EXTRACTION AND APPLICATION OF PLANT DYES TO SERVE AS COLOURANTS FOR FOOD AND TEXTILES

BY

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DECLARATION

I hereby declare that this submission is my own work towards the Master of Philosophy in Art Education and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the university, except where due acknowledgment has been made in the text.

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ABSTRACT

Synthetic or chemical food dyes are used locally to colour pastries, beef, and pig feet among others which has consequential health implications. Synthetic fabric dyes used in teaching and learning of textiles are also expensive and often inaccessible to some schools for lack of funds to purchase them, hence the need to plant dyes for use as alternative colourant for food and textiles. The study based on qualitative research method employed interviews, observation and experimentation to study thirty (30) different local plants under art studio conditions. The dye extraction process involved the use of the bark, leaves, seeds, whole fruits, and roots of the different plants, each of which was boiled for 30 minutes. Among the plant samples studied, only three did not yield dyes that could successfully colour fabric while the other 27 yielded colourful dyes that could be used to teach basic skills in tie-dye, batik, printing, dyeing of yarns for macramé, and crocheting without the use of mordants. Using lime juice, baking powder and alum as mordants either enhanced or slightly changed the colour of dyes obtained. Dyes obtained from Prekese (Tetrapleura tetraptera), Widie aba (Momodora myristica), and Hwentea (Xyanlopia aethiopicum) which are known spices were too weak to stain the test fabric but found useful in flavouring for drinks made from *Hibiscus Sabdariffa*, *Tefashia*, *Sorghum bicolour* and *Samia* plants. Boiling yam, rice and spaghetti in *Tefashia* dye solutions gave the three a rich golden colour as if they were cooked with curry powder. Though *Sorghum bicolour* proved unsuitable for spaghetti, it was a good colourant for rice while *Hibiscus Sabdariffa* was found most suitable for drinks. The results suggest that very aesthetically pleasing colourants can be derived from the local environment for use as instructional resource for the teaching and learning of colouring techniques in Visual Arts and

Home Economics and as suitable organic replacements for the chemical colourants used in the food industry.

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DEDICATION

This piece of work is dedicated to my lovely husband Asiedu Kofi Yeboah, who supported me throughout the project, not forgetting my first daughter Nhyira whose birth brought this work into fruition.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Although dyes abound in the natural environment, dyes can also be formed in different ways and used in different applications depending on their manufacturing process. Dyes can be formed by using chemicals like acids or extracted from earth and mineral sources. Natural dyes can be obtained even from our own backyards and used to colour fabric and other household items. These include various parts of plants such as flowers, roots, and nuts which can be processed to obtain many colours. Natural dyes produce vibrant colours, creating a palette that is compatible and blend with each other.

Adu-Akwaboa (1994:129) shares the view that natural dyes of various colours can be obtained from many local plants in Ghana and that dyes can be extracted from barks of trees, leaves, roots, seeds, fruits, flowers, or the young shoots. Similarly, Harris (1995) asserts that plants in the environment can be exploited to achieve natural colours of various shades to colour natural fibres and textiles by means of dyeing, printing or painting. Harris mentions that the roots of some species of the madder plant which could be grown practically everywhere were used from the earliest times to produce a whole range of reds. Red animal dyes derived from certain species of scale insects were also highly valued from ancient times and right through the Middle Ages. The literature indicates that until the 19th century, all dyes were derived from vegetable or more rarely animal or mineral sources. By the early part of the last century, only a small percentage of textile dyes were extracted from plants.

Natural dyes generally require a mordant, which are metallic salts of aluminum, iron, chromium, copper and others, for ensuring the reasonable fastness of the colour to sunlight and washing. Natural dyes are also used to colour food. In nature, colour is determined by a food's inherent qualities, indicating types of flavour, and degrees of sweetness, ripeness, or decay. However, humans have contrived to add or change the natural colour in foods from very early times and for a variety of reasons—for aesthetic purposes, to increase appetite appeal, for symbolic effect, to make a less desirable food seem more desirable, and to mask defects.

From ancient times, wide varieties of food colourants were derived from natural sources—plant, animal, or mineral. This changed in the middle of the nineteenth century with the discovery of synthetic dyes that soon found their way into food. These synthetics were, in general, less expensive as well as more stable, controllable, and intense in hue than natural colour sources. Since that time, the safety and acceptable use of food colourants, both natural and synthetic, remain controversial topics, eliciting debate, continual scientific study, and periodic legislative action (www.answers .com/library/food & cultures Encyclopedia).

In addition, Fox and Cameron (1970) explain that, one way of solving food problems such as low food production, food spoilage and food insecurity is by using food additives. These food additives can be used during production, processing or any phase of the food utilization in which they are useful in enhancing or maintaining some desirable quality of the food. In the developed world, food additives or chemical processing aids are used because of the growing urbanized `nature of their populations, which necessitates the availability of constant and whole farm food supplies.

The knowledge of the potential of the natural environment need not be over emphasized, since it is glaring for the eyes to see and appreciate; hence the need to explore the extraction of dyes from natural plants to produce suitable dyes for selected textile fabrics and also serve as colourants for food.

1.2 Statement of the Problem

Since time immemorial, the roots, seeds, leaves, bark and flowers of plants and also mineral matter have been used to dye textiles. Natural dyes or colourants are also used in the food manufacturing industry with the prime motive of making their products very attractive.

Until the 1850s, the World Book Encyclopedia (2001) reports that all dyes were made from natural sources such as the roots, seeds, leaves, bark and flowers of plants and also mineral matter. Synthetic dyes came into existence during the late 1800s and 1900s, and were widely used owing to their property of better colour fastness. The industry now uses a wide variety of these synthetic dyes. As a result, the natural dyes which are less harmful are no longer used while more chemical dyes are used. These toxic materials pollute the environment and create more hazards to life.

The adaptation of synthetic dyes in Ghana has drastically reduced interest in exploration of plant dyes from our environment. This is because, one can get the synthetic dyes which have better fastness property easily on the market instead of going through the long process of walking through the forest to collect the plants from which dyes are extracted.

As though this was not enough, synthetic food colourants are being used to colour food items like fried yam and turkey tail, beef, bread, pig feet and pastries which are sold in the market. Even though these synthetic dyes come in handy, they are expensive and may be environmentally unfriendly.

Furthermore, educational institutions located in rural communities where commercial dyes are unavailable for lack of suppliers or inaccessible for lack of funds to purchase them, could use the resourcefulness of our natural environment; thus coming out with their own dyes from flora available in their localities (Opoku-Asare, 2004). This project is intended to serve as reference material for practical art works. Also, not paying attention to the extensive possibilities and creative capacity of the art practitioners to develop technical skills through the use of the material resources in the natural environment will jeopardize the classroom setting, which is expected to be a field with the right kind of artistic experiences needed to obtain the objective of self expression among students.

It is therefore expedient in this regard that, research be carried out into basic ways of the extraction and application of dyes from local plants found in the environment as substitute for synthetic colourants used in the textile and food industry, which will not be harmful to the human system. In addition, this research can help to alleviate boredom and create versatility in the art setting by educating urban dwellers and students of art on the processes involved in obtaining and producing natural dyes from the environment, including the forest reserves.

1.3 Objectives of the Study

1. To study existing synthetic dyes and their effect on food and textiles.
2. To identify some plants from which dyes can be extracted.

3. To test the properties of the plant dyes and introduce them to food products and textile fabrics.

1.4 Research Questions

1. What are some of the natural plants from which dyes can be extracted?
2. How can these extracted dyes be used to dye textiles and food?
3. To what extent can the forest reserves be explored to create wealth for the Ghanaian textiles and food producers?

1.5 Delimitation

The study was limited to exploring the natural plants from which dyes can be extracted and used as colourants for selected food items and textile fabrics. The study was also limited to surveying the indigenous cloth dyers at Ntonso located in the Ashanti Region due to their known skills in traditional dyeing with *badie* and *kuntunkuni*. Although there are different food additives (Nutritional Supplements, Flavors, Colouring agents, Preservatives, Emulsifiers, Stabilizers and Thickeners, Acids and Alkali) that are, used to enhance food, the study was limited to colouring agents.

1.6 Limitations

The research was characterized by extensive traveling to enable the researcher collect and ascertain data on the existence of some natural plant dyes and dyers in our local textile and food industry. However, resource and funding constraints was a major drawback in gathering data, since more areas could not be covered especially taking snap shots of the various regions where natural dyes are cultivated and used.

1.7 Importance of the Study

The study seeks to explore and capture some natural plants from which dyes can be extracted and applied to selected foods and textile fabrics. The study also plays a distinctive role in providing beneficial information to the textile and food industries, Art lecturers, students and scholars. In addition, the study would create the awareness of unexplored plant dyes and finally serve as a reference material to other research works.

1.8 Facilities Available

The following were subservient to gathering data for the study.

1. Kwame Nkrumah University of Science and Technology Main library, Kumasi.
2. College of Art and Social Sciences Library, KNUST, Kumasi.
3. Art Education Library, KNUST, Kumasi.
4. University of Education, Winneba (Kumasi campus).
5. University of Ghana main Library, U.G, Legon.
6. Nutrition and Food Science Department, U.G., Legon.
7. Department of Chemistry, KNUST, Kumasi.
8. Department of Chemistry, University of Ghana, Legon.
9. Centre for Scientific Research into Plant Medicine (CSRPM).
10. Food And Drugs Board, Kumasi.
11. Internet Cafés.

1.9 Definition of Terms

Adhere	The ability for a dye to stick firmly to a substrate.
Affinity for dye	The ability for a fibre or fabric to attract dye and exhaust it.
Bleed	To spread colour from one area of a substrate to another area, bleeding may produce both colour loss and staining.
Crack	To transfer colour as a result of abrasion or rubbing.
Exhaustion	The amount of transfer of dye from the bath to the fiber, either by, adsorption or absorption.
Dye stuff	To change the colour of something by using a special liquid. The substance has the ability to change the appearance of a substrate.
Dye liquor	This is a solution or liquid mixed with colour to enable dyeing.
Fabric	This is formed by assembling yarns and or fibers into one cohesive Structure. The most common fabric structures are woven, knit, and non-woven. Fabric may be referred to as cloth, material, piece goods or goods.
Fade	A fabric is said to fade when it loses colour or runs out during washing.
Fastness	The resistance of a material to change in colour characteristics.
Fibre	These are fine hair-like substances. They may be natural or manufactured and are the smallest components of a textile product. Cotton is an example of a natural fibre while polyester on the other hand is a manufactured fibre.
Finish	This is any chemical or mechanical treatment or process that modifies the properties of textile products.
Frost	Loss of colour resulting from localized abrasion.
Migrate	Shift colour; this occurs when moisture lifts colour and deposits it in another area. This is most seen in the underwear area.
Textiles	It is a broad classification of materials that can be utilized in constructing fabrics, including textile fibres, and yarn. It is

also used to designate the constructed fabric including woven, knitted, and non-woven structures as well as lace and crocheted goods.

Yarn Yarns are groupings of natural or manufactured fibers that are combined to form a continuous strand that can be used to produce fabric.

1.10 Abbreviations

K.N.U.S.T. - Kwame Nkrumah University of Science and Technology.

C.S.R.P.M. - Centre for Scientific Research into Plant Medicine.

F.D.B. - Food and Drugs Board, Kumasi.

U.G. - University of Ghana.

U.E.W. - University of Education, Winneba.

MSG - Monosodium Glutamate.

1.11 Organization of the Text

Chapter One is the introduction of the project report. It contains background to the study, statement of the problem, objectives, research questions, delimitations, limitations, importance of the study, facilities available, definition of terms, abbreviations and organization of text.

Chapter Two is the review of related literature which primarily deals with documented information from various sources on colour in textiles, dyes, natural plant dyes (types of natural dyes), synthetic dyes, characteristics of natural dyes, mordants, uses of plant dyes in Ghana, food additives, food colourants and summary of discussion.

Chapter Three explains the research methodology adopted for the study. It embodies the overview, research design, primary and secondary sources of data, population for the study, sampling design, descriptive research, experimental research, primary and secondary data, population for the study, sampling design, data collection instruments (interviews and observation), data collection procedures, interpretation and analysis of data.

Chapter Four focuses on the identification and description of the sample plants studied, presentation of findings, the experimental procedures followed to ascertain their dye yielding properties and their applications on textiles and food.

Chapter Five is the presentation of results of the experiment on plant dyes or colourants on textiles and food, discussion of dyes or colourants, application on textiles and food with summary.

Chapter Six gives the summary of the main findings of the study, conclusions drawn and recommendations for utilizing the research findings.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Overview

Over the years, dyes have been used to colour textile fabrics, fibres, yarns and other non-woven items. Dyes are applied to textiles in the form of a solution or paste just as manufacturers add dyes to colour food items to either conceal the original colour or enhance their colours to make them attractive to buyers. With respect to textile products, colour is accepted as a common language that consumers are usually more concerned with than any other characteristic. The desire for colourful textiles led to the discovery of synthetic dyes and the manufacture of dyestuff and chemical agents that produce long lasting colours in materials. Colour for the textiles industry is mostly obtained from dyes and pigments.

The review of literature covers colour in textile, dyes, natural plant dyes (types of natural dyes), synthetic dyes, characteristics of natural dyes, mordants, uses of plant dyes in Ghana, food additives, food colourants and summary of discussion.

2.2 Colour in textiles

Dyes, also referred to as dyestuffs, are the most common way to add colour to fibres, yarns and fabrics. Manufacturers of food, fur, ink, leather, paper, plastics and wood also use dyes (World Book Encyclopedia, 2001) to colour their products. The appeal of colour is universal. According to Kadolph (2007), colour is one of the most significant factors in the appeal and marketability of textiles products. Colour is a very important aspect of textiles production because as Elsasser (2007) asserts, consumers generally expect two things: aesthetically pleasing colours and prints;

and colour permanence, implying that the aesthetic aspects of a textile fabric is the prime consideration for consumers. According to Adu-Akwaboa (1994:126), colour is often the primary consideration in the selection and purchase of clothing and other household textiles and to a large extent, the most exciting thing about textiles.

Kuehni (2004) asserts that for the normally sighted, colour is everywhere, in the interior of a dwelling, natural and stained wood, wallpapers, upholstery fabrics, pottery, paintings, plants and flowers. Collier and Tortora (2001) share the view that most objects made by human beings are decorated in some way and that the decoration of textile fabrics may be achieved by varying the construction of the fabric and adding colour through dyeing or printing. The World Book Encyclopedia (2001) also reports that besides textiles, manufacturers of food, fur, ink, leather, paper, plastics and wood also use dyes to colour their products.

2.3 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 the fibre. Dyes are molecules that can be dissolved in water or some other carrier so that they will 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. Dyes may be applied as a solution or paste to patterns created on fabric. 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 (Tortora & Collier, 1997).

Also referred to as dyestuffs, dyes are 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. Because dyed textiles vary in their ability to hold colour (The World Book Encyclopedia, 2001), chemical additives or mordants such as salt and acid are sometimes used to regulate absorption of the dye into the 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. The implication is 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.

2.4 Natural dyes

Natural dyes of plant, mineral and animal sources are fascinating, beautiful and sometimes they challenge the wits of researchers and educators. Most of them produce very colourful effects that are so amazing to behold. Natural colours are beautiful to behold (Lyon Tex, 1992:732). Colouring matter extracted from the roots, stems, leaves or barriers, and flowers of various plants have various exceptions and are also not substantive (have little or no colouring power by themselves) except when used in conjunction with mordants. Joseph (1977) adds that the beautiful colours that are created from natural dyes would initially appear vivid, but soon fade. Lack of colour fastness resulted in the discovery of mordants - substances which aid in the absorption of dyes.

2.4.1 Plant dyes

The roots, nuts and flowers of plants that grow in our backyards are all sources of colouring pigments and dyes. The World Book Encyclopedia (2001:212) notes that most natural dyes come from such parts of plants as the bark, berries, flowers, leaves, and roots while Storey (1997) and Adu-Akwaboah (1994) mention the use of seeds, fruits, and young shoots as other sources of natural dyes. The outer, inner bark and heartwood of trees also produce dyes. Dyer (1976) points out the madder plant that grows in Asia and Europe as a source of bright red dye that is used on fabrics that include linen and silk. According to Aimson (1999), the madder plant (*Rubia tinctorum*) was the source of a brilliant red permanent dye called “Turkey Red” or “Adrianople Red” which was very well known in 19th century domestic history for “maddering” wool and cotton.

Aimson (1999) reports that madder was cultivated and first exported from South East Europe and Turkey to the rest of Europe. The wild madder (*Rubia peregrina*) is known to provide a subtler, rose-pink dye. The roots of some species of the madder family were also used from the earliest period to produce a whole range of reds since the plant could be grown practically everywhere. Logwood, a natural dye extracted from the pulp of the logwood which grows in Central America, Mexico and the West Indies, is known to produce excellent dark colours and bright black and brown dyes for such materials as cotton, fur and silk for special purposes. Natural indigo, a dark blue dye derived from the indigo plant, which grows chiefly in India is also used to dye cotton, wool, and other fibres. Yang and Narasin (1989) cite indigo as an extremely important source of blue dye that is still very popular in making special types of designs for modern fabrics such as denim.

In Japan, the authors indicate that dyers revere indigo and pray to their god, Arizen Myoo, for good fortune in their work with it. The dyers also carefully tend the dye vat and give it the respect they would a friend and stir the dye daily to keep it alive and replenish it when the need arises. Indigo can be produced in a wide variety of shades ranging from very pale to almost black. Indigo was a rare commodity in Europe throughout the Middle Ages so woad was used instead. Stuart (1969) posses that indigo is among the oldest dyes to be used for textile dyeing and printing. India, China, Japan and many Asian countries have used indigo as a dye for centuries. India is believed to be the oldest centre of indigo dyeing in the old world. India was a primary supplier of indigo to Europe as early as the Greco-Roman era. The dye was also known to ancient civilizations in Mesopotamia, Egypt, Greece, Rome, Britain, Peru, and Africa.

Indigo was the foundation of the centuries-old textile traditions throughout West Africa. The use of indigo here pre-dates synthetics and from the Tuareg nomads of the Sahara to Cameroon, clothes dyed with indigo signified wealth. Women dyed the cloth in most areas, with the Yoruba of Nigeria and the Mandingo of Mali particularly becoming well known for their expertise. The Hausa male dyers who worked at communal dye pits served as the basis of the wealth of the ancient city of Kano in Nigeria, where men can still be seen employing their skilled trade today at the same pits.

Aimson (1999) mentions the woad tree as another important source of natural dye. Also known as Dyer's Woad (*Isatis tinctoria*), the plant was cultivated as the source of a blue dyestuff for over 2000 years in Europe, and was only superseded around 50 years ago by indigo, a dyestuff that was first extracted from the subtropical *Indigofera* species. *Isatis* is an ancient name for a healing herb, which ancient warriors painted themselves with before battle for both its psychological effect and as a means of healing the wounds of battle. In processing woad, the leaves were fermented, dried out, re-fermented, and then rinsed in lime-water. Its blue dye was more permanent than indigo. Woad dye was also made from the bark of the plant up to the end of the Middle Ages (Collier and Tortora, 2001). Henna, an orange-brown dye made from a shrub of North Africa and the Middle East, was also used to colour leather and dye human hair (The World Book Encyclopaedia, 2001).

The literature confirms the existence of over 1,000 sources of plant-based dyes that were used across the world until the early 1900s. Included in this vast array of dye-yielding plants are the following (Corbman, 1959; The World Book Encyclopedia; 2001) and Plate 1.

- Henna (orange-red) - from leaves of the henna plant
- Catechu (brown) - from resin (sticky substance from plant) of acacia tree
- Fustic (yellow) - from the wood of the fustic tree
- Indigo (blue), is from leaves and stems of the indigo plant
- Logwood (black) - from the core (heart) of the logwood tree
- Madder (Turkey red) - from the roots of the madder plant
- Quercitron (yellow) - from the inner bark of the black oak tree
- Saffron (yellow) - from stigmas of the common crocus
- Turmeric (violet) - from roots of the turmeric plant

Plate 1.Assorted plant dyes

Source: (htt://hubpages.com/hub/natural-source-Of-The-Different-Colour-Of-Dyes)

2.4.2 Animal dyes

Red animal dyes derived from certain species of tiny scale insects known as cochineal (*Dactylopus coccus costa*) that fed on red cactus berries. These insects were gathered by hand and ground into pigment, requiring 70,000 carcasses to make a pound of dye. By 1600, approximately 500,000 pounds of cochineal were shipped annually to Spain (www.answers.com/library/food&cultures encyclopedia). The dyes were highly valued from ancient times and right through the Middle Ages. Aimson (1999) states that the purple robes of royalty in Ancient Rome were dyed using a substance extracted from a rare crustacean called Trumpet Shell (Purple Fish) which was found near Tyre on the Mediterranean coast. An estimated 8,500 shellfish were crushed to produce one gram of the dye, which made it so expensive that only kings could afford to use it. Major sources of animal dyes are:

- Cochineal (red) - from bodies of cochineal insects.
- Tyrian purple or crimson - from the bodies of some types of marine snails.

- Sepia (brown) - from secretions of several types of cuttlefish.

Table 1 Categories of some natural dyes.

Natural dye classification		
Colours	**Chemical classifications**	**Common names**
Yellow and Brown	Flavone dye	Weld, Quercitron, Fustic, Osage, Chamomile, Tesu, Dolu, Marigold, Cutch
Yellow	Iso-quinoline dyes	Barberry
Orange-Yellow	Chromene dye	Kamala
Brown and Purple-Grey	Naphthoquinone dyes	Henna, Walnut, Alkanet, Pitti
Red	Anthraquinone dye	Lac, Cochineal, Madder (Majithro)
Purple and Black	Benzophyrone	Logwood
Blue	Indigoid	Indigo
Neutral	Vegetable,Tannins, Gallotannins, ellagitannins, and catechol tannins	Wattle, Myrobalan, Pomegranate, Sumach, Chestnut, Eucalyptus

Source: (htt://www.info.usaid.gov.)

2.4.3 Mineral dyes: (derived from coloured clays and earth oxides)

- Chrome Green - from a compound of chromium and oxygen.
- Chrome Red - from a compound of chromium and lead.
- Chrome Yellow - from a compound of chromic acid and lead.
- Prussian blue - from a compound of iron and cyanide.

An ochre dye made from iron ore is one of the oldest pigments that have been in use since pre-historic times.

2.5 Synthetic dyes

Since loss of colour in use is a major source of consumer dissatisfaction, the use of the appropriate dye for a particular fibre is crucial to colour fastness hence reputable manufacturers should choose dyes carefully. In the past, dyes were produced individually by harvesting natural fruits, vegetables and other items, boiling them, and submerging fabrics in the dye bath. This long and tedious process was the common practice until the mid-1800s (Joseph, 1977). Gebelein (1997) reports that the cost of the natural dyes was equivalent to the cost of gold and silver and so were used mainly on clothing worn by the wealthy while poorer people wore white or drab colours made from vegetable dyes. According to Gebelein, chemistry radically changed this situation when in 1856, William Perkin, an English chemist working in London, made an accidental discovery of a purple dye while trying to synthesize quinine by reacting aniline sulphate with an oxidizing agent.

This purple dye, which Perkin called *mauve*, was found to dye silk and although it was not particularly fast, it became popular. Encarta 2003 indicates that this first synthetic dye influenced the development of the synthetic dye industry. Today, industry uses synthetic dyes almost entirely because they hold their colour better and cost less to produce than natural dyes. Pre-packaged dyes are also readily obtainable in almost every colour, and are available to anyone who can purchase the end product. Perkin's discovery showed chemists that dyes and pigments could be produced synthetically in a laboratory and it was no longer necessary to search out natural products for use as colourants. Besides industrial use, professional and home dyeing of apparel and household decorations is practiced widely based on the different types of dyes and their ability to resist fading.

As Storey (1985) indicates, dyes were mainly derived from vegetable matter and a few mineral colours until the latter half of the 19th century, but rarely from animal or mineral sources. Specifically, the World Book Encyclopedia (2001) states that until the 1850s, all dyes were made from various parts of plants and certain animals, and that the earliest fabrics excavated by archeologists show evidence of ornamentation through the use of natural fibres of contrasting colours. Natural dyes are hardly used today except for educational and recreational purposes.

2.6 Characteristics of natural dyes

Dyer (1976) indicates 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 (Lyon Tex, 1992:732) 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 (Joseph, 1977) - 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.

2.7 Mordants

According to Aimson (1999), mordants play an essential part of the dyeing process. Mordanting is very necessary, except for plants which contain a lot of tannin and do not necessarily require mordants. Mordants "bite" into the fibre, and make the dye stick to the fibres and also have the ability of changing the colours of dyes. The most commonly used mordants are Alum (Potassium Aluminum Sulphate), Chrome (Bichromate of Potash), and Tin (Ferrous Sulphate). Others include Iron sulphate, Tin crystals and Stannous chloride, Tannic acid, Aluminum chromium, Copper and iron. Chrome and Tin are poisonous, so Alum is recommended for first attempts at mordanting. All yarns and fabrics must be well washed and rinsed before a mordant is applied.

2.8 Use 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. Irvine (1961) mentions 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 Opoku-Asare (2005), 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.

Adu-Akwaboa (1994:129) reports 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).

2.9 Food additives

Food additives are substances other than nutrients added to food or any substance that a consumer, chef or food manufacturer adds to food (Gardner, 1993). Some additives increase food's nutritional value whiles others improve the colour, flavour and texture of foods. Many of these additives occur naturally in foods that people have eaten for centuries but scientists have also created synthetic or chemical food additives which may pose danger to the health of the consuming public. Fox and Cameron (1970) cite food additives as one way of solving food problems such as low food production, food spoilage and food insecurity. The food additives can be used during production, processing or any phase of food utilization if they are useful in enhancing or maintaining some desirable quality of the food. In the developed world, food additives or chemical processing aids are used because of the growing urbanized nature of their populations, which necessitates the availability of constant and whole form food supplies. Most of their foods are processed into a readily usable form, which makes it necessary to use additives for preservation.

A food additive is described by Weisser et al. (1971) as any substance added to food whereas the USA 1958 Amendment of the Federal Food, Drugs and Cosmetic Act of

1938 says it is “...any substance the intended use of which result or may be reasonably expected to result, directly or indirectly in its becoming a component or otherwise affecting the characteristics of any food (including any substance intended for use in producing, manufacturing, packaging, packing, processing, preparing, treating, transporting or holding food; and including any source of radiation intended for any such use) if such a substance is not generally recognized among experts qualified by scientific training and experience to evaluate its safety” (Weisser et al., 1971). In addition, Codex Alimentarius indicates they are any substance not normally consumed as food by itself but which by its use becomes a component of a food (Johnson and Peterson, 1974). The term “food additive” however, does not include chance contaminants.

An additive may either be nutritive or non-nutritive; it may be physiologically active or inert; it may be present internationally to achieve some modification in the foods, or incidentally and serving no useful purpose in the final product (Johnson and Peterson, 1974). This means that food additives perform a variety of functions in food that are often taken for granted. Food additives have been used for years to preserve flavour, blend, thicken and colour foods (Johnson and Peterson 1974). In Ghana food additives for flavouring purposes (Ampofo Frimpong, 1992) are imported or locally made. These include Monosodium Glutamate (msg), *cumincus cyminum (umbelliferaa)*, and *eugenus calophylloides*, curry powder and turmeric.

Since most people no longer live on farms to eat fresh food, additives help keep processed food wholesome and appealing while en route to market sometimes thousands of miles away from where it is grown or manufactured. In addition Birch and Parker (1980) note that food additives are used in flour milling and bread-making to improve the texture and colour of breads (improvers such as potassium bromate and cystein – a naturally occurring amino acid), and the texture of cake (chlorine bromate and various emulsifying agents).

Food additives are added to foods for five main reasons:

1. To maintain product consistency emulsifiers give products a constant texture and prevent them from separating; stabilizers and thickeners to give it a smooth and uniform texture. Anti-caking agents help substances such as salt to flow freely.

2. To improve or maintain nutritional value, vitamins and minerals are added to many common foods such as milk, flour, cereals and margarine to make up for those likely to be lacking in a person’s diet or lost in processing.

3. To maintain palatability and wholesomeness. Preservatives retard product spoilage caused by mould, air, bacteria, fungi or yeast.

4. To improve leavening or control acidity or alkalinity. Leavening agent that release acids when heated can react with baking soda to help cakes, biscuits, and other baked foods to rise during baking. Other additives help modify the acidity and alkalinity of foods for proper flavour, taste and colour.

5. To enhance flavour or impart desired colour. Many spices and nutritional and synthetic flavours enhance the taste of foods. Colours likewise enhance the appearance of certain foods to meet consumers’ expectations.

As to whether colouring material should be added to foods to improve their appearance and attractiveness is hotly debated. All the reasons cited appear acceptable because the majority of the buying public or consumers seem to have been brought up to prefer foods made with characteristic colours, and have become accustomed to them. The introduction of food additives fulfills commercial needs and makes a positive, though not majority, contribution to the ability of the food industry to satisfy the needs of the public. In addition, many colouring food additives may improve the nutritive value, texture, flavour, eating quality or attractiveness of the food; these are considerations that cannot be ignored.

Mehas and Rodgers (1989) assert that natural food additives are normal components of natural food products, which come from foods or specific parts of plants that are separated for their particular properties. For instance, Beta Carotene, the vitamin A precursor, is present in many foods and is a natural additive in others, whiles being also used as a colouring agent and as a nutrient for margarine. Colour additives make food appetizing to consumers. Because appearance of food is important to all soft drinks, cheeses, ice creams, jams and jellies for example, colouring agents are added to please food buyers. Morton and Macleod (1986) say that the characteristic amber colour of apple juice is critical to customers' acceptance of the juice. Gelatin can be added to help precipitate the tannins, which are responsible for the astringency and some of the colour. Similarly, the brownness of the crusts of breads and pies, and the brightness and trueness of the colour of fruits and vegetables are important characteristics that customers look out for in making purchasing decisions.

Colour is used as an index to the quality of a number of foods. The strength of coffee and tea is judged in part by the colour of the beverages. The colour of roasted beef is used as an index to doneness. However, synthetic dyes are being used in the majority and the researcher believes it could be reduced to a lower concentration if colours derived from natural sources are used at higher concentrations for desired colours. The colour of foods therefore contributes immensely to one's aesthetic appreciation of them. These Additives are classified according to the purpose for which they are used. It can be deduced from the discussion that food additives can be used for such purposes as nutritional supplement, flavour enhancer, colouring agent, preservative, emulsifier, stabilizer, thickener, acid or alkali.

For the purpose of this study and in line with the Objective Two, the discussion of food additives is limited to their use as colouring agents for food.

2.9.1 Food colourants

Humans have always used the colour of a food to form judgments about its desirability. The act of eating (and deciding what to eat) is a multi-sensory experience, synthesizing perceptions of sight, taste, smell, and touch. Colour provides visual information about a food's quality and condition, and influences the perception of its flavour. In nature, colour is determined by a food's inherent qualities, indicating types of flavour and degrees of sweetness, ripeness, or decay. Nonetheless, humans have contrived to add or change the natural colour in foods from very early times and for a variety of reasons such as aesthetic purposes, to increase appetite and appeal, for symbolic effects, to make a less desirable food seem more desirable, and to mask defects (www.Answers.com). From ancient times, wide varieties of food colourants have been derived from plant, animal, and mineral sources. This changed in the middle of the 19th century with the discovery of synthetic dyes that soon found their way into food.

These synthetics were, in general, less expensive as well as more stable, controllable, and intense in hue than natural colours. Since that time, the safety and acceptable use of food colourants, both natural and synthetic, remain controversial topics, eliciting debate, continual scientific study, and periodic legislative action (www.answers .com/library/food & cultures Encyclopedia). The visual appearance of a food is a major factor in determining its acceptance by the consumer, who has a number of inbuilt expectations regarding the ‘proper’ colour for a particular type of food, such as accepting peas to be green and strawberry jam to be red. Conducting sensory evaluation of foods is often necessary in order not to bias the result with the consumer’s expectations (Gardner, 1993).

According to Lugutuah (2004), the stalk of the sorghum plant is a colour additive that is used in the preparation of “waakye” to make it appear reddish. It is also used as an additive for ham, in cosmetics such as lipstick and shampoo, in medicine as a colouring agent of sugar coated pills and in candies (www.fao.org).

Colour, whether natural or synthetic, are added to foods for a number of reasons such as:

1. To replace natural colour where they have been destroyed by heat or by preservatives.
2. To ensure uniformity of colour from batch to batch, where raw materials of varying colour intensity have to be used.
3. Where the colours of the natural ingredient are too weak and it is believed that the public prefers stronger colours.
4. Where natural colours are affected by light.
5. To give an attractive appearance to foods which otherwise look unattractive or unappetizing. It is believed that the enjoyment of food depends on “eye appeal” among many other factors.

Because of the above considerations, it is believed that the use of added colours, whether natural or synthetic has a direct bearing on the acceptance of the food.

Answers.com/topic/saffron provides ample evidence that early civilizations introduced colour into their food. It cites ancient Egyptians who coloured food yellow with saffron, a dye which is mentioned in Homer's *Iliad* which talks about wines being artificially coloured around 400 BC. This source also states that wealthy Romans ate white bread that had been whitened by adding alum to the flour while in the great houses of medieval Europe, cooks employed plant extracts of many hues. Party-coloured dishes, jewel-toned cordials, and shimmering jellies coloured red, purple, blue, green, and yellow are also mentioned. Saffron is believed to have migrated from Persia as far as England by the mid-14th century, while indigo, turnsole, alkanet (borage root), red saunders (a powdered wood), marigold, turmeric, safflower, parsley, spinach, fruits, and flower petal extracts commonly coloured the foods of the wealthy (www.answers .com/library/food & cultures Encyclopedia).

In the early Renaissance (1470–1530) era, a common belief in Europe based on Arabic ideas was that colour in food not only indicated nutritional value but also inherent medicinal power connected to spiritual, celestial substances. Eating sweet red grapes was believed to produce full rich blood, black food like pepper or fungi induced melancholy moods, and colouring foods golden promoted divine solar healing. In the 16th century the New World food colourants annatto, paprika, Brazil wood, and cochineal arrived in Europe (www.answers .com/library/food & cultures Encyclopedia).

Food colourants used in Ghana are derived from a variety of sources. Natural dyes are widely used.

Some naturally occurring food colourants are listed in Table 2.

Naturally occurring colorants			
Substance	Colours	Sources	Used in
Anthocyanins	orange-red to red to blue	berries, grapes, apples, roses, hibiscus, red cabbage, sweet potato	candy, fruit beverages, ice cream, yogurt, jams
Betacyanins	red	red beets, red chard, cactus fruit, bougainvillea	candy,yogurt, ice cream, salad dressing,
Caramel	beige to brown	heated sugars	cake mixes baked goods, gravies, vinegars, syrups, colas, seasonings, sauces
Carmine	red	cochineal insects	candy, dairy products, drinks, fruitfillings, surimi
Carotenoids	yellow to orange to red	saffron, tomatoes, paprika, corn, butter, palm oil, red salmon, marigolds, marine algae, carrots, annatto	meat products, cheese, butter, spice mixes, salad dressings
Chlorophylls	green to olive green	green plant leaves	green pasta, dehydrated spinach
Riboflavin	yellow	vegetable leaves, milk, eggs, organ meats, malt	flour, bread, pastries, cereals, dietary products
Turmeric	yellow	*Curcuma longa* rhizome	pickles, mustard, spices, margarine, ice cream, cheese, baked goods, soups, cooking oil, salad dressings

Table 2: Naturally occurring colorants

Source: www.answers .com/library/food & cultures Encyclopedia

From Pg. 27, Opoku-Asare (2005) reports observing *Kanne* (*Anogeissus leiocarpus*) leaves being cooked with peeled cassava in the Brong Ahafo Region to give it the purplish look of cooked cocoyam in the famine days of 1983, and the dry leaves of the red sorghum plant being cooked with rice and beans to give the popular "shinkafa-da-waakye" dish its distinctive purplish colour and flavour. Other colour additives are curry powder, saffron, tomatoes, pepper and turmeric. These and other synthetic dyes that may be harmful to humans are sold on the open market and supermarkets and consumed by people who purchase food items mainly by colour appeal.

The products are used to colour local food items such as fried yam chips, turkey tail, pig feet, powdered pepper, groundnut paste, beef and pastries although they may pose serious health threat to consumers and the environment. Besides yielding food colours, many of the known dye-yielding plants of Ghana provide medicinal remedies for various tropical diseases and ailments (Irvine, 1961). For example, the bark infusion of Nyamedua is used as a tonic for diarrhea; *c*ola acuminata bark chips are eaten for colic and an infusion of them drunk to get rid of bile; the seeds of the Hwintea (Xylopia aethiopicum) is used for coughs; Lawsonia inermis leaves are applied to the nails to prevent inflammation and promote healthy growth; and with lime juice for inflamed bruises and swellings; while fresh juice of the rind of Anacardium occidentale (cashew) nuts is employed for the removal of warts, corns, ringworms, and as a stimulant to indolent ulcers.

Since a large number of the dye-yielding plants are also consumed as food additives, beverages and medicinal remedies for various ailments, it makes enormous health and economic sense to research their use in the food chain. The non-toxic nature of these dyes and the fact that the plants are easily accessible implies the need for developing and marketing them as viable replacements for the synthetic and chemical food colourants found on the local market. This knowledge will more than compensate for the health of Ghanaians and also create awareness for the environment as a sustainable source of dyes and colourants for the local food and textiles industries.

2.10 Medicinal uses of plants

Henna *(Lawsonia inermis)* leaves are mashed and applied to the nails to prevent inflammation and promote healthy growth, as well as to the eyelids to prevent eye strain. Adding lime juice to the prepared fresh leaves are used for inflamed bruises and swellings in man and animals for skin diseases and leprosy, or painted on the body for fever, especially for children.

The bark chips of Cola nuts *(Cola acuminata)* are eaten for colic and an infusion of them drunk to get rid of bile, while a pinch with a little salt and seeds of *xylopia aethiopica* is used for coughs (Irvine, 1961).

Prekese (Tetrapleura tetraptera) is used in baths as tonic after illness or great fatigue and as a beverage and enema against gonorrhoea. It has a caramel-like smell and commonly used as flavouring for soups and palm oil or roasted and ground to make ‘black soup’ or sauce. The fruit and flowers are added as perfume to pomade.

The bark concoction of *Kuminini (Lenea welwitschii)* is drunk for coughs whiles the seeds are used as a purgative. Miracle fruit *(Synsepalum dulcificum)* has the property of turning such substances as bitter medicines (quinine) or sour fruit (like limes) sweet as much as an hour or two afterwards hence its name “miraculous berry”. It has greater effects in sweetening acidity as in lime juice than in countering bitterness such as quinine.

A preparation of young leaves of Brimstone *(Morinda lucida)* gives a green dye used for dyeing mats. Roots or stem with spices is drunk or used as enema for fever, constipation, piles and dysentery. The bitter roots are used in local gonorrhoea prescriptions, added as flavouring to food or as a “bitter” in drinks.

The bark and leaves of Camwood *(Baphia nitida)* are used in enema for constipation. The red heartwood is powdered, mixed with shea butter and rubbed on the body and applied as an ointment with palm oil to the feet for a skin disease between toes attributed to going barefoot in muddy water in Ghana. The leaves or sap obtained by heating them is applied to parasitic skin diseases.

A bark decoction of *Onyame dua (Alstonia boonei)* is used for cleaning suppurating wounds and open fractures in Cote d’Ivoire while the bark is used for malaria in the Cameroons. In Ghana the bark decoction is used after child birth to assist the delivery of the placenta. The bark decoction is drunk by the Krobos for stomach complaints and in Ashanti for dysentery (Irvine, 1961).

The bark of *Siriga (Pseudocedrela kotschyi)* is used with other ingredients in treating leprosy and epilepsy. A decoction of root-bark and leaves is used as a sitz-bath for piles. The roots and leaves are used in Nigeria in treating rheumatism and other diseases. The root-bark is used for dysentery as a febrifuge and aphrodisiac.

The flowers of Mango *(Mangifera indica)* yield an amber-coloured and solid kind of honey of beautiful flavour. The bark is sometimes used in tanning leather and in making a yellow dye. The sap from the trunk is used as an anti-syphilitic for treating termites and borers.

Nim tree *(Azadirachta indica)* leaves are relatively rich in potash and phosphate and are used in South India as green manure and cattle feed. Leaves placed in books in India are sometimes used to keep away book mites. The leaves in Ghana are used to repel locusts and have been successful to protect cocoa beans from *Ephestia cantella* and also used for its anti-malarial properties (Irvine, 1961).

The roots of *Tamarindus indica* with other ingredients are used in treating leprosy. The pulped bark with lemon forms a medicine for diarrhea. The bark infusion is drunk by women after child birth. The Dagarti people of Ghana crush the leaves and use them as dressing for circumcision. The juice is given with ginger for bronchitis. A leaf decoction especially of the buds is used as a lotion effective in eye troubles.

The extracts of the herb *Bo womba gu w'akyi (Phyllanthus niruri)* have shown promise in treating a wide range of human diseases. Some of the medicinal properties suggested by numerous preclinical trials are anti-hepatotoxic, anti-lithic, anti-hypertensive, anti-HIV and anti-hepatitis B. However, human trials have yet to show efficacy against Hepatitis B virus. The plant has long been used in Brazil as an herbal remedy for stones (Irvine, 1961).

2.11 Summary of discussion

It is evident from the literature gathered and reviewed so far that, natural plant dyes play a very important role in the culture of our indigenous textiles and as such, must be developed. It was common during the 18th and 19th centuries to employ food colourants to disguise inferior products, flour was whitened with alum, pickles were coloured green with copper sulphate, and cheeses tinted with red lead and red mercuric sulfide. By the mid-19th century, black lead, Prussian blue, lead chromate, copper carbonate, vermillion, and copper arsenite were also used to color food (www.answers .com/library/food & cultures Encyclopedia).

Since food is one of the most basic needs that we cannot live without, enhancing the quality, flavour and colour of food can increase the desire to eat and nourish the body. Colour can be extracted from grains, fruits and vegetables for food and textiles. The visual appearance of food is a major factor in determining its acceptance by the consumer, who has a number of inbuilt expectations regarding the 'proper' colour for a particular type of food. Colour in this regard is often the primary consideration for purchasing clothing, household textiles and food items. This notwithstanding, the safety of food colourants are essential in promoting healthy living just as natural dyes give beautiful colours that make textiles products attractive to consumers.

Because textiles and food producers are especially concerned with the colour of their products, colouring agents used as food additives in particular should be organic dyes and not synthetic. This helps in making food look appealing just like margarine manufacturers add yellow colouring to make their product look like butter. The literature reveals that many plants produce stable colouration or pigments which have been used as dyes in the past.

Furthermore as dyes were developed and experimented with, people became more adventurous and would attempt different mediums in making dyes, hence, coming out with synthetic dyes which helped the dyeing industry to develop fast. Though synthetic dyes are colourfast, they pose a danger to the health of people owing to the harmful chemicals in them. They could cause cancer and other diseases and consumption should be minimized or eliminated altogether. Research into the extraction and application of dyes from local plants to serve as colourants for textiles and food is therefore very critical to assessing the potency of the dyes and the various medicinal and food plants for their potential to colour everyday clothes, fibres, yarns and also food items to enhance their appeal to consumers while also promoting healthy lifestyles through the use of plant-based food colours as substitutes for the chemical ones sold on the open market.

CHAPTER THREE

METHODOLOGY

3.1 Overview

This chapter provides the conceptual framework for the study of plant dyes for food and textiles. It gives information on the procedure for collecting the necessary primary and secondary data needed to answer the research questions. It describes the project, the research design, population for the study, sampling design, data collection instruments, and data analysis plan as well as the tools and equipment used to produce the dyes.

3.2 Research design

The qualitative research method was employed because of its systematic approach in unraveling certain truths as regards events and phenomena. According to Eisner (1991), qualitative research is the search for qualities, the characteristics of our experiences which we translate in qualities through our chosen representation, form and conceptual outlook. Leedy and Ormrod (2005) assets that to answer some questions in qualitative research, we must dig deep to get a complete understanding of the phenomenon we are studying; thus qualitative research provides opportunity to collect numerous forms of data and examine them from various angles to construct a rich and meaningful picture of a complex, multifaceted situation. It also focuses on the phenomena that occur in the natural setting and further has the ability to interpret and make sense of what it reveals in order to understand it.

Lincoln and Guba (1988) and Stake (1988) also refer to qualitative research as a naturalistic inquiry, which is a careful study of human activity in its natural and complex state. It is the appropriate research method for collecting detailed data on sources of natural dyes from the local environment and experimenting on their extraction and use as resources for the teaching and learning of textiles and food colouring.

According to Fraenkel and Wallen (1993), the characteristics of qualitative research are:

1. The natural setting is the direct source of data and the researcher is the key instrument in the qualitative research. This means that the qualitative researchers go directly to the particular setting in which they are interested to observe and collect data

2. Qualitative data are collected in the form of words or pictures rather than numbers. Data collected includes: transcript, field notes, photographs, audio and video tapes.

3. Qualitative researchers are concerned with process as well as the product, thus the researchers are especially interested in how things occur.

4. Qualitative researchers tend to analyse their data inductively and they tend to "play it as it goes". This means they do not usually formulate a hypothesis before hand and then seek to test it out. They spend much time collecting their data before deciding what or the important questions to consider.

5. Qualitative researchers are also concerned with how people make sense out of their lives. They focus on the perspectives of the subjects of a study, what they are thinking and why they think so.

Best (1981) contends that the qualitative studies or research is the type in which the description of observation is not ordinarily expressed in quantitative terms but usually based on quality rather than quantity. Thus, qualitative research is cautious, being a systematic process of describing, analyzing, and interpreting results discovered in the environment. In this study, natural materials were explored and experimented on as a means to understand the nature and dye-yielding properties of the identified plants and how the extracted dyes could be used in decorating fabric and food items.

The research involved visits to market places to learn of the various food colourants sold and used locally, their effect, method of administration and collection of samples and other relevant data. Experiments to understand how cotton fabric and different food items would react with the dyes extracted from some of the identified plants were carried out under basic art studio conditions to assess their suitability for that purpose. The descriptions also include digital photographs illustrating the various plants, dyed fabric and coloured food samples that were experimented on. The data from interviews conducted with the indigenous dyers at Ntonso and how they process the plant samples they use also added to the procedure for ascertaining the effectiveness of the dyes these resource persons use.

3.2.1 Descriptive research

Direct observation is an integral aspect of description which reveals the nature of certain situations, settings, processes, relationships, systems, or people. The major concern about descriptive research is to both describe and interpret existing relationships, attitudes, practices, processes and trends or compare variables (Leedy and Ormrod 2005). The reason for choosing descriptive research under the broad field of qualitative research was that the procedures for carrying out the experiments needed to be described systematically and as vividly as possible in order to interpret the conditions under which the dyes work. The primary aim was to establish the correlation between the variables “natural plants” and “plant dyes”. These essential steps described were the extraction, production, application processes and the appreciation of the results of the experiment.

3.2.2 Experimental research

Best (1981) explains that experimental research describes what will be when certain variables are carefully controlled or manipulated. The method focuses on studying relationships between variables in order to draw conclusions. This method was used to assess the suitability of the identified plants, fabric, food, tools and materials. Since the research was mainly experimental, the dye-yielding properties of the sample plants were tested on both fabric and food.

3.3 Primary and Secondary source of data

Primary data was obtained from field work carried out through visits to observe indigenous dyers at Ntonso and market women in Kumasi, as well as assisted trips to identify and take photographs of the various plants and food colourants. Informal and formal interviews with the dyers and market women enabled the researcher to elicit the required firsthand information. Experiments on the plant samples also provided primary data for the study. Secondary data was collected from 34 books, two journals and magazines, six Masters thesis and 17 websites.

3.4 Population for the Study

The population studied consisted of 30 different types of plants commonly found in Ghana, most of which were obtained on KNUST campus; and ten (10) resource persons.

3.5 Sampling design

The purposive sampling method was employed to select indigenous dyers (Leedy and Ormrod, 2005) and market women who sell food dyes in the Kumasi Central Market where samples were obtained as research respondents. This enabled the researcher to select specific places where dyers could be located and the identified plants could be obtained for the research.

3.6 Data collection Instruments

According to Leedy and Ormrod (2005), there are common tools of research that majority of researchers regardless of the field of enquiry use. These are the library and its sources, the computer and its software, techniques of measurement, the human mind and language. Qualitative research allows the use of interview, observation, visual recordings and photographs to collect data. The authors say that in any single study, qualitative researchers generally use multiple forms of data obtained through observation, interview, objects, written documents, audiovisual materials, electronic documents such as e-mail and websites. The research should however, record any potentially useful data thoroughly, accurately and systematically using field notes, audio tapes, sketches, photographs or any suitable means. Thus, the kind of data a researcher collects tends to be descriptive or narrative. The data collected engages activities that seek to answer questions.

3.6.1 Interview

Interviewing is the careful asking of relevant questions of selected individuals. It is an important way for a researcher to check, verify or refute impressions gained through observation. The method provides a means to gain information about things that cannot be observed directly (Fraenkel and Wallen, 1993). Interview involves the researcher gathering data directly from others through face-to-face or telephone contact. The interview is superior to other methods of data gathering devices. After the researcher gains rapport or establishes a friendly relationship with the subject, certain types of information an individual might be reluctant to put into writing may be obtained.

The researcher employed the informal interview technique in collecting data on existing knowledge of plant dyes and how they are produced. Individuals with expertise on textiles dyeing and food colouring were also consulted, as well as indigenous dyers at Ntonso who willingly provided important information concerning dye giving plants that they use.

3.6.2 Observation

Observation underlines all research; it plays a particularly important part in the survey procedure. Experimentation is simply observation under controlled conditions. Observation is a more natural way of gathering data. Data collection through observation may yield more real and true data than by any other method. Best (1981) states that observation has been a prevailing method of inquiry and continues to be a character for all research, be it experimental, historical or ethnographic. As a scientific tool, observation may range from the most casual to the most scientific and precise, involving modern mechanical and electronic means (Sidhu, 1984:158). The degree of observer participation can however, vary considerably. In its simplest form, observation consists of measuring and counting material objects as used in this project. Thus, observation was a key factor in gathering data through direct examination.

3.7 Data collection procedure

According to Creswell (1994) and Miles and Huberman (1994), the main aim of qualitative research is to select informants or documents or visual images who or that will best answer the research questions or meet the objectives of the study. Hence, the researcher must be present in setting where the research will take place so that he or she can observe the actors (who will be observed or interviewed), the events (what the actors will do), and the processes (the evolving nature of the event undertaken by the actors within the setting) on which data is to be collected. In this study, field work involved visits to some local textiles dyers, the KNUST Botanic Gardens, University of Ghana Botany Department, the CSRPM Herbarium, and Kumasi Central Market to observe the relevant raw plant materials and food colourants. Additionally, the informal interview with the respondents enabled the researcher to ask follow-up questions to obtain more clarification on the data obtained on the raw materials, dyes and food colourants.

3.7.1 Samples of plant yielding dyes

Samples of 29 dye-yielding plants were collected through assisted visits on KNUST campus, including the Botanical Gardens, sorted and photographed before the extraction process. This enabled correct identification and classification. The researcher’s interest in the listed plants was strictly to obtain their dye yielding properties; however, the fact could not be over-ruled entirely that, these plants listed below have medicinal properties other than their aesthetic values. A discussion of this appears in the subsequent chapter. Plates 2-35 are illustrations of the plants that were used in the experiment.

Plate 2: Nim tree

(*Azadirachta indica)*

Source: www.top tropicals.com

Plate 3: Turmeric plant

Source: www.eco India

turmeric plant.com

Plate 4: Tulip tree

Source: www.eco India

tulip plant.com

Plate 5: Bixa orellana *(annatto)*

Source: www.usda plant.com

Plate 6: Mango *(Mangifera Indica)*

Source: www.Mango plant profile.com

Plate 7: Brimstone *(Morinda lucida)*

Source: http://en.wikipedia. org/wiki/Morinda

Plate 8: Henna “Lalle” plant

(*Lawsonia inermis)*

Source: (http://en.wikipedia .org/wiki/Henna)

Plate 9: Camwood

(*Baphia nitida)*

Source: Field research

Plate 10: Teak *(Tectona grandis)*

Source: http://en.wikipedia.org/wiki/Teak/Field research

Plate 11: Flamboyant plant *(Delonix regia)*

Source: (http://nl.wikipedia.org/wiki/Flamboyant plant)

Plates 12 –18 illustrate medicinal plant extracts found on the local market.

Plate 12a Dried leaves

(Phyllanthus nuriri)

“Bo womba gu w’akyi”

Plate 12b: fresh leaves

(*Phyllanthus nuriri)*

Plate 13a: Dried Sorghum leaves

(*Sorghum bicolor*)

Source: Field research

Plate 13b: Fresh Sorghum leaves

Source: www.plantzafrica.com/

Plate 14a: Dried “Sobolo”

(*Hibiscus Sabdariffa)*

Source: Field research

Plate 14b: *Hibiscus Sabdariffa* plant

Source: www.pfaf.org/database/

plants.php?Hibiscus+Sabdariffa

Plate 15a “Prekese” fruit

(Tetrapleura tetraptera)

Source: Field research

Plate 15b: (*Tetrapleura tetraptera)*

plant

Plate 16: “Hwenteaa”

(Xyanlopia aethiopicum)

Source: Field research

Plate 17*:* “Dawadawa” plant

(Parkia Clappertoniana)

Source: Field research

Plate 18: “Widie aba”

(*Momodora Myristica)*

Source: Field research

Plate 19: India tamarind

(*Tamarindus indica)*

Source: Field research

Plate 20: Avocado pear

(*Persea americana*)

Source: http://en.wikipedia.org /wiki/Pear

Plate 21: Pawpaw

(Carica papaya)

Source: http://www.crfg.org/ pubs/ff/pawpaw.html

Plate 22: Miracle fruit

(Synsepalum dulcificum)

Source: (http//:en.wikipedia.org/wiki/ miracle_au/trop/j.htm)

Plate 23: Jackfruit fruit

(Artocarpus heteropyllus)

Source: (http://www.proscitech. com.fruit#column-one)

Plate 24a: Mahogany tree

(*Khaya senegalensis*)

Source: www.eco India mahogany.com

Plate 24b: Mahogany tree bark

(*Khaya senegalensis*)

Source: Field research

Plate 25: Cashew plant (*Anacardium occidentale)*

Source: Fieldwork

Plate 26: Cola nuts (*Cola Acuminata)*

Source: (http://www.solarnavigator.net/solar_cola/cola_nuts.htm)

Plate 27: “Siriga”

(Pseudocedrela kotschyi)

Source: Fieldwork

Plate 28: “Kraman kote”

(Sphenocentrum jollyanum)

Source: Field research

Plate 29: “Ayigbe mogya duro”

(Pseudocedrela kotschyi)

Source: Field research

Plate 30: “Nyame dua”

(Alstonia bonnei)

Source: Fieldwork

Plate 31: “Kuminini”

(Lannia welnistseini)

Source: Fieldwork

Plate 32: “Adasamayaadi”

Source: Fieldwork

Plate 33: “Samia”

Source: Fieldwork

Plate 34: “Sanikasani”

Source: Fieldwork

Plate 35: “Tefashia”

Source: Field research

3.7.2 Extraction of dyes from identified plants

Dyes produced from natural materials are processed mainly by mechanical ways like grinding, crushing, or steeping in water. In extracting plant dyes under art studio conditions, Sowah (1979) advocates washing all the root, seed, fruit and leaf samples first, and cutting them into pieces before mashing or boiling them. He recommends adding water or alcohol to the stuff and then leaving it to stand for about 24 hours. Salt is added only to fix the dye. He mentions the need to collect assorted open tins and cans, sieve of 120 mesh, knives, stove, clean water, alcohol, cartridge paper, and salt as the materials required.

The plants from which dyes were extracted in the experiments and their local or botanical names were outlined as follows: For the purpose of easy identification of each plant sample, a coding system of labeling based on the first letters of the botanical names of the plants was adopted. This helped in sorting, describing and recording colour changes that occurred in the dye samples during the extraction process within the predetermined duration of the experiment.

3.7.3 Materials and methods used for the dye extraction

Materials: Empty tins, cans, a sharp knife, water, barks, roots, leaves of plant samples, stove for boiling.

Method: After securing the various materials needed for the experiment, the containers to be used were coded according to the first two letters of the name of each plant. This was done to prevent placement of samples into wrong containers and oversight of right matches and thereby ensure accuracy and total control of the research environment. The plants studied were coded as shown in Tables 3 and 4.

Table 3: Plants used on fabric

Name of plant	Botanical name	Code
Annatto	Bixa orellana	Bo
Kraman kote	Sphenocentrum jollyanum	Sj
Sobolo	Hibiscus Sabdariffa	Hs
Lalle	Lawsonia inermis	Li
Ayigbe mogya duro	Pseudocedrela kotschyi	Pk
Nim tree	Azadirachta indica	Ai
Bo womba gu woakyi	Phyllanthus nuriri	Pn
Camwood	Baphia nitida	S
Indian tamarind	Tamarindus indica	T
Onyama dua	Alstonia booni	Ab
Kumenini	Lennea welwitschii	Lw
Flamboyant fruit pods	Delonix regia	Dr
Sorghum leaves	Sorghum bicolour	Sb
Fresh mango leaves	Mangnifera indica	Mlf
Dried mango leaves	Mangnifera indica	Mld
Annatto	Morinda lucida	Ml
Mahogany	Khaya senegalensis	Ks
Fresh cashew leaves	Anacardium occidentale	Aof
Dry cashew leaves	Anacardium occidentale	Aod
Fresh teak leaves	Tectona grandis	Tgf
Dry teak leaves	Tectona grandis	Tgd

Table 4: Plants used on food

Name of plants	Botanical names	Codes
Prekese	Tetrapleura tetraptera	Tt
“Hwenteaa”	Xyanlopia aethiopicum	Xa
“Dawadawa”	Parkia clappertoniana	Pc
“Widie aba”	Momodora myristica	Mm
“Asaa” Miracle fruit	Synsepalum dulcificum	Sj
Jack fruits	Artocarpus incisus)	Ai
Sanikasani	Not found	Sn
Turmeric	Curcuma longa	Cl
Cola nuts	Cola acuminate	Ca
Pear seed	Persea Americana	Pa
Fresh pawpaw leaves	Carica papaya	Cpf
Dry pawpaw leaves	Carica papaya	Cpd
Adasamayadi	Not found	A
Siriga	Pseudocedrela kotschyi	Pk

3.8 Extraction of dyes and dyeing of textile samples

After the plant samples were collected, the empty containers were made ready for the experiment to proceed. This began by sorting the plant materials for the dye extraction into the respective parts: leaves, bark, seeds, and roots – and arranging them nicely into the respective labeled containers, adding just enough water to cover the samples and then boiling each one for a maximum of 30 minutes. Thirty minutes was chosen because the researcher realized at the preliminary stages of the experiment that when a plant sample was boiled for 10 minutes or less, the dye produced had neither the expected deep colour of a dye nor could it stain fabric well as any dye should. This lack of ability to dye led to an extension of the boiling time to 30 minutes for all the plants collected. This however, does not mean that the time frame gave the best of results for all plants. After boiling, each dye was poured out of its container into another labeled container and the test fabric immersed in the dye solution and left in it to enable the dyeing process go on.

This procedure notwithstanding, some of the test fabrics were dyed while the samples were still on fire as a way of checking the effect of higher temperatures on the dyeing quality. The results obtained proved that, higher temperatures aid fast absorption of dye molecules to the fibrous regions of the fabric thus giving darker shades of colours or dyes. In other words, the higher the temperature the higher the dye absorption. When the fabrics were dyed on fire it took less time for the fabrics to get dyed as compared to when the dye was poured and allowed to cool. Either way after dyeing, the fabric samples were hung on a drying line to allow dripping of excess dye, one set in direct sunlight and the other inside the room. After drying, the researcher collected all the samples and recorded the observed results of both samples: dried in sunlight and under normal room temperature.

The researcher also tested for wash fastness by washing the dyed samples with traditional laundry soap (Keysoap) and realized that some dyed samples showed major differences in their wash and light fastness by either fading grossly, slightly or in some cases rarely. Almost all the listed plants were tested on textiles but a selected number of them were tried or applied on food since matters of food needs strict scientific experiments to check their chemical bonds. The results of the experiments are provided in pages 63- 67 of the study.

3.9 Use of mordants

Materials - Empty containers, mordants (Soda ash, common salt, lime, alum and baking powder etc.) barks, roots and leaves of the plants (the dye extracts).

Method - The dye extracts were poured into mordant coded containers, and mordants added. Test fabrics were immersed in dye baths and observed. Results of the dyed samples were recorded and conclusions drew.

Result - See Table 5 which show the samples of colours obtained and subsequent mordanting with the various mordants.

3.10. Experiment with food colourants

The second part of the experiment involved extracting dyes from the plants collected as colourants for food (Plate 12-35). This part of the project was very important and at the same time delicate since food consumption is a matter of life and death. Since the colourants were to be used finally for food, the researcher started out by first looking at edible plants like *Bixa orellana* used in margarines and custards, *Hibiscus sabdariffa* (popularly called "sobolo" in Ghana), that is used as a beverage, *Sorghum bicolour* for colouring "waakye", Jack fruits *(Artocarpus incisus)*, *Miracle fruits (Synsepalum dulcificum)*, *"Dawadawa"(Parkia clappertoniana),*"Samia*"* and "Tefashia",

3.10.1 Materials and methods

Materials: Spaghetti (Plate 48), rice (Plate 49), yam (Plate 50), empty tins, cans, a sharp knife, water, salt, barks, roots, leaves of plant samples and stove for boiling. Method: After securing the various materials needed for the experiment, the containers to be used were coded as shown in Table 4. This was done to prevent mismatches of plants and materials, thus ensuring accuracy and total control of the research environment. The colourants extracted from the said plants and the food items (spaghetti, rice, yam) were put respectively in the coded containers and boiled. Salt was added to the content with a measured quantity of water. Boiling spaghetti took a maximum of five minutes while rice took about 15-20 minutes. Boiling yam took 20 minutes. The results of the aspect of reearch were recorded and presented in table 13.

Most of these dye-yielding plants which come as fruits or flowers are known to be used as drinks and beverages. Also, many plants considered as food colourants in this experiment were identified by the research informants in the Kumasi Central Market as traditionally having medicinal properties. A large number of them are used as aphrodisiacs.

CHAPTER FOUR

PRESENTATION AND DISCUSSION OF FINDINGS

4.1 Overview

This chapter describes the procedure of the experiment. The researcher adopted three major objectives of collecting data, which was collated and presented. It also deals with the analysis and the interpretation of the data collected from the field.

4.2 Presentation of findings

The presentation has been organised according to two main objectives namely:

- To visit the indigenous textiles centre at Ntonso and collect data on the natural plant dyes used by the local dyers and to ascertain dyes used in Ghana.
- To survey the Kumasi Central Market for information on food dyes and colourants that is locally used on food and other consumable products.

4.2.1 Objective One – Uses of Plant Dyes In Ghana

The trip to Ntonso was made successful by David, a local dyer who works with natural dyes. According to this informant, the dye he works with is obtained from the Badie (*Bridelia ferruginea*) plant which grows widely in the savanna areas of Ghana. He said the bark of the Badie tree is sold to them by traders who transport them from Kintampo to the dyers at Ntonso. On examination, the outer bark of the Badie tree bark looks very rough (Plate 36a) and has to be scraped off with a cutlass to expose the red inner bark (Plate 36b) which yields the dye. After scraping off the rough outer bark, the dyers cut the smooth pieces into smaller units and pound them with mortar and pestle (Plate 37) to obtain a textured fluff that allows water absorption and enable good extraction of dye.

Plate 36a: Badie tree bark

Plate 36b: Scraping Badie bark

Plate 36c: The scraped bark

ready for pounding

Plate 37: Pounding badie

bark into fluffy

Source: Field work

The resulting fluffy fibrous stuff is then put into a large container with water and boiled (Plate 38) for three hours after which this is either strained or sieved (Plate

39) and the solution further boiled for another four hours to obtain the black sticky dye just as Adu-Akwaboah (1994) describes.

Plate 38: Boiling Badie fluff

Plate39: Sieving the badie dye solution

After this lengthy series of boiling, the dye turns into a paste that is used in printing traditional symbols to create the design for Adinkra cloth as shown in Plate 40 and 41.

Plate 40: *Adinkra s*tamping process

Plate 41: Printed Adinkra cloth

Source: Field research at Ntonso

According to the respondents at Ntonso, the dyers extract another important natural black dye called "Kuntunkuni" from the roots of the *Kuntunkuni* (*Bombax* *brevicuspe*) tree. The roots are boiled in water (Plate 42) to obtain the dye. In this case, more roots are added till the required consistency of dye is obtained. The end product is a black dye that is used to dye cotton fabric as shown in the background of the Adinkra cloth (Plate 43) which serves as the foundation for printing Adinkra symbols as indicated. However, unlike the use of the *Badie* dye, the fabric has to be dyed in the *Kuntunkuni* root dye several times over to enable the dye seep into the pores of the fabric. It is reported that the *Kuntunkuni* root dye has such an unpleasant smell that when a fabric is dipped into it, the dye bath cannot be used again and has to be discarded. As a result, the dyers boil just enough roots to make the quantity of dye suitable for the measure of fabric they need in order not to waste it.

Quite apart from the beautiful prints produced with *Badie,* it is also used medicinally in treating stomach upset and as aphrodisiac. This notwithstanding, when the boiled residue of Badie is thrown away, it geminates into mushrooms. The kuntunkuni dye extraction and use in Adinkra cloth printing shown in Plates 42 and 43.

Plate 42*: Kuntunkuni* roots drip off excess dye

Plate 43: *Adinkra* print on black Kuntunkuni-dyed fabric

4.2.2 Objective Two –Food Colourants

The Kumasi Central Market and other places surveyed revealed that synthetic or chemical dyes are used to colour fried yam, turkey tail, pig feet, powdered pepper, palm oil, beef and pastries sold on the open market. According to the market women, the dyeing process involves adding the dry powdered synthetic dye to the food in the dry state or steeping the item in the dye solution. Imported trotters (pig feet) and beef are dyed red with "A Dainess Quality Product (Bright Red Powder)" shown in Plate 49, by diluting a measured amount in water that is determined by the quantity of meat they have to dye at a time. The beef or pig feet are then soaked in the coloured solution for some time and then removed for sale. This revelation compelled the researcher to visit the Kumasi Central Market and other markets to find out more about these chemical food colourants that could be harmful to the health of people who consume such dyed foods.

The market survey revealed that the colour of imported pig feet and beef that are sold in Ghana are generally whitish or the natural reddish colour of meat respectively but the traders choose to colour the two items with the colours with the intention of making them look more attractive. The traders confessed that some consumers are usually moved to buy the items by their outward appearance and so colouring pig feet and beef makes it easy to attract such buyers who make purchasing decisions based mainly on the colour. This notwithstanding, the traders said there are other consumers who know what they want and will not be swayed or lured into buying something outside the normal, so they exhibit the two items in the dyed and natural colours to meet the demands of the two categories of consumers.

To preserve these food items, a trader said they sprinkle salt on the beef and trotters after colouring them. The problem of food contamination gets worse where such dyed products remain in the chemical solution for a long time when purchase is delayed, considering the poor conditions under which many items are sold on the open market in Ghana. Plates 44 - 45 show the difference between the natural and dyed colours of imported pig feet and beef found in Ghanaian Markets.

Plate 44a: Natural colour of pig feet Plate 44b: Dyed pig feet

Source: Field research at Kumasi Central Market

Plate 45a: Natural colour of beef Plate 45b: Dyed beef

Source: Field research at Kumasi Central Market

Plates 46- 47 show samples of food colours used by traders in the Kumasi Central Market.

Plate 46: Colourant used for beef and pig feet

Plate 47a: Food colourants for cake

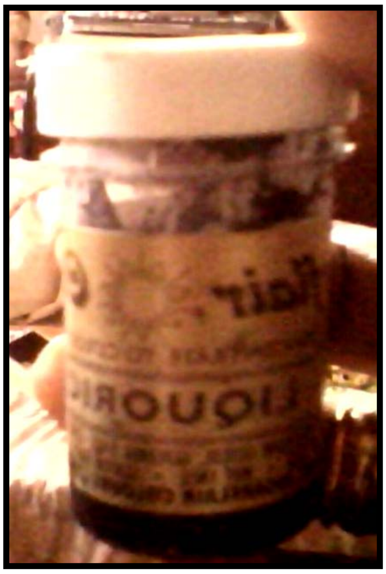


Plate 47b: Colourant for cakes

Plate 47c: Colourant for cakes

To substantiate the use of these food colours by the traders, the researcher bought a 500gm bottle of the powdered colourants which bore the inscription “A Dainess Quality Product (Bright Red Powder)” shown in Plate 46. Its constituents comprise-Sodium chloride, E124 Ponceau 4R, and E102 Tartrazine was tested as part of the research. The elements of the Bright Red Powder dye raised a lot of questions which propelled further search into its effects on humans, and the following results were obtained.

Sodium chloride-With increasing age, the kidney's ability to excrete daily net acid loads declines, invoking homeostatically increased utilization of base stores (bone, skeletal muscle) on a daily basis to mitigate the otherwise increasing baseline metabolic acidosis, which results in increased calciuria and net losses of body calcium. Those effects of net acid production and its attendant increased body fluid acidity may contribute to development of osteoporosis and renal stones, loss of muscle mass and age-related renal insufficiency. Because it is an azo dye, it may elicit intolerance in people allergic to salicylates (aspirin), (Microsoft Encarta 2009, http//en.wikipedia.org/wiki/).

E102 Tartrazine- Otherwise known as E number **E102**, **C.I. 19140**, or **FD&C Yellow 5**) is a synthetic lemon yellow azo dye used as a food coloring. It is water soluble and has a maximum absorbance in an aqueous solution at 427±2. The dye is derived from coal tar and has been banned in several countries (Austria, Norway) because of serious side effects such as causing potentially lethal asthma attacks and nettle rash, hives, DNA damage, tumors of the thyroid. A variety of immunologic responses have also been attributed to tartrazine ingestion, including anxiety, migraines, clinical depression, blurred vision, itching, general weakness, heatwaves, feeling of suffocation, purple skin patches and sleep disturbance http//en.wikipedia.org/wiki/Tartrazine).

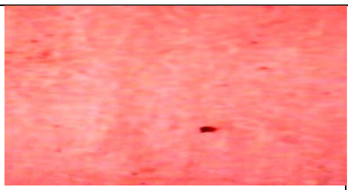
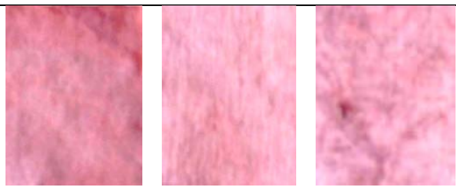
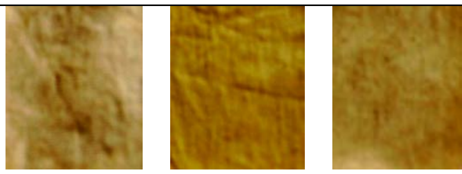
E124 Ponceau 4R

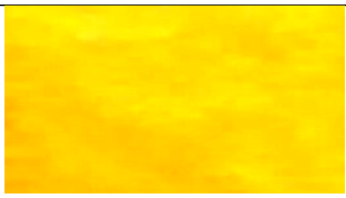
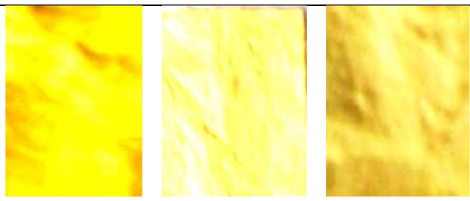
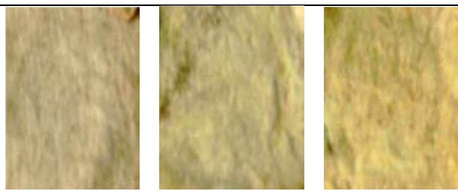
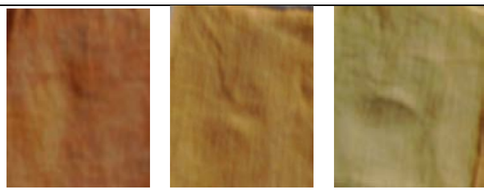
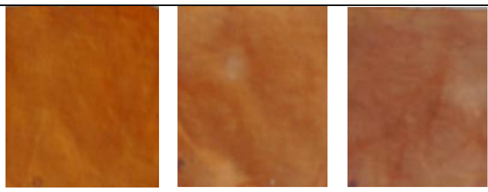
Because it is an azo dye, it may elicit intolerance in people allergic to salicylates (aspirin). Additionally, it is a histamine liberator, and may intensify symptoms of asthma. Ponceau 4R is considered carcinogenic in some countries, including the USA, Norway, and Finland, and it is currently listed as a banned substance by the U.S. Food and Drug Administration (FDA). Since 2000, the FDA has seized Chinese-produced haw flakes (a fruit candy) on numerous occasions for containing Ponceau 4R (http//en.wikipedia.org/wiki/Histamine). It is certain that, the Bright Red Powder has consequential effect on users thus the need to substitute with plant dyes which are not harmful to health.

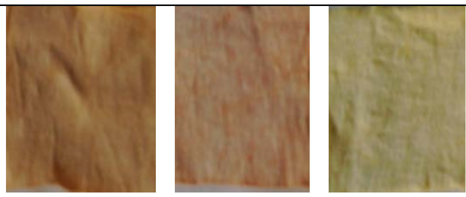
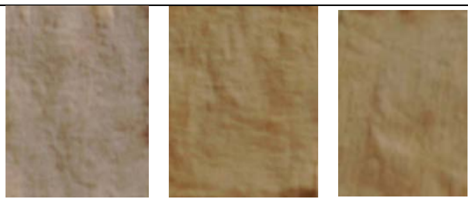
4.3 Table 5: Results of extracted dye applied on fabric

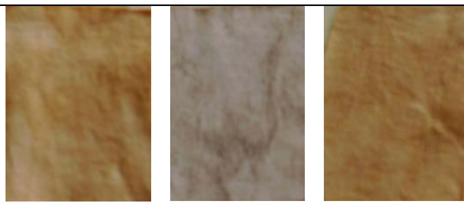
This section shows the colours obtained from the sampled plants and with mordants.

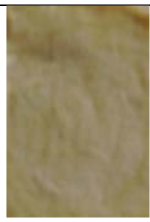
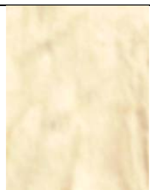
Name of plant	Original dye colour	Colour with mordants (A)-Alum, (B)-Baking powder, (C)-Lime
Bixa orellana		   A B C
Kraman kote (Sphenocentr-um jollyanum)		 A B C

“Sobolo” (Hibiscus sabdariffa)		 A B C
“Lalle” (Lawsonia inermis)		 A B C
“Ayigbe mogya duro” (Pseudoced-rela kotschyi)		 A B C
Nim tree (Azadirachta indica)		 A B C
“B) womma gu w’akyi” (Phyllanthus niruri)		 A B C
“Samia”		 A B C

"Tefashia"		 A B C
"Onyame dua" (Alstonia booni)		 A B C
"Kuminini" (Lennea welwitschii)		 A B C
"Sanikasani"		 A B C
Sorghum leaves (Sorghum bicolor)		 A B C
Fresh Mango leaves (Mangifera indica)		 A B C

Dry Mango leaves (Magnifera indica)		 A B C
Morinda lucida		 A B C
Mahogany (Khaya Senegalensis)		 A B C
Fresh Cashew leaves (Anacardium occidentale)		 A B C
Dry Cashew leaves (Anacardium occidentale)		 A B C
Fresh Teak leaves (Tectona grandis)		 A B C

Dry Teak leaves (Tectona grandis)		 A B C
Adasamayadi		 A B C
“Siriga”		 A B C
Cola nuts (Cola acuminata)		 A B C
Pear seed (Pesea americana)		 A B C
Fresh Pawpaw leaves (Carica papaya)		 A B C

Dry Pawpaw leaves (Carica papaya)		 A	 B	 C
“Prekese” (Tetrapleura tetraptera)		 A	 B	 C

The results of the experiment are the myriad of colours of dyes obtained from the various plants studied as shown in Tables 3 and 4. The table reveals distinctively the natural colours of the extracted dyes and when mordanted, produced the shades and tints as applied on the cotton fabric (Table 1), which was used to test the dyeing properties of the various plant samples. However, some of the plants used did not give satisfactory results with the fabric but were found to be more useful as food colourants as discussed in the following sections.

4.4 Discussions of dye results on textiles

During the experiment, it was observed that *Bixa orellana* seeds (Plate 5) have a rich red covering around the seeds which stain the hands on being handled and does not wash off very easily. When the seeds are removed and dropped in water, they infuse the water with a red-orange colour which is enhanced by boiling.

At certain stages of the experiment, there were considerable changes in the dye samples obtained from the various parts of the plants studied. The deterioration of these dyes was so fast that the researcher had to add lime juice, baking powder or alum as mordants to improve the stability and ledge or shelf life of these natural dyes being extracted under basic art studio conditions. Adding lime juice to the extracted dyes took away the pungent smell that is associated with boiling organic matter. When common salt was added to the dye extracts, they remained stable throughout the observation period and further prolonged their ledge life. It was also observed that the leaves of the various plants decayed faster than the bark and root samples which remained stable in the unused state.

In the case of dyes extracted from fresh *Mangifera indica*, "Adasamayadi", *Tectona grandis*, *Anacardium occidentale* and *Morinda lucida* roots, adding lime juice, baking powder and alum as mordants changed the original colours drastically. The process of mordanting had the effect of deepening or changing the original dyes from either a darker shade to a lighter one, or vice versa. The dye from *Adasamayadi* (Plate 32) for instance changed from a rich cream to brilliant yellow with baking powder and alum mordants respectively while the creamy orange dye from *Morinda lucida* (Plate 7) tree bark turned orange with baking powder, and yellow with lime juice. A light orange *Sanikasani* (Plate 34) wood dye turned darker with baking powder and yellow with lime juice while a pale *Hibiscus sabdariffa* dye (Plate 14) turned darker and stronger with alum, baking powder and lime juice. Alum, baking powder and lime had no observable effect on "Kuminini", *persea americana*, *Cola acuminata*, *Azadirachta indica* leaves and "Tefashia", the brown Henna *(Lawsonia inermis)* dye assumed a darker shade with all three mordants.

4.4.1 Wash fastness tests

Wash fastness with Key soap turned dyes from Henna *(Lawsonia inermis)*, dried Pawpaw *(Carica papaya)* leaves, "Onyame dua*"(Alstonia boonei)*, fresh Pawpaw leaves and dry Teak *(Tectona grandis)* leaves paler than the original colours, portraying them as unsuitable for regular use without mordants. On the other hand, the soap had no significant effect on the dyes of “Tefashia”, dry Cashew *(Anacardium occidentale)* leaves, “Kuminini” *(Lenea welwitschii),* and *Khaya Senegalese.* The fresh Cashew leaves rather dye changed from the original pale dye to a slightly darker shade.

4.4.2 Light fastness test

Observation done with light fastness revealed that for *Bixa orellana* and Teak dyes, direct sunlight changed the original colours of the dyed samples, exhibiting its deteriorating nature within time. In the case of “Samia” and Prekese *(Tetrapleura tetraptera)* dyed samples, there was no difference between direct sunlight and under room temperature yet, the two dyes were too pale and unsuitable for colouring fabrics.

Tables 6-11 illustrates details of results of the experiment, showing the names of samples, parts used and colour of dyes obtained.

Table 6: Shades of cream dyes

Plant	**Part used**	**State**
Nim tree	Leaves	Dry
Nyamedua	Root wood	Dry
Bo womba gu w’akyi	Leaves	Dry
Pawpaw	Leaves	Dry
Mango	Leaves/ bark	Dry
Prekese	Fruit	Dry
Samia	Fruit	Fresh

Siriga	Bark	Dry
Adasamayadi	Wood	Dry
Cashew	Leaves	Dry
Flamboyant	Seeds pods	Dry

Table 7: Shades of yellow dye

Plant	**Part used**	**State**
Kraman dua	Root wood	Dry
Tefashia	Bark	Dry
Pawpaw	Leaves	Fresh
Baphia nitida	Bark	Dry
Mango	Leaves/ bark	Fresh

Table 8: Shades of red dye

Plant	**Part used**	**State**
Tectona grandis	Leaves	Fresh & tender
Ayigbe mogyaduro	Wood	Dry
Khaya Senegalese	Bark	Dry
Bixa orellana	Seeds	Fresh & tender
Lawsonia inermis	Leaves	Fresh & tender

Table 9: Shades of orange dye

Plant	**Part used**	**State**
Bixa orellana	Seeds	Dry
Sanikasani	Bark	Dry
Siriga	Bark	Dry
Morinda lucida	Root wood/bark	Fresh

Table 10: Shades of pink dye

Plant	**Part used**	**State**
Hibiscus Sabdariffa	Leaves/stalk	Dry
Tectona grandis (teak)	Leaves	Fresh
Sorghum colour	Leaves/stalk	Dry

Table 11: Shades of brown dye

Plant	**Part used**	**State**
Lawsonia inermis	Leaves	Dry
Cola nuts	Fruit	Dry/fresh
Pear seed	Seed	Fresh
Cashew	Leaves	Dry
Khaya Senegalese	Inner bark	Dry

Table 12: Shades of black dye

Plant	**Part used**	**State**
Kuntunkuni	Bark /roots	Dry

As can be seen from the Tables, all the plants used for the experiments are viable and have some possibility of being used as sources of dyes to colour food and textiles.

4.5 Results of dye application on food

The coloured food items are illustrated in Plates 48-50.

Plate 48: Spaghetti

Plate 49: Rice

Plate 50: Yam

Table 13: Food items boiled in *Tefashia* solution

Names of Plants	Cooked Rice	Cooked Yam	Cooked Spaghetti
"Tefashia"			

The rich golden yellow colour obained by boiling rice, yam and spaghetti in "Tefashia" extracted colour, are aesthetically pleasing, attractive and highly decorative for parties. This notwithstanding, the food items coloured with "*Tefashia*" could easily be taken for "curry powder" equally a natural plant colour commonly used in foods by caterers. Traditionally *Tefashia* is used as medicine to cleanse the system of pregnant woman of phlegm and also strenghten them through to delivery of the child.

Table 14: Food items coloured with Hibiscus Sabdariffa dye

Name of plant	Spaghetti	Drink	Beef
Hibiscus sabdariffa			

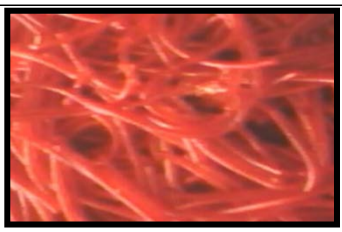
The *Hibiscus sabdariffa* dye presented unsuccessful and unattractive colours for spaghetti and beef. However, the drink produced from it looked very pleasing and mouth watering just as normal wine produced from berries. This plant is a folk medicine used as an antiseptic, aphrodisiac, astringent, cholagogue, diuretic, purgative, tonic for coughs, cancer, fever, heart ailment just to mention a few. Medicinally, the leaves, seeds and ripe calyces are diuretic and refrigerant.

Table 15: Drink made from Samia

Name of plant	Drink
"Samia"	

The brown colour obtained from *Samia* solution looks like traditional ginger beer popularly brewed as a traditional drink in the Northerners parts of Ghana. It could also be compared to the well known Ghanaian cocoa drink in colour but not in taste because; *Samia* has a biting effect after sipping.

Table 16: Food item coloured with sorghum colour

Name of plant	Spaghetti
Sorghum colour	

The *Sorghum colour* proved unsuitable for spaghetti but more suitable with rice and beans, a local delicacy known as "shinkafa-da-waakye". The *Sorghum bicolour* is also used for the production of alcoholic beverages, drinks and sorghum syrup. Sorghum is a traditional staple food that is a little-known grain with high potential to improve nutrition, boost food security, foster rural development and support sustainable land care in places which experience much drought. Furthermore, sorghum's protein level of typically 9% enables dependent human populations to subsist on it in times of famine. Numerous sorghum species are used for food and in "sorghum molasses", fodder, as well as bio-fuels (www.fao.org).

4.6 Summary of discussion

The results of the experiment shows that some of the sampled plant dyes are suitable for the food industry where the importance of a dye is not its ability to remain colourful for a long time but is mostly used as a means of concealing the real nature of the food item or to give it aesthetic appeal only. In this connection, *Bixa orellana, Tetrapleura tetraptera* (Prekese), *Synsepalum dulcificum* (Miracle fruit), "Samia", *Hibiscus sabdariffa*, *Sorghum bicolour* leaves, Jack fruit, Dawadawa *(Parkia clappertoniana)*, "Hwentea" *(Xyanlopia aethiopicum)*, "Wedie aba" *(Momodora myristica)* and Avocado pear *(Persea americana)* are suitable for use in the preparation of drinks, beverages, cakes and pastries, and for other cooked food items.

As the second part of the experiments relates to the use of food incorporated to make it appeal to the senses of smell, sight and taste, the results indicate that getting natural dyes which can give food items the right appearance, aroma and taste will have very positive implications for improving the presentation, wholesomeness and appeal of the variety of food items provided on the local Ghanaian market. Since most of the plant samples researched is used locally as food colourants, additives and medicinal remedies, the researcher found it rather timely to prepare a drink out of *hibiscus sabdariffa* which is locally called *"Sobolo"* (Plates 14a and 14b). This involved placing some flowers of the plant in a big bowl with water, adding chunks of pineapple peels (to serve as flavour), "*Wedie aba*" (Plate 18), ginger, *Hwentea* (Plate 16), and then sugar for taste. The mixture was left to simmer on low fire for

15-20 minutes and left to cool. The result was a fruity, aromatic and attractive wine coloured drink that no one will refuse. The ready-to-drink cocktail can be bottled and served chilled with any food.

Another fruit very common in the Muslim community is *"Samia"* (Plate 33). The fruit was first soaked in water for some time, boiled with ginger, "Hwentea" and other traditional spices. On cooling sugar was added, then chilled in a refrigerator and served. Furthermore, the yellow dye extracted from "Kraman kote" *(Sphenocentrum jollyanum)* (Plate 28) which was found very useful in dyeing textiles, was also tested in colouring cooked yam but it yielded little effect. On the other hand, the *Tefashia* dye (Plate 35) used in colouring rice appeared yellow just as curry powder does when used in boiling rice. However, some of the plants could not be used as dyes for fabrics or as food colourants because they lacked the ability to stain, yet found use as flavoring agents and as food sweeteners. Examples of these include Miracle fruit (Plate 22), "Prekese" (Plate 15), *"Hwentea"* (Plate 16) and *"Wedie-aba" (*Plate 18).

In addition, the mealy yellow "pulp" in which the seeds of *Dawadawa (Parkia clappertoniana)* (Plate 17) are embedded, are extracted and eaten in the dry state, or made into cakes, dried and sold on Ghanaian markets as flavouring for soups, meats, sauces and other purposes. It is sometimes made into drinks and is very rich in protein. The roots and leaves of this plant are pounded with water and used as an eye wash in Nigeria while a bark infusion is used in Cote d'Ivoire as a tonic for diarrhea and enema (Irvine, 1961).

Finally, it can be inferred from the literature, field data and the interesting results of the experiments that all the plants studied do not only yield viable dyes that can be used to promote quality teaching and learning of Visual Arts and Home Economics but, they also have potent medicinal properties as Irvine's study (1961) of woody plants of Ghana indicates. This information was confirmed by research material and information obtained from the Centre for Scientific Research into Plant Medicine (CSRPM) at Mampong Akuapim where all the plants studied have been used in the production of several medicines for fever, malaria, diabetes, hypertension and many other tropical ailments. This research, though on a small scale and also as an art project and not a scientific project, holds promise for making indigenous knowledge on scientific material readily available to the reading public.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Overview

The end of a thing is more important than the beginning, thus, a summary of the relevant points and findings revealed by the study, the informed conclusions and beneficial recommendations are important elements that should convey the relevant material derived from the study to promote discussion on effective teaching and learning of technical and aesthetic skills.

5.2 Summary

The extraction process focused on bark, leaves, seeds, whole fruits, and root samples of 30 different plants, each of which has known medicinal properties and traditional uses for various ailments and diseases. From these, 27 yielded strong dyes that coloured cotton fabric without applying any mordant. However, when lime juice, baking powder and alum were applied as mordants to these dyes, they only caused slight changes to the colour of dyes obtained. When yam, rice and spaghetti were cooked in selected dye solutions, *Tefashia* dye turned the natural cooked colours gold as if curry powder was put in the water.

Prekese (Tetrapleura tetraptera), Widie aba(Momodora myristica), and *Hwentea (Xyanlopia aethiopicum)* which are known traditional spices, only found use as flavouring for drinks produced from *Hibiscus Sabdariffa*, *Tefashia*, *Sorghum bicolour* and *Samia* plants. Tests with the *Sorghum bicolour* dye proved its suitability for colouring rice while *Hibiscus Sabdariffa* found use as a natural drink. The results suggest that very aesthetically pleasing colours of natural dye and food additives can be derived from the local environment. These can be adapted for effective teaching and learning of colouring techniques in Visual Arts and Home Economics. The results also indicate the feasibility of local plants dye extracts as suitable organic replacements for the chemical colourants used in the textiles and food industry.

It is important that teachers and students explore and adapt resources in the local natural reserves for promoting increased artistic productivity, versatility, creative skills, and variety with employing environmental materials to produce art works. The success of this study has potential for textile dyers and personnel in food art such as those engaged in cake and confectionery craft who must explore the potential of plant products for their decorative art so that, they can create aesthetically pleasing, healthy and attractive consumable products that result from imaginative thinking.

These natural raw materials can help improve the appeal of many local foods the same way as margarine manufacturers add yellow colouring to make their product look like butter. The beautiful colours can give various textile and food products the appeal that consumers cannot overlook in making purchasing decisions. Besides, these natural dyes can ensure the safety and wholesomeness of processed food and promote healthy living just as parts of the plants are used for healing purposes.

5.3 Conclusions

The purpose of this project has been to explore the natural reserves, identify plants from which dyes can be extracted and applied to food and textiles. This task was accomplished by means of assisted visits to various locations to identify, photograph and collect samples of the plants for the experiments; interviews with some indigenous dyers and observation of traditional processing techniques and uses of the dyes; and experiments to explore the dye yielding properties, possibilities in extracting dyes from the identified plants under basic art studio conditions, and their suitability for colouring textiles and food. The aim was to seek ways to expand the raw material base to sustain the teaching of “Colour” which is an integral component of the Visual Arts and Home Economics curricula in particular; making indigenous knowledge available to teachers and students; and creating awareness for the potential in such art projects as a basis for teaching basic Science, and employable skills that could be gained by students, teachers, food craft technicians, and the unemployed.

The result of the experiment with different parts of the identified plants was a remarkable range of colourful direct dyes of various shades and tints. The dyes were colourfast on cotton fabric and could be used directly without mordants to teach basic skills in tie-dye, batik. Several of these natural dyes could be used to colour textile products such as raffia, jute yarns and cotton thread for teaching macramé, crocheting and food. The coloured dye extracts on textile fabric and food cannot be over emphasized. For instance the yellow dye obtained from *Tefashia* gave a brilliant colour to a cotton fabric whiles at the same time, serving as a yellow food colourant for boiled rice, spaghetti and yam just as curry powder and saffron do with food.

In addition, evidence from the study also revealed a lot more than just colour which was the prime objective. The results as seen in the previous chapter lays bare the potentials of local plant dye extracts that can be used as colourants for food and textiles. It is however, imperative for the food and textiles industry to develop effective strategies for incorporating this experiment on plant dye extraction into their core research and development business so that they can explore the other plants and come up with more scientific ways of producing and preserving these plant dyes and food colourants for extensive use. The study further highlights the need to tap existing indigenous knowledge and understanding of plants to promote art education and technical skills development so that traditional values can be incorporated in the schools and colleges curricula towards the creative educational development particularly in the vocational subjects. This exercise also offers opportunity for teachers and their students to get firsthand information about the nature of the plants, their characteristics, local and botanic names, medicinal value, dye-yielding quality, and their uses in Ghana and other parts of the world.

Since the dye extraction and application project involves visits to nature reserves and the indigenous textiles production centers where plant dyes are traditionally used on a large scale, the students will be knowledgeable in using dyes extracted from plant source for use as colourants for food and textiles to sustain life and generate employable skills. This will also offer opportunity for students to learn skills in tie-dye, batik, printing, dyeing of yarns for macramé, and crocheting at little or no cost and only buy synthetic dyes and food colourants for examination purposes since WAEC does not recognize the use of natural dyes and pigments for this purpose.

5.4 Recommendations

The benefits of exploring plant dyes and their application on food and textiles will improve the socio- economic and artistic development of the nation. In view of the results of the study the following are recommended for consideration.

1. The Visual Arts departments in Senior High Schools, Polytechnics and the Universities could use the results of the study as resource material for teaching creative skills in the dyeing of fabrics, fibres, yarns, tie-dye,

batik, macramé, jute yarns, thread and twine for crocheting, straw for basketry, leather, and some techniques in painting.

2. Home Economics departments or practitioners should adapt the study to educate their students on the health benefits of natural food colourants and incorporate the natural dyes into their cookery syllabus to encourage their use in practical lessons. They could further explore the possibility of making drinks, beverages and wines from various parts of the identified plants to serve as a replacement for synthetic food additives, by extracting the dyes to colour rice, spaghetti, fried yam, meat, cakes, bread, chicken, ice cream, yoghurt and other food items to reduce expenditure, promote plant production and increase employment avnues for the youth in Ghana.

3. Vocational institutions, Non-Governmental Organizations, public and private agencies involved in skills training and youth employment can engage their trainees in the cultivation of herbal plants for sustainable extraction of dyes that the CSRPM could further develop and make available to educational institutions, the textiles and food industry, as well as for the pharmaceutical and beverages industry.

4. The Ministry of Education and Ghana Education Service should liaise with WAEC to allow the use of natural dyes and pigments in place of conventional art materials for examination project works to encourage schools to research into plant material for course work. A policy on this would create room in the creative arts for students to produce their own dyes from environmental resources and thereby reduce educational costs.

5. The Ministry of Education and Ghana Education Service should liaise with the CSRPM to make their knowledge, expertise and documentation on local plants available to train teachers to identify and process them into dyes and colourants that they could use to guide their students to explore, extract and apply the plant dyes to their course work.

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