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Assessment of the Potentials of Dyes Extracted from Selected Plants on Cotton Fabric

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Abstract

The research work was focused on assessment of the potentials of dyes extracted from selected plants; curcuma longa (Turmeric), spinacia olerecea (spinach) and lunchocarpus cyunescens (Anunu) on cotton fabric. The aforementioned plants were extracted through an aqueous method to produce dye used in dyeing 100% cotton fabric which is the scope of the study. The study was undertaken to assess the acceptability of the resultant products which is the main objective. Descriptive analysis (mean) was used to analyze the results and one way analysis of variance (ANOVA) was used to calculate the result at 0.05% least significant difference. The above mentioned plants extracts were used separately to tie-dye the cotton fabrics. The spinacia olerecea (Spinach) was the least accepted from the panelists of 20 experts. However, there was no significant difference between the cotton fabric dyed with Curcuma longa (Turmeric) and the cotton fabric dyed with vat dye as the control sample with respect to beauty, sharpness, colorfastness and general acceptability. The mean values for the general acceptability products ranges from 5.55, 5.95 and 6.90 of Spinach, Anunu and Turmeric respectively. Three recommendations were made: (1) Turmeric plant should be planted in large quantity so that it could be readily available for use in producing dye for fabric. (2) Further work should be done in the various methods of extracting pigments from these plants and with some other plants found around the house. (3) It is also recommended that these dyes should go into large scale domestic and commercial production.

Keywords: *Potentials of dyes, Plants, Cotton fabric*

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Background to the Study

Generally, consumers are interested in the stability and fastness of dye colors to their clothing. Colorfastness is the characteristic that makes textile products useful over a long period of time. One of the major reasons why textile products are discarded is that they have lost their color. Colors may fade under exposure to sun, dry cleaning, weathering, washing, perspiration and abrasion which is most common with dyed fabrics (Anyakoha and Eluwa, 2010)

Dyes: A dye is a colored substance that has an affinity for the substrate to which it is being applied. Dye is generally applied on an aqueous solution and requires a mordant (substance used to set dye on fabric) to improve the fastness of the dye on the fabric. Dyes and pigment appears to be colored because they absorb some wavelength of light. In contrast with dye, a pigment is generally insoluble and has no affinity for the substrate. Natural dyes are pigments, requiring a mordant to fix them to the fabric. Dyes from natural sources are gotten from barks, roots, leaves, flowers of plants, insects and some specific animals while others are chemically produced. Those ones chemically produced are referred to as synthetic dyes. Dyes are applied according to the type of fabric being used and the desired result.

Types of Dyes and Dyeing Methods

There are various types of dyes and methods of dying, but this study was basically focused on one method which is "tie and dye".

The process of applying color to fiber, stock, yarn or fabric is called dyeing. There may or may not be thorough penetration of the colorant into the fibers or yarns.

Dyes can be used on vegetable, animal or manmade fibers only if they have affinity to them. Textile dyes include the following:

1. **Acid Dyes**, used mainly for dyeing wool, silk and nylon and direct or substantive dyes, which have a strong affinity for cellulose fibers.
2. **Mordant dyes** require the addition of chemical substances, such as salts to give them an affinity for the material being dyed. They are applied to cellulose fibers, wool or silk after such materials have been treated with metal salts.
3. **Sulfur dyes**, used to dye cellulose, are inexpensive, but produce colors lacking brilliance.
4. **Vat dyes,** insoluble in water, are converted into soluble compounds by addition of alkaline and sodium hydrosulfite. These colorless compounds are absorbed by the cellulose, which are subsequently oxidized to an insoluble pigment. Such dyes are colorfast.
5. **Disperse dyes** are suspensions of finely divided insoluble, organic pigments used to dye such hydrophobic fibers as polyesters, nylon and cellulose acetates.
6. **Reactive dyes** combine directly with the fiber, resulting in excellent colorfastness. The first ranges of reactive dyes for cellulose fibers were introduced in the mid-1950. Today, a wide variety is available.

Objective of the Study

The major objective of this study was to determine the potential of dyes extracted from Spinaciaoleracea,(Spinach) Curcumalonga(Turmeric), and Lonchocarpus Cyanescens (Anunu).The specific objectives were to:

1. Extract pigments from Spinaciaoleracea, (Spinach) Curcuma longa (turmeric) Lonchocarpussericeus (Anunu).for the purpose of dyeing;
2. Ascertain the potentials of pigments extracted from the different plants on the cotton fabric in beauty;
3. Compare the potentials of pigments extracted from these plants on the cotton fabric with that of vat dye in colorfastness;
4. Ascertain the differences in sharpness of cotton fabric dyed with these plants pigments;
5. Access the differences in general acceptability of cotton fabric dyed with these plants pigments.

Statement of the Problem

The fading of clothes especially dyed ones is a problem common with contemporary fabrics which has become a major problem to the homemakers. Questions arise daily about the quality of dyes used on fabrics to produce household materials. Most vegetable dyes are now superseded by artificial dyes; vat dye and other products of coal tar are still commercial important and are generally considered more permanent because some plants have not been considered important sources of natural dye. Due to permanent effect these synthetic dyes give to the fabric, it has made the vegetable dyestuff look inferior, but this study is designed in achieving a permanent effect on cotton fabric dyed with the dyes extracted from the aforementioned plants.

Research Questions

This research is tailored toward answering the following questions;

1. How can the pigments extracted from Spinach, Turmeric and "Anunu" be useful to the homemaker, clothing and textile students, and the society?
2. What is the quality of pigments extracted from the specific plants on cotton fabric in terms of beauty?
3. What are the results of the pigments extracted from these plants on cotton fabric in colorfastness when compared with that of vat dye?
4. What are the differences in sharpness of cotton fabrics dyed with the extracted plants pigment?
5. What is the acceptability of cotton fabric dyed with the extracted plants pigments?

Literature Review

Natural Dyes

Cultivation and use of dye plants was very common in Europe up to the end of the 19th century; pigments from leaves, fruits, seeds, wood and roots were used as dye stuffs for textiles, paint in art and craft. The discovery of synthetic dyes led to a breakdown of the natural dye market and, as a result, cultivation of dye plants came to a standstill. Natural dyes, made from plants, animals and shells provide important alternatives to

petrochemical-based dyes and, if harvesting is carefully managed, offer environmental and social benefits in comparison with synthetic dyes (Thomson, 2013). Natural dyes have large variations in color tone, because of the quality differences of different provenances of the dye plant. They obviously require longer, slower dyeing treatments to achieve good color, particularly for vegetable fibers, making the process more costly than dyeing with synthetics. One of the reasons why chemical dyes are suitable for commercial purposes is that the cloth from every dye bath will be almost identical in color; one of the pleasures of dyeing with herbs is that no two baths will ever give exactly the same results, there will always be an element of surprise, with variations according to the season, the weather, the maturity of the plant, its position in the sun or shade and the quality of the water used for dyeing (ObuteandOsuji,2002)..

Yet the higher cost, subtle color variation and greater demands on time means that natural dye technology has a particular cachet and quality that works well in specialist production. According to Igbo (2013), over the last few years synthetic dyes have been losing good reputation because of the risk of toxicity, negative influence on the environment and high allergic potential. Consequently, an increasing demand has naturally developed. Really, no chemical dye can achieve quite the depth and lustrous effect of many plant dyes (Simon, 2000). The rich and subtle variations of tone and color derived from plants may mellow and soften with time but never will lose their natural harmony.

Varenya *et al (*2014), stated that the use of colorants dated back to thousands of years ago in all societies around the globe. Even before people began to spin yarn and weave cloth, they applied colored earth, plant saps and juices directly to their skin: this was the first type of cosmetics. Among the ancient peoples, the Egyptians of the Middle kingdom not only dyed textiles but also understood the use of mordant (metallic salts with an affinity for both fibers and dyestuffs that improved the colorfastness of certain dyes).

The Phoenician dye industry, begun in 15th century BC, was renowned for its Tyrant purple, or royal purple obtained from a species of shellfish processed in the city of Tyre, which actually produced a range of colors from red to blue, including violet. India, the country whose dyeing practices have exercised the greatest influence on European dyers from the 16th century, appears to have had a dye industry long before its transactions were recorded in writing, perhaps extending to the period of the Indus Valley civilization 2500 BC. Dyers in India and southeast Asia not only mastered the art of producing bright colors on cotton, but also developed techniques for printing colors on woven fabric and making designs with resisting dyeing. Marco Polo described in detail its indigo manufacture during the 13th century AD, about three hundred years before the Portuguese introduced it to Europe. Our major dye plants, along with our staple foodstuffs and a vast dispensary of medicinal plants, were all recognized thousands of years ago. Most modern people, who shop for food and drugs in supermarkets and buy their clothes already colored, are relatively unaware of the plants in their neighborhoods; if they think about them at all, they feel bewildered by all the different kinds of grasses, herbs, bushes and trees, and can't imagine how anyone could ever tell one from another.

Earlier generations of people had a deeper love for the environment and explored it very thoroughly. So they learned which plants were nourishing and which were poisonous, which contained fibers, which provided dyes, which were narcotic. Sooner or later, they found all the good stuff. For example, the blue pigment indigo is invisibly present in several completely different kinds of plants, but ancient dyers found these varied sources and learned to extract indigo and use it as a dye.

Methods of Dyeing

1. **Tie dyeing**: is a hand method in which certain areas of the fabric are so prepared that they resist being dyed when the fabric is placed in the dye solution. Tie-dyeing literally means that small puckers of fabric are tied securely by thread. It is these tied areas that resist the dye. After the fabric is dipped into the dye solution, it is rinsed, dried and tied areas unknotted (Anyankoha and Eluwa 2010)
2. **Batik Dyeing:** This is one of the oldest forms known to man. It originated in Java. Portions of the fabric are coated with wax so that only un-waxed areas will take on the dye matter. The operation may be repeated several times and several colors may be used for the bizarre effect
3. **Beam Dyeing:** In this method the warp is dyed prior to weaving. It is wound onto a perforated beam and the dye is forced through the perforations thereby saturating the yarn with color.

Cotton: Cotton botanically called *Gossypiumhirsutum* is one of the most versatile, traditional and popular fabrics available to man, which has been used for making cloths for many centuries. It is a natural raw material gotten from cotton plant and is made by twisting together the long hairs that covers the seed of pods of the cotton plant. These fibers vary in length and thickness and have an absorbent quality, making cotton soft and comfortable to wear (Hughs et al, 2008). Due to absorbent nature of cotton fiber, the fabric is suitable for home dyeing and for teachers of Home Economics in primary, secondary and tertiary institutions. Cotton is an agricultural crop that grows in warm, moist climates or in warm dry climates with moisture supplied by irrigation (Igbo, 2013). For at least 5000 years, cotton has fulfilled man's need as a textile fiber for clothing.

Spinach: (Indian spinach) botanically called *Spinacia oleracea* is an edible flowering plant in the family of Amaranthacea. It is native to Central and Southwestern Asia. It is an annual plant (rarely biannial), which grows to a height of 30 cm. Spinach may survive over winter in temperate regions. The leaves are alternate, simple, and oval to triangular-based, very variable in size from about 2–30 cm long and 1–15 cm broad, with larger leaves at the base of the plant and small leaves higher on the flowering stem. The flowers are inconspicuous, yellow-green, 3–4 mm diameter, maturing into a small, hard, dry, lumpy fruit cluster 5–10 mm across containing several seeds (Joseph, 2013).

Turmeric, botanically called *curcuma longa* is a rhizomatous herbaceous perennial plant of the ginger family, Zingiberaceae. It is native in southeast India, and needs temperatures between 20°C and 30°C and a considerable amount of annual rainfall to thrive, which is 60-90cm high. It has a short stem. It has large leaves oblong and up to one

meter long. Flowers of turmeric appear on a spike like the stalk. Its flowers are yellow white in color. They are sterile and do not produce viable seed. The lamina is green above and pale green below, and is 30 -40 cm long and 8 -12 cm wide. Approximately 30 flowers are produced in a spike. Inflorescence is a central spike of 10 -15 cm in length. Its pant looks like the ginger plant (http://en.wikipedia.org/wiki/turmeric).

"Anunu", botanically called *Lonchocarpuscyanescens* commonly found in the leguminous family is a plant with leaves and young shoots, sometimes also the flowers and fruit, are collected from wild plant which are usually spread in clearing the bush, or from regular plantations in which the plant is cut back and grown as a shrub 7-8 ft. high. Fresh leaves of *L. cyanescens* in South Nigeria have been found to yield from1.1-3.6 Oz per 100ibs, and the product may contain up to 43% of indigotin, which is less than that of the best Indian indigo (60%). Dried leaves may yield less than 1% of indigotin, but experimental extraction by the Indian vat method has shown that indigo of good quality containing up to 56% of indigotin can be obtained from the plants of West Africa (Burkill, 2012).

The scarcity of dye and the production of dye stuff have been a problem facing the production of colorful and wonderful designs on fabrics, the production of various types of synthetic dyes with some hazardous chemicals has become a threat to the homemakers, students of clothing and textile and also to the country at large.

Methodology
Design of the Study: Experimental research design was used for this study.

Area of the Study: The experiment was conducted at Michael Okpara University of Agriculture, Umudike in the food and clothing Laboratory of home Economics.

Population for the Study: Twenty semi-trained panelist which comprised students and staff of the Department of Home Economics were used for the assessment comparison. The attributes assessed were beauty, sharpness and general acceptability of the cotton fabrics dyed with the pigments from the selected plants.

Sample and Sampling Techniques: The turmeric, spinach *and "anunu"* were gotten within the university premises. The Vat dye, Caustic soda, Hydrous, vinegar, alum, twine and cotton fabric were all purchased from Umuahia main market (Ubani). While the other materials like the electric blender, old pot, scissors, muslin cloth, medium sized bowls, industrial hand glove, measuring cups mortar and pestle, knife, chopping board, stove, salt, sieve and water used were all gotten from the food and clothing laboratory. The plants were harvested fresh in the morning of the experiment, sorted, washed with cold water and placed in a sieve to drain; while the cotton fabric was already laundered to ensure dyeing efficiency. (See appendix A for raw materials).

The laboratory Phase: In the laboratory, the skin of the Turmeric was scrapped and diced into smaller sizes to enable it blend effectively. The fresh leaves of the Spinach and "Anunu" were sliced into smaller sizes. The turmeric and the spinach were taken to the

food laboratory for blending because they are edible plants while the "Anunu" was grinded with the mortar and pestle because it is not edible. The two sample spinach and turmeric was blended with 250ml of water respectively while the "Anunu" leave was pounded until it turned into paste. 1,000ml of water was added to the "Anunu" paste to get a mixture. The turmeric and spinach solution were diluted with 750ml and 500ml of water respectively. Standard muslin cloth was used to separate the residue to obtain the extracts (filtrate). The extracts were labelled A, B, and C for Turmeric, Spinach and "Anunu" respectively. The method used was an aqueous extraction.

Recipes/ Procedure for Dyed Cotton Fabric with Turmeric (Sample A)
100g of turmeric root, 750ml of water: The extract was poured into an old pot and the fabric (already treated with mordant) was placed into the extract and was allowed to boil up to boiling point stirring occasionally with a spatula. The solution was brought down, cooled and washed in cold water until the water runs clear.

Recipe/ Procedure for Dyed Cotton Fabric with Spinach (Sample B)
500g of spinach leaves, 500ml of water: The extract was poured into an old pot and the fabric (already treated with mordant) was placed into the extract and was allowed to boil up to boiling point (under low heat) stirring occasionally with a spatula. The solution was brought down, cooled and washed in cold water until the water runs clear.

Recipes/ Procedure for Dyed Cotton Fabric with "Anunu" (Sample C)
500g of "Anunu" leave, 750ml of water:
The extract was poured into an old pot and the fabric (already treated with mordant) was placed into the extract and was allowed to boil up to boiling point stirring occasionally with a spatula. The solution was brought down, cooled and washed in cold water until the water runs clear.

Recipes/ Procedure for Dyed Cotton Fabric with vat Dye (Sample D)
1 teaspoon of caustic soda,1 teaspoon of hydrous,1 teaspoon of yellow vat dye:
The three ingredients were mixed together in a plastic bowl until they become even.
In the plastic bowl, boiling water was poured inside and stirred to dissolve the mixture. The cotton fabric was added to the solution and allowed to absorb dye. Wearing a rubber glove the cotton fabric was turned the other way for it to absorb dye. The fabric was removed and washed in cold water until the water runs clear.

Instrument for data Collection: Seven point hedonic questionnaire and experiment test were used to determine the difference in beauty, sharpness, colorfastness and general acceptability of the dyes extracted with water from *turmeric, spinach and anunu* on cotton. The resultant effect of the cotton fabric dyed with vat dye was compared with that of the three samples. The panelists assessors chosen were experts and considered appropriate. According to Onwuka (2005), a small panel of highly trained and experienced expert assessors will be capable of discriminating and describing suptle differences between samples.

The analysis of Variance (ANOVA), least significant difference (LSD) and the like scale analysis of hedonic scale were used to test for the difference among the samples. Reliability of the instrument was determined through pilot test. This involved using the dyes separately on 5 inches of a clean cotton fabric and was examined by five – six same persons. From the pilot test, it was observed that vinegar was the most effective among the three mordant used (Alum, Salt and Vinegar).

Data Collection and Analysis Techniques

The analysis of variance (ANOVA), least significant difference (LSD) and the like scale analysis of hedonic scale were used to test for the difference among the samples. Like scale was employ ed to test the level of acceptability. The seven point hedonic scale ranges from dislike extremely to extremely like (1 – 7). From the likeness scale and the fastness scale of data collection, the decision point was from the range of 5-7.The processes employed was according to Riekier (2006).

Results

The following findings were made from the Study:

Table 1:Anova Table for the four Parameters being Evaluated

SN	Sample	Beauty	Sharpness	Colorfastness	General Acceptability
1	A	6.8000[a]	6.8500[a]	6.3500[a]	6.9000[a]
2	B	5.5000[a]	5.0500[b]	5.8000[a]	5.5000[b]
3	C	6.1000[b]	5.5500[b]	6.1500[a]	5.9500[b]
4	D	6.6000[a]	6.4500[a]	6.2500[a]	6.7000[a]

i. **Beauty**: Table 1 showed a significant difference ($p< 0.05$) in beauty among the samples in comparison with the control sample D. However, there was no significant difference between sample A and the control sample D. sample A was extremely liked thus beautiful sample B is least beautiful than the other samples. The mean value for beauty ranged from 5.55 – 6.80

ii. **Sharpness:** From the table above, sample B was least with the mean value of 5.05 and a total score of 101 out of the highest score of 137 with a mean value of 6.85 for sample A.In comparison, sample A is sharper than sample B, and C but there is no significant difference with sample D

iii. **Colorfastness:** There was no significant difference in colorfastness among samples. The mean values ranges from 5.80 – 6.35

iv. **Overall Acceptability:** S/ample A is more acceptable than B and C though there is no significant difference between sample B and C. There is no significant difference between sample A and the control sample D. Sample A and C are the best among the evaluated samples.

Table 2: Assessors mean Response for Beauty

SN	Samples	Scores	Mean
1	A	136	6.80
2	B	111	5.55
3	C	122	6.10
4	D	132	6.60

Table 2 showed that even with the control sample D, sample A was rated highest in beauty with a mean score of 6.80 and sample C was rated next apart from the control sample D with a mean score of 6.10 and the least was sample B with a mean score of 5.55.

Table 3 Assessors mean Response for Sharpness

SN	Samples	Scores	Mean
1	A	137	6.85
2	B	101	5.05
3	C	111	5.55
4	D	129	6.45

Table 3 revealed that sample A scored the highest in sharpness with a mean score of 6.85 which is higher than the control sample D and sample B scored the least in sharpness with a mean score of 5.05

Table 4 Assessors mean Response for Colorfastness

SN	Samples	Scores	Mean
1	A	127	6.35
2	B	116	5.80
3	C	123	6.15
4	D	125	6.25

Table 4 indicated that sample A was rated highest in colorfastness and sample B the lowest with their mean scores of 6.35 and 5.80 respectively.

Table 5 Assessors mean Response for General Acceptability

SN	Samples	Scores	Mean
1	A	138	6.90
2	B	110	5.50
3	C	119	5.95
4	D	134	6.70

Table 5 revealed that the control sample which is D is not higher than sample A in general acceptability. Nevertheless, the control sample is generally accepted than sample B which is the least accepted with their means ranged from 5.50- 6.90.

Discussion of the Findings

Table1 revealed that there is a significant difference in beauty among the samples in comparison with the control sample D. However, there was no significant difference between sample A (Turmeric dye) and the control sample D(Vat dye). Sample A was extremely liked and best for beauty with mean values ranged from 5.55- 6.80.In sharpness, sample B(Spinach dye) was the least and the mean values ranged from 5.05-6.85 with sample A being the best. There was no significant difference in colorfastness among the samples, though sample A was rated highest and their mean values ranged from 5.50- 6.90. Sample A was also rated highest in general acceptability and there is no significant difference between sample A and the control sample D.

These findings are important in this work because they have proved that Turmeric Spinach and "Anunu" contain high level of Curcumin, chlorophyll and indigotin respectively. These pigments contained in these plants are the principal agents responsible for the colorations used as dyes on cotton fabric. The findings have also shown that turmeric, spinach and "Anunu" are not dangerous to health (the skin). Cotton fabric dyed with these plants pigment can be used to produce clothing's for both children and adults in the family without the fear of causing allergy. This is in agreement with Joseph (2003) that these plants pigments can be used as colorants in foods. Varenya et al (2014) also emphasized that the use of plants colorants dated back to thousands of years in all societies around the world.

It is also encouraging that these plants are available in our home and school environments. Teachers in primary and secondary schools can use the dyes extracted from them to teach students simple home dyeing.

Turmeric in its form has medicinal and nutritional value such that it is used as colorants in food and drinks. The dyes produced from these plants can also be commercially, locally, individually, institutionally, and nationally used to produce colorful fabrics and for the renovation of faded cotton fabrics into a new color that can improve their designs. Application of home and institutional dyeing of this type, as a matter of fact enhances skill acquisition that leads to self-reliance.

Conclusion and Recommendations

In conclusion, this research work by all analysis showed that the roots of turmeric, the leaves of spinach and "Anunu" plant could be used in producing natural dyes of such beauty, sharpness and colorfastness that were comparable with existing vat dye (synthetic dye). These plants do not only end its value as natural dyes, they can also be applied to health such that Turmeric is used as blood purifier, Spinach rich in Omega 3 fatty acid (Which has being shown to help with rheumatoid and depression) and "Anunu" leaves are applied as poultice for ulcers of the foot. This research work appreciates the work of nature that dyes could be extracted from Spinach which is known as green leafy vegetable that contains almost all the vitamins, minerals and nutrients the body requires, Turmeric which is also known as food dye and "Anunu" that is known for its high percentage content of indigotic.

Based on the findings of this study, the following recommendations are made:

1. Turmeric plant should be planted in large quantity so that it could be readily available for use in producing dye for fabric.
2. Further work should be done in the various methods of extracting pigments from these plants and with some other plants found around the house.
3. It is also recommended that these dyes should go into large scale domestic and commercial production.

References

Anyakoha, .E & Eluwa .M. (2010). *Home management for schools and colleges*. Onitsha: Africa- Feb publication Onitsha Nigeria.

Ashok, K.P & Bangaraiah, P. (2013). Extraction of curcumin from turmeric roots. *International Journal of Innovative Research & studies (IJIRS).* 2(5), 290-298

Balter, M. (2009). *Clothes Make the (Hu) Man. Science.* 325 (5946):1329.Doi: 10.1126/science.325_1329aPMID 19745126 (http://www.ncbi.nlm.nih.gov/pubmed /19745126?dopt=abstract.)

Burkill, H. M (2012). *http://theusefulplantofWestTropicalAfrica.com* Cotton-(2014) Wikipedia the free encyclopedia

Home-made plant dyes. (2009). *The Tear fund International Learning Zone*. Web. 05 Oct. http://en.wikipedia.org/wiki/turmeric
http://www.hugpages.naturaldyes.com/Varenya_2014

Hughs S. E, Valco, T. D. & Williford, J. R. (2008). *100 Years of Cotton Production, Harvesting and Ginning Systems Engineering: 1907-2007.* Transactions of the ASABE **51**(4): 1187–1198.

Hunger, K., ed. (2003). *Industrial Dyes: Chemistry, Properties, Applications*. Weinheim: Wiley-VCH.

Igbo, C. A., (2013). *An introduction to fibre and yarn studies*. Enugu: Inselberg (Nig) Ltd, Nigeria. Page 27-31.

Joseph, C. (2013). *Spinach: the true food.* http://truththeory.com/category/articles/911

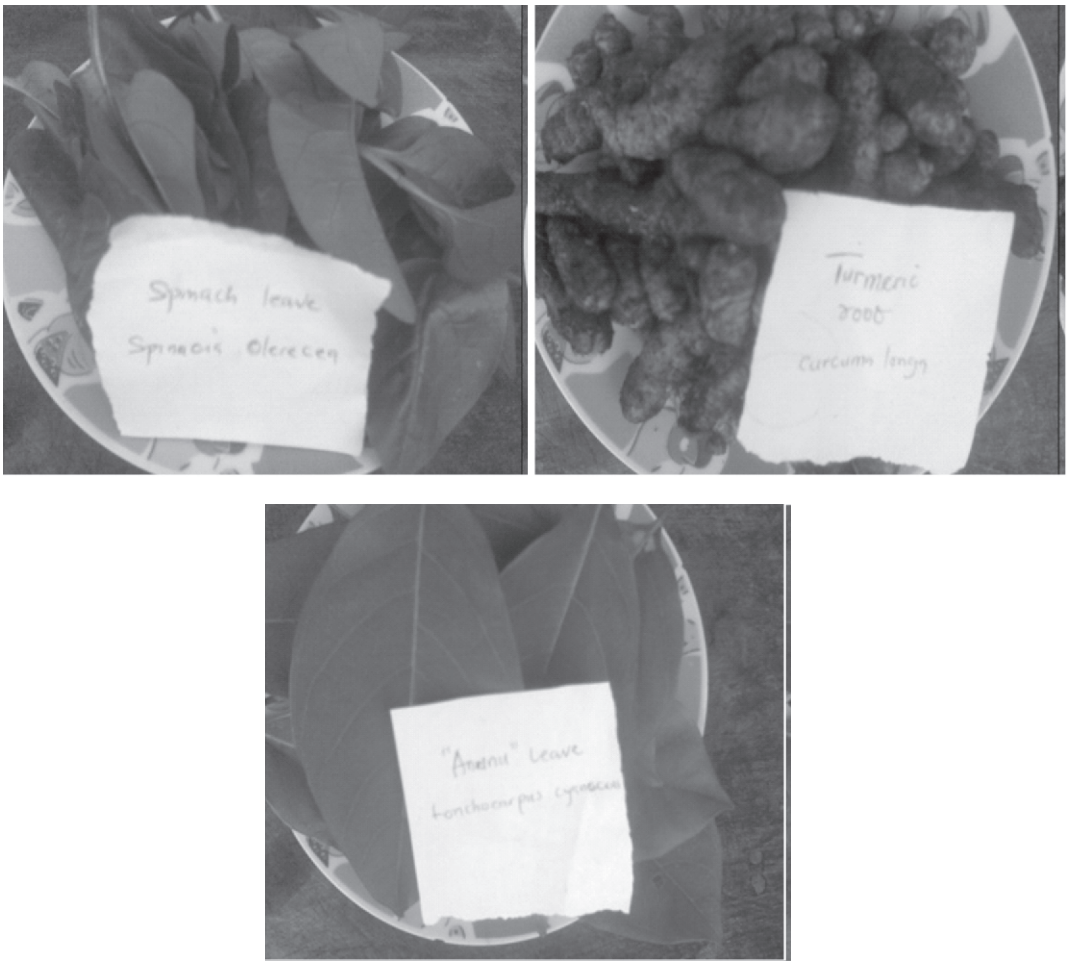
Obute G. C & Osuji L.C.(2002). Environmental Awareness and Dividends: A Scientific Discourse. *African Journal of Interdisciplinary Studies.* 3(1): 90 - 94.

Onwuka, G. I (2005). *Food Analysis and Instrumentation: Theory and Practice.* Lagos: Napthaliprints, Surulere Lagos, Nigeria.

Riekie, S. (2006). *Dyeing of textile (practical action).* Tthe New England unit of the herb society of America

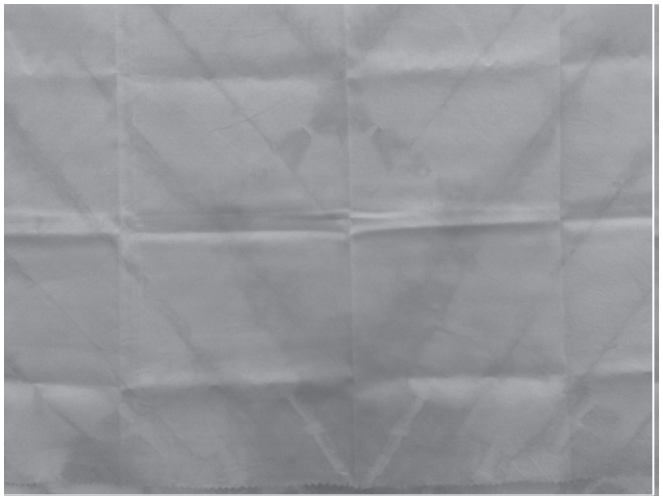
Simon, G. (2000). *Mauve: how one man invented a color that changed the world*. Faber and Faber. ISBN 0-393-02005-3

Appendix A
Data collection techniques: The field phase.



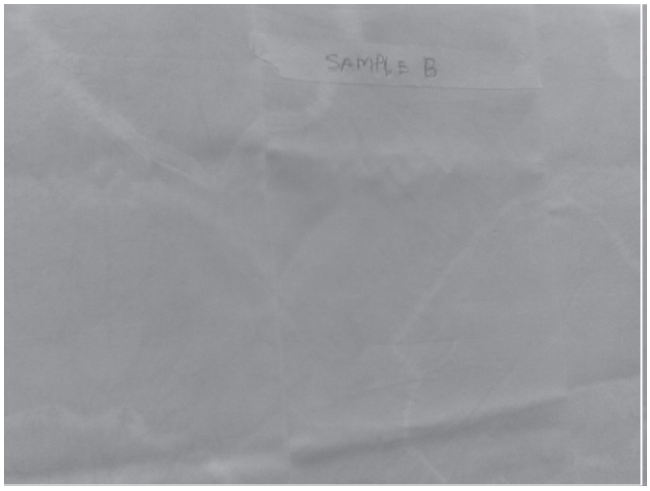
Apendix A1 pictures of fresh *Spinaciaolerecea,* (spinach)*curcuma longa*(Turmeric) *and Lonchocarpuscyanscens*(Anunu) respectively

Cotton fabric dyed with turmeric extract



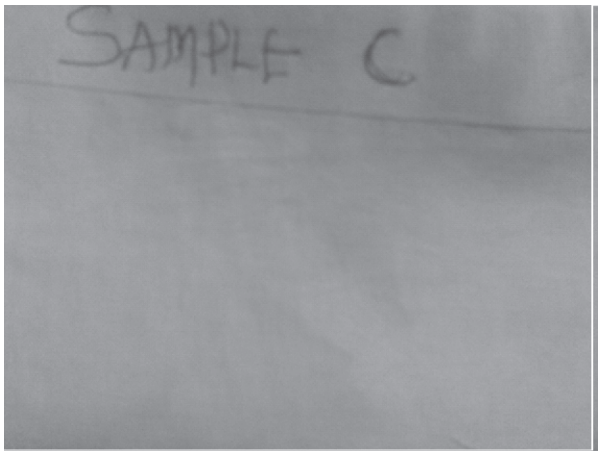
Appendix A2: Picture of Cotton fabric tie-dyed with turmeric extract (Sample A)

Cotton Fabric Dyed with Spinach Extract



Appendix A3: Picture of Cotton fabric tie-dyed with spinach extract (sample B)

Cotton fabric dyed with 'Anunu' extract



Appendix A4: Picture of Cotton fabric tie-dyed with "Anunu" extract (Sample C)

Cotton fabric dyed with vat dye

Appendix A5: Picture of Cotton fabric tie dyed with vat dye (Sample D)