leather in a mortar and striking with the pistil to soften the leather to aid in the dyeing process.
5. **Cold dye:** It refers to any dye which does not require very hot water for fixation.
6. **Hot dye:** It refers to any dye which requires very hot water for fixation.
7. **Dye stuff:** A substance yielding a dye or that can be used as a dye, especially when in solution.
8. **Fat liquoring:** It is the process in which oils and fats are used to soften leathers.
9. **Dyeing:** It is the process of adding colour to textile products like fibres, yarns and fabrics.

10. **Oxidation:** It is the act of putting the dyed leather in fresh water and removing it to allow air to pass through.

Forms of Mordant Application in Dyeing

i. **Pre-mordanting (Pre-mordanting (onchrome):** The substrate is treated with the mordant and after that dyed.
ii. **Meta-mordanting (metachrome):** The mordant is included the dye bath itself.
iii. **Post-mordanting (after chrome):** The dyed material is treated with a mordant.

1.10 Organization of Chapters

This study is presented in five chapters. Chapter one introduces the study, and comprises the background to the study, statement of the problem, general objectives, specific objectives, research questions, significance of the study, limitations of the study, delimitations of the study, definition of terms and organisation of the study. Chapter Two reviews all related available literature on the study. Chapter Three discusses the methodology of the study. Chapter Four consists of results and findings of the study, where it focuses on the findings and discussion of results (data observation). Chapter Five consists of the summary, conclusions and recommendations.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Overview

The related literature reviewed, was on theoretical and empirical foundations of the study. Frantic efforts were made to identify and understand the underlying theoretical perspective and existing research findings regarding the problem at hand. The literature is reviewed under the following headings:

2.2 Mordant Concept in Dyeing Activities

Natural dyes are readily available in our environment in various parts of plants, however, due to lack of proper affinity with various substrates, they are not given adequate recognition in Leatherwork. Asmah et al. (2015) has however emphasized that making plant dyes fast to fibre based materials requires the identification and application of appropriate mordants.

A mordant is a chemical agent which allows a reaction to occur between the dye and the fa bric in textiles, mordant are used to fix the colour in dyeing or fabric printing. The mordant has the capacity of bonding the structures of the dye in the interstices of the garment. Mordant is added to the dye source to influence it, it does not serve as a color source on its own. The fabric is impregnated with the mordant, then during the dyeing process the dye re -acts with the mordant, forming a chemical bond and attaching it firmly to the fabric.

The natural dyes having limited substantively for the fibre, require use of the mordant which enhances the fixation of the natural colorant on the fibre by the formation of the complex with the dye. Some of the important mordants used are alum, potassium dichromate, ferrous sulphate, copper sulphate, zinc sulphate, tannin, and tannic acid. Although these metal mordant contribute to developing wide gamut of hues after completing with the natural colouring compounds, most of these metals are toxic in nature and only in trace quantity their presence is found to be safe for the wearer.

A mordant is a chemical which can itself be fixed on the fibre and also forms a chemical bond with the natural colorants. It helps in absorption and fixation of natural dyes and also prevents bleeding and fading of colours i.e., improves the fastness properties of the dyed fabrics. This complex may be formed by first applying the mordant and then dyeing (pre-mordanting process) or by simultaneous application of the dye and the mordant (meta-mordanting process) or by after treatment of the dyed material with the mordant (post-mordanting process). There are three types of mordants namely Metal salts or Metallic mordants, tannic acid (Tannins) and Oil mordants.

2.2.1 Common Mordants Used in Natural Dyeing

There are basically three types of mordant known and used by most textile artisans (Aniket 2012). They include the following:

2.2.2 Metal Salts or Metallic Mordant

Metal salts of Aluminium, chromium, iron, copper and tin are used. Some of the common mordants used are Alum, Copper sulphate, ferrous sulphate, Potassium dichromate, Stannous Chloride and Stannic Chloride. Based on the final colour produced with the natural dyes, these metallic mordants are further divided in to two types i.e., Brightening

Mordants and Dulling Mordants. Alum, Potassium dichromate and Tin (Stannous chloride) falls under the category of brightening mordants and Copper sulphate and Ferrous sulphates are dulling mordant.

2.2.3 Oil-Mordants

Oil mordants are utilized for the most part in colouring of Turkey red shading from madder. The fundamental capacity of the oil mordants is to shape a complex with alum utilized as the primary stringent. Since alum is dissolvable in water and not it has liking for cotton, it is effectively washed out from the treated texture. The regular happening oil contains unsaturated fat, for example, palmetic, Stearic, oleic and so forth, and their glycerides. The COOH gathering of unsaturated fat respond with metal salts and gets changed over in COOM, where M indicates the metal. In this way, it was discovered that the treatment of oils with concentrated metal restricting limit than the characteristic oil due to the sulphonic bunches SO3 H. The sulphonic corrosive can respond with metal to deliver – SO 3M. This bound metal can frame complex with stringent colour, for example, madder to give Turkey red shade of unrivaled speed and tint. Along these lines, the sulphonated oils were called Turkey Red Oils (TRO). The term TRO is currently utilized just for the sulphonated castor oil. TRO is likewise herald of the advanced engineered surfactants.

Table 1.1 Tabular Presentation of Common Mordants (David A. Katz 2004)

COMMON NAME	CHEMICAL NAME	USE
Alum plus Cream of tartar	Aluminium potassium sulphate Potassium bitartrate	Usually combined in a ratio of 3 parts alum to 1 part cream of tartar
Chrome	potassium dichromate	Used to deepen colours and make them more lasting
Iron (copperas)	Iron(II) sulphate	used as a saddening agent because it makes a colour darker or duller
Tin	Tin(II) chloride	used as a brightening agent to make colour sharper or lighter
Copper sulphate (blue vitriol)	copper(II) sulphate	used to make colours in the green range as it itself imparts a bluish-green colour to fibres
Vinegar	Acetic acid	used to heighten colour of a dye bath, especially with reds
Ammonia (non-sudsy, clear)	Ammonia	used to draw colour out of dye materials, especially grasses and lichens

2.3 Concept of Dyes and Dyeing Processes

A dye is an organic compound composed of a chromophore (the coloured portion of the dye molecule) and an auxochrome (which slightly alters the colour) (Asmah et al. 2015). The auxochrome makes the dye soluble and is a site for bonding the fibre. Dyes are molecules that can be dissolved in water or some other carrier so that they can penetrate the fibre. Dyeing processes may be used either to colour fibres and yarns before they are made into cloth or to colour the fabric itself. Dyeing also provides a means to decorate fabrics.

For dyes to be applied to fabric Tryfos (1996), opines that, the dye must be in a solution or paste to create patterns on the fabric. For dyes to be usable in colouring fabrics, a dye must be highly coloured; must yield goods that are "colourfast" or resistant to colour change or loss during use and care; and, must be soluble or capable of being made soluble in water or other medium in which they are applied, or they must themselves be molecularly dispersible into the fibres of the fabric.

Tryfos (1996) also referred to as dyestuffs, dyes as the most common way to add colour to fibres, yarns and fabrics. When a textile fabric, fibre or yarn is placed in the dye bath (dye solution), the item absorbs the molecules of the dye and assumes the colour of the dye. Any excess dye that remains on the outside of the fibre can bleed or become sensitive to surface abrasion. Chemical additives or mordants such as salt and acid are sometimes used to regulate absorption of the dye into a fibre. This suggests using the proper dye for particular fibres which also demands knowledge of the affinity of the fibre or substrate for particular dyes, whether it is mineral, vegetable, animal or synthetic. This implies that all textiles could be made colour fast to an extent so that the fabric can hold its colour under normal use, laundering or exposure to sunlight.

2.3.1 History of Natural Dyes

Natural colours of plants and minerals have been admired by humans since several centuries. Natural dyes are applied to fabrics for thousands of years for body painting and making foods for ancient humans Tryfos (1996). The action was exercised in Europe during the Bronze Age. The *first written evidence of the usage of natural dyes was discovered in China dated 2600 BC. However, dyeing process was believed to start as early as 2500 BC in the Indus Valley and this information has been supported by findings of traces of madder dye and coloured garments of cloth in the ruins of the Indus Valley Civilization at Mohenjo-Daro and Harappa 3500 BC period (Ruznan, 2009).

Dyes from natural sources have become the main source of textile colouring material till the mid to late 19th century (Best,1981). During the mid of 19th century almost all dyes were extracted from the leaves stems, roots, berries, petals of various dye-yielding plants and from animals such as insects, shellfish as well as from minerals (ocher). Chemical tests of red fabrics found in the tomb of King Tutankhamen in Egypt showing the presence of alizarin which is a pigment that can be extracted from the roots of the madder plant. The coloured fabric was considered of having brilliant and exotic colours (Ruznan, 2009).

According to Nor & Azlin, (2012) by the 4th century AD natural dyes from Brazilwood, weld, indigo, madder, wood and dark reddish-purple were identified while in the 15^{th} century, dyes from Kermes and cochineal were turning to be increased in popularity for dyeing. However, Sharphouse (1983), stated that in the Mediterranean prior to the arrival of Christianity, almost all dyeing industry came up around Tyrian purple. Tyrian purple is derived from the mucous gland adjacent to the respiratory cavity within some species of Purpura and Murex.

In 1869, William Henry Perkin introduced the first synthetic dyes thus making natural dyes to lose their popularity. In the end of the 19th century, some tweed producers from

Scotland were the only ones who were still using natural dyes and later the use of natural dyes on a commercial scale hardly exists. At that time, natural dye was mainly used in remote areas where people have either limited access to synthetic dyes or a vested concern in continuing their ancient dyeing traditions only (Clair, 1986).

It is known that natural dyes have been in existence since creation, its uses have always depended on when and where they were discovered. The use of natural dyes is gaining popularity again with the resurgence of new developed technology in hand crafting, most notably in the fields of weaving, spinning, papermaking, leather works and basketry (Ruznan, 2009). The renewed technology and historic concern in natural dyeing assist to identify dyestuffs discovered by archaeologist in order to preserve the dyed textiles housed in museums and private collections (Ruznan 2009). As Pegs and Aquye (2008) have said "Whilst the dyeing industry of today keeps pace with modern science, the future use of natural dyes will also follow a new path, but one firmly rooted in tradition".

2.4. Sources of Natural Dyes

Natural dyes have been used since prehistoric times for dyeing and printing fabrics. There are primarily three main sources from which natural dyes can be obtained such as from plants, animals and minerals.

2.4.1 Natural Dyes from Plants

Boahen (2005), stated that prior to the introduction of synthetic dyes, plants were a major source of pigments for inks, paints and dyes. Dyes from plants were grown as farm crops such as indigo (a deep blue dye), wood, madder (red dye), henna (a reddish-brown dye used on hair, skin, and fingernails), safflower petals (a red dye used to make cosmetic rouge) and autumn crocus (a yellow pigment used to colour textiles and food products).

Plants which are abundantly available in almost every country in the world have played their role as important sources of natural dyes for natural dyeing process (Frey & Oishi, 1995), Several parts of plants such as barks, stems, fruits, leaves, roots, berries and seeds might bear colouring matter which can functioned as natural dyes. According to Boahen (2005) some plants may have many colours depending upon which part of the plants is been used.

In India, it has been recorded that approximately 450 plants are able to produce natural dyes. Some of them also possess medicinal values in addition to their dye producing characteristics. Natural dyes from turmeric that produced bright yellow colours are a powerful antiseptic which can revitalise the skin while indigo gives a cooling sensation. Several other sources of plant dyes rich in naphthoquinones such as *Lawsoniainermis* L.(henna), juglone from walnut and lapachol from alkanet are reported to have antifungal and antibacterial activity (Boahen, 2005)

Indian researchers also studied the antibacterial activity of other plants *such* as that also show antimicrobial activity and consist of pigment which can be used as source of natural dyes (Asubonteng, 2010)

Moreover, currently most of researchers are trying to find an alternative source other than parts of the plant such as by-products of farming and forestry as well as wastes from food and beverage industry to be used as raw material for production of natural dyes. The by-product and waste such as bark or saw-dust from timber industry, onion peels, pressed berries and black tea residue were used as dye source (Ruznan, 2009). The usage of these materials as raw material for natural dyes can contribute to preservation of the environment and also reduce the cost of natural dyeing process.

At present, Ruznan (2009) has successfully used forest tree wood disposals as natural dye that extracted from Alder *(Alnus. Glutnisa)* and dyed on nylon fibre. The wood of Alder forest tree is known to contain extractable natural dyes such as hydroxycinnamic acid derivatives and tannins (Pauline et. al., 2006).

2.4.2 Natural Dyes from Animals

The most punctual creature colours originate from different types of snails that can be found along the shores of the Mediterranean. One of them is Tyrian purple which was found by the Phoenicians around 1500 BC and turned into the most imperative colour of the human advancements that fell and rose in the zone (Clair, 1986). The molluscs as appeared in Figure 2.1 were assembled as colour industrial facilities emerged along the West African coasts,

2.4.3 Natural Dyes from Minerals

Colours also can be produced from mineral dyes such as manganese, Prussian blue (Fe7 (CN)i8), antimony orange, chrome yellow, bronze, teal green and iron buff.

However, lately more sources of mineral dyes were introduced including dyes from ferruginous clay and sedimentary rocks (Driessen, n.d.). Mineral natural dyes commonly gave colours like yellow (limonite) or red (hematite). The development of natural dyes from minerals has not been well documented since the ancient times.

Red ocher also known as " a *la almagra"* or red ceramics has first attracted attention in the Iberian Peninsula based on observations held in the 1930's in several areas of Andalusia. Most of the remains at archaeological spots were two types of red ceramics (Clair, 1986). were discovered that can be distinguished from direct observation where a first type has a red (intense red to orange) external colour adhering very well to the ceramic surface and a second type is considered as painted ceramic which is less firm and very friable which is believed were coloured using red ochre (Ruznan, 2009).

Additionally, Sharphouse (1983) has written that dyes can be extracted from rocks and used for dyeing. He explains that extracted colourant from soils/rocks are natural and real in application. The material was grinded into small micron size and then dyed on silk and polyester fabrics. The colourfastness results obtained were encouraging and comparable to other natural colourant. Nano-size rocks' colourants have been proven suitable on polyester with good fastness properties and can be marketed as niche products for niche market as well as for crafts and probably for painting colourants. The colourants are cheap, easily source even though they are difficult to be prepared (Godfrey,1999).

2.4.4 Characteristics of Natural Dyes

Asmah et al. (2015) indicate that the effectiveness of natural dyes differ with each plant, with distinct differences in the colour obtained at different times of the day. Some may require mordant to improve their fastness but others may be used as direct dyes on fibre. Natural dyes also have various exceptions: they are not substantive, with little or no colouring power in themselves except when used in conjunction with mordants although most of them produce very colourful effects so amazing to behold. Asmah et al (2015) have it that sometimes they challenge the wits of researchers and educators. Natural dyes initially appear vivid but they soon fade; very few of them prove to be colourfast. It is this fastness problem that led to the discovery of mordants. Ruznan (2009) natural acids and oxides that react both with the dyestuff and the fibres to form an insoluble compound that "fixes" the colour firmly in the fibres and prevents the dye from dissolving easily. Some natural dyes also require mordants to make them colourfast.

2.4.5 Uses of Plant Dyes in Ghana

In Ghana, plant dyes play a major role in the indigenous textiles industry. Dyes from a variety of woody plants and herbs are used in dyeing cloth, straw and fishing nets, for tanning leather and also as food colourants. Ruznan (2009) has mentioned over 100 woody plant species found in the forests and grassland areas of Ghana that yield dyes of varying strengths and colour that are widely used across the country for a variety of purposes. According to Asmah et al. (2015), natural dyes which have sustained the centuries old indigenous cloth dyeing and printing industry in Ashanti, Eastern and Brong Ahafo Regions centre on the "Badie" (*Bridelia ferruginea*) and "Kuntunkuni" (*Bombax brevicuspe*) trees which yield dark brown and black dyes respectively.

Asmah et al. (2015) again report that chips of the bark of the "Badie" tree, which grows mostly in the Brong Ahafo Region, are pounded in a mortar, boiled in big containers for three hours, strained or sieved and the solution further boiled for another four hours till it turns into a dark sticky paste which is used to print traditional Adinkra symbols on fabric. Plate 36 shows fresh "Badie" bark ready for processing into dye. Other plants known to yield dyes of varying strengths and colour include the Mahogany (*Khaya Senegalensis*), Mango (*Mangifera Indica*), Nim tree (*Azadirachta Indica*) and Teak (*Tectona Grandis*) trees which also provide medicinal remedies for many tropical diseases and ailments (Irvine, 1961).

2.4.6 Concept of Dyes

A dye is an organic compound composed of a chromophore, the coloured portion of the dye molecule, and an auxochrome, which slightly alters the colour. The auxochrome makes the dye soluble and is a site for bonding to the fiber.

Dyes are molecules that can be dissolved in water or some other carrier so that they will penetrate into the fiber. Any undissolved particles of dye remain on the outside of the fiber, where they can bleed and are sensitive to surfaces abrasion. Dyes have great colour strength; a small amount of dye will colour a large quantity of fabric. Most dyes bond chemically with the fiber and are found in the interior of the fiber, rather than on the surface, where pigments are found. Dyes can be used in either solutions or pastes. Dye pastes are used for printing.

A fluorescent dye absorbs light at one wavelength and re-emits that energy at another. Fluorescent dyes are used for many applications. In detergents, they make whites appear whiter and mask the yellowing of fibers. Fluorescent dyes are used in clothing to increase the wearer's visibility at night, in costumes and protective clothing to produce intense glow – in – the – dark effects, and in some medical procedures.

A dry process describes the environment created for the introduction of dye by hot water, steam, or dry heat. Chemical additives such as salt or acid are used to regulate penetration of the dye into the fiber. Knowledge of fiber – dye interactions, methods of dyeing, and equipment produces a better understanding of colour behaviour.

In order for a fabric to be coloured, the dye must penetrate the fiber and either be combined chemically with it or be locked inside it. Fibers that are absorbent and have chemical sites in their molecular structure that will react with the dye molecules will dye easily. The dye reacts with the surface molecules first. Moisture and heat swells the fibers, causing their polymer chains to move farther apart so that sites in the fiber's interior are exposed to react with the dye. During cooling and drying the chains move back together, trapping the dye in the fiber. Wool dyed with an acid dye is a good example of a fiber that is absorbent and has many sites that chemically react with the dye to colour.

The thermoplastic fibers can be difficult to dye because their absorbency is low. However, most of these fibers are modified to accept different classes of dyes. This makes it possible to achieve different colour effects or a good solid colour in blends of unlike fibers by pierce – dyeing.

Dyes are classified by chemical composition or method of applications. No one dye is fast to everything. And the dyes within a class, a grouping of similar dyes, are not equally fast. A complete range of shades is not available in each of the dye classes; for example, some dye classes are weak in greens. The dyer chooses a dye or mixes several dyes to achieve the colour desired based on the fiber content, the end use of the fabric, the performance expectations of the product, and the dye and process cost. The dyer must apply the colour so that it penetrates and is held in the fibre.

2.5 Stages of Dyeing

Dyeing application follow processes or stages towards ensuring the achievement of the expected colour effect. Colours may be added to textiles during the fiber, yarn, fabric, or product stage, depending on the colour effects desired and on the quality or end use of the fabric. Better dye penetration is achieved with fiber – dyeing than with yarn – dyeing, with yarn – dyeing than with piece – dyeing, and with pierce – dyeing than with product – dyeing. Good dye penetration is easier to achieve in products in which the dyeing liquor or liquid is free to move between adjacent fibers. This freedom of movement is easiest to achieve in loose fibers. It is more difficult to achieve in products in which yarn twist, fabric structure, and seams or other product features minimize liquor movement.

2.5.1 Fiber Stage

In the fiber-dyeing process, colour is added to fibers before yarn spinning. Fiber – dyed items usually have a slightly irregular colour, like a heather or tone – on – tone gray. Mass pigmentation is also known as solution – dyed, producer – coloured, spun – dyed, dope – dyeing or mass colouration. It consists of adding coloured pigments or dyes to the spinning solution before the fiber is formed. Thus, when each fiber is spun, it is fast to most colour degradants. This method is preferred for fibers that are difficult to dye by other methods, for certain products, or where it is difficult to get a certain depth of shade. Colours are generally few because of inventory limitations. Example of mass – pigmented fibers include many olefins, black polyester, and acrylics for awnings and tarpaulins. Another type of dyeing similar to mass pigmentation is gel dyeing. The colour is added to the acrylic fiber while it is in the soft gel stage. This occurs in the limited time between fiber extrusion and fiber coagulation.

Stock, or fibre, dyeing is used when mottled or heather effects are desired. Dye is added to loosen fibres before yarn spinning. Good penetration is obtained but it is expensive. Top dyeing gives results similar to stock dyeing and is more commonly used. Tops, the loose ropes of wool from combing, are wound into bails, placed on perforated spindles, and enclosed in a tank. The dye is pumped back and forth through the wool. Continuous processes with loose fibre and wool tops use a pad – steam technique.

2.5.2 Yarn Stage

Yarn – dyeing can be done with the yarn in skeins, called skein dyeing; with the yarns wrapped on cones or packages, called package dyeing; or with the yarn wound on warp beams, called beam dyeing. Yarn dyeing is less costly than fibre dyeing but more costly than fabric or product dyeing and printing. Yarn – dyed designs are more limited and larger inventories are involved.

Yarn –dyed fabrics are more expensive to produce because larger inventories of yarns, in a variety of colours, are required and more time is needed to thread the loom or set up the knitting machine correctly. In addition, whenever the pattern of colour is changed, time is needed to rethread the loom or change the setup for the knitting machine. Yarn – dyed fabrics are considered to be better - quality fabrics, but it is rare to find solid – colour yarn – dyed fabrics. It is much cheaper to produce solid coloured fabrics by other processes. Yarn – dyed fabrics include stripes, plaids, checks, or other patterns that result from yarns of different colours in different areas of the fabric. Examples of yarn – dyed fabrics include gingham, chambray, and many woven or knit fancy or patterned fabrics.

2.5.3 Piece or Fabric Stage

When a bolt or roll of fabric is dyed, the process is referred to as piece dyeing. Piece dyeing usually produces solid – colour fabrics. It generally costs less to dye fabric than to dye loose fibres or yarns. With piece dyeing, colour decisions can be delayed so that quick adjustments to fashion trends are possible. Solid – colour piece – dyed fabrics of one fibre are common, but piece dyeing offers additional possibilities for dyeing multiple colour patterns into a fabric. When a fabric incorporates yarns representing two or more fibres of different dye affinities or dye – resisting capabilities, cross dyeing presents many colour combinations and pattern options. Union dyeing is just the opposite. Here the goal is for a solid colour even though different fibres are combined or blended in the fabric.

2.5.4 Cross Dyeing

Cross dyeing is piece of dyeing of fabrics made of fibres from different generic groups – such as protein and cellulose – or by combining acid - dyeable and basic – dyeable fibres of the same generic group. Each fibre type or modification bonds with a different dye class. When different colours are used for each dye class, the dyed fabric has a yarn – dyed appearance. An example is fabric made of wool warp and cotton filling dyed with a red acid dye and a blue direct dye, respectively. In this example, the warp would be red and the filling blue. Garment cross dyeing is also used with 100 percent cotton knits that are dyed in two separate steps with two classes of dyes. For instance, a T-shirt is dyed with a direct dye, treated to prevent the direct dye from bleeding, and coloured with a pigment. This process produces a unique iridescent shirt.

2.5.5 Union Dyeing

Union dyeing is another type of piece dyeing of fabrics made with fibres from different groups. Unlike cross dyeing, union dyeing produces a finished fabric in a solid colour. Dyes of the same hue, but of a type suited to each fibre to be dyed, are mixed together in the same dye bath. Union – dyeing is common – witness the entire solid – colour blend fabrics on the market. A problem with these fabrics involves the different fastness characteristics of each dye class. Aged, union – dyed fabrics may look like heather because of the differences in colourfastness of the dyes. Piece dyeing is done with various kinds of equipment.

2.5.6 Product Stage

After the fabric is cut and sewn into the finished product, it is product – or garment – dyed. Once the colour need has been determined, the product is dyed. Properly prepared grey goods are critical to good product dyeing. Great care must be taken in handling the materials and in dyeing to produce a level, uniform colour throughout the product. Careful selection of components is required, or buttons, thread, and trim may be a different colour because of differences in dye absorption between the various product parts. Product dyeing is important in the apparel and furnishing industries, with an emphasis on quick response to retail and consumer demands.

2.5.7 The Dyeing Process from Understanding Textiles

The science of dyeing is highly complex, and the mechanisms of dyeing are not completely understood. This discussion is necessarily superficial and does not provide an in depth exploration of the subject.

The medium most often used to dissolve or disperse dyes for application to textiles is water. The dye solution, called the dye liquor, is agitated or circulated to increase the migration of the dye to the fibre surface. The attraction or affinity of the dye for a particular fibre is influence by several factors. Different dye types are attracted chemically or physically to specific fibres. Fibres often undergo swelling in aqueous dyeing processes, increasing dye absorption. For hydrophobic fibres that do not swell in water, organic solvents can be used as swelling agents or "carriers" for the dye. Mordants can be added to increase the acceptance of dyes. Dye bath additives such as these are classed as dye auxiliaries.

Surface features such as the scales on wool or waxes or finishes on fibres can inhibit attraction of the dye to the fibre. Careful preparation of fabrics for dyeing minimizes this effect by removing waxes and sizes. Further, application of aesthetic and functional finishes usually follows the dyeing process, so that the finishes do not compete for dye sites on the fibre.

Once dyes are attracted to the fibre, they should diffuse through it rather than remaining absorbed on the surface. Dyes are absorbed into the fibre predominantly in the amorphous areas, and making these areas larger or more accessible enhances that dyeing process. Mercerization of cotton, which moves the polymer chains farther apart, allows more dye in. Higher temperatures, around the glass transition phase of thermoplastic fibres, cause some of the crystalline areas or to move and separate more, increasing dye accessibility. Nylon fibres have a low glass transition temperature and can often pick up dyes from other fibres.

Exhaustion is the amount of transfer of dye from the bath to the fibre, either by adsorption or absorption. It is possible for all the dye to be removed from the bath and for the dye bath to be clear at the end of the process. Some dye classes exhaust better than others. It is not always prudent or even necessary, to dye to complete exhaustion of the bath.

A concern in dyeing is how evenly distributed the dye is in the fibre, a characteristics known as levelness. Low levelling will result in streaked appearance of the fabric. Dyes may be only adsorbed on the fibre surface, or dyes that have been absorbed by fibres may migrate back to the surface when the textile is dried, resulting in uneven dyeing. Levelling agents and retarders are dye bath auxiliaries than can promote even dye absorption.

Once the dye has entered the amorphous regions of fibre, it must be retained within the fibre not only during the dyeing but also when fabrics are laundered or dry cleaned during use. Several factors make for dye retention. The nature of the chemical bonds and physical attraction between fibre and dye is a crucial element. Dyes may be physically bound to fibres by forces such as hydrogen bonding or ionic forces. Ionic forces are the attraction between positively and negatively charged ions, one on the dye, and the other on the fibre. The chemical structure of dye and fibre may allow the formation of covalent chemical bonds between fibre and dye. Dyes are absorbed into swollen fibres can be physically trapped when the fibres are cooled and dried. Dyes that are soluble in water, which may also swell some fibres, can be removed when the textile is wetted.

Table 2.1: Classification of Dyes by Radolph

DYES	END USES	CHARACTERISTICS
Acid (Ionic) Complete colour range	Wool, silk, modified rayon, modified acrylic and polyester.	Bright colours. Vary in lightfastness. May have poor wash fastness.
Azoic (Naphthol and rapidogens) Complete colour range Moderate cost	Primarily cotton. May be used on manufactured fibres such as polyester.	Bright shades. Good to excellent lightfastness and wash fastness. Poor crocking resistance.
Cationic (basic) Used with mordant on fibres other than silk, wool, and acrylic. Complete colour range	Used on acrylics, modified polyester and nylon, direct prints on acetate, and discharge prints on cotton	Fast colours on acrylics. May bleed and crock. On natural fibres, poor fastness to light, washing, perspiration.
Developed, Direct Complete colour range.	Primarily cellulose fibres Discharge prints	Duller colours than acid or basic Good to excellent lightfastness Fair wash fastness
Direct (Substantive) Commercially significant dye class. Complete colour range.	Used on cellulose fibres.	Good colourfastness to light. May have poor wash fastness.
Disperse Commercially significant dye class. Dye particles disperse in water Good colour range	Developed for acetate, used on most synthetic fibres.	Fair to excellent lightfastness and wash fastness. Blues and violets on acetate fume fade.
Fluorescent brighteners Specific types for most common fibres.	Used on textiles and detergents. Used to achieve intensely bright colours	Mask yellowing and off – whiteness that occur naturally or develop with age and soil.
Mordant Fair colour range	Used on same fibres as listed for acid dyes.	Good to excellent lightfastness and wash fastness. Duller than acid dyes.

Nat**ural or Vegetable** Derived from plant, animal, or mineral sources. Earliest dyes used.	Minor dye class; used to dye some apparel and furnishings. Primarily used on natural fibres.	Fastness varies Limited colours and availability.
Reactive or Fibre – Reactive Combines chemically with fibre.	Used on cotton, cellulose fibres, wool, silk, and nylon.	Bright shades. Good lightfastness and wash fastness. Sensitive to chlorine bleach.
Sulphur Insoluble in water. Complete colour range except for red.	Primarily for heavyweight cotton. Most widely used black dye	Dull colours. Poor to excellent lightfastness and wash fastness. Sensitive to chlorine bleach. May tender stored goods.
Vat Insoluble in water Incomplete colour range.	Primarily for cotton work clothes, sportswear, prints, drapery fabrics. Some use on cotton/polyester blends.	Good to excellent lightfastness and wash fastness.

2.5.8 The Specific Objectives when Dyeing

The most punctual creature colours originated from different types of snails that can be found along the shorelines of the Mediterranean. One of them is Tyrian purple which was found by the Phoenicians around 1500 BC and turned into the most vital colour of the civic establishments that fell and rose in the territory (Ruznan 2009). The molluscs were assembled as colour manufacturing plants emerged along the West African coasts,

2.5.9 Common Issues Related with Colouring

i. Poor lightfastness

- This is influenced by numerous components, the shading required, the profundity of shading (lighter hues having lower lightfastness) and the properties and structure of the dyestuff utilized. Premetalised colours normally offer the best outcomes. Lightfastness is likewise influenced by alternate chemicals utilized as a part of the procedure, for example, fatliquors and retannages. Poor determination of these items can bring down the lightfastness of the completed article.

ii. Bronzing

- This is caused by surface testimony of abundance dyestuff on the surface of the calfskin. It is typically observed as a metallic sheen and is regularly observed on dark and dull hues where the surface is over-burden with colour trying to accomplish a dim shade. Most colours utilized as a part of calfskin are anionic in cowhide handling, however, Fundamental (cationic) colours are utilized on dark and dim shades to help the power and, if utilized erroneously, these can demonstrate bronzing.

iii. Poor Obsession

- This for the most part prompts poor quickness properties, for example, wet and dry container speed, poor speed to sweat and cleaning. Poor obsession is regularly caused when the anionic dyestuffs can't discover enough cationic destinations on the calfskin substrate keeping in mind the end goal to connect. This absence of locales is extraordinarily impacted by the other compound utilized as a part of the colouring procedure, for example, retanning and fatliquoring operators.

2.6 Concept of Colour

- Colour is one of the most significant factors in the appeal and marketability of textiles products. The goal of adding colour to textiles is to produce an appealing, level, fast colour on a product at a reasoning price, with good performance characteristics and with minimal environmental impact. Colour has always been important in textiles. Until 1856, plants, insects, and minerals were the sources for natural dyes and pigments. When William Henry Perkin discovered mauve, the first synthetic dye, a new industry - synthetic dyeing - came into being. Europe was the centre for synthetic dyes until World War 1 interrupted trade with Germany and a dye industry developed in the United States. Today there are hundreds of colourants or colouring agents from which to choose.

- A match between the chemistry of the dye and that of the fibre is needed in order for the colour to be permanent. Any coloured textile product may be exposed to such potential colour degradants as detergent, perspiration, dry-cleaning solvents, sunlight, and makeup. To achieve a fast colour, the dye must be permanently attached to or trapped within the fibre by using a combination of heat, pressure, and chemical assistants.

2.6.1 Chemical Selection

The next critical factor is the determination of dyestuffs. Components impacting the procedure are fondness, entrance, ionic charge, profundity of shading and similarity. It is vital that colours utilized as a part of blends have comparative properties to guarantee level colouring.

The retannage and colouring process is a blend of including shading, conferring feel, snugness and delicate quality to the cowhide through a mix of helpers, retannages and fat liquors. The assistants are there to help control the colouring by affecting entrance and levelness. The colours bestow the required shading and cautious choice is essential to guarantee levelness and great covering of the flaws and deformities on the cowhide surface. Re-tanning gives the vibe and body to the cowhide by specially filling frail open regions of the stow away and making the expected immovability to the last article. The fat liquor gives the grease that gives cowhides its delicate quality, adaptability and regular feel.

2.6.2 Process Variables

The next piece of the condition is the procedure control which includes another arrangement of parameters. One main consideration is the dissolvability of the dyestuff, which influences huge numbers of alternate properties. The fundamental ones influenced are infiltration and surface collection (which likewise profoundly affects the quickness properties and levelness). A decent colouring will incorporate dyestuffs with comparative solvency. Assistants can likewise be utilized to try and out the dyestuff varieties.

Other factors in the process are the temperature of colouring, drift length (measure of water), balance and obsession. A higher temperature gives more fast obsession and a darker shade. The buoy length will likewise influence the procedure with less water giving better infiltration and more water more levelness. Selection of the colouring vessel is additionally of principal significance as the mechanical activity of the vessel will impact the procedure, particularly the infiltration and temperature.

2.6.3 Concept of Dyeing Leather

Dyeing as described by Asubonteng (2010) is the process of applying dyes to render colour unto a material, usually fabric for enhanced aesthetics. In dyeing concepts, understanding of the fibre structure of the material to be dyed is very important to ensure efficiency. Bonding between the dye and the fibres of the material is what guarantees fastness of the dye to the material. This is what makes it difficult for many tanners to depend on plant dyes to render colour on leather. It is clearly explained by Boahin (2008) that leather has compact collagen fibres which makes dye penetration and absorption difficult but not impossible. He explains further that one needs to understand the fibre structure of leather to guarantee good dyeing.

2.6.4 Impact of Dyeing on Leather Composition

Cover up (or skin) is typically considered to contain three layers of which the dermis or corium (which may change from 0.5 – 3mm in thickness in various parts of the body) is the calfskin shaping district (Frendrup and Buljan, 2000). The dermis, which is nearly and firmly connected with epidermis through an undefined storm cellar layer, is fundamentally a connective tissue that backings the specific components of the skin and is made out of fibroblast cells and a system of collagen strands implanted in the additional cell lattice (ECM) (Stanley et al., 1982). Upper dermis, otherwise called grain layer is rich in solvent proteins, type I collagen, proteoglycans (PG) solidifying substances, for example, hyaluronic corrosive and dermatan Sulfate and flexible filaments and some non-stringy collagens separated from fibroblasts.

The fibroblasts integrate the segments of the ECM including collagen, reticular and versatile strands and other globular proteins and proteoglycans. The individual unit of corium is collagen fibrils which are woven together to frame fibril groups which are thus cross-connected to make collagen strands. The structure of the collagen filaments fluctuates all through the cross segment of the cover up, with most extreme width at the inside and diminishes towards the upper and lower end.

The system of fibre is alluded as weaves, comprise of strands isolating and recombining with different filaments. Fibril packs of the corium render it solid to withstand the pressure and make it stretchable. Subcutaneous (fat tissue) underneath the dermis layer is free connective tissue contains lipids.

2.6.5 Tannin as a Means of Making Leather for Dyeing

The name ‘tannin’ is derived from the French ‘tannin’ (tanning substance) and is used for a range of natural polyphenols. The term ‘tannin’ was first used by Seguin in 1796 and used to describe the process of transforming animal hides into leather by using plant extract from different parts of different plant species. Tannin is an astringent vegetable product found in a wide variety of plants. Plant parts include bark, wood, fruit, fruit pods, leaves, roots and plant galls. Tannin is defined as naturally occurring water soluble polyphenolic compounds of high molecular weight (about 500-3000) containing phenolic hydroxyl groups to enable them to form effective crosslink between proteins and other macromolecules. The molecular formula of tannin is C 76 H52 O46, molecular weight of 1701.22 and it melts at 220ºC. Tannins do not denote a single compound. They include a large class of organic substances which often differ widely in their chemical composition and reactions.

CHAPTER THREE

METHODOLOGY

3.1 Overview

It is always important to adopt strategic approach to address the needs of the research, to test hypothesis or answer questions. This chapter seeks to expatiate on the research methodology which will serve as the basis to assemble the expectations of the study to give a logical understanding of the study. This chapter presents the research method employed, the library research conducted, the population for the study, the sampling technique, instrumentation, primary and secondary source of collecting data, data collecting procedures and data analysis plan.

3.2 Research Design

According to Frey & Oishi (1995) there are two main types of research design. The quantitative and the qualitative research design. The choice for the design is entirely dependent on the number of variables. Ary, Donald and Jacobs, qualitative research focuses on understanding social phenomenon from the perspective of human participants in the study. The data are collected in natural setting and research aims at generating theories than testing theories. Qualitative research explains the importance of looking at variables in their natural setting and how they interact. Important data are gathered things open finished inquiries that give coordinate citations. In the subjective research, the questioner shapes a basic piece of the examination. In any case, this is not quite the same as quantitative which endeavours to assemble information by target articles to give data about relations, associations and expectations, and endeavour to expel the specialist from the examination.

3.2.1 Qualitative Research

Qualitative research also known as field research is typically involved in field work in which the scientist watches and records conduct and occasions in their characteristic settings. (Ashley Crossman), subjective research is tied in with clarifying issues, understanding wonders and noting inquiries in their social settings. Field inquire about is particularly viable for concentrate inconspicuous subtleties in states of mind and practices of inspecting social procedures after some time. The principle quality of this strategy at that point lies in the profundity of understanding that it permits. Then again, there are inadequacies with the subjective technique for inquire about. Field examine has an issue with unwavering quality which can likewise be thought of as reliability.

As part of the researcher's interest in understanding the behaviour of objects in their natural settings, this design was included to understanding the workability and the viability of leather as a seldom material which can be manipulated and changed to different forms. The content analysis design was used also under the qualitative research method. The purpose of the content analysis is to give much emphasis and focus on actual content and internal features of a media. With respect to the research, the researchers as part of plans in getting deeper knowledge on the content of the research, the information retrieved from the literature review were carefully scrutinized so to help give better conclusions and recommendations to activities. In giving better discussions to mordants, the content analysis helped the researcher to make inferences from the literature.

3.2.2 Descriptive Research

Frey & Oishi (1995) believe that descriptive research involves gathering data that described events, organizes, tabulates, depicts and describes the data collection. Leedy & Ormrod (2005) affirm descriptive studies aim at finding out 'what is', for this reason interview and observations are mostly used to collect descriptive data. The research adopted a descriptive design to delve into the basic performance of some selected mordants with natural dyes on leather, how some mordants have behaved over time when used on leather.

3.2.3 Experimental Research

Cohen et al, (2007), the essential feature of experimental research is that, investigator's deliberately control and manipulate the conditions which determine the events, in which they are interested, introduced an intervention and measure the difference it makes. The basis of the research is to discover the best mordant(s) which would aid natural plant dyes stay over time on indigenous tanned leather. The motive led to the conduct of several experiments with selected mordants with plant dyes on leather to determine their efficacy on the leather. Control parameters were set to determine procedures. The resultant leathers were intentionally left and soaked in water for some days to test its affirmative to wash and same were to done to determine its strength in light.

3.2.4 Library Research

To have good overview of the research topic and develop insight prerequisite for understanding the concepts, perspective and crucial references regarding the study area, researchers made a good use of information from books, lecture notes, articles and internet source. The following libraries were accessed:

1. Main library, Kwame Nkrumah University of Science and Technology, Kumasi.
2. Faculty of Art Library, Kwame Nkrumah University of Science and Technology, Kumasi.
3. Ashanti Library, Kumasi.

3.2.5 Population for the Study

In order to limit the number of the people and materials use, it is always important to adopt sample which controls size or the scope of the entire population. For the purpose of the research, purposive sampling technique was adopted to provide a maximum understanding of the study. Under the purposive sampling technique these tools were chosen:

1. Homogeneous Sampling

This sampling considers a sub-group that is considered to be homogeneous in attitude, experience and so on. The population considered for the study was limited to people who have adequate knowledge in the field of leather making and dyeing.

2. Random Sampling

This method considers a large but small groups which are believed to have divergent ideas on issues. Some group of mordant sellers, students were interviewed to have their thought on the issue.

Table 3.1: Population for the Study

Population	Target Population	Accessible Population	Sampling Technique
Dyers	30	20	Simple random
Mordant traders	8	4	Simple random
Lecturers	10	6	Purposive Sampling
Students	15	15	Purposive sampling
Mordants	12	10	Purposive sampling
Plants	10	5	Purposive sampling
Total	**97**	**60**	

3.3 Data Collection Instruments

In order to stimulate and make the collection of data successful, and give better understanding to answer the questions posed out from the objectives and get a good basis to develop a more sustainable means of making natural plant dyes develop sustenance on natural vegetable tanned leather; interviews were conducted to the various stakeholders needed for the purpose of this study.

3.3.1 Interview

Interview is one of the tools in obtaining qualitative opinions on subjects, beliefs and feelings about event or situations L. Cohen, M. Lawrence, M. Keith (2007). Interview is an exchange of views between people on a topic (Pegs and Aquye, 2008). It has the advantage of providing an insight on participants' perspective on event and behaviour. Researchers however, interviewed people on the subject of leather, natural plants and their dye yielding properties and mordants.

3.4 Sources of Data

Two main types of data source were used in the study. These are:

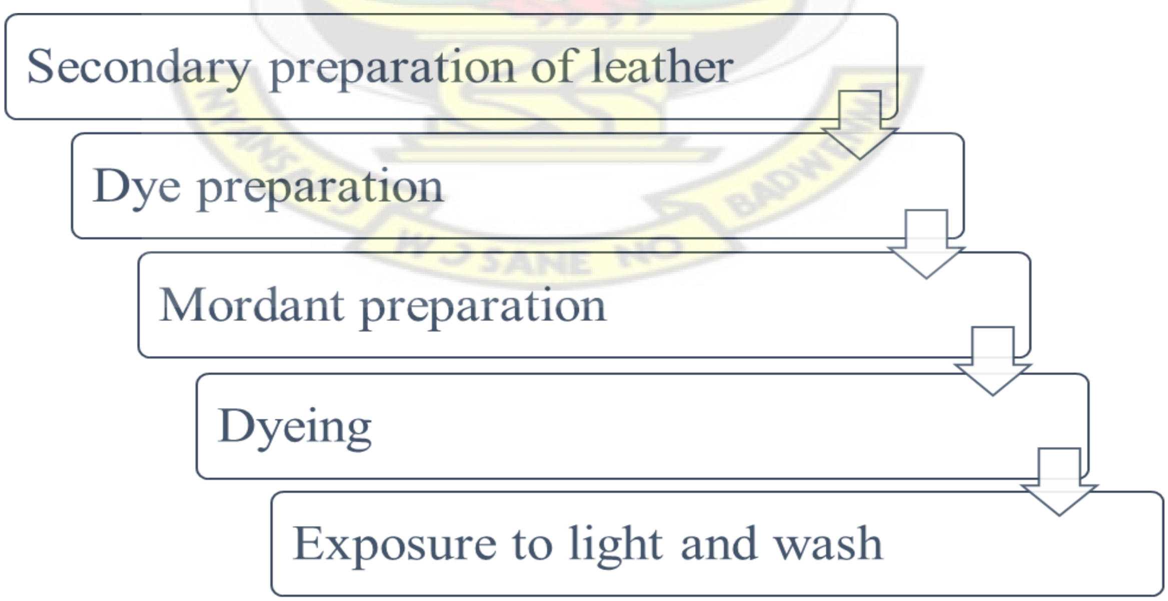
3.4.1 Primary Data Source

These are the data obtained through the application of the research instrument, interview

3.4.2 Secondary Data Source

From the libraries visited, adequate data relating to leather production, natural dyes, dyeing processes and techniques were documented from books, articles and the internet.

3.5 Experimentation Process



3.6 Data Collection for Objective One

Natural dyes are readily available in our environment in various parts of plants, however, due to lack of proper affinity with various substrates, they are not given adequate recognition in Leatherwork. Asmah et al (2015) has however emphasized that making plant dyes fast to fibre based materials requires the identification and application of appropriate mordants. The objective one of this study was to identify various mordants which can aid the wash, light and abrasion fastness of natural dyes. The researcher in pursuing this quest visited Kumasi Central Market to investigate from various dealers of dye related materials the types of mordants available on the local market. Also tie and dyeing shops were visited, as well as Asawasi tannery to identify the types of mordants been employed there. The researcher went further to experiment the identified mordants with natural dyes to test their ability to fix to leather. Table 4.1 presents the mordants identified and their impact on fastness to plant dyes when applied on leather.

Table 3.2: Sampling Method – Homogeneous

MORDANT	SIZE	DYE USED	SUBSTRATE
Sodium hydroxide	6	Vat and reactive	Mercerized cotton, wool, Line, leather
Sodium hydrosulphite	6	Vat and reactive	Mercerized cotton, wool, Line, leather
Salt	6	Plant	Cotton, linen
Wood ash	3	Plant	Cotton, linen
Iron filings	3	Pigment and plant	Cotton, leather, linen
Alum	2	Plant	Cotton
Iodine	1	Pigment	Cotton
Lime	5	Plant	Cotton
Carbide	2	Plant and vat	Leather, cotton

POPULATION – DYERS: SIZE – 20

Table 3.3: Sampling Method – Homogeneous

MORDANT	SIZE	DYE USED	SUBSTRATE
Sodium hydroxide	20	Vat	Mercerized cotton, linen, Wool
Sodium hydrosulphite	20	Vat	Mercerized cotton, linen, Wool
Iron filings	8	Adinkra	Mercerized cotton

POPULATION – MORDANT TRADERS: SIZE – 4

Table 3.4: Sampling Method – Homogeneous

MORDANT	SIZE	HIGHLY PATRONIZED (size)
Sodium hydroxide	4	4
Sodium hydrosulphite	4	4
Salt	4	4
Carbide	1	1
Alum	2	1
Iodine	1	1

POPULATION – STUDENTS: SIZE – 15

Table 3.5: Sampling Method – Homogeneous

MORDANT	SIZE	DYE USED	SUBSTRATE
Salt	15	Vat, reactive, plant	Mercerized cotton, wool, Line, leather
Sodium hydrosulphite	15	Vat, reactive, plant	Mercerized cotton, wool, Line, leather
Sodium hydroxide	15	Vat, reactive, plant	Cotton, linen
Wood ash	12	Plant	Cotton, linen
Iron filings	14	Pigment and plant	Cotton, leather, linen
Alum	8	Plant	Cotton
Iodine	10	Pigment	Cotton
Lime	15	Plant	Cotton
Carbide	9	Plant and vat	Leather, cotton

3.7 Data Collection for Objective Two

To experiment the various mordants with plant dyes on indigenous tanned leather.

Having identified the various mordants available locally as demanded by objective one of this study, the need to find the ones which best suite the purpose of aiding in achieving fastness for plant dyes, the researcher carried out some experiments with the various mordants by manipulating their quantities and combinations, and tried them with selected plant dyes to evaluate their effectiveness in ensuring both wash and dry fastness.

Experiment One: Experimentation of Various Types of Mordants

Materials: Indigenous tanned leather**,** Mordants**,** Dyes

MORDANTS

Salt

alum

iodine

Sodium hydroxide

sodium hydrosulphite

Figure 3.1: Experimentation of Plant Dyes

Samples of Plant Based Dyes

Hibiscus sabdariffa

Sorghum bicolour

Onion bark

Emere

Figure 3.2: Plant Based Dyes

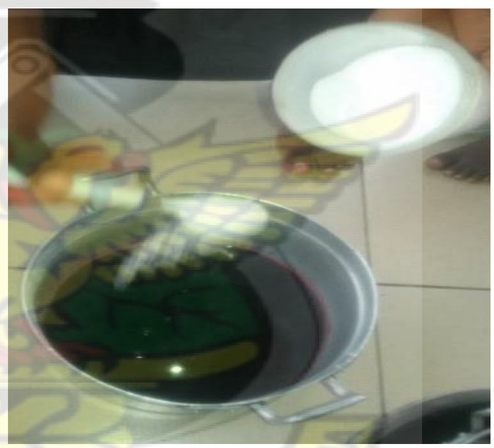
Table 3.6   Activity One : Dye Extraction

BOILING	 Hibiscus Sabdariffa  Sorghum bicolor  Onion Peel  Bark of Emere plant
SIEVING	 Sorghum bicolor solution  Hibiscus Sabdariffa solution
RESULTS DYE BATH	

Hibiscus Sabdariffa and Alum

Hibiscus Sabdariffa and carbide solution

Sorghum bicolor and lime juice



Emere and salt solution

Figure 3.3(a) Mordant Application

Sorghum bicolor and iodine solution (pre-mordanting)

Hibiscus Sabdariffa and iron filings (meta-mordanting)

Hibiscus Sabdariffa and salt (post-mordanting)

Sorghum bicolor and sodium hydroxide (meta-mordanting)

Figure 3.3 (b) Mordant Application

Figure 3.4 Samples After Dyeing

The first experiment was done on the assertion of trying natural plants which had the dye yielding properties. Though mordants were used to effect this test but little attention was ascribed to the impact it would have on the colour to the leather.

EXPERIMENT TWO

To experiment the identified mordants with plant dyes on indigenous tanned leather.

To deliver the expectations of this objective, the researcher needed to put together a setup to support the experimentation process towards using the identified mordants to treat plant dyes and applying the dyes on local vegetable tanned leather to ascertain their efficacy in terms of fastness, thus, the ability to make plant dyes stable and fast to washing, drying and abrasion. Ten sample mordants identified were put into experimentation to help select the most appropriate ones for plant dyes (Dyes from Sorghum Stock, and hibiscus plant.)

Activities and processes

Leather size:12.5x15cm

Mordant weight: 0.02 grams

Water: 0.05 grams

Experimentation of selected plants and selected mordants and their application on indigenous tanned leather.

Table 3.7 Application of Hibiscus sabdariffa and sodium hydroxide

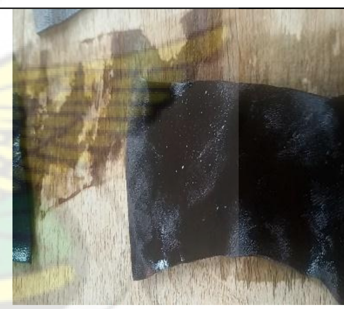
Pre- mordanting	**Meta- mordanting**	**Post- mordanting**
		

Table 3.7.1 Application of Hibiscus Sabdariffa and salt

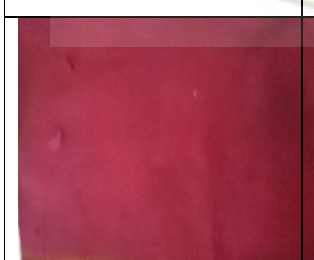
Pre- mordanting	**Meta- mordanting**	**Post- mordanting**
		

Table 3.7.2 Application of Hibiscus Sabdariffa and alum

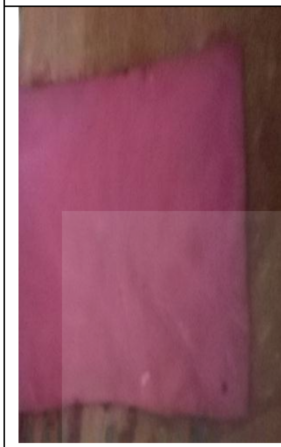
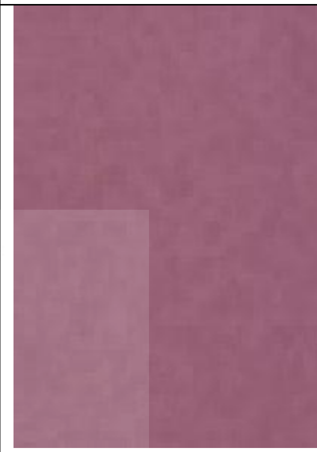
Pre- mordanting	Meta- mordanting	Post- mordanting
		

Table 3.7.3 Application of Sorghum bicolour and sodium hydrosulphite

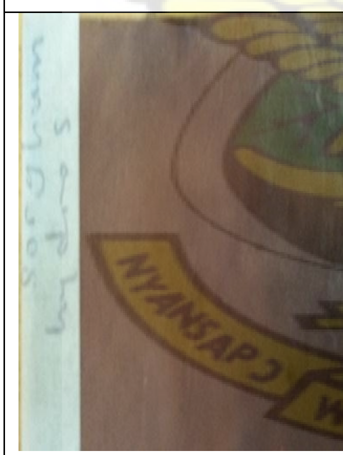
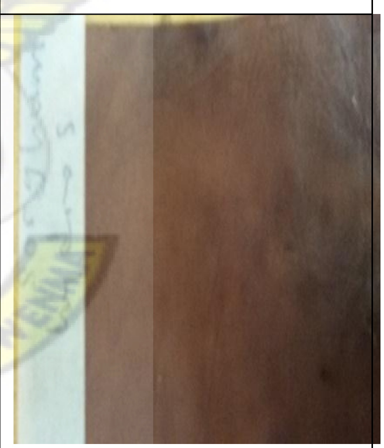
Pre- mordanting	Meta- mordanting	Post- mordanting
		

Table 3.7.4 Application of Sorghum bicolour and iodine

Pre- mordanting	Meta- mordanting	Post- mordanting
		

Table 3.7.5 Description of experiment two

MORDANT AND DYE	PRE- MORDAN Colour effect	META- MORDAN Colour effect	POST-MORDANT Colour effect
Hibiscus sabdariffa and sodium Hydroxide	Black	Dark green	Black
Hibiscus sabdariffa and salt	Red	Dark red	Pale red
Hibiscus sabdariffa and alum	Pink	Dark pink	Light pink
Sorghum bicolour and iodine	Brown	Dark brown	Light brown
Sorghum bicolour and sodium hydrosulphite	Brown	Dark brown	Light brown

3.8 EXECUTION OF EXPERIMENT THREE

The purpose of the third experiment was to secure a more effective mordant which would serve the purpose of providing better affinity of the dye to wash and light. The leather used for this experiment was a full size sheep skin and the right amount of dyes and mordants were selected for the purpose. The leather was taken through series of activities before the actual dyeing started. Since the first and the second experiment considered only a mordant, the third went a step further and different mordants were sampled together. The reason was since the individual mordants have their own strenghts, it was assumed that when two or more are put together, the two mordants will combine their forces together and help produce the intended purpose of achieving the needed fastness. Table 3.8 shows the processes the leather went through before being injected into the mordanted dyes.

Table 3.8 Secondary preparation of Leather preparation

Activity	Objective	Image
Fat liquoring	To make the leather extremely soft	
Soaking	To make the leather softer	

Pounding	To make the leather softer	
Processed Leather		

Table 3.8.1 Dye preparation

Activity	Objective	Image
Breaking	To get the plant in small size for easy pounding	
Pounding	To get the plant broken to a powdery form	

Wetting	To get the dye in a bath form	
Sieving	To separate the chaff from the soultion	

Table 3.8.2 Dyeing and mordant application

Mordant and dye	Pre mordanting	Meta mordanting	Post mordanting
Carbide, wood ash Sorghum Bicolor			
Lime, salt and sorghum bicolor			

3.9 Data Collection for Objective Three

To analyse the potential effects of mordant(s) with plants dye on the indigenous tanned leather over time. At this stage, the strength of the mordants in holding the dyes have to be proven. This is done by subjecting the dyed leather to series of activities like exposing it to the sunlight for very long time and leaving the dyed leather in water for time. The dyed leather was exposed to the sun for seven days and kept in water for twenty-four hours.

Table 3.8.3 Result after dyeing and drying at the tannery

A NATURAL LEATHER	DYE SOLUTION	MORDANT(S)	IMMEDIATELY AFTER DYEING	AFTER STRETCHING AND DRYING AT TANNERY
 CREAM COLOUR	SORGHUM BICOLOR SOLUTION	CARBIDE WOOD ASH		
	SORGHUM BICOLOR SOLUTION	IRON FILLINGS		

		HIBISCUS SABDARIFFA AND SORGHUM BICOLOR SOLUTION	CARBIDE AND WOOD ASH		
		HIBISCUS SABDARIFFA SOLUTION	SALT AND		
		HIBISCUS SABDARIFFA SOLUTION	IRON FILINGS		

		SORGHUM BICOLOR AND HIBISCUS SABDARIFFA SOLUTION	CARBIDE, WOOD ASH AND SALT		
		HIBISCUS SABDARIFFA SOLUTION	CARBIDE, WOOD ASH AND SALT		

CHAPTER FOUR

PRESENTATION AND DISCUSSION OF FINDINGS

4.1 Overview

This chapter discusses the results and discussions of information gathered from interviews, observations, experiments and deductions from documented information obtained in the course of this research. The results are in relation to the objectives and the research questions outlined for the project. This chapter also contains the summery of findings.

Natural dyes have been developed and used by people from generation to generation to meet various needs in terms of colours for dyeing fabric for garments. Different people have devised means to give different shades to their garment. Dyes obtained from animals, plants, and the earth have been manipulated to produce different shades to serve variety of purposes. It is a clear fact that in Ghana plant dyes abound as emphasized by Asmah et al. (2015), and textile producers have made efforts to use plant dyes for various dyeing activities, it has been difficult for the leather tanner to depend on plant dyes to meet the colour needs. This is due to the inability to achieve colour fastness when employ locally available plant dyes to leather surface. The local tanners have been complaining that leather customers always report that colours on leather surfaces fade when used in the sun, and also when the leather is washed or gets into contact with water. This research has therefore been undertaking with the intention of exploring various locally available mordants as a means of finding possible solution to guarantee fastness for locally plant dyes for application on leather.

To meet the intention of the study, three major objectives were set and the researcher has duly pursued all of them through the application of various research methodologies, and the results obtained are classified and discussed as follows:

4.2 Results for research question one

The objective of this study was to identify various mordants which can aid the wash and light fastness of natural dyes. The researcher in pursuing this quest visited Kumasi Central Market to investigate from various dealers of dye related materials the types of mordants available on the local market. Also tie and dyeing shops were visited, and well as Asawasi tannery to identify the types of mordants been employed there. The researcher went further to experiment the identified mordants with natural dyes to test their ability to fix to leather. Table 4.1 presents the mordants identified and their impact on fastness to plant dyes when applied on leather.

Table 4.2.1 Presentation of Common Mordants Available Locally

COMMON NAME	CHEMICAL NAME	USE
Alum	Aluminium potassium	Usually combined in a ratio of 3 parts alum to 1 part cream of tartar
plus	sulphate	
Cream of tartar	Potassium bitartrate	
Chrome	potassium dichromate	Used to deepen colors and make them more lasting
Iron ccoppers	Iron(II) sulphate	used as a saddening agent because it makes a color darker or duller
Tin	Tin(II) chloride	used as a brightening agent to make color sharper or lighter
Copper sulphate (blue vitriol)	copper(II) sulphate	used to make colors in the green range as it itself imparts a bluish-green color to fibers
Vinegar	Acetic acid	used to heighten color of a dye bath, especially with reds
Ammonia (non-sudsy, clear)	Ammonia	used to draw colors out of dye materials, especially grasses and lichens

Table 4.2.2: Presentation of common mordants available locally

MORDANT	SIZE	DYE USED	SUBSTRATE
Salt	15	Vat, reactive, plant	Mercerized cotton, wool, Line, leather
Sodium hydrosulphite	15	Vat, reactive, plant	Mercerized cotton, wool, Line, leather
Sodium hydroxide	15	Vat, reactive, plant	Cotton, linen
Wood ash	12	Plant	Cotton, linen
Iron filings	14	Pigment and plant	Cotton, leather, linen
Alum	8	Plant	Cotton
Iodine	10	Pigment	Cotton
Lime	15	Plant	Cotton
Carbide	9	Plant and vat	Leather, cotton

4.3 Results for Objective Two

To experiment the identified mordants with plant dyes on indigenous tanned leather.

Sorghum bicolor

Hibiscus sabdariffa

Figure 4.1 : Mordants with plant dyes on indigenous tanned leather

4.4 Results for Objective Three

To test and analyse the potential effects of the mordant(s) with plants dyes on the indigenous tanned leather over time.

Cream Leather to be dyed at the crust state

Application of oil for fatliquoring

Soaking of leather

Pounding of leather

Figure 4.2: Preparation of Leather for Dyeing

Pounding of **Sorghum bicolor Stock**

Addition of carbide solution to sorghum bicolor

Figure 4.3 Preparation of Dye Bath from Sorghum bicolor

A mordant is a chemical agent which allows a reaction to occur between the dye and the fabric in textiles, mordant are used to fix the colour in dyeing or fabric printing. The mordant has the capacity of bonding the structures of the dye in the interstices of the garment. Mordant is added to the dye source to influence it, it does not serve as a colour source on its own. The fabric is impregnated with the mordant, then during the dyeing process, the dye reacts with the mordant, forming a chemical bond and attaching it firmly to the fabric.

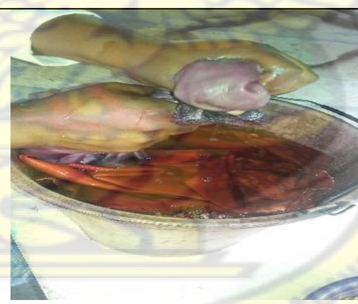
The natural dyes having limited substantively for the fibre, require the use of the mordant which enhances the fixation of the natural colorant on the fibre by the formation of the complex with the dye. Some of the important mordant used are alum, potassium dichromate, ferrous sulphate, copper sulphate, zinc sulphate, tannin, and tannic acid. Although these metal mordant contribute to developing wide gamut of hues after completing with the natural colouring compounds, most of these metals are toxic in nature and only in trace quantity their presence is found to be safe for the wearer.

RESULTS FOR RESEARCH QUESTION THREE

Post Dyeing Activities

The activity mainly consists of the intentions of the research that is testing for the strength of the mordant in sustaining the dyes in the leather. The dyed leather was left in water for twenty-four hours to test for capacity to maintain its colour in water and also left in a broad day light for seven days to test its affinity to light. The dyed leather was taken through some preliminary activities which basically do not form part of the purpose of the research but necessary to be done. Those activities include sanding at the flesh side and washing. The sanded leather continued to stay in the water for twenty-four hours after which it was stretched on board and left in the sun for seven days.

Table 4.2.3 : Subjecting the dyed leather to wash and light fastness test

Sanding off excess flesh	soaking and washing (twenty four hours)	Drying in sun (seven days)
		
		

After these activities the effects of the leather came out in this form. The images are arranged in the order of the mordants used.

Table 4.2.4 Results of Wash Fastness and Light Fastness

Mordant and dye	Effect after being exposed in Water (24 hours)	Effects after being exposed to Sunlight (seven days)
Carbide and wood ash Sorghum bicolor		
Iron filings Sorghum bicolor		
Carbide and wood ash Sorghum bicolor and hibiscus Sabdariffa		

Salt and lime and hibiscus Sabdariffa		
Iron filings and hibiscus Sabdariffa		
Carbide, wood ash and salt Sorghum bicolor and hibiscus Sabdariffa		
Carbide, wood ash and salt and hibiscus Sabdariffa		

After subjecting the dyed leather to soaking and washing for 24 hours and drying in direct sunlight for 7 days, the original colour as obtained from the tannery is maintained. This means that the dyes were able to fix permanently in the leather fibres without fading. After the entire experiments these are the major findings

- Fastness is possible when some specific mordants are used with natural plant dyes. Eg. Salt, wood ash, carbide solution, iron filings.
- The most appropriate and the effective mordanting styles is the meta-mordanting which creates an effective bond between the dye and the leather and helps to maintain the full colour of the dye.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Overview

This chapter of the study deals with the summary of major findings, conclusions drawn from the study and recommendations for further improvement of the studies.

5.2 Summary of Findings

Natural dyes are readily available in our environment in various parts of plants, However, due to lack of proper affinity with various substrates, they are not given adequate recognition in Leatherwork. Asmah (2008) has however explained that making plant dyes fast to fiber based materials requires the identification and application of appropriate mordants. With various users of chemical and artificially formulated dyes realizing their toxic and expensive nature, Asmah (2012) has emphasized that artisans and interested stakeholders who depend on dyes for their activities are now looking out for the best means to make natural dyes work effectively and efficiently like the chemical dyes in behaviour. Its capacity of bonding with all fibre based garments without fading out when exposed to light or wash. Against this background that artisans are seeking to get the best fixatives in the form of mordant to help curb the problem associated with the use of natural dyes.

In the arena of leather making, tanners have also realised that natural dyes, particularly, plant dyes are not able to have permanent affinity to locally tanned leather in general. In their quest to solve this situation, several affinities types of materials have been used but they seem not to address it properly. This is due to the fact that mordants appropriate to fix the dyes have not been secured to serve the affinity purpose needed. This research sought to identity mordant types and explore their possible abilities to fix with local plant dyes for improved wash and light fastness on local vegetable tanned leather.

The study was conducted in the Ashanti region of Ghana based on three objectives set. A heterogeneous population made up of dye users, mordant sellers and distributors, leather tanners and dye experts were identified, and the appropriate research methods were chosen to tackle each objective. Since the purpose of the study was to explore mordants with locally available plant dyes to evaluate their fastness to wash and light when applied on leather, the right research methods were selected. In this case, studio experiments, observations and interviews were the research instruments identified for the conduct the study. Descriptive method was used to analyse the data and interpret them for the findings. Specifically, the study sought to find out mordants requisite to guarantee dye fastness on leather.

To identify various mordants which can aid the wash, light fastness of natural dyes, research into the types of mordants were conducted as readings were done from the KNUST library and the Ashanti library as different books identified various mordants and their effects mostly in the textile industry. The internet also provided valuable information on the types of mordants and their application. To top it all homogeneous samples were interviewed to ascertain their knowledge on the types of dyes they have known, sold and used over time. The researcher has explored the various mordants available locally, and has further experimented samples of mordants with plant dyes to ascertain their fastness to wash and light. After pursuing the three objectives and discussing the data secured, the findings obtained are presented as follows:

1. Since the locally available plant dyes have not been explored nor projected often as representational dyes for application on leather in the Ghanaian concept dyeing, its introduction into the tannery industry has always resulted in complaints from customers that the dyes bleed and fade with time. This is what called for the need to research into the possibility of finding mordants within the local parlance to aid in achieving fastness.
2. Mordants exist in natural and artificial forms, however, the appropriate ones to make local plant dyes fast on leather is still not dully identified. There is therefore the need to explore various mordants to unearth the most effective and appropriate ones for plant dyes which would improve fastness on Ghanaian indigenous vegetable tanned leather.

5.3 Conclusions

Based on the major findings of the study, the following conclusions have therefore been drawn:

1. Plant dyes available locally require mordants to ensure fastness to light and washing, especially if applied on leather. However, not all mordants available on the local market work well with any plant dyes.
2. Mordants used with plant dyes need to be applied in the right quantities to achieve the required efficacy.

3. From all the mordants explored, three main ones worked very well in this study: salt, carbide, lime juice

5.4 Recommendations

Based on the conclusions drawn, the researcher recommends that

1. Locally available plant dyes when given the needed attention can serve as a breakthrough for obtaining variety of dye colours to enhance the aesthetics appeal of leathers tanned locally. Dye chemists and leather technicians therefore need to join forces to advance deeper research to harness the potentials of local plant dyes to expand socio-economic benefits.
2. Tanners and leather workers are encouraged to use the outcome of this study for improved economic essence of leathers produced. The application of the plant dyes with the mordants identified would help add extra value to leather colours, and enhance customer attraction.
3. It is finally recommended that, further research is encouraged towards quantifying the specific amounts of mordants for specific types of plant dyes for specific sizes of local vegetable tanned leather.

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APPENDICES

Appendix 1

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF INTEGRATED RURAL ART AND INDUSTRY

Interview Guide for Asawase tanners (Open-ended questions)

Objective: To identify various mordants which can aid the wash, light and abrasion fastness of natural dyes.

1. What dyeing activity are you involved in?
2. Do you use plant dyes?
3. Do you use mordants?
4. What mordants do you use?
5. From what source do you acquire the mordant
6. Are you a mordant dealer?

Appendix II

Observation Guide

Objective: To experiments the various mordants with plant dyes on indigenous tanned leather.

1. Observe work conduct of tanners.
2. Observe tools, materials and their impact of leather making.
3. Systematically the activities will be critically observed and studied for the purpose of evaluation

a. Activities carried out before soaking of pelts and soaking in general
b. Types of soaking done
c. Methods of soaking
d. Unhairing and liming processes
e. Pre-unhairing activities
f. Types and mechanism of unhairing and liming
g. Fleshing and splitting methods and procedure
h. Deliming, bating and materials used
i. Tanning procedure and principles carried out
j. Finishing activities done